COLUMBIA BASIN COLLEGE
BOARD OF TRUSTEES' MEETING
October 9, 2017
Beers Board Room — 4:00 p.m.

Agenda
Call to Order

***Agenda Changes**

***Approval of Minutes**
September 1, 2017 Board of Trustees' Meeting — Exhibit A
September 11, 2017 Board of Trustees' Meeting — Exhibit B
September 18, 2017 Board of Trustees' Meeting — Exhibit C

Celebrating Excellence

Linkage with Community

Remarks
By Administration
President
Cheryl Holden – Enrollment — Exhibit D
Michael Lee – New Horizons
By CEO, Foundation
By ASCBC — Exhibit E
By Faculty Senate Chair
By AHE
By Classified Staff
By Board Members

Reports
Budget Tracking and Fund Balance — Exhibit F
Agriculture Research — Exhibit G

Discussion

Consent

Public Comments

Executive Session

Adjournment

***(Requires motion/approval)**

Exhibit A

Columbia Basin College
Board of Trustees' Meeting Minutes
September 1, 2017
Beers Board Room – 9:00 a.m.

Members in attendance: Kedrich Jackson, Bill Gordon, Sherry Armijo (Phone), Duke Mitchell

Interim President Thornton, Secretary to the Board; Kaitlyn Hamilton, Recording Secretary

Others in Attendance: Camilla Glatt, Kevin Hartze, Steven Foster

The Agenda	The Discussion	Action
Call to Order	• Meeting called to order by Chair Jackson at 9:00 a.m.	
Executive Session	• RCW 42.30.110(h): To evaluate the qualifications of a candidate for public office.	Board went into Executive Session at 9:00 a.m. for 1 hour and 23 minutes.
Discussion	• None	
Adjournment: 10:25 a.m.	Next Board of Trustees' Meeting Beers Board Room September 11, 2017- 9:00 a.m.	

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Kedrich Jackson, Chair

Exhibit B

Columbia Basin College
Board of Trustees' Meeting Minutes
September 11, 2017
Beers Board Room – 9:00 a.m.

Members in attendance: Kedrich Jackson, Bill Gordon (Phone), Sherry Armijo, Duke Mitchell, Allyson Page

Interim President Thornton, Secretary to the Board; Deb Severin, Recording Secretary

Others in Attendance: Camilla Glatt, Kevin Hartze, Steven Foster

The Agenda	The Discussion	Action
Call to Order	• Meeting called to order by Chair Jackson at 8:59 a.m.	
Executive Session	• RCW 42.30.110(h): To evaluate the qualifications of a candidate for public office.	Board went into Executive Session at 9:00 a.m. for 28 minutes.
Discussion		Board reconvened and announced Dr. Rebekah Woods accepted the President position. Chair Jackson asked for a motion to select Dr. Woods as CBC's new president with a starting annual salary of $220,000. Trustee Mitchell moved and Trustee Page seconded the motion. Approved unanimously.
Adjournment: 9:31 a.m.	Next Board of Trustees' Meeting Beers Board Room September 18, 2017- 4:00 p.m.	

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Kedrich Jackson, Chair

Exhibit C

Columbia Basin College
Board of Trustees' Meeting Minutes
September 18, 2017
Beers Board Room – 4:00 p.m.

Members in attendance: Kedrich Jackson, Sherry Armijo, Bill Gordon, Duke Mitchell, Allyson Page
President Thornton, Secretary to the Board; Deb Severin, Recording Secretary
Others in Attendance: Tyrone Brooks, Cheryl Holden, Camie Glatt, Melissa McBurney, Michael Lee, Monica Hansen, Mary Hoerner, Daphne Larios, Deborah Meadows, Jason Engle, Josh Ellis, Frank Murray, Brian Dexter, Jesus Mota, Alissa Watkins, Janese Thatcher, Eduardo Rodriguez, Kelsey Myers, Lane Schumacher

The Agenda	The Discussion	Action
Call to Order	• Meeting called to order by Chair Jackson at 3:59 p.m.	
Approval of Minutes	• August 23, 2017 • August 24, 2017 • August 25, 2017	• Trustee Armijo moved and Trustee Mitchell seconded the motion to approve all minutes as written. Approved unanimously.
Celebrating Excellence	• None	
Linkage to Community	• None	
Opening comments	<u>Chair Jackson</u> • Welcome	
Remarks Administration	<u>President Thornton</u> • Appreciated Chair Jackson's comments at the All Campus Welcome meeting and felt it was a good opening week. He received a lot of positive feedback. Acknowledged Daphne Larios' 10 year service award and Mary Hoerner's 30 year service award again. Appreciated all the ambassadors who helped. • President Thornton asked Cheryl Holden to provide an update on the new residence hall. Cheryl stated they have 30 students in the residence hall, 10 applications on hold with no security deposit. They held a social and 17 students attended, which is over 50% participation. Tomorrow night (9/19) they are providing a game night for the students and hope they get to know each other. The punch list continues – trying to get mailboxes figured out. The Resident Advisors are on board. Daniel reported the students are happy with their rooms and communicate through e-mail. Their only complaint is there are not enough outlets. There has been discussion and concern there is not a crosswalk between the residence hall and the College closer to the College, rather than at Argent and 20th Street. Chair Jackson asked if getting a crosswalk was in the future plans. Brian Dexter stated the City of Pasco was working on it. Tyrone Brooks stated there is an impact fee and he was not sure if it is paid. The City of Pasco controls and performs the work for crosswalk crossing. Trustee Gordon asked about the street lights and Tyrone stated there is no flashing crosswalk beacon. Tyrone also acknowledged the work the City of Pasco completed for the	

	traffic signals and the turn signal on 20th Avenue is functioning in a new way – smoother flow of traffic.	
Foundation	Alissa Watkins, Executive Director, CBC Foundation • Thanked the Trustees and the presidential search committee for the hard work and selection of the new CBC President, Dr. Rebekah Woods. Looking forward to welcoming her. Chair Jackson stated it's a win the way we treat our students and hopes the deans are telling the faculty members. • Online Giving Platform – Foundation staff have acquired a new online donation platform. We will have the ability to create unique pages for specific CBC program needs. Initial platform page should be ready within two weeks and will be used for general donation and "Giving Tuesday" on Nov. 28. • Press Conference – There are 2 press conferences coming up. First will recognize the Gates Foundation ($100K) and MSA ($33K) for the purchase of 125 laptops for the English Language Acquisition (ELA) program. Second will be for WRPS who donated $33K to purchase equipment and fund scholarships for the Nuclear Technology program. No dates yet on the press conferences. • Scholarship Award Ceremony is Friday, November 3, 2017, 10:00 a.m. at the Pasco Red Lion.	
ASCBC Faculty Senate Chair Classified Members	• None • None • None	
Board Members	Trustee Page • Reported she has heard comments from parents that are thrilled with CBC, especially that Running Start is a great program. Trustee Mitchell • Toured CBC Sunhawk Hall Student Housing Building and participated in the Ribbon Cutting Ceremony. • Attended the CBC Board Meeting and Executive Session. Thanked the Attorney General's regarding the presidential search process and their help in hiring Dr. Rebekah Woods. • Attended Richland School Board Meeting • Attended WSU-Tri-Cities New Student Union Building Ribbon Cutting Ceremony. It is a very energy-efficient building. Spoke with Dr. Kurt Schultz, WSU President, and Dr. Keith Moo-Young, WSU Tri-Cities community leader. • He spoke with Dr. Schultz about his strong desire, and his, to improve working relationships between WSU-TC and CBC. They both believe they have a tremendous opportunity upon the arrival of the new CBC President and the new WSU-TC Chancellor. Mary Hoerner stated the relationship was much better, but the path is not clear yet. • Someone asked Trustee Mitchell what the construction was that was going on by the W Building. He did some asking around and discovered it was the City of Pasco working.	

	Trustee Gordon • Followed up with what Trustee Mitchell stated and that he and Dr. Schultz talked about the same thing. He stated Dr. Schultz would like Dr. Woods to contact him when she arrives at CBC and set up a meeting. Additionally, would like Dr. Woods to meet with the new Chancellor in the January/February timeframe. • Attended the Ribbon Cutting Ceremony for the new Sunhawk Hall Student Housing Building. He was surprised how many attended the ceremony and felt it was a good sign. Trustee Armijo • She was honored to be part of the presidential search process and thanked Dr. Thornton for the process and transition. She also thanked Chair Jackson and Camie Glatt and her HR staff. Chair Jackson • Jackson College in Michigan sprawls out in rolling hills and is beautiful. They have three residence halls and it was interesting that around 5:30 they checked out the campus and students were everywhere. It felt like a four-year school. Could be a vision for CBC's future. We will provide support to Dr. Woods in her success for the College.	
Reports Budget Training and Fund Balance	Tyrone Brooks • Enrollment – the data provided is a week old, predicts more students will show up next week. Normally these numbers spike. Running Start numbers are great, 206 ahead of our target. Chair Jackson stated this was significant and to rethink key strategies. Tyrone stated we treat Running Start students like college students and that is one of the key factors – we don't differentiate, we view them as young adults in a collegiate experience. Chair Jackson asked if there is a connection to New Horizons and Michael Lee stated yes there is. • New Allocation Model – there is a new weighted FTE. Comparison data shows we are 184 down from last week. A lot of this is timing. Daphne Larios' enrolling is Thursday night and he is cautious but optimistic. • Operating P&L Report – The report is light because it was free of faculty payroll. Goods services is a little ahead and under budget. The inter-intra agencies are in the red but those come and go as they are projects areas of the State. • Operating Funds Variance – We are dead even. Front loaded $22M, allocation of COLA amount and benefits rates. Local fees increased by 2.2%. We would expect this at this time of year. • No fund balance report. We are running stable with fund balance. Expecting $2.1M from the federal government for reimbursement for financial aid payments. • Capital Budget – DES is laying off around 27 employees, program staff employees. This will hurt local economy as there are around 15,000 affected in the general contractors union statewide. Chair Jackson stated a talk with the legislators was necessary. There is a new special interest group regarding water rights and that's the big deal. Although not approved yet, CBC has bids for roofs, pipes, electrical, sidewalk repairs, etc. to have a functioning campus. Dr. Thornton stated we are lucky we don't have any major projects as some campus across the State are having troubles. • Trustee Gordon asked when is the requirement to provide enrollment numbers. Jason	

	Engle stated at the end of the quarter term.	
Redefining Mission Fulfillment/Accountability/ Monitoring Reports	Lee Thornton • Dr. Thornton met with Jason Engle, Dean for Organizational Learning, Josh Ellis, Director for Institutional Research, and Joe Montgomery a number of times regarding the fulfillment, assessment and monitoring reports to help the Board assess if the College is meeting its goals by summative measures. What affect do higher education strategies have on meeting its mission and on our students? External: They looked at external impacts (employment rate, wages – minimum wage jobs) and identified completers (those with credentials) which become the summative measures and have designed a method for assessing their impact on larger systems: 1) Occupational, 2) Economic, 3) Social, and 4) Cultural. One definition of mission fulfillment would be an impact assessment of college completers on the external environment. In this context, the external assessment would be a summative measure and rate of completion would be formative. Internal: Mission fulfillment from an internal context would include: 1) completer as summative measure following with credentialing, SLO, course/program reports, and quarterly reports/institutional progress (academic professional/technical transitional studies). The Board would be engaged around the monitoring reports and if something came out in the news, the Board would look into the report. This will provide bench marks and the Board can say this was accomplished or what the barriers are to no completion. These summative measures can identify key barriers to completion: How much can be explained? Designing strategies to overcome barriers. Example: Guided Pathways should improve completion – by how much? • Jason Engle Jason presented an example of what a "Quarterly Report of Institutional Progress" might include as part of a focus on completion. This work was based on "Steps to Success" research from California State University which identified key milestones and success indicators that relate to completion of a degree program. Key components to the tentative proposal include the use of research-based indicators, incorporation of projections/analytics to make estimates more current, more regular updates (every 3 months instead of once per year), and a "Research Topics" presentation where the Board may request additional analyses to answer more specific questions that arise from the data and/or cover topics that are timely for CBC. • Monica Hansen A draft was handed out of the new program review template which will be a vehicle for faculty, leads, coordinators and deans to reflect on goals and set targets based on regular data reports throughout the evolution of traditional disciplines into pathways	

	for students. The intent of revising the program review is to facilitate better information and data accessible at all levels (course, program, and institution) for meaningful processes of interpretation and review. In addition, she provided a sample "program report" submitted by Josh Ellis to demonstrate how the metrics could be generated and used in the program review process and summed for institutional reporting. Chair Jackson stated from a policy standpoint we can tie back to mission fulfillment and need to be educated on some of the stuff. Dr. Thornton closed stating we can identify the barriers, create a design to help completion, and finally provide research to the Board. The goal is engage in monitoring and meeting the College mission. We have two Ph.D. Researchers and a great group of problem solvers. Trustee Armijo stated this should be shared with the faculty and can ultimately change the classroom and experience on campus and used Running Start as an example. Chair Jackson asked Melissa McBurney, AVPI of Professional Technical Education & Instructional Services to discuss New Horizons. Melissa stated students are graduating with CBC credentials and align with the vision. They are trying to align courses (e.g., English 98, 99) ready for college level. Lee discussed articulation agreements and CBC students and the Second Harvest.	
Board Clarification of Delegated Authority	<u>Chair Jackson</u> • Passed out a draft Addendum of Board-Staff Linkage Employment Responsibilities. Responsibilities are not clear in the Board policies regarding Board to Staff Linkage. The Board will review offline. Because the Board policies are designed after the Carver Model, Chair Jackson is recommending changes to the current policy. Dr. Woods is familiar with the Carver Model and is strongly supportive of it. Trustee Mitchell asked for a schedule and suggested discussing at the November 6, 2017 Board meeting. Chair Jackson agreed to discuss at the November 6, 2017 Board meeting.	
Consent	• None	
Public Comment	• None	
Executive Session	• None	
Adjournment: 5:37 p.m.	Next Board of Trustees' Meeting Beers Board Room October 9, 2017	

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Kedrich Jackson, Chair

Exhibit D

Fall to Fall FTE Comparison, September 28, 2017

	Fall 2016 Day 10 3-Oct-16	Fall 2017 Day 10 1-Oct-17	Change From Last Year
State Supported FTE	4111.86	4071.71	**-40.15**
Worker Retraining	231.55	239.11	**7.56**
Total State FTE	**4343.41**	4310.83	**-32.58**
International	0.00	6.07	**6.07**
Running Start	801.39	956.29	**154.90**
Total State Reported FTE	**5144.80**	5273.19	**128.39**
All FTE	**5339.57**	**5481.09**	**141.52**
Coding Errors Not Counted	0.01	0.00	**-0.01**
FTE by Institutional Intent			
Academic	3096.03	3252.79	**156.76**
Workforce	1049.91	1116.87	**66.96**
Apprenticeships	9.97	64.31	**54.34**
WorkFirst	25.17	12.34	**-12.83**
IBest	19.91	29.53	**9.62**
Developmental	526.87	518.00	**-8.87**
Basic Skills	471.99	385.53	**-86.46**
ESL	312.20	245.93	**-66.27**
ABE/GED	159.79	139.60	**-20.19**
State Supported Headcount	5654	5421	**-233**
Worker Retraining	279	341	**62**
Total State Headcount	**5933**	5762	**-171**
International	0	7	**7**
Running Start	883	1073	**190**
Total State Reported Headcount	**6816**	6842	**26**
All Students	**7058**	**7087**	**29**

Change in State FTE
-33
-0.8%

Source: SMIS Database

Exhibit E

Associated Students of Columbia Basin College

ASCBC

October Newsletter

Service & Activities Board (SAB)

Ashley

Ashley is a running start student who cares about domestic violence prevention and would like to host an event that promotes awareness and prevention. She is also hoping to increase ASCBC's outreach on social media.

Tamra

Tamra is our digital media officer and is currently researching various YouTube video options to promote ASCBC. She is also working on a CarSmash Event, as a stress-reliever for CBC students before spring finals.

Viktoria (Tori)

Viktoria is one of organizers for Club Rush. She is extremely interested in creating a close community by supporting clubs. She is also working on a Thanksgiving scavenger hunt.

Heather

Heather is a returning SAB officer from last year. She loves bringing people together. This year, she is organizing CarniFall, a large fall festival for students & their families.

Executive Council

Garrett

Secretary of Legislative Affairs

Garrett's main objective is to educate students on legislative happenings and bills that effect higher education. He represents ASCBC at the Washington Community and Technical College Student Association (WACTCSA).

Abigail

Vice - President

Abigail's goal is to strengthen our college community and provide support to clubs. She is one of the organizers for the Club Rush, an annual ASCBC event that connects clubs with possible new student participants.

Vlada

President

Vlada is the returning ASCBC President. She continues working on her Mental Health platform, but this year she is also organizing a DACA forum in November.

Exhibit F

FY1718 Operating Funds Variance Report

% of Fiscal YR: 25.48% 10/2/2017

By FUND					% of Bdgt Exp EXP/BDGT	% of Rev Exp EXP/REV	% of Bdgt Rev REV/BDGT
*State Allocation 101,3E0,BD1,BG1,BK1,123	000	BDGT	$23,676,879.00		17.24%	18.21%	94.66%
		EXP	$4,082,510.10				
		REV (Alloc)	$22,413,670.00				
Local Fees	148	BDGT	$3,464,813.00		14.98%	36.64%	40.88%
		EXP	$518,919.81				
		REV	$1,416,456.39				
Local Tuition	149	BDGT	$16,978,168.00		14.36%	60.75%	23.64%
		EXP	$2,438,482.71				
		REV	$4,013,870.41				
Running Start	145	BDGT	$230,056.00		6.44%	0.00%	0.00%
		EXP	$14,820.20				
		REV	$0.00				
**ASCBC	522	BDGT	$1,135,900.00		11.28%	30.72%	36.72%
		EXP	$128,146.03				
		REV	$417,148.83				
TOTALS		BDGT	**$45,485,816.00**		15.79%	25.42%	62.13%
		EXP	**$7,182,878.85**				
		REV	**$28,261,145.63**				

BY OBJ, ALL FUNDS COMBINED			BDGT	EXP	EXP/BDGT
SALARIES	A		$26,107,102.00	$3,710,783.66	14.21%
BENEFITS	B		$8,751,614.00	$1,674,581.33	19.13%
PERSONAL SERVICES CONTRACTS	C		$152,111.00	$24,197.48	15.91%
GOODS & SERVICES	E		$6,378,321.00	$1,594,754.33	25.00%
COST OF GOODS SOLD	F		$0.00	$0.00	0.00%
TRAVEL	G		$761,060.00	$72,647.27	9.55%
CAPITAL OUTLAYS	J		$987,934.00	$46,687.29	4.73%
SOFTWARE	K		$0.00	$0.00	0.00%
GRANTS BENEFITS & CLIENT SVCS	N		$1,035,653.00	$77,583.09	7.49%
***DEBT SERVICE	P		$1,534,732.00	$0.00	0.00%
INTERAGENCY REIMBURSEMENTS	S	Revenue Bdgt	($217,386.00)	($2,647.65)	1.22%
INTRAAGENCY REIMBURSEMENTS	T	Revenue Bdgt	($5,325.00)	($15,707.95)	294.98%
DEPRECIATION, AMORTIZATION, BAD DEBT	W		$0.00	$0.00	0.00%
			$45,485,816.00	**$7,182,878.85**	15.79%

NOTES

* Per Allocation 2 - $6860 increase - SSB5100

** Includes ASCBC debt service budgets and revenue collected through quarterly fees

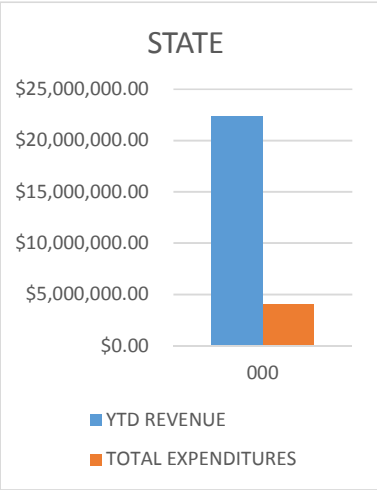
*** Principal and interest debt service expenditures occur in December and June

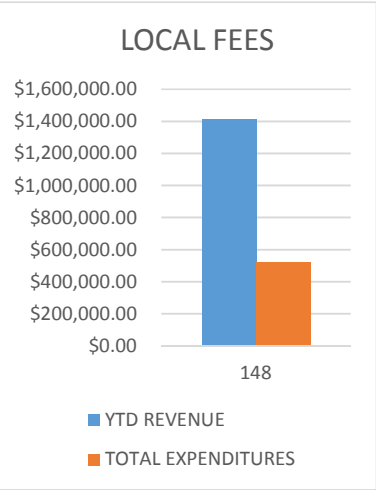
**** variance of $8.23 among all funds is due to conversion of Budget Pak decimal numbers to whole number

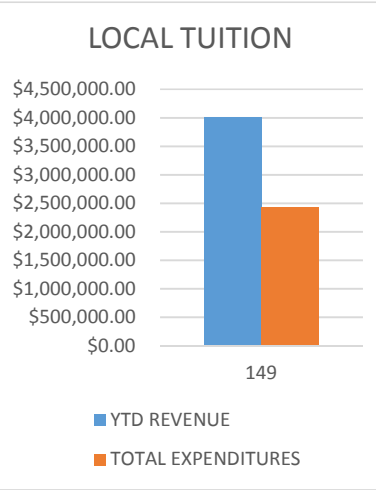
FY 1718 Operating P&L Report

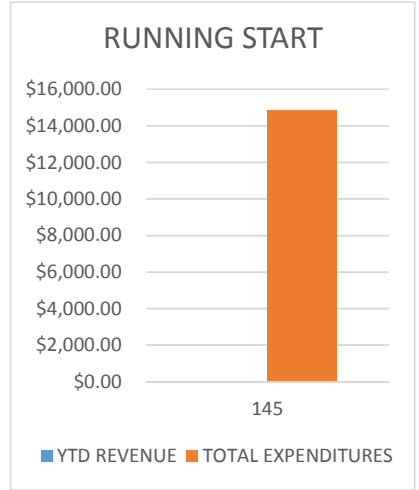
10/2/2017

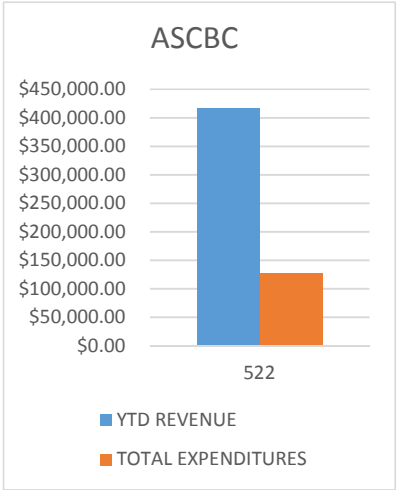
			STATE	LOCAL FEES	LOCAL TUITION	RUNNING START	ASCBC	
			000	148	149	145	522	TOTAL
YTD REVENUE			$22,413,670.00	$1,416,456.39	$4,013,870.41	$0.00	$417,148.83	**$28,261,145.63**
YTD EXPENDIT…	SALARIES & WAGES	A	$2,406,195.37	$229,668.36	$1,038,903.95	$9,705.00	$26,310.98	**$3,710,783.66**
	BENEFITS	B	$1,062,042.92	$88,547.29	$512,389.52	$4,766.32	$6,835.28	**$1,674,581.33**
	PERSONAL SERVICES CONTRACTS	C	$4,861.48	$21,250.00	($2,064.00)	$0.00	$150.00	**$24,197.48**
	GOODS & SERVICES	E	$528,220.33	$163,883.17	$839,798.43	$348.88	$62,503.52	**$1,594,754.33**
	COST OF GOODS SOLD	F	$0.00	$0.00	$0.00	$0.00	$0.00	**$0.00**
	TRAVEL	G	$23,636.79	$14,662.98	$14,149.07	$0.00	$20,198.43	**$72,647.27**
	CAPITAL OUTLAYS	J	$21,202.55	$5,388.40	$12,465.40	$0.00	$7,630.94	**$46,687.29**
	SOFTWARE	K	$0.00	$0.00	$0.00	$0.00	$0.00	**$0.00**
	GRANTS BENEFITS & CLIENT SVCS	N	$60,502.80	$11,340.15	$1,223.26	$0.00	$4,516.88	**$77,583.09**
	DEBT SERVICES	P	$0.00	$0.00	$0.00	$0.00	$0.00	**$0.00**
	INTERAGENCY REIMBURSEMENTS	S	($2,647.65)	$0.00	$0.00	$0.00	$0.00	**($2,647.65)**
	INTRAAGENCY REIMBURSEMENTS	T	($21,504.49)	($15,820.54)	$21,617.08	$0.00	$0.00	**($15,707.95)**
	DEPRECIATION, AMORTIZATION, BAD DEBT	W	$0.00	$0.00	$0.00	$0.00	$0.00	**$0.00**
TOTAL EXPENDITURES			$4,082,510.10	$518,919.81	$2,438,482.71	$14,820.20	$128,146.03	**$7,182,878.85**
NET RESOURCES			$18,331,159.90	$897,536.58	$1,575,387.70	($14,820.20)	$289,002.80	**$21,078,266.78**











CBC Operating Reserves
FY 2018

Board of Trustee's Reserve by Policy FY18	Purpose	Amount	Fund
Current Operations	*Campus cash flow needs*		
	2 months operating expense	$7,500,000	149
Unplanned Capital Repair & Replacement	*Covers largest potential system failure*		
	Core systems such as: plumbing, electrical, HVAC, etc.	$750,000	149
	Failing roof systems	$1,000,000	149
		$1,750,000	
Real Estate Debt Fund	*Provides for real estate debt needs of CBC not easily funded from State sources*		
Debt Service Reserve		$1,500,000	149
Real Estate Acquisitions		$9,225,000	Various
		$10,725,000	
Planned Future Operations	*Future new program offerings by project*		
ctcLink Implementation		$475,000	149
Degree Map Program		$465,000	149
Culinary Program		$1,500,000	149
		$2,440,000	
Capital Facilities Projects	*Covers current and planned capital projects*		
Argent Street Widening	Future Project Share	$1,250,000	145
Various Capital Projects	Minor Works $	$105,000	149
4th Floor Buildout	Future Buildout of Shell Space	$2,000,000	148
		$3,355,000	
BOT Designated Reserves		**$25,770,000**	

Investments	Amount	Ave Maturity Yrs	Ave YTW
TVI	$3,980,000	1.46	1.04%
Buckley	$4,999,828	0.75	0.93%

CBC GRANT STATUS REPORTS SUMMARY

Updated through August 31, 2017

CURRENT GRANTS

Project Name	Page No.	Funding Agency	Director/Contact	Renewal	Start Date	End Date	Term Year	Total Award	Total Expended	Indirect Costs				Grant Objectives Performance Summary
										Recovery Rate	Total Allowed	Total Recovered	Difference Due To	Color Key: On track; Met some, but not all, objectives; Objectives not met
College Assistance Migrant Program (CAMP) 2012-2017	2	U.S. Department of Education	Miriam Fierro	Every 5 years	7/1/2012	9/30/2017	5 of 5	$2,101,850	$2,096,816	8% total direct	$129,636	$125,905	Vacancies in all positions throughout 5 years except Director, anticipated COLAs not received, unable to hire one position due to lack of a proper position/classification	On track
College Assistance Migrant Program (CAMP) 2017-2021	2	U.S. Department of Education	Miriam Fierro	Every 5 years	7/1/2017	6/30/2022	1 of 5	$2,125,000	$15,416	8% total direct	$141,818	$1,142	Years 1-5 direct costs not fully expended yet	TBD - new award
High School Equivalency Program (HEP)	3-4	U.S. Department of Education	Dalina Hoffman	Every 5 years	7/1/2015	6/30/2020	3 of 5	$2,271,390	$905,719	8% total direct	$163,990	$65,240	2 positions vacant for 5 months each and 1 staff member on maternity leave. Remaining indirect should be recovered in Years 3-5 due to COLAs not included in the original budget	Behind in Year 1, improved in Year 2, on track for Year 3
Nuclear Scholarship Program	5	Nuclear Regulatory Commission	Leah Gillette-Fox	Every 2 years	7/1/2016	6/30/2018	2 of 2	$150,000	$55,371	Not allowable	$0	$0	N/A	On track
Student Support Services (SSS)/TRiO	6	U.S. Department of Education	Amy Stroud	Every 5 years	9/1/2015	8/31/2020	2 of 5	$1,468,785	$592,770	8% total direct	$110,010	$43,582	Years 2-5 direct costs not fully expended yet, otherwise on track	On track - exceeded all objectives
Title V - Student Transitions and Achievement (STAA)	7-10	U.S. Department of Education	Vacant	Unknown	10/1/2015	9/30/2020	2 of 5	$2,624,983	$943,691	Not allowable	$0	$0	N/A	On track in some areas, behind in others
Upward Bound	11	U.S. Department of Education	Susan Vega	Every 5 years	9/1/2012	8/31/2017	5 of 5	$1,779,940	$1,769,756	8% total direct	$123,953	$123,507	Year 5 direct costs were not fully expended.	Exceeded in some areas, behind in others; objectives revised for 2017-2022 grant (approved)
Mathematics Engineering Science Achievement (MESA) Community College Program (MCCP)	12	State Allocated Funds	Debbie Padilla	Yearly	7/1/2017	6/30/2018	1 of 1	$125,000	$15,097	Not allowable	$0	$0	N/A	Low enrollments in 2016-17, restructured roles and revised objectives for 2017-2018.
Worker Retraining	13	State Allocated Funds	Michelle Mann	Yearly	7/1/2017	6/30/2018	1 of 1	$1,520,323	$89,352	Not allowable	$0	$0	N/A	On track
MESA K-12	14	University of Washington (Contract)	Vacant	Unknown	7/1/2017	6/30/2018	1 of 1	$0	$18,007	Not allowable	$0	$0	N/A	Behind in data entry, resulted in less annual funding. No contract in place yet, proposal out to move program and grant award to PNNL
Pacific Northwest Louis Stokes Alliance for Minority Participation (LSAMP)	12	National Science Foundation via University of Washington	Vacant	Unknown	9/1/2014	8/31/2017	3 of 3	$30,000	$7,411	Not allowable	$0	$0	N/A	See MCCP - Provides University visits and research for MCCP students. Additional $10,000 may be provided in 2017 and 2018 depending on performance.
Title V Cooperative Agreement	15-18	U.S. Department of Education via BBCC	Deborah Brown	Unknown	10/1/2014	9/30/2019	3 of 5	$1,197,254	$490,259	Not allowable	$0	$0	N/A	Initial delays in Years 1 and 2, gaining ground in Year 3, on track for Years 4 and 5
Basic Education for Adults (BEdA) - Master Grant	19	SBCTC	Erin Holloway	Yearly	7/1/2017	6/30/2018	1 of 1	$186,794	$0	5% of salaries	$0	$0	No indirect budget amount requested in grant application, even though indirect is an allowable cost. Director has been advised to submit budget revision to SBCTC to include indirect costs.	On track
BEdA - IEL Civics	20	SBCTC	Erin Holloway	Yearly	7/1/2017	6/30/2018	1 of 1	$39,049	$2,626	5% of salaries	$1,200	$110	Year 1 salary costs not fully expended yet	On track
BEdA - I-DEA Technology Expansion Grant	21	SBCTC	Erin Holloway	Unknown	5/18/2017	3/31/2018	1 of 1	$100,000	$0	Not allowable	$0	$0	N/A	On track
BEdA - Leadership Block Grant	N/A	SBCTC	Erin Holloway	Yearly	7/1/2017	6/30/2018	1 of 1	$5,228	$0	Not allowable	$0	$0	N/A	N/A - Provides travel funds for BEdA trainings
BEdA - Early Achievers Grant	N/A	SBCTC	Erin Holloway	Yearly	7/1/2017	6/30/2018	1 of 1	$91,300	$0	Not allowable	$0	$0	N/A	Unknown, report not submitted to Grants Department
Basic Food and Employment Training (BFET)	22	SBCTC	Debra Wagar	Yearly	10/1/2016	9/30/2017	1 of 1	**Target to Recover:** $261,514	**Total Recovered:** $183,668	45.9% of salaries + FB	$36,009	$36,009	N/A	On track. Grant requires 100% upfront expenditures, 50% of which are reimbursed. Upfront expenditures are paid for using other State-funding sources.
Perkins Plan	23	SBCTC	Melissa McBurney	Yearly	7/1/2017	6/30/2018	1 of 1	$297,842	$34,758	Not allowable	$0	$0	N/A	Exceeded all objectives except non-traditional indicators. Perkins has not met non-traditional objectives for multiple years.
Perkins Leadership Block Grant	N/A	SBCTC	Melissa McBurney	Yearly	7/1/2017	6/30/2018	1 of 1	$21,000	$0	Not allowable	$0	$0	N/A	N/A - Provides funds for CTE staff/faculty to attend trainings
Perkins Non-Traditional Employment & Training - WOW	24	SBCTC	Keeley Gant	Yearly	7/21/2017	6/30/2018	1 of 1	$5,000	$0	Not allowable	$0	$0	N/A	See Perkins Plan
WorkFirst Delivery Agreement	25	SBCTC	Debra Wagar	Yearly	7/1/2017	6/30/2018	1 of 1	$194,638	$17,120	5% of salaries	$2,105	$0	Indirect budget amount requested in grant application is lower then 5% of salaries allowed. Director has been advised to submit budget revision to SBCTC to increase the budget to the fully allowable amount. Indirect billed quarterly.	Low enrollments due to decreases in the number of eligible students in our service area.
Frontier Set - Guided Pathways	26	Aspen Institute	Kristen Billetdeaux	No	1/1/2017	6/30/2020	1 of 4	$630,000	$71,918	10% total direct	$57,273	$6,538	Years 1-4 direct costs not fully expended yet	On track
							TOTAL	**$17,226,890**	**$7,309,754**	-	**$765,994**	**$402,033**	-	-

FUTURE GRANTS

Project Name		Funding Agency	Director/Contact	Renewal	Start Date	End Date	Term Year	Total Award	Total Expended	Indirect Costs				Grant Objectives Performance Summary
										Recovery Rate	Total Allowed	Total Recovered	Difference Due To	
Upward Bound	N/A	U.S. Department of Education	Susan Vega	Every 5 years	9/1/2017	8/31/2022	0 of 5	$1,841,550	$0	8% total direct	$129,490	$0	No expenditures to date.	N/A
Women Helping Women (WHW)	N/A	WHW Fund Tri-Cities	Anneke Rachinski	No	1/1/2018	12/31/2018	0 of 1	$20,000	$0	Not allowable	$0	$0	N/A	N/A

College Assistance Migrant Program (CAMP)
Grantor: U.S. Department of Education

Director: Miriam Fierro
2012-2017 Total Award: $2,101,850
2017-2022 Total Award: $2,125,000

Reports To: Cheryl Holden
Term Year: 5 of 5
Term Year: 1 of 1

Mission: Provide students from migrant/seasonal farmworker (MSFW) backgrounds with academic, career, financial, and support services during their first year of college.

Population Served: Approximately 55 MSFW students annually.

Project's Impact on CBC's Mission and Student Success
CAMP participants receive admissions assistance, financial support for tuition/supplies, academic advising, the benefits of a Summer Bridge Program, tutoring, math-focused supplemental instruction, and career counseling.

CAMP directly impacts Goal 1 of CBC's Strategic Plan: Be a national leader in student retention and completion. CAMP students have **fall-to-fall retention rates 34% higher than the general CBC population and are 29% more likely to complete their degree.**

Source: CBC – Institutional Research, 2012-2016

Since CAMP serves only first-year students, participants are encouraged to utilize other CBC support programs in their second year. Since the beginning of the grant term, **61% of CAMP students have transitioned into Student Support Services/TRiO.**

Financial Benefits
CAMP financially benefits CBC by successfully retaining students. For every student not retained, CBC loses $7,146 per year in tuition, fees, and state funding (Internal Report, 2015). Additionally, since 99% of 2012-2017 CAMP students are Hispanic, CAMP also contributes to CBC's ability to obtain Hispanic Serving Institution funding.

2012-2017 Grant Objectives Performance Summary

Annual Objective	Actual Performance				
	12-13	13-14	14-15	15-16	16-17
1. Outreach to **500** potential participants and enroll **55** eligible MSFWs	**863** 54	**885** **58**	**1,059** **55**	**777** **55**	**1,042** **55**
2. Provide **100%** accepted students with admissions, financial aid assistance and scholarship information to successfully complete their first year of college and continue in post-secondary education.	98%	**100%**	**100%**	**100%**	**100%**
3. **86%** of students will complete their first academic year (GPRA 1).	**96%**	75%	**91%**	**87%**	**88%***
4. Provide **100%** students with academic, career, and counseling/ advising services to enable them to succeed in their first year of college.	98%	**100%**	**100%**	**100%**	**100%**
5. **85%** of first academic year completers will continue in postsecondary education (GPRA 2).	**96%**	**98%**	**94%**	**94%**	**98%***
6. **100%** of first year completers will be referred to other state and federal projects on campus and be offered follow-up services.	**100%**	**100%**	**100%**	**100%**	**100%**

** **To date**, 2016-2017 numbers will be finalized in November 2017 when the Annual Performance Report is submitted.*

Next Steps
Grant renewal occurs every five years. The 2017-2021 renewal application was approved for $2,125,000. CAMP recently started this new grant cycle and is preparing to conclude the 2012-2017 grant cycle in September.

High School Equivalency Program (HEP)
Grantor: U.S. Department of Education

Director: Dalina Hoffman
2015-2020 Total Award: $2,271,390
Reports To: Daphne Larios
Term Year: 3 of 5

Mission: Assist migrant and seasonal farmworkers (MSFW) and their children in earning their High School Equivalency Diploma (HSED), and, subsequently in gaining post-secondary education/training or employment.

Population Served: 293 MSFW students since beginning of grant term; 2,696 MSFW students total since the program began in 2000.

Project's Impact on CBC's Mission and Student Success
HEP links to the overarching strategy of CBC's Strategic Plan: **connectivity** (i.e., to be the local community's solution to higher education needs). CBC's service district has a high migrant population (average of 15%[1]), and a state study indicated a dropout rate as high as 50% for migrant students[2]. As one of the only HSED providers in our service area, HEP is critical for providing this local disadvantaged population with higher education and the opportunity to acquire a more livable wage.

Participants receive academic advising, tutoring, support for textbooks and supplies, career planning/advising services, college tours, referrals to postsecondary educational institutions and employment agencies, and follow-up services.

- In 2015-2017, an average of 47% of HEP students obtain their HSED.
- Within one to six months of graduating, **58% of HEP graduates continue their postsecondary education**, and 28% of HEP graduates enter the workforce.
- Of the HEP graduates that choose to continue their postsecondary education, **98% enroll at CBC.**

Note: The number of HEP graduates who earn their degree/certificate from CBC is currently unavailable, as students are often assigned new ID numbers upon enrollment.

Financial Benefits
HEP financially benefits CBC by bringing in new student tuitions and contributing to testing income. Since 99% of HEP graduates enrolled at CBC this period are Hispanic, the program also contributes to CBC's ability to obtain Hispanic Serving Institution funding.

2015-2017 Grant Objectives Performance Summary

No.	Annual Objective	Actual Performance	
		15-16	16-17
1.	Recruit **over 250** MSFW students for consideration into CBC HEP	**356**	**352**
2.	Conduct **150** intakes to determine initial eligibility and enroll into CBC HEP	98	140
3.	Administer HEP Educational Assessments and Occupational Evaluations to **150** students	98	140
4.	Provide **150** HEP students with HSED preparation assistance and remedial instruction	98	140
	75% of participants will obtain HSED (GPRA 1)	50%	44%
5.	**100%** of graduates receive placement referrals	**100%**	**100%**
	Place **85%** of HEP HSED graduates into post-secondary education/careers (GPRA 2)	**88%**	79%*
6.	Provide **150** participants with academic and career advising	98	140

** **To date**, number will be finalized in November 2017 when the Annual Performance Report is submitted.*

[1] Washington State Office of Superintendent of Public Instruction, School District Data, 2015-2016.
[2] Washington State Office of Superintendent of Public Instruction, Farmworker Dropout Study, 2008.

Challenges

- Due to lack of a full-time recruiter in Year 1, the program was unable to enroll as many students as anticipated. At the time the 2015 Interim Performance Report was submitted, the national GPRA objectives were not being met, and HEP was required to submit monthly progress reports to the Department of Education (DOE). A full-time recruiter was hired in October 2016, and significant progress was made on both GPRA objectives by the end of Year 1. **HEP is on track for meeting both GPRA objectives by the end of Year 3 and is no longer required to submit monthly progress reports to DOE.**
- Lack of a Retention Specialist for almost half of Year 2 effected student graduation rates. A Retention Specialist was hired in March 2017, and HEP is on track for meeting this year's graduation requirements.
- In 2014, the 21st GED initiative changed drastically. The new assessment measures high school equivalency and career and college readiness through a new endorsement delivered only in a computer-based format. The CBC HEP program incorporated these new initiatives into the service delivery model to meet the new standards required for all students taking the new assessment.

Next Steps

- Since Year 1, HEP has made significant improvements in meeting all grant objectives and anticipates meeting all objectives in Year 3.
- Grant renewal occurs every five years. This grant renewal application will be available in 2019.

Nuclear Scholarship Program
Grantor: Nuclear Regulatory Commission

Director: Leah Gillette-Fox
Reports To: Janese Thatcher
2016-2018 Total Award: $150,000
Term Year: 2 of 2

Mission: Increase the number of students pursuing careers in the nuclear industry through scholarships and support services that promote full-time enrollment and completion of an AAS in Nuclear Technology (NT), assist students in identifying post-graduation occupations in the industry prior to completion of their degree, and increase the participation of low-income, academically talented students in the nuclear industry careers.

Population Served: 25 students to date, preference given to low-income students (44%) and underrepresented minority students (44%).

Project's Impact on CBC's Mission and Student Success
The Nuclear Scholarship Program is directly related to CBC's mission for Occupational Programs/Workforce Development: to enable students to complete requirements that would allow them to earn degrees/certificates to assist them to gain employment and pursue life-long learning opportunities. Participants are provided with funding to complete the NT AAS degree, academic support, and employment support services.

- 67% of scholarship recipients eligible to graduate in 2017 graduated.
- 100% of scholarship recipients eligible to graduate in 2018 are on track to graduate.
- Of the second-year students who received scholarships in 2016-17, **67% of are employed in the nuclear technology field,** and the remaining 33% are looking for employment.

Grant Objectives Performance Report

Project Objective	Actual Performance		
	2016-2017	2017-2018*	Total/Average
1. Provide **(13)** $6,576 scholarships to **1st-year** NT students and **(13)** $4,576 scholarships to **2nd-year** NT students.	3 - 1st-year 3 - 2nd-year	9 - 1st year 10 - 2nd year	12 - 1st year 13 - 2nd year
2. Increase the number of academically talented **underrepresented minority students** pursuing careers in the nuclear industry.	Scholarship recipients were:		
	33% women 60% students of color	21% women 19% students of color	27% women 39% students of color
3. Provide academic support to participating scholars that will result to maintain or exceed a **3.0 GPA** and **persist throughout their first academic year.**	100% of students had a GPA ≥3.0 and 100% continued to 2nd year	TBD	TBD
4. Provide job placement assistance to **100%** of the students prior to completion of the funding period.	Students are encouraged to complete industry standard tests (i.e., CORE, NUF, and POSS) to be more marketable, and workshops are held to prepare students for the tests. Mock interviews are also conducted. Services are available to 100% of students; however, not all participate.		
5. Disseminate program activities, scholarship opportunities, and provide community outreach to inform the area of the NT program.	Students participate in plant field trips and tour the B Reactor. Regular meetings are held with students to share information about scholarships, job opportunities, community events, etc. Community outreach includes a Nuke Tech day with Delta High School and a table at College Night as well as other high school/college expos.		

** **To date** – 2017-2018 numbers will be finalized at the end of the grant period in June 2018.*

Challenges
The number of students applying for the scholarships has been less than anticipated, likely due to the eligibility requirements. Staff/faculty have strongly encouraged students to apply.

Next Steps

- Award the last remaining 1st-year scholarship.
- The 2018-2020 grant application was recently made available, and proposal completion is currently underway.
- The current director Leah Gillette-Fox, is resigning from CBC on October 13, 2017. Janese Thatcher will serve as interim director until a new director is appointed.

Student Support Services (SSS)/TRiO
Grantor: U.S. Department of Education

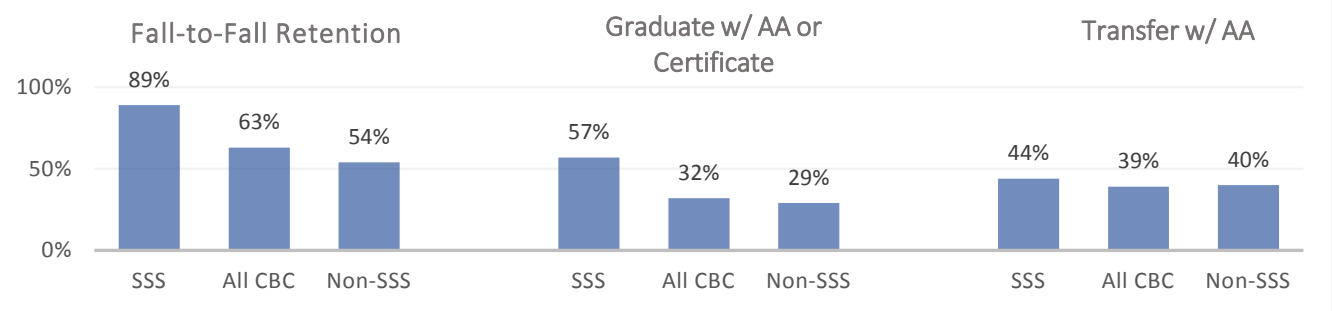
Director: Amy Stroud
2015-2020 Total Award: $1,468,785
Reports To: Cheryl Holden
Current Term: 2 of 5

Mission: Provide at-risk students with the academic skills to succeed in a postsecondary institution and ultimately enter the workforce. Prepare and motivate students to continue their education at a four-year institution and complete their baccalaureate degree.

Population Served: 200+ annually – low-income, first generation, and/or students with disabilities

Project's Impact on CBC's Mission and Student Success
Participants receive academic advising, financial aid information, tutoring, educational counseling, and transfer/career planning services.

SSS directly impacts Goal 1 of CBC's Strategic Plan: Be a national leader in student retention and completion. SSS students have **fall-to-fall retention rates 35% higher** than non-SSS students from similar demographic backgrounds (i.e., low income, first generation, and/or students with disabilities) and are **28% more likely to complete their degree/certificate**. Additionally, SSS students are 4% more likely to transfer to a four-year institution with their AA degree or certificate than non-SSS students from similar demographic backgrounds.



Source: CBC - Organizational Learning Report (Data Warehouse, Financial Aid, National Student Clearinghouse), 2014-2016

Financial Benefits
SSS financially benefits CBC by successfully retaining students. For every student not retained, CBC loses $7,146 per year in tuition, fees, and state funding (Internal Report, 2015). Additionally, since 75% of current SSS students are Hispanic, SSS also contributes to CBC's ability to obtain Hispanic Serving Institution funding.

2014-2016 Grant Objectives Performance Report
The SSS program has consistently met and exceeded all program objectives.

Annual Objective	Actual Performance*	
	2014-2015	2015-2016
Objective A: Persistence Rate		
72% of all participants will persist from one academic year to the beginning of the next academic year or graduate, and/or transfer from a 2-year to a 4-year institution during the academic year	**90%**	**88%**
Objective B: Good Academic Standing Rate		
90% of participants will meet the performance level required to stay in good academic standing at the grantee institution	**98%**	**97%**
Objective C: Graduation/Transfer Rate		
40% of new participants will graduate with an associate's degree or certificate within four years	**49%**	**64%**
33% of new participants will transfer with an associate's degree or certificate within four years	**40%**	**48%**

**To date - 2016-2017 numbers will be finalized in December 2017 when the Annual Performance Report is submitted.*

Next Steps
Grant renewal occurs every five years. This grant renewal application will be available in 2019.

Title V Student Transitions and Achievement (STAA)
Grantor: U.S. Department of Education

Director: Vacant
Reports to: Michael Lee
2015-2020 Total Award: $2,624,983
Current Term: 2 of 5

Mission: Improve student success and retention by redesigning developmental Math courses, renovating the Math Center, implementing a Summer Bridge program, and creating a new Hawk Alert system.

Population Served: Campus-wide benefits, emphasis on low-income, first generation, and/or Hispanic students testing into developmental Math courses.

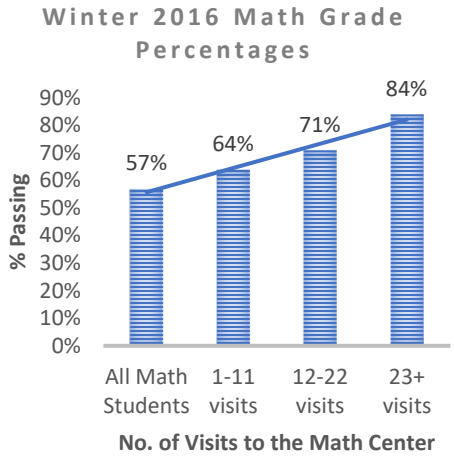
- Math Center – Average of 500 students per week (48% low income, 46% Hispanic)
- Summer Bridge – 89 students total

Project's Impact on CBC's Mission and Student Success
Title V STAA impacts the following Strategic Plan objectives:

1b – Create excellence in student support activities
The new Hawk Alert system allows faculty to easily identify and communicate with students who are struggling. In Spring 2017, six faculty sent 292 alerts, and **34% of these students came to the Math Center** for a tutoring session. Of the students that received tutoring, **46% passed their class**.

2a – Support state-of-the-art teaching practices and processes that optimize student learning
Six developmental math courses have been redesigned to incorporate modular, mastery-based strategies shown to improve student success, and 10 faculty have been trained in these strategies and tools for effective online teaching.

4 – Be a national leader in transitioning students from Pre-College to College-levels in Math and English.
The new Math Center provides qualified tutors particularly beneficial for high-need students. Data shows that **the more students utilize the Math Center, the more likely they are to succeed.**



Additionally, the new Summer Bridge program accelerates underprepared students into college-level courses. In 2016, **85% of the students who completed the new math Summer Bridge were prepared for next level course.**

2015-2017 Grant Objectives Performance Summary *(abbreviated – full performance report included as Attachment A)*

Objective	Actual Performance	Comments
Year 1 (2015-2016) – Objective Deadline = September 30, 2016		
1. Increase by **five** the number of developmental math course options by revising courses.	**Two** courses were redesigned	**Two** more courses were redesigned later in 2016. Redesigning the **one** learning community pilot will be discussed after receiving the report from the external evaluator.
2. At least **60%** of students completing the 80s-level math Summer Bridge are prepared for next level.	**85%**	13 completed, 11 prepared for the next level
Year 2 (2016-2017) – Objective Deadline = September 30, 2017		
3. Students in new developmental math courses succeed at rates **10%** higher than those in the non-treated comparison groups.	**5%** (average of all redesigned courses)	The percent of students passing redesigned courses ranged from 3% to 6% higher than those in the non-treated comparison groups.
4. At least **60%** of students completing the 90s-level math Summer Bridge are prepared for next level.	**55%** (to date)	Some students have not yet taken the placement test.
5. Increase by **five** the number of developmental math course options by revising courses.	**Four** courses were redesigned	The remaining course redesign will be complete by June 2018.

Challenges

- Delays in hiring key personnel led to delays in the course redesigns. Year 1 redesigns are now complete except for the learning communities pilot, and Year 2 redesigns are scheduled to be complete by Summer 2018.
- The staff involved in writing the goals and performance measurements listed in the grant are no longer employed at CBC. This has led to uncertainty in how some of the objectives were intended to be met relative to the funding provided. More clarification of objectives is needed.
- RetentionPro was not purchased as Student Services advised that this is not a viable program. A different program (CMS) is being explored by IS and Student Services.
- Leonor de Maldonado, the previous Grant Director, resigned in July 2017. This position is currently being advertised.
- Difficulty in obtaining high school transcripts has led to delays in developing a new placement rubric. Initial contact was made with the Pasco High School principal; however, confirmation from the district superintendent has not occurred. A meeting with the new Grant Director and superintendent will be needed to further discuss collaboration/partnership. Various CBC parties have met to discuss placement models in place since Canvas went away and what options are available for using other means to place students into English, Math, and Reading.

Next Steps

- Hawk Alerts will be open for all math instructors' use in Fall 2017 and extended to other divisions by Spring 2018. In years 3, 4, and 5 of the grant, more areas will be included in the Hawk Alert System. With more alerts created, additional support will be needed at the Math Center/Academic Success Center to attend to the referrals.
- Title V's external evaluation visit occurred September 7-8, 2017, and the final report should be provided by October. Overall, the evaluator was very impressed at the amount of organization and commitment demonstrated by the Title V team.

ATTACHMENT A
2015-2017 Grant Objectives Performance Report (Full Detail)

Objective	Actual Performance	Comments
Year 1 – 2015-2016		
1. By Sept. 30, 2016, increase by **five** the number of developmental math course options by revising face-to-face and online courses and by linking developmental math and English into the learning community with HDEV.	**Two** courses were redesigned	**Two** more courses were redesigned later in 2016. Redesigning the **one** learning community pilot will be discussed after receiving the report from the external evaluator.
a. By May 30, 2016, at least **10** faculty show increased knowledge of modular, mastery-based instruction, Learning Communities, and/or online teaching.	**0** faculty	**10** faculty trained by Spring 2017.
b. By Aug. 15, 2016, **five** redesigned developmental math options developed, ready to pilot: face-to-face Math 83, 84, and 96; online Math 96; and one Learning Community linking Engl 98/99 with Math 96 and the HDEV course.	**Two** courses were redesigned (Math 83 and 84 face-to-face)	**Two** more course redesigns (Math 96 face-to-face and online) were completed in 2016. Redesigning the **one** learning community pilot will be discussed in Fall 2017.
c. By Aug. 31, 2016, **100%** of Math Center renovation is complete, ready to be equipped for math students.	**90%** complete	Math Center renovation was **completed in October 2016.**
2. By Sept. 30, 2016, at least **60%** of students completing the 80s-level math Summer Bridge are prepared for next level course.	**85%**	19 students enrolled 13 completed 11 prepared for the next level
a. By May 31, 2016, **80s-level math Summer Bridge curriculum fully designed** and ready for pilot.	Summer Bridge curriculum **100%** designed	
b. By August 30, 2016, a total of **60** newly enrolling students pilot at least **two** sections of 80s-level math Summer Bridge.	**19** students piloted **two** 80's level sections	Enrollment low despite heavy recruitment; **2017 Summer Bridge enrollment = 89 students**
c. By Sept. 15, 2016, at least **60%** of students completing the 80s-level math Summer Bridge pilot place into Math 96 or 97.	**69%**	9 of the 13 completers placed into Math 96 or higher
Year 2 – 2016-2017		
3. By Sept. 30, 2017, students in pilots of new developmental math courses succeed at rates at least **10%** higher than those in the non-treated comparison group.	**5%** (average of all redesigned courses)	The percent of students passing redesigned courses ranged from 3% to 6% higher than those in the non-treated comparison group.
a. By December 31, 2016, **Phase I** of Math Center equipment and technology **installed and ready** for student and tutor use.	**Phase I installed and ready**	
b. By May 31, 2017, at least **200** students using new tutoring services.	**1,006** students	
c. By August 31, 2017, **100** enrollees placed using new placement rubric.	**0** enrollees	Placement rubric not yet developed (see Challenges)
d. By Sept. 30, 2017, data analytics drive design of Hawk Alerts and advising dashboard; at least **200** alerts sent.	**292** alerts sent as of Spring 2017	

2015-2017 Grant Objectives Performance Report (Continued)

Objective	Actual Performance	Comments
Year 2 – 2016-2017 (Continued)		
4. By Sept. 30, 2017, at least **60%** of students completing the 90s-level math Summer Bridge are prepared to enroll in next level course.	**55%** (to date)	Some students have not yet taken the placement test
a. By April 30, 2017, **90s-level math Summer Bridge curriculum fully designed** and ready for pilot.	**90's level math Summer Bridge fully designed**	
b. By Aug. 15, 2017, a total of **60** newly enrolling students pilot at least **two** sections of 90s-level math Summer Bridge.	**89** students piloted **two** sections	
c. By Sept. 15, 2017, at least **60%** of students completing the 90s-level math Summer Bridge pilot place into the appropriate next level course.	**55%**	
5. By Sept. 30, 2017, increase by **five** the number of developmental math course options by revising face-to-face and online courses (face-to-face Math 94, 95, & 97 and online Math 95 and 97).	**Four** courses were redesigned (Math 94 face-to-face, 95 online, 95 face-to-face, and 97 online)	The remaining course redesign (Math 97 face-to-face) will be complete by June 2018.
a. By May 31, 2017, at least **8** developmental math instructors trained in strategies and tools for modular, mastery-based instruction and/or effective online teaching strategies	**10** instructors trained	Ryan Orr, Rebecca Luttrell, Virginia Hughes, Jose Vidot, Nick Gardner, Limin Zhang, Tracie Russel, Alexandria Anderson, Anthony Zanatta, Cristina Rodrigues
b. By Aug. 1, 2017, at least **210** students enrolled in pilots of **five** revised developmental math options.	**230** students enrolled in **five** revised courses	

Upward Bound (UB)
Grantor: U.S. Department of Education/TRiO

Director: Susan Vega
2012-2017 Total Award: $1,779,940
Reports To: Cheryl Holden
Term Year: 5 of 5

Mission: Academically prepare low-income high school students to become first-generation college graduates.

Population Served: 83 students annually (low-income, at risk of academic failure, and first generation students)

Project's Impact on CBC's Mission and Student Success
UB links to the overarching strategy of CBC's Strategic Plan: **connectivity** (i.e., to be the local community's solution to higher education needs). UB prepares disadvantaged students from three target high schools (Pasco, Chiawana, and Connell) to matriculate to college. **CBC becomes a first choice for more than half of UB participants.**

Participants receive tutoring and academic advising, visit colleges, and attend cultural events. CBC staff from Financial Aid, Recruitment, and Running Start present to students and parents. Currently, 19% of UB students participate in Running Start, but this number should increase due to a new initiative beginning in September.

Compared to other low-income, at-risk students from the three target high schools, **UB participants are 30% more likely to enroll in postsecondary education and 34% more likely to obtain a postsecondary degree or certificate** (comparative data found in Objective Report).

- 54% of UB graduates who enter college the fall immediately after graduation enroll at CBC
- 87% of UB graduates enrolled at CBC utilize CBC support services (SSS, CAMP, etc.)
- 67% of UB graduates who enroll at CBC complete their degree/certificate

Financial Benefits
UB financially benefits CBC by bringing in new student tuitions (including Running Start and Summer Bridge). Since 100% of UB graduates enrolled at CBC this period are Hispanic, UB also contributes to CBC's ability to obtain Hispanic Serving Institution funding.

2012-2016 Grant Objectives Performance Report

Annual Objective	Actual Performance[1]				Target Schools
	12-13	13-14	14-15	15-16	15-16
1. **78%** of participants will have a GPA ≥2.5 on a 4-point scale	**80%**	**79%**	**81%**	**78%**	63%
2. **68%** of UB seniors will have achieved at the proficient level on state assessments in Reading/Language Arts and Math	**88%**	**82%**	**100%**	**100%**	25% smarter balance
3. **85%** of participants continue in school at the next grade level or graduate with a regular secondary school diploma	**99%**	**100%**	**100%**	**98%**	59% (grad. rate)
4. **85%** of all participants expected to graduate high school in the school year will complete a rigorous secondary school program of study and graduate in that school year	82%	73%	**85%**	79%	31%
5. **80%** of all participants expected to graduate high school in the school year will enroll in a program of postsecondary education by the fall term immediately following high school or defer enrollment until the next academic semester	**82%**	**82%**	**85%**	76%	45%
6. **60%** of participants who enrolled in postsecondary education attain an AA or BA degree within six years of graduation	N/A	42%	**67%[2]**	39%[2]	36% AA 15% BA

[1] ***To date*** *– Data for 2016-2017 will be finalized in December 2017 when the Annual Performance Report is submitted.*
[2] ***To date*** *– many students are enrolled but have not yet completed a degree and are consequently not included.*

Challenges
In the 2012-2017 grant cycle, several of the objectives were scored as likely unattainable by the grant readers. **These issues were addressed when writing the new, approved grant for 2017-2022.** UB does not anticipate any challenges in meeting the new objectives because, in addition to more realistic expectations, services were increased with new initiatives, especially in the area of encouraging Running Start and focusing on Summer Bridge mentorship.

Next Steps
Grant renewal occurs every five years. UB recently began its new 2017-2022 grant cycle in September.

Director: Debbie Padilla
Reports To: Curtis Crawford
2017-2018 Total Award: $125,000
Current Term: 1 of 1

Mission: Provide enriching educational opportunities and practical help to prepare underrepresented students for university-level studies in science, technology, engineering, and mathematics (STEM).

Population Served: Approximately 100 students annually who are underrepresented in STEM fields (i.e., African American, Native American, Latino, women, etc.).

Project's Impact on CBC's Mission and Student Success
MCCP began in 2009 and links to the Academic and Cultural Effectiveness aspects of CBC's mission. Participants are provided with a dedicated study center, Academic Excellence Workshops (AEWs), academic advising, and career/professional development. University visits and research opportunities are available to MESA students via funding from WSU's LSAMP Program.

MESA students complete Associate's degrees at a rate 43% higher than average CBC students and 31% higher than CBC STEM students (CBC Institutional Research, 2017). Of MESA students who completed an AA degree in 2017, 100% of the graduates transferred to a four-year institution.

2017-2018 Contract Objectives Performance Report

Required Components	Provided at CBC?	Comments
Provide full-time MESA Director	☒ Yes ☐ No	Debbie Padilla will serve as the full-time MCCP Director.
Serve 100 students	In Progress	Currently 47 students; 100 students will be enrolled by Nov 2017.
Provide a dedicated study center	☒ Yes ☐ No	CBC's MESA center meets all requirements.
Provide AEWs	In Progress	Four workshops per week will be provided each quarter.
Provide an orientation course	In Progress	A one-hour orientation workshop will be offered in Fall 2017.
Designate an academic advisor	In Progress	An advisor will be designated by December 2017.
Dedicate at least 10% of funding for student activities	☒ Yes ☐ No	$17,000 (13.6% of total funding) is dedicated for student activities.
Provide career and professional development services	In Progress	A STEM speaker series and other workshops will be held on campus, and students will travel to the LSAMP conference.
Develop an Industry Advisory Board	In Progress	An advisory board will be developed by December 2017.
Promote the MESA program	In Progress	A website, brochure, and PowerPoint will be created in Fall 2017.

Key Performance Indicators	Actual Performance
1. Center Infrastructure - Provide **1 FTE**, key facilities, technology infrastructure, funding, and advocacy	**1 FTE**, all infrastructure in place except website (to be established in Fall 2017)
2. Outreach and Recruitment - **100** students enrolled (**90%** minority, **80%** low-income, and **80%** first-gen)	**47** students enrolled to date (**90%** minority, low-income, and/or first gen)
3. Academic Programming and Enrichments - Provide orientation class, tutorial services, and STEM and LSAMP conferences	All to be provided
4. Student Career Development - Provide academic advising/transfer prep, and leadership development	All to be provided
5. Outcomes - No targets set for 2017-2018, data will be collected for future years on: GPA, retention, and transfer success	**87%** of MESA students had a GPA ≥ 2.5 **100%** of graduates transferred to a 4-year

Challenges
- Enrollment was below the target in 2016-17. MCCP is being restructured to emphasize recruitment efforts.
- The previous Program Director resigned in June 2017. The previous Retention Specialist will serve as the new full-time MCCP Director.

Next Steps
Increase enrollment by working with CBC's outreach program/admissions and presenting program information to faculty and students.

Worker Retraining Program (WRT)
Grantor: SBCTC

Director: Michelle Mann
Reports To: Melissa McBurney
2017-2018 Total Award: $1,520,323
Term Year: 1 of 1

Mission: Help remove barriers in the pursuit of higher education by providing financial, advising, enrollment, and ongoing support services directly related to workforce education training programs in an environment of support, respect, and equality.

Population Served: 381 FTE (742 headcount) students in 2016-2017; current year goal is 292 FTE with 60 FTE (232 headcount) currently enrolled. WRT serves students who are laid off and collecting or have exhausted unemployment insurance, working in a low-wage survival job, displaced homemakers, formerly self-employed, recently separated veterans or soon to be released from the military, or at risk of losing a job unless occupational skills are updated.

Project's Impact on CBC's Mission and Student Success

WRT supports Goal 3 of CBC's strategic plan: CBC Professional/Technical Education students will be highly employable and highly effective once hired. The WRT program operates with the specific goal of moving students into high-wage, high employer demand jobs. WRT's Advisory Committee consisting of representatives from businesses and community groups directs program planning to ensure WRT's efforts are consistent with the needs of the local and regional economy. WRT funds are used to develop these programs and provide financial aid, academic/career advising, and job referral/development services to assist underserved populations in securing wage-gain employment. **Of WRT students who completed their degree/program and gained employment, 100% of those who were previously employed in low to middle wage positions are now earning higher wages than earned prior to job loss.**

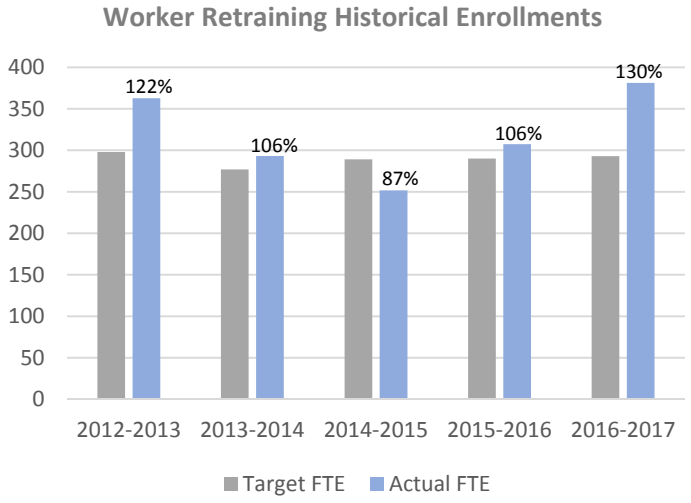
Grant Objectives Performance Report

Performance Measurement	2015-2016		2016-2017	
	Target	Actual	Target	Actual
Enrollment (FTE)	290	**307 (106%)**	293	**381 (130%)**
Completion	60%	**63%**	60%	**60%**[1]
Job Placement - 2 quarters after completion[2]	75%	69%	75%	TBD
Job Retention - 4 quarters after completion[2]	75%	72%	75%	TBD
Wage Recovery[2]	100% - middle/low wage 85% - high wage earners	**100%** **96%**	100% - middle/low wage 85% - high wage earners	TBD

[1] ***To date*** *– some students enrolled in 2016 are still working toward completion and are consequently not included.*
[2] *The most current State reported data for these performance measurements is from 2013-2014.*

Next Steps

- Proposed plan approved for program year 2017-2018.
- Increase connection to job placement services after program completion.
- Anticipate receipt of additional funding from the State to serve more FTEs.



Director: Vacant
Reports To: Curtis Crawford
2017-2018 Total Award: $199,809
Current Term: 1 of 1

Mission: Assist underrepresented students in excelling in science, technology, engineering, and mathematics (STEM) to be competitive for colleges.

Population Served: Approximately 1,000 students annually who are underrepresented in STEM fields (i.e., African American, Native American, Latino, women, etc.).

Project's Impact on CBC's Mission and Student Success
MESA's K-12 program began in 2015 and links to the overarching strategy of CBC's Strategic Plan: connectivity (i.e., to be the local community's solution to higher education needs) by establishing partnerships between CBC and the local service area and exposing students to our college environment. In 2016-2017, **1,281 students from nine local schools visited the CBC campus for MESA events**. K-12 MESA students participate in MESA Day events and receive academic advising, SAT/PSAT preparation, study skills training, and scholarships.

MESA also impacts Goal 4 of the Strategic Plan: Be a national leader in transitioning students from Pre-College to College-levels in Math and English by providing college tutors to high school math students.

2016-2017 Contract Objectives Performance Report

Annual Objective	Actual Performance	Comments
Increase the number of 9th grade students completing Algebra 1	Unknown	Provided Summer Math Scholars program. Statistics on the number of 9th grade students completing Algebra 1 are currently unknown
Implement academic plans in MESA middle schools	0% of MESA middle school students completed an academic plan by the end of 8th grade	Provided template to teachers, but they did not have time to complete them due to snow days
Increase high school student knowledge of STEM careers	67% of MESA high school students attended workshops focused on STEM careers	Hosted three STEM career-focused conferences: Health Science, STEM Explorers, and Expanding Horizons
Better prepare high school students to enter college-level math	Unknown	The High School Coordinator (HSC) provided tutoring services, but records of this work are unavailable
Juniors and seniors will have a polished academic plan	Unknown	The HSC provided planning services, but records of this work are unavailable
Increase local Teacher Professional Development (TPD) offerings and participation	Two local TPD's offered; 33% of teachers participated	Teachers were provided information and offered substitute teacher reimbursement, but few chose to participate
Increase MESA teacher attendance at WA MESA TPDs	17% of teachers participated	
Increase parents' knowledge of STEM education	Eight parents and students participated in a local workshop	Provided SCI Girls workshop

Challenges
- MESA's HSC resigned in January 2017. Records of work done with high school students were not accurately maintained, and the program's performance on several objectives is unknown.
- The State MESA's database for tracking student participation does not always function properly. MESA K-12 has struggled to maintain its database, resulting in a decrease in funding for FY 2017-2018. The program is currently being restructured and staff roles clarified to ensure sufficient database upkeep.
- Luis Alcazar, the previous Program Director, resigned in June 2017, and the Outreach and Retention Specialist resigned on June 30, 2017. No staff are currently employed for the program.

Next Steps
CBC recently submitted a proposal to Washington State MESA to move the K-12 MESA program to Pacific Northwest National Laboratories (PNNL). If approved, PNNL will be responsible for the grant and all program management. Given that no staff are employed, work is on hold pending approval of this proposal.

Title V Cooperative
A Partnership for Advancing Health Professions
Grantor: U.S. Department of Education via BBCC

CBC Director: Deborah Brown **Reports To:** Melissa McBurney **BBCC Interim Director** = Tim Fuhrman
2014-2019 Total Award: $1,197,254 **Current Term:** 3 of 5

Mission: Collaborate with BBCC to expand postsecondary access to healthcare opportunities by establishing new certificates and AAS/BAS degrees in Simulation Technology (Sim Tech), Medical Records and Healthcare Information (MRHI), and Healthcare Administration (HCAD). Promote completion through new healthcare advising system.

Population Served: Sim Tech = 21 BBCC students, MRHI = 56 CBC students, and HCAD = 157 CBC students and 7 BBCC students, with a focus on Hispanic and/or low-income students

Project's Impact on CBC's Mission and Student Success
The Title V Cooperative grant has directly contributed to meeting the following Strategic Plan objectives:

2a – Support state-of-the-art teaching practices and processes that optimize student learning
Title V Cooperative decreased the gaps in faculty expertise in best pedagogical practices for online courses. Thirty-six CBC faculty were trained in Quality Matters™ standards, and all new online courses meet these standards.

3 – Professional/Technical Education students will be highly employable and highly effective once hired
Title V Cooperative developed community-responsive programs (MRHI AAS and HCAD BAS) to provide students with access to our region's most promising healthcare-related career opportunities. The program's Professional Speakers' Series exposes students to potential healthcare careers.

Since launching the MRHI program in Fall 2016, 50% of eligible students have completed their first year certificate, and **100% of completers re-enrolled to begin the AAS degree**. Upon completing the new degrees, students will have the opportunity to earn average annual salaries beginning at $44,230 (MRHI technicians; DOL, 2016). Given that 55% of the students currently enrolled are low-income, these programs provide graduates with the opportunity to **significantly uplift their socioeconomic status**.

2014-2017 Grant Objectives Performance Report *(abbreviated – full performance report included as Attachment A)*

Objective	Actual Performance	Comments
Year 1 (2014-2015) – Objective Deadline = September 2015		
1. Enroll at least **65** students in new MRHI courses (BBCC-**30**, CBC-**35**).	Total students: **0**	As of Fall 2017, **56 CBC** students enrolled.
Year 2 (2015-2016) – Objective Deadline = September 2016		
2. Enroll at least **50** students in new Sim Tech certificate courses (BBCC-**30**, CBC-**20)**.	Total students: **0**	Currently, **21 BBCC** students.
3. At least **80%** of MRHI students complete certificate; at least **60%** of completers re-enroll to complete the AAS.	**0%** completed **0%** re-enrolled	As of Sep 2017, **50%** had completed, and **100%** of completers are re-enrolled.
Year 3 (2016-2017) – Objective Deadline = September 2017		
4. At least **80%** of Sim Tech students complete certificate; at least **60%** of completers enroll in AAS.	**0%** completed **0%** enrolled in AAS	To date, **24%** of students have completed and **100%** of completers are enrolled in AAS.
5. Enroll at least **65** students in BAS core courses (**25**-BBCC, **40**-CBC).	Total students: **164** (BBCC-**7**, CBC-**157**)	BBCC student enrollment is low, more outreach is needed.

Color Key: BBCC and CBC Objective, BBCC Objective
Note: *Objectives not met by the designated deadline were often accomplished at a later date (see Comments and Attachment A).*

Challenges

- Hiring Delays – While Year 1 funding was awarded in October 2014, the program was not fully staffed until August 2015. Once hired, staff worked quickly to develop curriculum for the new certificates/degrees.
- Curriculum Approval Delays – At the time the grant was written, it was assumed CBC's previous Health Information Technology (HIT) program could be revived from Inactive status. Unfortunately, after the grant was awarded, the State had already removed HIT from CBC's program inventory, and a new program had to be developed and approved. Once approved, CBC was enrolling students in the new courses within eight months.
- Technical Delays – With the State switching to CTCLink, BBCC decided to delay development of the new Healthcare Advising system to avoid duplicating efforts. Given that CTCLink may not be in place by the end of the grant period, CBC is using one-on-one advising.
- Collaboration – Until recently, a Memorandum of Understanding (MOU) was not in place for referring students between the two colleges. An MOU between CBC and BBCC is now in place for the Sim Tech program, as well as an Affiliation Agreement to host Sim Tech practicum students at CBC. The MOU for the MRHI program has also been signed and is now in place.

Next Steps

Despite initial delays, the program is now moving forward as scheduled, and all goals (with the possible exception of the Healthcare Advising system) should be achieved by the end of the grant timeline. Year 4 will include:

- Continue work on BAS in Applied Management courses to ensure that all online/blended classes meet Quality Matters Standards.
- Continue outreach efforts for the BAS in Applied Management program to meet the grant goals, specifically, increasing student enrollment from the Central Washington region (BBCC students).
- Clarify with the grant holders regarding Year 4, Objective 7's requirement that 80% of students enrolled in the new BAS in Applied Management will enroll in the Healthcare Administration track. This objective does not appear beneficial to the students, as the industry would not support that many new hires.
- Work with the Outreach Retention Specialist to better track students that are specifically seeking a degree in Healthcare Administration (currently, the coding for a BAS in Applied Management is the same as for a BAS in Applied Management – Healthcare Administration Track).

ATTACHMENT A
2014-2017 Grant Objectives Performance Report (Full Detail)

Objective	Actual Performance	
1. By Sept. 2015, enroll at least **65** students (BBCC-**30**, CBC-**35**, at least **50%** Hispanic and/or low income) in new MRHI Certificate/AAS core courses.	Total students: **0** BBCC: **0** CBC: **0** % Hispanic/LI: **N/A**	
a. By May 2015, overall curricula plan for new Certificate/AAS option **100% developed and approved** by BBCC Instructional/CBC Curriculum Committees	% Developed: **100%** Approved: **No**	
b. By Aug. 2015, at least **10** faculty from BBCC and CBC develop 55 hours of MRHI core curricula, addressing industry competencies and infusing Quality Matters™ standards for distance instruction	No. of faculty who developed 55 hours: **10**	
c. By Sept. 2015, at least **20 students at each institution** participate in Professional Speakers' presentation.	Total students: **90** BBCC: **20** CBC: **76**	
2. By Sept. 2016 enroll at least **50** students (BBCC-**30**, CBC-**20**, at least **50%** Hispanic and/or low income) in Sim Tech certificate courses.	Total students: **0** BBCC: **0** CBC: **0** % Hispanic/LI: **N/A**	
a. By Jan. 2016, renovation to complete BBCC Sim Tech Lab **100%** complete.	Renovation Complete: **100%**	
b. By May 2016, overall curricula plan for new Sim Tech certificate **100% developed and approved** by BBCC Instructional/CBC Curriculum Committees	% Developed: **100%** Approved: **No**	
c. By Aug. 2016, at least **8** faculty from BBCC and CBC develop 23 hours of Sim Tech certificate requirements, addressing industry competencies and infusing Quality Matters™ standards for distance instruction.	No. of faculty who developed 23 hours: **8**	
3. By Sept. 2016 at least **80%** of students enrolled in new MRHI courses complete certificate; at least **60%** of completers re-enroll to complete the AAS.	**0%** completed (no students enrolled) **0%** re-enrolled in AAS	
a. By Aug. 2016, at least **70%** of students enrolled in MRHI courses pilot new Healthcare Advising.	**0%** (no students enrolled)	
b. By Aug. 2016, at least **85%** of MRHI enrollees report satisfaction	**0%** (no students enrolled)	

Color Key: *BBCC and CBC Objective*, *BBCC Objective*, *CBC Objective*

2014-2017 Grant Objectives Performance Report (Continued)

Objective	Actual Performance	Comments
Year 3 (2016-2017)		
4. By Sept. 2017, at least **80%** of students in new Sim Tech courses complete certificate. At least **60%** of completers enroll in AAS.	**0%** completed certificate **0%** enrolled in AAS	To date, **24%** of students have completed and **100%** of completers are enrolled in AAS.
a. By June 2017, at least **70%** of students enrolled in Sim Tech courses pilot new Healthcare Advising.	**0%**	The proposed Healthcare Advising System has not been developed (see 3a).
b. By Aug. 2017, at least **80%** of students in Sim Tech pilots have grades of "C" or above.	**94%**	
c. By Aug. 2017, at least **12** faculty from BBCC and CBC develop at least 22 hours of Sim Tech AAS curricula, addressing industry competencies and infusing Quality Matters™ standards for distance instruction.	No. of faculty who developed 22 hours: **8 BBCC faculty**	BBCC's Sim Tech curricula is not yet Quality Matters infused.
5. By Sept 2017, enroll at least **65** students (**25**-BBCC, **40**-CBC, at least **50%** Hispanic and/or low income) in BAS core courses in online/blended format.	Total students: **164** BBCC: **7** CBC: **157** % Hispanic/LI: **42%**	BBCC student enrollment is low, more outreach is needed.
a. By May 2017, overall curricula plan for new BAS in HCAD track **100%** developed and approved by BBCC/CBC Committees	Developed: **100%** Approved: **Yes**	CBC is well ahead of this deadline – all BAS in HCAD curricula is developed and approved.
b. By Aug. 2017, at least **4** faculty from BBCC and CBC convert 25 hours of BAS in HCAD requirements to online/blended formats adhering to Quality Matters™ standards for distance instruction.	No. of faculty who converted 25 hours: **4 CBC faculty**	BBCC has not been involved in the creation of online/blended BAS in HCAD courses (mostly done prior to grant award). Work continues to ensure all HCAD classes meet Quality Matters standards.
c. By Aug. 2017, at least **85%** of students accessing new advising system rank the service at least 4 on a 5-point Likert scale.	**93%**	New advising system not in place, CBC is using one-on-one advising.

Color Key: BBCC and CBC Objective, BBCC Objective, CBC Objective

Basic Education for Adults (BEdA) Master Grant
Grantor: SBCTC

Director: Erin Holloway
2017-2018 Total Award: $186,794
Reports To: Daphne Larios
Current Term: 1 of 1

Mission: Provide adult students with the integrated education and training necessary to earn a high school diploma/equivalency, transition to and complete postsecondary education programs, and advance in a career that leads to economic self-sufficiency. Instruction contextualizes and integrates reading, writing, speaking and listening, mathematics, English language acquisition (ELA), information literacy, and employability skills aligned with CBC and career readiness standards.

Population Served: Adults with academic skills below high school completion or who are seeking to improve their English language skills. Serves an average of 1,855 students a year.

Project's Impact on CBC's Mission and Student Success
The BEdA Master Grant is the primary grant supporting the Transitional Studies division programming. This work fulfills the Basic Skills section of CBC's mission: to prepare students for success in college-level skills courses. Transitional Studies encompasses ELA, Adult Basic Education (ABE), High School 21+ (HS21+), and Integrated Basic Education Skills and Training (I-BEST) programs. The grant primarily funds faculty salaries, including one full-time ELA faculty, one full-time ABE faculty, and a part-time instructional technician. The grant also funds instructional materials/supplies, including a new math curriculum for ELA and ABE.

One of the program's primary goals is to transition students into post-secondary education. In the 2015-2016 school year, 32% of the Transitional Studies cohort transitioned into CBC's developmental and college-level courses. **Approximately 11% of all CBC FTE and about 19% of all CBC headcount comes from students who participate in Basic Skills programs and course work.**

2015-2016 Grant Objectives Performance Report *(2016-2017 data not yet available)*

Performance Measurement		
Educational functioning level increases (measurable skill gains)	38%	38%
Attained high school diploma or equivalent	-	66%
Entered Employment	-	32%
Retained Employment	-	43%
Entered Post-Secondary Training	-	32%

** In 2015-2016, only one performance target was established. The Workforce Innovation and Opportunity Act (WIOA) defined new common performance measurements that will be reporting objectives for future grant years, but targets have not yet been set at the state and federal level.*

Next Steps
Though targets for the newly defined WIOA common performance measurements have not yet been set, CBC is currently preparing to meet the new objectives. Targets on progression and transition will be achieved through:

- Increased curricular rigor in lower-level coursework for both ELA and ABE students – The use of the computer based I-DEA modules in all lower-level ELA classes will significantly enhance both student measureable skill gains and employability.
- Continued expansion of I-BEST programming options – The development of Academic I-BEST programming will provide a new layer of support for degree-seeking students entering the college with basic skills.
- Continued expansion of the HS21+ program offerings – Continued growth of the HS21+ program will provide a competency-based alternative for students lacking a high school diploma or equivalency.
- Additional navigational support from Retention Specialists in the Transitional Studies division – Extra support will continue to increase successful transitions of students into college-level coursework and program completion.

BEdA IEL/Civics Grant
Grantor: SBCTC

Director: Erin Holloway
2017-2018 Total Award: $39,049
Reports To: Daphne Larios
Current Term: 1 of 1

Mission: Provide adult education concurrently and contextually with workforce training for specific occupations and occupational clusters.

Population Served: Adults with academic skills below high school completion or who are seeking to improve their English language skills. Served 114 students during the 2016-2017 academic year, and 20 students were enrolled in Summer 2017.

Project's Impact on CBC's Mission and Student Success
The IEL/Civics Grant is the primary grant supporting the Transitional Studies Integrated Basic Education Skills Training (I-BEST) programs. IBEST programs allow students to enroll in and complete college level credits with added support in the classroom. This work fulfills the Basic Skills section of CBC's mission: to prepare and support students for success in college-level skills courses.

CBC currently offers I-BEST programs for a variety of professional/technical education certificates including: Nursing assistant, phlebotomy, commercial driver's license, early childhood education, and certified logistics technician. The IEL/Civics grant provides funding for faculty salaries as well as instructional materials in I-BEST classrooms.

Of the Transitional Studies students that transitioned into CBC's developmental and college-level courses in 2015-2016, 11% entered into an I-BEST program.

2015-2016 Grant Objectives Performance Report *(2016-2017 data not yet available)*
The IEL/Civics Grant funding is provided as a supplement to the BEdA Master Grant. Data provided is based on the entire Transitional Studies 2015-2016 cohort.

Performance Measurement	Target	Actual Performance
Educational functioning level increases (measurable skill gains)	38%	38%
Attained high school diploma or equivalent	-	66%
Entered Employment	-	32%
Retained Employment	-	43%
Entered Post-Secondary Training	-	32%

** In 2015-2016, only one performance target was established. The Workforce Innovation and Opportunity Act defined new common performance measurements that will be reporting objectives for future grant years, but targets have not yet been set at the state and federal level.*

Next Steps
Transitional studies is seeking to expand I-BEST programming to include Academic I-BEST courses. The department is seeking additional grant funding

Integrated Digital English Acceleration (I-DEA) Technology Expansion Grant

Grantor: SBCTC

Director: Erin Holloway
Reports To: Daphne Larios
2017-2018 Total Award: $100,000
Current Term: 1 of 1

Mission: Provide non-native English speaking adult students with the integrated education and training necessary to earn a high school diploma/equivalency, transition to and complete postsecondary education programs, and advance in a career that leads to economic self-sufficiency. Instruction contextualizes and integrates reading, writing, speaking and listening, mathematics, English language acquisition (ELA), information literacy, and employability skills aligned with CBC and career readiness standards.

Population Served: Non-native English speaking adults seeking to improve their English language skills.

Project's Impact on CBC's Mission and Student Success
The I-DEA Technology Expansion Grant supports the Basic Skills section of CBC's mission: to prepare students for success in college-level skills courses. The purpose of the grant is to expand implementation of the I-DEA program, which consists of instructional modules that blend English language instruction with employability skills and digital literacy. The I-DEA program is designed to improve instruction for low-level English learners and prepare students for entry into the workforce and/or college coursework. The grant provided funding for the purchase of 125 new laptops and five computers-on-wheels carts for use with the I-DEA Canvas based modules.

The use of the computer based I-DEA modules in all lower-level ELA classes will significantly enhance both student measureable skill gains and employability. Use of the newly purchased laptops and full implementation of the modules will begin on September 25, 2017.

Grant Objectives Performance Report
Performance data for the I-DEA program is currently unavailable, as the program has not yet started. When available, statistics will be provided on the:

- Post-test rate for students enrolled in the I-DEA program
- Measurable skills gains
- Student distance education completion hours
- Student retention rates

Next Steps
Transitional Studies will serve 300 students each quarter on the acquired laptops throughout the 2017-2018 academic year.

Basic Food Employment and Training (BFET)
Grantor: SBCTC

Director: Debra Wagar **Reports To:** Melissa McBurney
2016-2017 Target to Recover: $261,514 **Current Term:** 1 of 1

Mission: Help remove barriers in the pursuit of higher education by providing financial, advising, enrollment, and ongoing support services directly related to workforce education training programs in an environment of support, respect, and equality.

Population Served: Current enrollment = 109; BFET serves low-income students receiving food benefits and not receiving a Temporary Assistance for Needy Families grant who are enrolled in a professional/technical pathway.

Project's Impact on CBC's Mission and Student Success
BFET directly impacts Goal 1 of CBC's Strategic Plan: Be a national leader in student retention and completion. BFET students receive financial support for costs such as tuition, books, program tools, travel, clothing, and emergency expenses that often impede attendance for low-income students. Participants also receive one-on-one advising and academic/career planning support to increase the likelihood of persisting to completion.

- BFET students have **retention rates approximately 17% higher** than other low-income/first generation students.
- BFET students are **24% more likely to complete their degree/certificate** than other low-income/first generation students.

BFET also impacts Goal 3 of the Strategic Plan: Professional/Technical Education students will be highly employable and highly effective once hired. BFET serves professional/technical education students with the specific goal of moving them out of poverty and into living wage positions. Of students who completed their degree/certificate in 2016, 66% are currently employed. **Nearly 40% of BFET graduates work in the Health Care industry earning average hourly wages of $20.60.**

Financial Benefits
BFET is a largely self-sustaining program. The grant requires 100% upfront expenditures, 50% of which are then reimbursed. All upfront expenditures are paid for using other state funding sources (i.e., Opportunity Grant, Worker Retraining, etc.). Each year, the State awards a "target" amount of funds to be reimbursed. Once BFET expends its target funds, it can rebill up to 50% of these funds, and the State refunds the money back to the college for a second time. When available, the State also provides 100% funding for administration services. **Since 2012, BFET has recovered almost $1 million back to CBC that would otherwise not have been reimbursable.**

2015-2017 Grant Objectives Performance Report

Performance Measurement	Actual Performance		2016-2017 Target
	2015-2016	2016-2017	
Enrollment	177	174	150
Retention	65%	71%	-
Completion	70	68	-
Transitions from Basic Skills to College Level	116	91	-
Employment (3 quarters post completion)	66%	TBD	60%

Challenges
Funding beyond 2017-2018 is uncertain due to potential changes to the Federal budget (BFET is connected to the SNAP program, which is included in the U.S. Department of Agriculture Farm Bill).

Next Steps
BFET submitted the 2017-2018 grant application requesting a target of $308,254 and is currently waiting for funding approval.

Perkins Plan
Grantor: SBCTC

Director: Melissa McBurney
2017-2018 Total Award: $297,842
Reports To: Lee Thornton
Term Year: 1 of 1

Mission: Support career and technical education (CTE) that prepares students both for further education and the careers of their choice. Perkins funds help ensure career and technical programs are challenging and integrate academic and technical education to meet the needs of business and industry.

Population Served: CTE students with an emphasis on nontraditional students.

Project's Impact on CBC's Mission and Student Success
Perkins Plan funds directly support Goal 3 of CBC's Strategic Plan: CBC Professional/Technical Education students will be highly employable and highly effective once hired. The grant funding provides the following services to help with student retention, completion, and ultimately the ability to acquire employment.

- A Completion Coach for CTE students
- Equipment to ensure students have access to the same equipment that is used in industry
- Professional development or industry certifications for faculty

2015-2016 Grant Objectives Performance Report *(2016-2017 data not yet provided by the State)*

State Target	Annual Goal	Actual Performance
Performance Indicator 1P1 – Technical Skill Attainment		
1,184 CTE students will attain a degree/certificate or complete at least 45 vocational credits with a 2.0 or higher GPA	**90%** of target = **1,066**	**103%** of target = **1,218**
Performance Indicator 2P1 – Credential, Certificate, or Degree		
922 CTE students will attain a degree/certificate	**90%** of target = **830**	**120%** of target = **1,108**
Performance Indicator 3P1 – Retention and Transfer		
65% of CTE students will be retained or transfer	**90%** of target = **58.5%**	**92%** of target = **59.8%**
Performance Indicator 4P1 – Placement		
58% of students will be employed during the 3rd quarter after they exit	**90%** of target = **52.2%**	**105%** of target = **60.74%**
Performance Indicator 5P1 – Non-Traditional Participation		
19.25% of CTE students from underrepresented gender groups will enroll in non-traditional programs	**90%** of target = **17.33%**	**66%** of target = **12.69%**
Performance Indicator 5P2 – Non-Traditional Completion		
18.5% of CTE completers from underrepresented gender groups will earn certificates/degrees from non-traditional programs	**90%** of target = **16.65%**	**78%** of target = **14.37%**

Challenges
- Perkins has not met the targets for the non-traditional indicators for multiple years. Better communication with staff regarding the grant's goals and performance indicators is needed, as well as examining data to show the impact of funding.
- A position was not hired last year, so not all the funds were spent.

Next Steps
- The Perkins Plan team is working to hire all positions. One position is currently being advertised, and plans to post the remaining position are underway.
- Select Vice Presidents met to discuss the grant requirements. Meetings with all pertinent staff will occur to educate the team as to the grant requirements, and plans will be made as to how to reach the targets.
- Internal quarterly reports will be completed to provide information regarding the grant's impact on student success and progress toward reaching goals.

Perkins Non-Traditional Employment & Training
Grantor: SBCTC

Director: Keeley Gant
2017-2018 Total Award: $5,000
Reports To: Michael Lee
Term Year: 1 of 1

Mission: Provide workshops that allow women to gain skills in non-traditional technical areas. Encourage women to enroll in non-traditional Career & Technical Education (CTE) programs at CBC such as Welding Technology and Automotive Technology.

Population Served: Females from local middle/high schools, as well as the community at large. One Women of Welding (WOW!) workshop was held September 12-14, 2017 and included 16 participants.

Project's Impact on CBC's Mission and Student Success
WOW! is linked to Objective 3A of CBC's Strategic Plan: Ensure that Professional/Technical Programs provide cutting-edge technical training and skill development. The funding provides professional training, safety equipment, supplies, tools, and machinery for workshops. Participants are surveyed to determine event success, and 9 out of 10 survey respondents agreed or strongly agreed they had a better understanding of the skills required to weld.

The women-only workshops also support CBC's mission of cultural effectiveness and promote recruitment by allowing prospective students to explore non-traditional careers in a safe, gender bias-free environment. At the recent workshop, nine out of 10 survey respondents agreed or strongly agreed they would consider welding a viable career option for women. After the 2016-17 workshops, several women stated they would be pursuing a non-traditional professional-technical program at CBC upon graduating from high school. Within one year of participating in the workshop, **44% of WOW! high school-age attendees enrolled at CBC.**

2015-2016 Grant Objectives Performance Report *(2016-2017 data not yet provided by the State)*
Perkins Non-Traditional Employment & Training funding is provided as a supplement to the Carl D. Perkins Grant with the purpose of assisting recipients in addressing Performance Indicators 5P1 and 5P2.

State Target	Annual Goal	Actual Performance
Performance Indicator 5P1 – Non-Traditional Participation		
19.25% of CTE students from underrepresented gender groups will enroll in non-traditional programs	**90%** of target = **17.33%**	**66%** of target = **12.69%**
Performance Indicator 5P2 – Non-Traditional Completion		
18.5% of CTE completers from underrepresented gender groups will earn certificates/degrees from non-traditional programs	**90%** of target = **16.65%**	**78%** of target = **14.37%**

Challenges
WOW! is challenged to ignite a serious intent about entering the workforce degree program. Many participants attend the workshops for skill development, but only a few express interest in enrolling in a full-time, non-traditional CTE program. Additionally, data for the number of workshop attendees who enrolled in a non-traditional CTE program at CBC is currently unavailable.

Next Steps
- Funds permitted, a second-level workshop will be held in Spring 2018 for previous participants desiring to build upon their welding skills gained from a former workshop.
- Depending on faculty availability, CBC may apply for another $5,000 grant to host a second-level workshop for women who previously attended the Girls Engaged in Automotive Repair (1st GEAR) event.

WorkFirst
Grantor: SBCTC

Director: Debra Wagar
2017-2018 Total Award: $194,638
Department Head: Melissa McBurney
Term Year: 1 of 1

Mission: Help remove barriers in the pursuit of higher education by providing financial, advising, enrollment, and ongoing support services directly related to workforce education training programs in an environment of support, respect, and equality.

Population Served: 2017-2018 enrollment = 33 students. WorkFirst serves low-income student-parents who are receiving a Temporary Assistance for Needy Families (TANF) grant and seeking to earn GEDs, specific job skills, certificates, or AAS degrees.

Project's Impact on CBC's Mission and Student Success
WorkFirst supports the Workforce Development aspect of CBC's mission. WorkFirst is specifically geared toward moving students-parents who receive public assistance out of poverty and into self-supporting careers. Participants receive Work Study opportunities and career planning/job search assistance.

- **72% of WorkFirst students who complete their GED/certificate/degree enter the workforce within six months.**
- 57% of WorkFirst students who obtain employment earn a median hourly wage over $11.00.

WorkFirst is also geared toward supporting Goal 1 of CBC's Strategic Plan: Increase student retention and completion. WorkFirst students receive funding for tuition and books, as well as educational advising, assistance maintaining TANF compliance, and support with personal/family challenges that impact attendance. While the following numbers are low compared with CBC's general population, remembering that WorkFirst serves a highly disadvantaged population with multiple barriers to success helps put the statistics in perspective.

- 35% of WorkFirst students enrolled in a GED program receive their degree.
- 32% of WorkFirst students who earn a GED continue their post-secondary education at CBC.
- 41% of WorkFirst students enrolled in certificate/AAS programs complete their degree/certificate.

Grant Objectives Performance Report
WorkFirst funding is awarded based on a State funding formula that considers enrollment, student achievement, and employment data. There are no "target" objectives, instead, an increase in performance from the previous year results in an increase in funding and vice versa.

Performance Measurement	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018
1. Enrollment	156	108	92	80	33*
2. Retention	42%	44%	46%	38%	TBD
3. Degree/certificate completions	72	28	26	18	TBD
4. CASAS test improvements	66	42	Unknown	Unknown	TBD
5. Transitions from Basic Skills to College Level	38	26	24	19*	TBD

** To date*

Challenges
Since 2012, WorkFirst enrollments have consistently decreased, resulting in less annual grant funding. This is largely due to a decrease in the number of eligible students in our service area. TANF participants have dropped to the lowest level in history (427 adults), and only a minimal percentage are eligible to pursue education/training.

Next Steps
- Continue to co-locate at the local Department of Social and Health Services (DSHS) to maintain communication with our referral partners and benefit current as well as potential WorkFirst students.
- Provide updated information to DSHS regarding the short-term and certificate training opportunities provided at CBC (programs most available to and beneficial for WorkFirst students).
- Advocate for a revised institutional financial aid policy in which all low income students participating in short-term training programs are eligible to receive financial aid.

Frontier Set - Guided Pathways

Grantor: Aspen Institute (via Bill & Melinda Gates Foundation)

Director: Kristen Billetdeaux
Reports to: Melissa McBurney
2017-2020 Total Award: $630,000
Current Term: 1 of 4

Mission: Develop clear educational pathways and program maps that progress students through their courses and programs more efficiently to reach their educational goals.

Population Served: Campus-wide

Project's Impact on CBC's Mission and Student Success

The Guided Pathways initiative directly aligns with Goal 1 of CBC's Strategic Plan: Be a national leader in student retention and completion by addressing the first objective under this goal: Create empirically-based student pathways. The Guided Pathways efforts were initiated at CBC in 2012, and have included designing a Human Development Course Series and piloting an Exploratory Pathways Program. In Fall 2016, faculty began reviewing and developing course pathways within programs, and **most course pathways are anticipated to be developed by the end of the 2017-2018 academic year.**

The Frontier Set grant provides funding annually for two faculty coordinators who work in collaboration with the Director for faculty and campus outreach and workshops. This summer, the grant provided funding for 11 faculty to focus their efforts on pathways-specific projects, including developing pathways within their disciplines. The results of their processes and projects were presented at In-Service 2017, and the presentations were well attended by both faculty and staff colleagues.

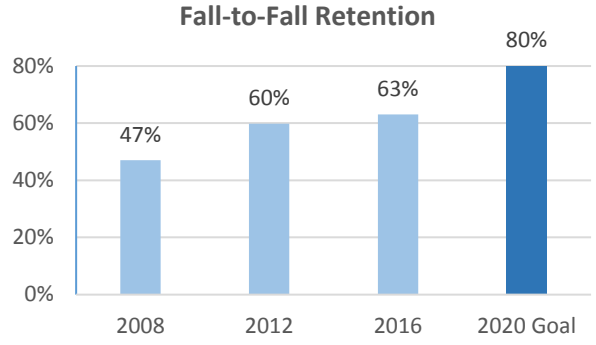
Guided Pathways also impacts Goal 4 of the Strategic Plan: Be a national leader in transitioning students from Pre-College to College-levels in Math and English. In coordination with the Title V Student Transitions and Achievement Grant program, the guided pathways initiative provided a foundation for remedial math by creating six distinct pathways from pre-college to college-level curriculum. The new structure includes pathways for completing Statistics, Calculus/STEM, Math and Society, Business, Education, and Career/Technical programs.

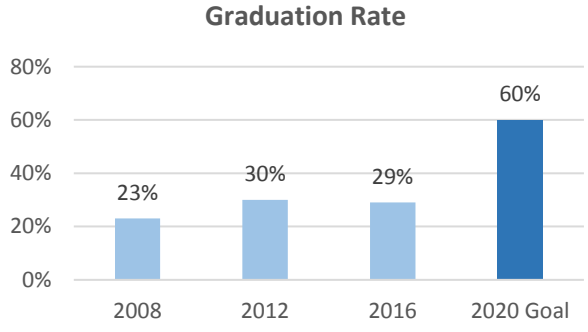
2017-2020 Grant Objectives Performance Report

Guided Pathways has two primary objectives to meet by the end of the grant period in December 2020.

1. Increase the fall-to-fall retention rate to 80%
2. Increase the annual graduation rate to 60%

Through multiple pathways efforts beginning in 2012, CBC's fall-to-fall retention rate has already increased from 47% in 2008 to 63% in 2016.





Source: CBC – Institutional Research, 2008-2016

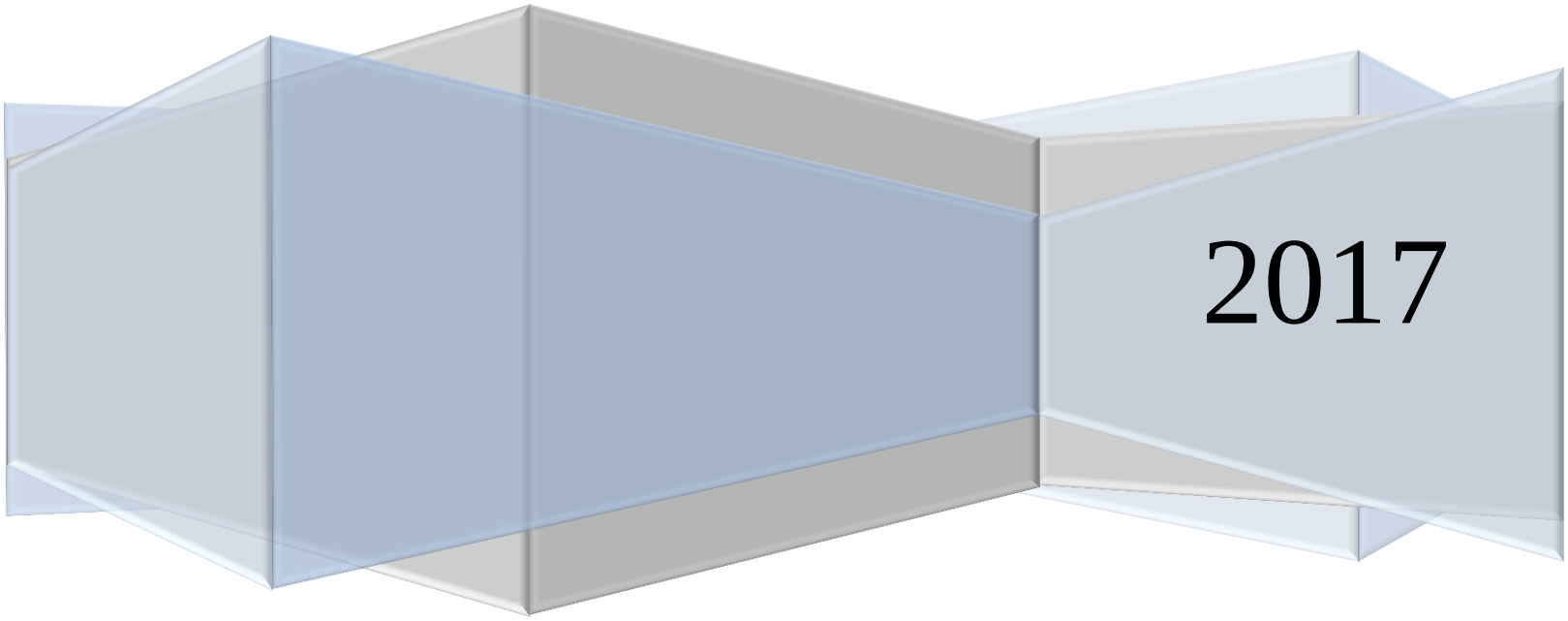
Next Steps

At In-Service 2017, the Guided Pathways Project Team announced the schools and the plan to establish taskforces associated with each school. This work will continue in Fall 2017 through AY 17-18, and the objectives for each taskforce will focus on pathway development, advising, pathway mapping, digital learning, pathways to/from transitional studies, and incorporating data into pathway development.

Exhibit G

REPORT ON RESEARCH, DEVELOPMENT, AND OUTREACH AT COLUMBIA BASIN COLLEGE

William T. W. Woodward—Dean of Agriculture Education, Research & Development



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Report on Research and Development at CBC

Introduction

Washington State's Renewable Fuel Standard was established in 2006 and designed to increase biofuel use in the state. The standard would require that two percent of the fuel purchased in the state by Dec. 1, 2008 be biodiesel and ethanol. More recently, the Washington State Biofuels Advisory Committee recommended to the Director of the Washington State Department of Agriculture to implement the two percent standard. The use of biodiesel ramps up to five percent for biodiesel and ten percent for ethanol and is to be produce primarily from agricultural crops produced in the state. Growers have considerable experience in growing wheat, barley and corn that can be used for ethanol production. Washington State's corn production alone in 2007 could support the two percent ethanol requirement. However, growers experience with oil seed crops for producing biodiesel is limited. Oil seed crops have generally not been profitable when grown under irrigated conditions. Columbia Basin College (CBC) research plans include testing various oil seed crops to determine if they would fit into a profitable enterprise budget for irrigated growers in the Columbia Basin.

The U.S. Department of Energy's biofuels initiative calls for reducing U.S. dependence on foreign oil by meeting the following targets:

- To make cellulosic ethanol (or ethanol from non-grain biomass resources) cost competitive with gasoline by 2012.
- To replace 30 percent of current levels of gasoline consumption with biofuels by 2030 (or 30x30).

In order to accomplish these goals, there will be a need of a billion tons of biomass that can be processed into ethanol. Because growers in the Columbia Basin have the knowledge base and the equipment for growing forage crops, the development of adapted feed stocks for ethanol production is a primary research goal at CBC. The research includes the development of alfalfa and switchgrass varieties for yield and adaptability in the Columbia Basin as well as research on giant Miscanthus which is an ornamental grass that grows to 15 feet and can produce considerable biomass under irrigation.

Enhancement and testing of feedstock for biofuel production

Oilseed Crops

Research on oilseed crops at CBC is limited to testing potential crops for economic yield under irrigated conditions. In 2006, yield tests were conducted on soybean and sunflower. Sunflower results indicated that yields were not high enough to justify production under irrigation at current crop prices. On the other hand, late planted soybean varieties yielded about 75 bushels. This prompted further testing of soybean

along with safflower and peanut in 2007. The best yielding safflower variety did not show promise as an oil seed crop under irrigated conditions. Although peanuts showed some promise, the crop may be more valuable as a food crop. However, the highest yielding soybean variety yielded about 85 bushels per acre. At 2007 prices of $12.00 per bushel, it was competitive with corn production. In addition, soybean requires no nitrogen fertilizer which is produced from fossil fuels. The cost savings for nitrogen would be about $150 per acre. In addition, research has shown that soybeans leave about 70 lbs. of nitrogen in the ground for the next rotational crop.

Research on oilseed crops at CBC includes attachments:

1. Sunflower results
2. 2007 Columbia Basin College Safflower Test
3. 2007 Columbia Basin College and WSU Peanut Test
4. Potential for Soybeans in the Columbia Basin
5. Potential for Double Cropping Soybeans in the Columbia Basin
6. 2009 Soybean Performance Tests in the Columbia Basin
7. 2010 Soybean Performance Tests

Biomass Crops

The need for a billion tons of biomass to produce enough biofuel to replace 30 percent of USA petroleum consumption has been reported by the United States Department of Energy (DOE). The high biomass yield of alfalfa in the state of Washington along with its perennial nature and ability to produce its own nitrogen provides considerable potential for the crop as a feedstock for the production of ethanol.

Switchgrass has been identified by the DOE as a primary crop for development because of its potential for high fuel yields and its ability to grow on marginal cropland without intensive management. Breeding efforts for biomass production in the western part of the U.S. for both switchgrass and alfalfa have been non-existent. Better adapted varieties are needed to meet the need of Washington's growers for economically producing products for cellulosic ethanol production.

Giant Miscanthus (*Miscanthus x giganteus*) is a tall perennial grass that is being grown experimentally in numerous European countries. It can be burned directly or with coal for the generation of electricity and used as a fuel for direct heating of homes and businesses. ZeaChem is in the planning stages of building a 50 million dollar cellulosic ethanol plant near the Port of Morrow in Oregon. Miscanthus could be the primary feedstock for that industry.

About one third of the harvested irrigated acres in the Columbia Basin are made up of forage crops with the majority in alfalfa. There are about 500,000 acres of alfalfa in Washington of which over 75% of the production is in the Columbia Basin. In the state of Washington, there are about 1.5 million acres of land in the Conservation Reserve Program (CRP), almost 5 million acres in pasture or rangeland and another 2.5 million in

summer fallow or idled. Much of that land could be used for the production of switchgrass or another suitable grass for biomass production.

If all the corn and soybean grown in the U.S. were dedicated to producing biofuels, they would meet just 12 percent of the nation's demand for gasoline according to Kate VanderBosch, professor of plant biology at the University of Minnesota. However cellulosic ethanol could displace at least 30 percent of the nation's petroleum consumption by 2030.

Brazil has made ethanol from switchgrass which is more efficient than corn and Iogen Corp., in Ottawa, Canada is the first business to commercially sell cellulosic ethanol. ZeaChem is in the planning stages of building a 50 million dollar cellulosic ethanol plant at the Port of Morrow in Oregon. Progress is being made toward producing cellulosic ethanol.

Columbia Basin College (CBC) is developing a program to conduct multi-year research for the development of high biomass alfalfa and switchgrass varieties for cellulosic ethanol production. In addition, CBC plans to work in the development and testing of Miscanthus as a feedstock for ethanol production.

Research and Information on Potential cellulosic ethanol feedstock crops at CBC includes attachments:

8. The Potential of Alfalfa, Switchgrass and Miscanthus as Biofuel Crops in Washington
9. Cellulosic Ethanol From Alfalfa, Switchgrass and Miscanthus (Research Proposal for funding from the Department of Agriculture, Research & Development)
10. Developing Non-lodging Alfalfa as a Feedstock for Biofuel Production (grant submission to NIFA for about $500,000)
11. Cutting Management for Biomass and Traditional Alfalfa Varieties

Alfalfa

Because of its high biomass production, perennial nature, its symbiotic relationship with specific bacteria for producing its own nitrogen, and valuable co-products, alfalfa (*Medicago sativa L.)* has the potential of being a leading crop in the production of cellulosic ethanol. More alfalfa acres for biofuel production would reduce greenhouse gas emissions, protect water quality, and improve our soils as a resource. Most importantly, it would contribute to making the United States more energy independent.

In the Columbia Basin, it is not uncommon to obtain yields of alfalfa above 10 tons per acre which are the highest yields in Northern Latitudes in the United States. When alfalfa is grown strictly for biomass with two to three cuts rather than four to five as compared to standard practices for producing dairy hay, total yield of alfalfa can increase as much as 42% and potential ethanol yield from stems doubles.

To maximize energy yield by reducing transportation costs, cellulosic biomass production and processing from alfalfa will need to be local. The fit is natural for the Columbia Basin when considering the high yield production by local growers. When located within 15 miles from a processing facility, the efficiency of energy production by alfalfa is 2 to 3 times that of corn grain or soybeans.

Although the USDA/ARS at the University of Minnesota is breeding alfalfa for ethanol production, the Midwest environment is much different from that of the Pacific Northwest (PNW). Yield potential is half of what it is in the Columbia Basin and it is grown under non-irrigated conditions. An alfalfa designed to fit a two or three cut system in the Columbia Basin will need to have large strong stems to avoid lodging under sprinkler irrigation and will need to have resistance to a number of pests that are not a problem in the mid-west. Columbia Basin College has begun an alfalfa breeding program for both standard varieties for dairy forage and germplasm for biomass types. One advanced variety was harvested for foundation seed production in 2007 while breeder seed was produced on eight more experimental varieties. Selections for non-lodging and biomass yield were made in the field and crossed in the greenhouse. Seven thousand progeny from this cross were planted in a spaced plant nursery. Selections for tall, upright growth habit suitable for infrequent cutting management were made from the nursery and are being crossed for potential new varieties targeted as feedstock for cellulosic ethanol production. Alfalfa varieties for the Columbia Basin, regardless of their use, will be selected for resistance to blue aphid, clover root curculio, Verticillium wilt, stem nematode, and root knot nematode to enhance persistence.

Research and Information on Alfalfa as a Potential Cellulosic Ethanol Feedstock; Traditional Alfalfa Attachments:

12. **A Plan for Alfalfa Research and Development**
13. Effects of Cutting Management on Forage Yield of Traditional and Non-Lodging Alfalfa Cultivars
14. Columbia Basin College 2011 Alfalfa Variety Trials
15. Economic thresholds – Weevils and Aphids
16. Optimum Planting Date for Alfalfa Grown in the Columbia Basin
17. Stem Nematode: Can It Be Defeated
18. Stem Nematode and Root Knot Nematode
19. Rethinking the Standard Test For Alfalfa Stem Nematode
20. Understanding Resistance Classifications for Pea Aphid on Alfalfa
21. Progress in Breeding For Pea Aphid Resistance

Switchgrass

Switchgrass (*Panicum virgatum L.*) is a perennial native grass adapted to the prairies of North America. The Department of Energy identified switchgrass as a primary species for development as an energy crop. It has the ability to grow well on marginal cropland

without heavy fertilization or intensive management and has a potential for high fuel yields.

A recent review of the initial DOE program to evaluate and develop switchgrass as a bio-energy crop has shown its potential as an alternative to corn for ethanol production. The program developed a research base for improvement of switchgrass through breeding. Yield gains for switchgrass were found to exceed that of corn. In addition, the energy ratio is more favorable for switchgrass than for corn. Although switchgrass has been grown for seed in the Pacific Northwest, breeding efforts for biomass production have been limited to the central and eastern parts of the United States. Yield gains through breeding in Washington could be even more significant since there has not been a breeding program for the grass in the West.

Breeding research is currently underway at CBC to develop adapted, high-yielding switchgrass experimental cultivars for the Columbia Basin. Five thousand switchgrass plants from four high yielding germplasm were started in the greenhouse and transplanted to the field in 2007.

Because the genetics of switchgrass are such that the phenotype of the parent plant is not a good indicator of the genotype, a progeny row experiment is planned for the selection of high biomass parents for the development of a suitable high yielding adapted variety. Upland and lowland types were observed in the field in 2007. Results showed that the lowland types were variable but higher yielding. Therefore, we will focus on breeding lowland types for Washington's environment.

Because of its dry conditions during seed maturation, eastern Washington is known for its excellent production of vegetable, legume and grass seeds. If switchgrass becomes the grass of choice for cellulosic ethanol production, the Columbia Basin would be perfect area for producing seed. Research in methods of seed production for switchgrass is needed to capture that potential.

Miscanthus

Giant Miscanthus (*Miscanthus x giganteus)* is a tall perennial grass that reproduces by underground rhizomes and has been evaluated in Europe during the past 10 years as a bioenergy crop. Miscanthus stems may be used as fuel for production of heat and electric power and as a feedstock for the production of cellulosic ethanol. Since the plant can get taller than 14 feet, it is speculated that 10 to 15 tons of dry matter could be harvested in one harvest in the fall, winter or early spring after dry down.

In the United States, the University of Illinois has been researching Miscanthus for about five years. The reasons for their interest are:

- Greater yields than switchgrass
- Sterile and propagated by rhizomes
- Low maintenance, perennial grass

- Long-life expectancy
- Hardy
- Nitrogen and other nutrients are moved into the rhizomes during the growing season for next year's growth
- 80 to 120 gallons of ethanol per ton of dry matter
- Energy ratio of input to output is expected to be less than 0.2
- Heat and power generation in Europe for over two decades
- Yields obtained in the U of I trials indicate that growing Miscanthus in 10% of Illinois farmland would provide sufficient fuel to produce 50% of the states electricity needs and significantly reduce carbon and sulfur dioxide emissions into the air.

In 2007 CBC acquired a single plant of Giant Miscanthus from Minnesota. The rhizomes were split to produce over 100 plants in the greenhouse and planted in the field. Plants will be harvested this winter to produce enough rhizomes to establish a nursery in the spring of 2008.

CBC planned to establish a large field test to evaluate the potential of Miscanthus to utilize potato waste water. The experiment would require the cooperation of the Port of Pasco, Lamb Weston and CBC. A possible future collaboration would be with a cellulosic ethanol producer such as the cellulosic plant built at the Port of Morrow by ZeaChem. CBC sent samples of selected alfalfa, Miscanthus and switchgrass materials to ZeaChem in November of 2007 for evaluation as a cellulosic ethanol feedstock under their system of production. They built a $50 million facility is based on the production system which utilizes an enzyme that has been isolated from termites. Their goal was to produce 150 gallons of ethanol from each ton of dry matter. Currently the plant is struggling financially.

Pepper Breeding

The Pepper breeding program began as a low priority project with the objective of breeding a sweet chili pepper for the local population that seemed to reject the spice that is normally found in most types of peppers. The idea was to provide the PAS (Post-secondary Agriculture Student) club a way of raising funds. It evolved to raising habanero peppers and processing them into a dry ground spice packaged in a shaker bottle. After working with habanero pepper, it became evident there was a need in developing a habanero that was amendable to removing the stem and easy to wash. The objectives of the program have expanded to:

1. Develop a sweet productive large chili pepper
2. Develop a habanero that is easy to wash and de-stem

Selection nurseries have been established in the past two years to accomplish these goals. More recently with the potential of a culinary school, collaboration could develop to making salsa as well as dry pepper for fund raising.

Examples, Collaborative efforts and Grant attachments:

22. Cages for 2013 (example of experimental descriptions)
23. Narrative on Grant submitted to NIFA for Developing Alfalfa Germplasm for Resistance to Stem Nematode-disease Complex requesting about $500,000 in funding.
24. Germplasm Enhancement for Blue Alfalfa Aphid and Stem Nematode Resistance (Submission to USDA for Germplasm enhancement funding). This was funded by USDA (about $40,000). Germplasm has been developed and will be released with a publication in Crop Science (technical journal).
25. Abstract of Coexistence and Market Assurance for Production of Non-Genetically Engineered Alfalfa Hay and Forage in a Biotech Era (A collaborative effort with UC Davis and Forage Genetics
26. 2008 Pacific Northwest Hay Market and Export Review and Outlook Report (a collaborative effort with WSU)

Education & Outreach

Help running the research farm which includes 8 acres on campus and about 20 acres off campus has been limited to student interns. The students have hands on experience working on research projects both in the field and in the greenhouse. Of the 14 interns that have worked in agriculture at CBC, 10 have agriculture jobs and 6 are continuing their education toward a Bachelor degree. Some continue their education while holding a job. One of the first student interns received his PhD from WSU and now holds a six figure job with a pesticide development company. One is working on his master's degree at WSU and others finished their bachelor's degree in crop and soil science at Eastern Oregon.

To supplement our education program, a PAS (post-secondary agriculture student club) was formed. State and national competition in various agriculture disciplines help the student in public speaking, interview, precision agriculture, crop protection, entomology, turf, biotechnology and others. CBC students have been very successful at the events.

Outreach has been limited to visitation to middle and high schools as well as tours of the campus research plots. A booth has been set up at various agriculture conferences to inform the participants of CBC research and education. Participation in the conferences has included educational booths, posters, and presentations and help in organization of the conferences as well as publishing the proceedings articles.

Attachment 1

Sunflower Results

Variety	plant height (in)	flower diameter (cm)	plant density (in)	Yield
SP270	35.0	18.1	14.2	671.22
B4289	44.8	14.9	9.1	759.96
Proseed 9441	70.8	18.2	10.6	860.4
Proseed E85	54.3	25.1	15.4	942.12
Proseed 84	50.1	22.7	13.7	1333.8
B4289 SS	47.9	21.2	14.3	680.76
CV	5.6	7.0	17.7	16.6
LSD	4.17	2.1	3.38	215.49

SS = standard seeding

Attachment 2

2007 Columbia Basin College Safflower Test

William T. W. Woodward[1]

Safflower performance tests were run at Columbia Basin College (CBC) to provide information on the relative performance of varieties under irrigated conditions for the Columbia Basin. Information on yield potential of safflower varieties is limited when trying to make a choice of safflower varieties.

Seeds for the tests were from private seed companies. All companies known to be developing and marketing safflower varieties for the area were invited to submit test seed. Interested companies entered on a voluntary basis.

Entries were planted in seven-row plots with rows 7.5 inches apart. Plots were 5 x 20 feet and replicated four times. Seeding rates were at 25 pounds per acre with the exception of one hybrid entry (Hybrid Oleic 16) which was also planted at 14 pounds per acre. The entire plot was harvested for yield. Results of the test are presented in Table 1.

DATA INTERPRETATION

Plots were harvested with a Wintersteiger research plot combine on October 1 and recorded as pounds per acre. Percent oil content was run blindly by an independent company. Mature plant height was measured in inches from the ground to the top of the main stem on September 25. Seedling vigor scores were taken on May 24 using a 1 to 9 scale with 9 = very vigorous and 1 = low vigor.

Statistics

For each trait measure, a LSD (least significant difference) was calculated. The significance level used to calculate the LSD was 5 percent. Unless two varieties differ by more than the LSD for individual traits, genetic difference for that trait should not be considered.

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[1] Dean of Agriculture Education, Research and Development Columbia Basin College, Pasco, WA. December 10, 2007. CBCAG701

ACKNOWLEDGMENTS

Columbia Basin College recognizes the following for their contributions to this project: Simplot, Gauntt Farms, L&H Seed, Pioneer Hi-bred, ConAgra Foods, USDA/ARS at Prosser, WA, First Line Seeds, Inc., and Manterola Hay.

Table 1: 2007 Safflower Variety Test

Columbia Basin College

Seeded: 05/08/07 Harvest: 10/1/07

Entry	Company	Yield lb/acre	% Oil Content	Mature Plant Height (inches)	Seedling Vigor*
Hybrid Oleic 16 norm rate	Safflower Technologies Int., LLC	1923.2	36.0	23.3	6.3
CW 88OL	Cal/West Seeds Inc.	1875.3	36.6	26.5	2.8
Hybrid Oleic 16 (14 lb/ac)	Safflower Technologies Int., LLC	1789.2	35.3	22.5	3.5
S-345	SeedTec	1524.6	39.8	27.8	4.3
5232	SeedTec	1512.6	37.9	27.3	7.5
Oleic 05	Safflower Technologies Int., LLC	1413.5	37.8	23.8	2.5
3268-8	Cal/West Seeds Inc.	1381.9	35.9	24.3	4.3
3125	SeedTec	1372.1	38.0	23.0	6.0
CW 99OL	Cal/West Seeds Inc.	1342.7	36.4	24.0	5.0
3268-6	Cal/West Seeds Inc.	1340.6	34.9	22.8	3.8
5244	SeedTec	1218.6	34.8	22.0	6.8
S-344	SeedTec	1179.4	37.4	23.3	5.8
S-719	SeedTec	1156.5	35.1	21.0	7.0
1133	SeedTec	1129.3	34.4	22.8	5.8
4409	SeedTec	1033.5	33.4	17.5	6.8
1137	SeedTec	1020.4	39.1	24.5	7.0
6127	SeedTec	963.8	28.2	21.5	7.3
CW 74	Cal/West Seeds Inc.	942.0	31.7	20.3	6.0
3151	SeedTec	865.8	36.7	23.0	5.3
2106	SeedTec	836.4	33.5	17.3	7.3
CW 2889	Cal/West Seeds Inc.	789.5	35.0	24.5	2.3
CW 4440	Cal/West Seeds Inc.	713.3	34.8	19.8	2.8
Nutra Saff	Safflower Technologies Int., LLC	688.2	42.8	20.5	3.8
CW 1221	Cal/West Seeds Inc.	524.9	36.3	20.3	5.8
Mean		1189.1	36.3	22.6	5.2
LSD 5%		449.53	4.70	4.55	2.10
CV %		26.5	9.1	14.1	28.2

* 9 = Very vigorus, 1 = low vigor

Attachment 3

2007 Columbia Basin College and WSU Peanut Test

William T. W. Woodward[2] and Tim Waters[3]

Introduction

With Washington State's renewable fuel standard designed to increase biofuel use with standards that start at 2% and ramp up to 5% for biodiesel and 10% for ethanol, investments in the design of the agricultural plant in addition to the bio-diesel plant (refinery) need to be considered. Since Washington State has suggested that the ramp up will come from feedstock produced from Washington's growers, then research is needed on crops that can be grown for biofuel at a profit. Although Washington farmers have extensive experience growing grain crops and biomass for ethanol production, there is little experience with growing oilseed crops. In addition, oilseed crops have not proven to be profitable. Washington farmers will be hesitant to grow oilseed crops until agronomic information is established and available.

Peanuts may have a potential for filling the void for oilseed production under irrigation in the Columbia Basin. Peanuts are mostly grown in the Southern and Southeastern parts of the United States (Table 1) where peanut varieties and agronomic information is abundant. Limited data on varieties or agronomics is available to Pacific Northwest growers.

A peanut performance test was run at Columbia Basin College (CBC) to provide information on the relative performance of varieties under irrigated conditions for the lower Columbia Basin. Results and entries are shown in Table 3. The highest

[2] Dean of Agriculture Education, Research and Development Columbia Basin College, Pasco, WA. December 10, 2007. CBCAG703

[3] Regional Vegetable Specialist, Washington State University Extension, Franklin and Benton Counties, Pasco, WA.

yielding variety was Tam Run OL02 at 3447 lbs./acre ranging to Valencia A at 1819 lbs./acre.

A comparison of the value of corn and other potential oil seed crops is shown in Table 2. To be competitive with 220 bushel corn (average yield in the Columbia Basin) at $4.00/bushel, peanuts would have to yield about 4200 lbs. /acre at $21.00 per pound. Although peanuts require no nitrogen fertilizer and provides about 70 lbs. of nitrogen for the following crop, yield of 4200 lbs. or does not appear possible. In addition, the highest yielding variety would be more valuable as a roasting peanut.

Materials and Methods

Entries were planted using a randomized complete block design with 4 replications following RR soybeans. One pre-plant application of Treflan (trifluralin) at a rate of 2 pints per acre was used to help control weeds. Hand weeding was applied as needed. Liquid and peat based inoculum was applied to seed in the planter box when seeding the plots. Plots were planted on May 14, 2007 and inverted on October 9, 2007 161 days after establishment. A Duncan's multiple-range test was used to determine significant differences among varieties. Yields not followed by the same letter are significantly different (Table 3).

Table 1: U.S. Peanut Acreage, Yield and Production, 2003 & 2004.						
State	**Harvested Acres**		**Yield**		**Production**	
	2003	**2004**	**2003**	**2004**	**2003**	**2004**
	1000 Acres	*1000 Acres*	*lbs./Acre*	*lbs./Acre*	*Million lbs.*	*Million lbs.*
AL	185	195	2750	2800	508.7	546
FL	115	135	3000	3100	345	418.5
GA	540	610	3450	3300	1863	2013
SC	17	33	3400	3100	57.8	102.3
SE	**857**	**973**	**3238**	**3165**	**2774.6**	**3079.8**
NM	17	16	2700	3000	45.9	48
OK	35	32	2800	3200	98	102.4
TX	270	235	3000	3300	810	775.5
SW	**322**	**283**	**2962**	**3300**	**953.9**	**925.9**
NC	100	105	3200	3200	320	336
VA	33	32	2900	3100	95.7	99.2
V-C	**133**	**137**	**3,126**	**3177**	**415.7**	**435.2**
US	**1,312**	**1,393**	**3,159**	**3,188**	**4,144.2**	**4,440.9**

Table 2: 2017 Average Prices

Comparisons for each pair using Student's t

Abs(Dif)-LSD

	Tam Run OL02	Tam Span 90	Gregory	Flavor Runner 45
Tam Run OL02	-1119.4	-1075.5	-748.4	-629
Tam Span 90	-1075.5	-1119.4	-792.3	-673
Gregory	-748.4	-792.3	-1119.4	-1000
Flavor Runner 458	-629.4	-673.3	-1000.3	-1119
Valencia C	-391.9	-435.8	-762.9	-881
Pronto	-84.7	-128.6	-455.7	-574
Olin	-30.5	-74.4	-401.4	-520
Gentex 102	361.6	317.8	-9.3	-128
Gentex 101	476.3	432.5	105.4	-13
Valencia A	509.4	465.5	138.5	19

Positive values show pairs of means that are significantly different.

Level		**Mean**
Tam Run OL02	A	3447.6220
Tam Span 90	A	3403.7642
Gregory	A B	3076.6974
Flavor Runner 458	A B C	2957.6483
Valencia C	A B C D	2720.1932
Pronto	A B C D	2412.9989
Olin	A B C D	2358.7510
Gentex 102	B C D	1966.6369
Gentex 101	C D	1851.9268
Valencia A	D	1818.8544

Levels not connected by same letter are significantly different.

ACKNOWLEDGMENTS

Columbia Basin College recognizes the following for their contributions to this project:
Simplot, Gauntt Farms, L&H Seed, Pioneer Hi-bred, ConAgra Foods, USDA/ARS at Prosser, WA, First Line Seeds, Inc., and Manterola Hay.

Attachment 4

Potential for Soybeans in the Columbia Basin

William T. W. Woodward[4]

Introduction

With Washington State's renewable fuel standard designed to increase biofuel use with standards that start at 2% and ramp up to 5% for biodiesel and 10% for ethanol, investments in the design of the agricultural plant in addition to the bio-diesel plant (refinery) need to be considered. Since Washington State has suggested that the ramp up will come from feedstock produced from Washington's growers, then research is needed on crops that can be grown for biofuel at a profit. Although Washington farmers have extensive experience growing grain crops and biomass for ethanol production, there is little experience with growing oilseed crops. In addition, oilseed crops have not proven to be profitable. Washington farmers will be hesitant to grow oilseed crops until agronomic information is established and available.

Soybean may have an excellent potential for filling the void for oilseed production under irrigation in the Columbia Basin. Soybeans are grown extensively in the Midwestern and Southeastern parts of the United States where soybean varieties and agronomic information is abundant. Limited data on varieties or agronomics is available to Pacific Northwest growers. Oregon State University tested 18 soybean entries over a 6 year period at Ontario, OR. The highest yielding soybean entry averaged less than 50 bushel per acre. (2) More recently average yields in tests run in 2005 and 2006 showed some entries with yield over 75 bushels (3). Washington State University indicated that maturity groups 00, 0 or 1 produce well in the southern Columbia Basin. (1) The top yielding varieties in biofuel variety trials at Patterson, WA yielded about 65 bushels per acre.

[4] Dean of Agriculture Education, Research and Development Columbia Basin College, Pasco, WA, December 12, 2007. CBCAG702

To be competitive with 250 bushel corn at $4.00/bushel, soybean would have to yield about 83 bushels at $12.00/bushel. Because soybean requires no nitrogen fertilizer and provides about 70 lbs. of nitrogen for the following crop, yield of 85 bushels or better would be more than competitive with corn.

Soybean performance tests were run at Columbia Basin College (CBC) to provide information on the relative performance of varieties under irrigated conditions for the lower Columbia Basin.

Materials and Methods:

In 2006, eight soybean varieties were planted with three replications in 20 ft. x 300 ft. plots. A commercial combine was used to harvest the plots and yields were determined using a commercial weigh wagon. Varieties were provided by Pioneer Hi-bred Int., Inc. and ranged in maturity from 0.2 to 2.9. Fertilizer was applied according to soil tests and irrigation was applied throughout the growing season.

In 2007, an early maturity and late maturity soybean performance test was established. Both tests were planted in a randomized complete block design with 16 entries and six replications. Indicated maturity for the varieties ranged from 0.0 to 1.5 for the early maturity test and 1.7 to 3.9 for the late maturity test. Seeds were from private seed companies that have the potential to market varieties for the area. Interested companies entered on a voluntary $40.00 per entry fee basis. Only Roundup® resistant varieties were tested.

Entries were planted in seven-row plots with rows 7.5 inches apart. Plots were 5 x 20 feet with the entire plot harvested for yield with a Wintersteiger research plot combine. Plots were harvested on October 12 for the early maturity test and on November 2 for the late maturity test. Moisture was measured using a Dickey-john Tri-Grain™ moisture tester. Test weight was measured using a Quart Cup 26 weighing apparatus sold by Seedburo Equipment Co. Yields are recorded as bushels per acre (60 pounds per bushel) adjusted to 13 percent moisture content. Mature plant height and lowest pod height were measured in inches on September 24. Mature plant height was the average length from the soil surface to the top of the main stem. Lowest pod height was a measure from ground to the lowest pod on the stem and can give an indication of harvest loss during combine operations. Varieties which produce pods lower to the ground are more susceptible to yield loss during harvest. Lodging was rated at maturity on a 1 to 5 scale with 1=most plants erect, 2=plants slightly leaning, 3=all plants moderately leaning, 4=all plants severely leaning, and 5=most plants down. Maturity was score from 6 to 8 with

6=full seed – pod containing a green seed that fills the pod capacity at one of the four uppermost nodes on the main stem, 7=Beginning maturity – one normal pod on the main stem has reached its mature pod color, and 8=95% or more of the pods have reached their full mature color. For each trait measure, LSD (least significant difference) was calculated. The significance level used to calculate the LSD was 5 percent. Unless two varieties differ by more than the LSD for individual traits, difference for that trait should not be considered.

Results and Discussion

The 2006 soybean variety trial was planted on April 28, 2006. However due to an infestation of seed corn maggot, the trial was replanted on May 25. Although there were no significant differences observed for yield at the 5% level, the trial showed that yields of over 70 bushels could be obtained even at a late planting date (Table 1).

Because of the high yields demonstrated on the late planted 2006 soybean variety test, it was decided to expand the testing to include more varieties with varying maturities to identify the right maturity groups for the lower Columbia Basin and potential higher yielding varieties. Results from the early maturing soybean variety test are presented in Table 2. Yields ranged from 47.9 to 86.6 bushels per acre for AG00603RR and for Integra 98150R, respectively. Integra 98150R had a significant higher yield than 14 other entries in the test. The test indicated that maturity groups from 0.8 to 1.5 were best adapted to the Lower Columbia Basin. Results from the late maturing soybean variety test are shown in Table 3. In general, maturity groups 2.6 and later retained their leaves through the first frost and were the lowest yielding varieties in the test. Maturity groups from 1.7 through 2.4 appeared to be the best adapted. When observing the two tests together, growers should select maturity groups from 0.8 to through 2.4 for the lower Columbia Basin. Low pod set appeared to be limited to 0.3 maturities and earlier while lodging appeared to be associated with the later maturing types. Both of these traits can cause yield loss at harvest.

Acknowlegements

Columbia Basin College recognizes the following for their contributions to this project:
Simplot, Gauntt Farms, L&H Seed, Pioneer Hi-bred, ConAgra Foods, USDA/ARS at Prosser, WA, First Line Seeds, Inc., and Manterola Hay.

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Table 1: 2006 Soybean Variety Trial, Columbia Basin College

Seeded May 25, 2006

Originator/Brand	Entry	Maturity Group	Harvest Date	Yield 13% Moisture
			2006	bu/A
Pioneer	90M20	0.2	10/11	59.3
Pioneer	90M60	0.6	10/23	68.0
Pioneer	90M91	0.9	10/23	71.1
Pioneer	91M13	1.1	10/23	65.6
Pioneer	91M70	1.7	10/23	68.7
Pioneer	92B38	2.3	11/1	70.3
Pioneer	92M61	2.6	11/1	62.9
Pioneer	92M91	2.9	11/1	63.0
	Mean			66.12
	LSD 5%			**NS**
	CV %			9.0

Table 2: Early Maturing Soybean Variety Test, Columbia Basin College

Planted: May 8, 2007
Harvested: October 12, 2007

Variety	Company Name	Maturity Group	Yield (bu/acre)	Percent Moisture	Test Weight	Mature Plant Height (in)	Lowest Pod Height(in)	Lodging	Maturity on 9/25
Integra 98150R	Wilbur-Ellis	1.5	86.6	9.0	52.7	44.0	6.3	3.7	7.8
91M40	Pioneer	1.4	80.7	9.1	53.3	41.7	5.8	4.5	7.9
Integra 96090R	Wilbur-Ellis	0.9	73.6	8.7	54.1	47.3	6.2	4.2	8.0
Integra 96081R	Wilbur-Ellis	0.8	71.7	8.4	52.5	42.8	5.7	1.8	8.0
Integra 96110R	Wilbur-Ellis	1.1	71.4	9.3	54.0	41.7	7.0	4.0	7.6
90M91	Pioneer	0.9	71.1	9.0	53.8	48.5	5.0	3.8	8.0
DKB08-51RR	DeKalb	0.8	70.2	8.8	53.5	48.5	6.0	2.8	8.0
AG1502RR	Asgro	1.5	68.2	9.2	53.3	43.5	5.4	4.3	7.7
Integra 97031R	Wilbur-Ellis	0.3	66.6	8.6	53.9	47.5	5.9	3.2	8.0
AG0202RR	Asgro	0.2	66.3	8.6	52.6	38.0	4.3	1.2	7.5
Integra 96062R	Wilbur-Ellis	0.6	65.9	9.0	53.7	45.3	5.9	2.8	7.8
90M60	Pioneer	0.6	62.7	8.9	52.2	40.5	5.8	2.3	8.0
90M20	Pioneer	0.2	61.2	8.5	53.8	38.0	4.2	2.3	8.0
AG0301RR	Asgro	0.3	61.1	8.5	52.8	42.5	4.6	1.8	8.0
90M01	Pioneer	0.0	60.7	8.8	53.8	36.5	3.6	1.3	8.0
AG00603RR	Asgro	0.0	47.9	8.7	53.6	29.7	3.8	1.0	8.0
		Average	67.9	8.8	53.3	42.3	5.3	2.8	7.9
		CV	8.2	6.4	1.7	9.6	26.9	30.8	4.2
		LSD.05	7.99	NS	1.26	5.79	2.05	1.24	NS

Table 3: Late Maturing Soybean Variety Test, Columbia Basin College

Planted: May 9, 2007
Harvested: November 2, 2007

Variety	Company Name	Maturity Group	Yield (bu/acre)	Percent Moisture	Test Weight	Mature Plant Height	Lowest Pod Height	Lodging	Maturity on 9/25
Integra 96170R	Wilber Ellis	1.7	76.4	8.2	55.5	42.2	6.3	2.7	8.0
92M02	Pioneer	2.0	74.3	8.0	54.9	44.3	6.7	3.0	7.3
AG2107RR	Asgro	2.1	68.1	8.4	55.6	44.0	6.1	4.3	7.5
DKB24-52RR	DeKalb	2.4	66.4	8.2	56.2	48.8	7.8	4.5	6.9
93M11	Pioneer	3.1	65.7	8.7	55.2	50.2	6.4	3.5	6.0
Integra 98190R	Wilber Ellis	1.9	64.6	7.9	54.7	46.2	6.8	4.5	7.2
AG1702RR	Asgro	1.7	64.1	7.9	54.3	43.5	8.0	1.8	8.0
DKB18-51RR	DeKalb	1.8	64.0	8.2	55.3	41.2	6.6	3.3	7.8
Integra 98260R	Wilber Ellis	2.6	62.4	8.1	56.2	45.3	9.4	3.7	6.2
92M61	Pioneer	2.6	62.3	8.1	55.0	49.0	5.2	4.3	6.0
92M32	Pioneer	2.3	62.2	8.2	54.7	43.5	8.5	4.8	7.0
Integra 98230R	Wilber Ellis	2.3	60.3	8.0	55.7	41.2	7.3	3.5	6.6
Integra 98300R	Wilber Ellis	3.0	58.5	9.2	55.2	47.2	8.4	3.7	6.0
AG3005RR	Asgro	3.0	58.3	9.7	54.8	45.5	7.9	3.8	6.0
91M70	Pioneer	1.7	56.5	7.8	54.7	42.0	7.8	4.7	7.5
93M96	Pioneer	3.9	53.9	10.7	55.3	47.7	7.8	3.2	6.0
		Average	63.6	8.5	55.2	45.1	7.3	3.7	6.9
		CV	11.6	8.6	1.5	10.4	23.5	17.0	5.7
		LSD.05	10.52	1.03	1.19	6.73	2.46	0.90	0.56

Attachment 5

Potential for Double Cropping Soybeans in the Columbia Basin

William T. W. Woodward[5]

Introduction

Washington State's renewable fuel standard was designed to increase biofuel use with standards that start at 2% and ramp up to 5% for biodiesel. The state of Washington has suggested that the ramp up will come from feedstock produced from Washington's growers. Although Washington farmers have extensive experience growing grain crops and biomass for ethanol production, there is little experience for growing oilseed crops. In addition, many oilseed crops have not proven to be profitable. Washington farmers will be hesitant to grow an oilseed crop until agronomic information is established and available.

Double cropping soybean may have an excellent potential for oilseed production under irrigation in the Columbia Basin. Double-cropping soybean after wheat has grown in popularity in the southern part of the mid-west and southeastern US. Advantages to growing and keeping a crop on the land all year include controlling soil erosion and spreading annual fixed costs over two crops. The idea is to increase gross return with relatively low increases in production costs. In Washington growers often take first cut alfalfa or a single cut of timothy hay and then establish a second crop such as sweet corn or silage corn. Soybean could be a profitable alternative second crop.

Materials and Methods:

Three soybean experiments were established in 2008 at Columbia Basin College in Pasco, Washington. Four soybean varieties of different maturities were selected for planting based on yield data results in 2007. Maturity groups included an early 0, late 0, mid I and a late I. Seed for the varieties was provided by Wilber-Ellis

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and planted on twelve dates. The first study was planted in late May through June to determine potential for double cropping early crops. Two additional studies were planted on six dates beginning in early July through the first week in August to determine potential following wheat. One of the later studies was planted following wheat planted in the spring and rotovated prior to planting the soybean entries. Experiments were planted using a randomized complete block design with four replications and analyzed using a two-factor (planting date and varieties) analysis of variance.

Entries were planted in seven-row plots with rows 7.5 inches apart. Plots were 5 x 20 feet with the entire plot harvested for yield with a Wintersteiger research plot combine. Plots were harvested on October 29 for the early test and on October 30 for the late planted tests. Moisture was measured using a Dickey-john Tri-Grain™ moisture tester. Test weight was measured using a Quart Cup 26 weighing apparatus sold by Seedburo Equipment Co. Yields are recorded as bushels per acre (60 pounds per bushel) adjusted to 13 percent moisture content. Mature plant height and lowest pod height were measured in inches on October 6. Mature plant height was the average length from the soil surface to the top of the main stem. Lowest pod height was a measure from ground to the lowest pod on the stem and can give an indication of harvest loss during combine operations. Varieties which produce pods lower to the ground are more susceptible to yield loss during harvest. Lodging was rated at maturity on a 1 to 5 scale with 1=most plants erect, 2=plants slightly leaning, 3= all plants moderately leaning, 4=all plants severely leaning, and 5=most plants down. Maturity was scored from 3 to 8 with 3=**Beginning pod** – pods are 3/16 inch at one of the four uppermost nodes, 4=**Full pod** – pods are 3/4 inch at one of the four uppermost nodes, 5=**Beginning seed** – seed is 1/8 inch long in the pod at one of the four uppermost nodes on the main stem, 6=**full seed** – pod containing a green seed that fills the pod capacity at one of the four uppermost nodes on the main stem, 7=**Beginning maturity** – one normal pod on the main stem has reached its mature pod color, and 8=**Full maturity** – 95% or more of the pods have reached their full mature color. For each trait measure, LSD (least significant difference) was calculated. The significance level used to calculate the LSD was 5 percent. Unless two entries differ by more than the LSD for individual traits, difference for that trait should not be considered.

Results and Discussion

Experiment 1: Evaluation of early planting dates and maturity group effect of soybean varieties for double cropping in the Columbia Basin.

Results for entries in the first experiment are shown in Table 1 sorted by yield. Yields ranged from 21.9 to 84.9 bushels/acre for Integra 96170R and Integra 98150R, respectively. Significant differences were observed for yield, lowest pod height, mature plant height, lodging and maturity. No significant differences were found for test weight and percent moisture. The maturity group I variety, Integra 98150R, had significantly higher yields across planting dates than the earliest and latest maturing varieties in the test (Table 2). As expected, yields declined significantly as planting was delayed (Table 3). The average yield for the four varieties in the test ranged from 77.3 to 35.7 bushels/acre for the earliest planting date to the latest planting date, respectively. The data indicates that for each day that planting is delayed there is a yield loss of about 1.2 bushels. However, the data also indicates that excellent yields can be obtained on soybean planted as a double crop through mid June. Soybeans appear to be suited to follow the first cutting of alfalfa and timothy in the Columbia Basin.

Experiment 2 and 3: Evaluation of late planting dates and maturity group effect of soybean varieties for double cropping in the Columbia Basin.

To determine if soybean could be double cropped with wheat, experiment 2 and 3 were established with planting dates bracketing mid July when wheat is often harvested from irrigated acres in the Columbia Basin. Experiment 2 was planted with no previous crop growing through the spring while Experiment 3 was planted following wheat. Results for entries are reported in Table 4 and Table 7 for experiment 2 and 3 respectively. Even though the tests were analyzed separately, it did not appear that soybean following wheat had a negative effect on yields. The two highest yielding entries, Integra 96081R and Integra 109R001 were the same for both tests planted on the first late planting date in July. There were significant differences for varieties across planting dates in both experiments Tables 5 and 8). Even though most studies in areas were soybeans are typically grown indicate that the best performing full season soybean should be grown when double cropping with wheat, our data indicated that the earlier maturing variety, 109R001, performed the best in the late planted experiments. Yields declined significantly as varieties were planted at later dates (Tables 6 and 9). The data indicated that planting soybean after the first of July would be risky for growers in the Columbia Basin. To be successful, an early maturing variety of wheat would need to be identified along with an early harvest.

Conclusion

Double cropping soybean following early crops such as first cut alfalfa or timothy could be a solution for growing an oilseed crop under irrigation in the Columbia basin. More research is needed prior to double cropping with wheat.

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Table 1: Early planting dates and maturity group effect on soybean varieties at Pasco, WA

Date	Maturity	Variety	Yield bu/A at 13% Moisture	Lowest Pod Height	Mature Plant Height (inches)	Lodging	Maturity on 10-6-08	Test Weight	Percent Moisture
23-May	1.5	Integra 98150R	**84.9**	7.3	36.3	1.3	8.0	54.5	10.1
30-May	1.5	Integra 98150R	**81.3**	7.3	33.9	2.0	8.0	55.8	10.1
23-May	0.8	Integra 96081R	**80.9**	5.5	35.5	1.8	8.0	55.5	10.0
23-May	0.0	Integra 109R001	**75.2**	2.5	28.8	1.0	8.0	55.5	10.0
30-May	0.8	Integra 96081R	**70.3**	5.3	35.5	2.5	8.0	55.0	10.7
30-May	0.0	Integra 109R001	**69.8**	4.0	29.5	1.0	8.0	55.8	10.0
23-May	1.7	Integra 96170R	**68.4**	4.8	39.5	3.5	7.3	55.5	9.8
6-Jun	1.5	Integra 98150R	**67.9**	7.1	34.0	1.8	7.8	55.5	10.2
13-Jun	1.5	Integra 98150R	**64.2**	5.5	33.3	2.3	7.5	55.5	10.5
6-Jun	0.8	Integra 96081R	**64.1**	6.5	35.8	2.5	8.0	56.8	9.9
6-Jun	0.0	Integra 109R001	**61.5**	4.8	30.3	1.3	8.0	55.3	10.1
30-May	1.7	Integra 96170R	**56.2**	6.5	39.4	3.3	7.0	57.5	10.2
13-Jun	0.0	Integra 109R001	**54.5**	3.1	29.8	1.5	8.0	55.8	10.1
20-Jun	1.5	Integra 98150R	**54.4**	6.4	33.0	2.3	6.5	56.3	10.3
13-Jun	0.8	Integra 96081R	**54.4**	5.1	31.5	3.0	7.8	56.5	9.9
6-Jun	1.7	Integra 96170R	**52.5**	6.4	36.3	3.3	7.0	56.8	10.2
20-Jun	0.8	Integra 96081R	**49.8**	6.5	30.8	2.5	7.8	55.0	9.8
20-Jun	0.0	Integra 109R001	**46.8**	2.3	29.8	1.5	8.0	55.8	10.3
13-Jun	1.7	Integra 96170R	**45.0**	7.5	35.5	3.3	7.0	57.3	10.1
27-Jun	1.5	Integra 98150R	**42.3**	6.6	33.5	2.3	6.3	55.5	9.9
27-Jun	0.8	Integra 96081R	**41.2**	5.6	31.8	2.3	7.3	55.3	10.7
27-Jun	0.0	Integra 109R001	**37.5**	3.8	28.6	3.0	8.0	55.5	9.9
20-Jun	1.7	Integra 96170R	**36.5**	6.4	36.3	3.3	6.0	58.3	10.3
27-Jun	1.7	Integra 96170R	**21.9**	6.6	35.0	2.5	6.0	55.3	10.8
		Mean	**56.0**	**5.5**	**33.5**	**2.3**	**7.5**	**55.9**	**10.2**
		LSD 5%	**5.33**	**0.86**	**1.7**	**0.5**	**0.2**	**NS**	**NS**
		CV %	**16.6**	**27.0**	**8.8**	**37.4**	**3.8**	**2.7**	**5.8**

Table 2: Soybean varieties across early planting dates

Variety	Yield bu/A at 13% Moisture	Lowest Pod Height	Mature Plant Height	Lodging	Maturity on Oct. 6, 2008	Test Weight	Percent Moisture
Integra 109R001	**57.5**	3.4	29.4	1.5	8.0	55.6	10.0
Integra 96081R	**60.1**	5.8	33.5	2.4	7.8	55.7	10.2
Integra 98150R	**65.8**	6.7	34.0	2.0	7.3	55.5	10.2
Integra 96170R	**46.8**	6.4	37.0	3.2	6.7	56.8	10.2
Mean	**57.6**	**5.5**	**33.5**	**2.3**	**7.5**	**55.9**	**10.2**
LSD.05	**13.47**	**2.11**	**4.15**	**1.20**	**0.40**	**NS**	**NS**

Table 3: Early planting dates across varieties

Seeding Dates	Yield bu/A at 13% Moisture	Lowest Pod Height	Mature Plant Height	Lodging	Maturity on Oct. 6, 2008	Test Weight	Percent Moisture
23-May	**77.3**	5.0	35.0	1.9	7.8	55.3	10.0
30-May	**69.4**	5.8	34.6	2.2	7.8	56.0	10.2
6-Jun	**61.5**	6.2	34.1	2.2	7.7	56.1	10.1
13-Jun	**54.5**	5.3	32.5	2.5	7.6	56.3	10.2
20-Jun	**46.9**	5.4	32.4	2.4	7.1	56.3	10.1
27-Jun	**35.7**	5.7	32.2	2.5	6.9	55.4	10.3
Mean	**57.6**	**5.5**	**33.5**	**2.3**	**7.5**	**55.9**	**10.2**
LSD.05	**11.00**	**NS**	**3.39**	**NS**	**0.33**	**NS**	**NS**

Table 4: Late planting dates and maturity group effect on soybean varieties at Pasco, WA

Date	Maturity	Variety	Yield bu/A at 13% Moisture	Lowest Pod Height	Mature Plant Height (inches)	Lodging	Maturity on 10-6-08
2-Jul	0.8	Integra 96081R	**58.3**	5.8	22.6	1.0	6.8
2-Jul	0.0	Integra 109R001	**52.0**	3.4	21.1	1.0	8.0
2-Jul	1.5	Integra 98150R	**49.9**	4.8	25.9	1.0	6.3
9-Jul	0.0	Integra 109R001	**43.8**	3.3	18.3	1.0	7.3
9-Jul	0.8	Integra 96081R	**41.7**	3.9	20.0	1.0	6.0
2-Jul	1.7	Integra 96170R	**36.1**	4.8	25.1	1.0	6.0
16-Jul	0.0	Integra 109R001	**29.8**	2.8	18.5	1.0	6.0
9-Jul	1.5	Integra 98150R	**24.4**	3.6	19.9	1.0	6.0
16-Jul	0.8	Integra 96081R	**19.6**	3.5	17.5	1.0	5.8
9-Jul	1.7	Integra 96170R	**14.5**	4.8	25.3	1.0	5.8
23-Jul	0.0	Integra 109R001	**13.9**	3.3	15.9	1.0	6.0
16-Jul	1.5	Integra 98150R	**8.6**	3.4	17.3	1.0	5.5
16-Jul	1.7	Integra 96170R	**4.9**	4.3	22.9	1.0	5.3
23-Jul	0.8	Integra 96081R	**3.2**	2.8	16.3	1.0	5.0
23-Jul	1.5	Integra 98150R	**2.3**	3.1	14.4	1.0	5.0
30-Jul	0.0	Integra 109R001	**2.0**	2.5	11.5	1.0	5.0
6-Aug	0.0	Integra 109R001	**0.7**	3.5	9.8	1.0	4.8
30-Jul	1.7	Integra 96170R	**0.6**	4.8	12.5	1.0	3.3
30-Jul	0.8	Integra 96081R	**0.5**	3.1	10.5	1.0	4.3
23-Jul	1.7	Integra 96170R	**0.4**	4.1	16.9	1.0	4.5
6-Aug	1.7	Integra 96170R	**0.2**	4.6	10.0	1.0	3.0
6-Aug	0.8	Integra 96081R	**0.1**	4.4	8.8	1.0	3.8
30-Jul	1.5	Integra 98150R	**0.1**	3.9	10.0	1.0	3.8
6-Aug	1.5	Integra 98150R	**0.1**	4.9	8.3	1.0	3.0
	Mean		**17.0**	**3.9**	**16.6**	**1.0**	**5.2**
	LSD 5%		**2.82**	**0.58**	**1.3**	**0.0**	**0.3**
	CV %		**28.9**	**26.2**	**13.3**	**0.0**	**8.6**

Table 5: Soybean varieties across late planting dates

Variety	Yield bu/A at 13% Moisture	Lowest Pod Height	Mature Plant Height	Lodging	Maturity on Oct. 6, 2008
Integra 109R001	**23.7**	3.1	15.8	1.0	6.2
Integra 96081R	**20.6**	3.9	15.9	1.0	5.3
Integra 98150R	**14.2**	3.9	15.9	1.0	4.9
Integra 96170R	**9.4**	4.5	18.8	1.0	4.6
Average	**17.0**	**3.9**	**16.6**	**1.0**	**5.2**
LSD.05	**6.90**	**1.43**	**3.11**	**NS**	**0.64**

Table 6: Late planting dates across varieties

Seeding Dates	Yield (bu/acre)	Lowest Pod Height	Mature Plant Height	Lodging	Maturity on Oct. 6, 2008
2-Jul	**49.1**	4.7	23.7	1.0	6.8
9-Jul	**31.1**	3.9	20.8	1.0	6.3
16-Jul	**15.7**	3.5	19.0	1.0	5.6
23-Jul	**5.0**	3.3	15.8	1.0	5.1
30-Jul	**0.8**	3.6	11.1	1.0	4.1
6-Aug	**0.3**	4.3	9.2	1.0	3.6
Average	**17.0**	**3.9**	**16.6**	**1.0**	**5.2**
LSD.05	**5.64**	**1.16**	**2.54**	**NS**	**0.52**

Table 7: Late planting date and maturity group effect on soybean following wheat at Pasco, WA

Date	Maturity	Variety	Yield bu/A at 13% Moisture	Lowest Pod Height	Mature Plant Height (inches)	Lodging	Maturity on 10-6-08
2-Jul	0.0	Integra 109R001	**61.4**	3.3	22.8	1.0	8.0
2-Jul	0.8	Integra 96081R	**56.2**	4.8	22.6	1.0	7.0
2-Jul	1.5	Integra 98150R	**44.1**	5.1	24.8	1.0	6.3
9-Jul	0.0	Integra 109R001	**42.1**	3.0	18.1	1.0	7.0
9-Jul	0.8	Integra 96081R	**33.5**	3.3	21.0	1.0	6.0
16-Jul	0.0	Integra 109R001	**31.2**	3.0	19.0	1.0	6.0
2-Jul	1.7	Integra 96170R	**28.6**	4.5	25.6	1.0	6.0
9-Jul	1.5	Integra 98150R	**22.7**	4.5	21.3	1.0	5.8
23-Jul	0.0	Integra 109R001	**14.9**	2.5	16.3	1.0	5.5
9-Jul	1.7	Integra 96170R	**12.5**	4.0	22.5	1.0	5.3
16-Jul	0.8	Integra 96081R	**11.9**	3.3	17.3	1.0	5.3
16-Jul	1.5	Integra 98150R	**6.3**	4.0	18.0	1.0	5.3
23-Jul	0.8	Integra 96081R	**3.5**	3.5	17.4	1.0	5.3
16-Jul	1.7	Integra 96170R	**3.1**	4.3	20.0	1.0	5.3
30-Jul	0.0	Integra 109R001	**3.1**	3.0	13.5	1.0	5.3
23-Jul	1.5	Integra 98150R	**1.0**	3.5	16.8	1.0	4.8
30-Jul	0.8	Integra 96081R	**0.7**	2.5	12.5	1.0	4.3
6-Aug	0.0	Integra 109R001	**0.6**	4.0	9.8	1.0	4.3
23-Jul	1.7	Integra 96170R	**0.4**	4.0	17.0	1.0	4.5
30-Jul	1.5	Integra 98150R	**0.1**	3.5	11.1	1.0	3.8
6-Aug	1.5	Integra 98150R	**0.1**	3.8	9.3	1.0	3.0
30-Jul	1.7	Integra 96170R	**0.1**	4.0	12.9	1.0	4.0
6-Aug	1.7	Integra 96170R	**0.1**	4.3	9.8	1.0	3.0
6-Aug	0.8	Integra 96081R	**0.0**	4.0	9.0	1.0	3.8
	Mean		**15.8**	**3.7**	**17.0**	**1.0**	**5.2**
	LSD 5%		**2.96**	**0.56**	**1.2**	**0.0**	**0.3**
	CV %		**32.7**	**26.1**	**12.4**	**0.0**	**8.8**

Table 8: Soybean varieties across late planting dates following wheat

Variety	Yield bu/A at 13% Moisture	Lowest Pod Height	Mature Plant Height	Lodging	Maturity on Oct. 6, 2008
Integra 109R001	**25.5**	3.1	16.6	1.0	6.0
Integra 96081R	**17.6**	3.5	16.6	1.0	5.3
Integra 98150R	**12.4**	4.1	16.9	1.0	4.8
Integra 96170R	**7.5**	4.2	18.0	1.0	4.7
Average	**15.8**	**3.7**	**17.0**	**1.0**	**5.2**
LSD.05	**7.24**	**1.37**	**NS**	**NS**	**0.64**

Table 9: Late planting dates across varieties following wheat

Seeding Dates	Yield bu/A at 13% Moisture	Lowest Pod Height	Mature Plant Height	Lodging	Maturity on Oct. 6, 2008
2-Jul	**47.6**	4.4	23.9	1.0	6.8
9-Jul	**27.7**	3.7	20.7	1.0	6.0
16-Jul	**13.1**	3.6	18.6	1.0	5.4
23-Jul	**4.9**	3.4	16.8	1.0	5.0
30-Jul	**1.0**	3.3	12.5	1.0	4.3
6-Aug	**0.2**	4.0	9.4	1.0	3.5
Average	**15.8**	**3.7**	**17.0**	**1.0**	**5.2**
LSD.05	**5.91**	**1.12**	**2.41**	**NS**	**0.53**

Attachment 6

2009 Soybean Performance Tests in the Columbia Basin

William T. W. Woodward[6]

INTRODUCTION

Since 2006, Columbia Basin College (CBC) has run tests on soybean to provide information on the relative performance of varieties under irrigated conditions for the Columbia Basin. Of the oilseed crops, soybean appears to have the best potential to be grown at a profit in the basin when considering the high input costs for irrigated crops. Information on yield potential and maturity of varieties continues to be limited when making a choice of which variety to grow.

Private seed companies, known to be developing and marketing soybean varieties, were invited to submit test seed. Interested companies entered only Roundup®-resistant varieties thought to perform well in the area. Focus was placed on early maturing varieties.

Entries were planted in five-row plots with rows 15 inches apart. Plots were 5 x 17 feet and replicated six times. Seeding rates were at 175,000 seeds per acre with each entry adjusted for seed size. The entire plot was harvested for yield.

Two tests were planted in Pasco and one test in Connell. Each test had 16 entries and was replicated six times.

A soybean strip test was planted in Pasco under pivot irrigation on June 8. Resulting data is an average of three samples and presented in Table 4.

DATA INTERPRETATION

[6] Dean of Agriculture Education, Research and Development Columbia Basin College, Pasco, WA, December 14, 2009. CBCAG901

Yields were recorded as bushels per acre (60 pounds per bushel) adjusted to 13% moisture content. Moisture was measured using a Dickey-john Tri-Grain™ moisture tester. Test weight was measured using a Quart Cup 26 weighing apparatus sold by Seedburo Equipment Co. Percent protein and oil was measured using a Foss Grainspec (Foss North America, Eden Prairie, MN) near-infrared whole-grain analyzer by Ceres Commodities LLC located in Newport, KY.

Mature Plant Height and **Lowest Pod Height** were measured in inches. Mature plant height is the average length from the soil surface to the top of the main stem. Lowest pod height is a measure from ground to the lowest pod on the stem and can give an indication of harvest loss during combine operations. Varieties which produce pods lower to the ground are more susceptible to yield loss during harvest.

Lodging was rated at maturity as follows:

1. Most plants erect
2. Plants slightly leaning
3. All plants moderately leaning
4. All plants severely leaning
5. Most plants down

Maturity is the average of the following scores:

6. Full seed – pod containing a green seed that fills the pod capacity at one of the four uppermost nodes on the main stem.
7. Beginning maturity – one normal pod on the main stem has reached it's mature pod color
8. Full maturity – 95% of the pods have reached their full mature color

Statistics

For each trait measured, LSD (least significant difference) was calculated. The significance level used to calculate the LSD was 5%. Unless two varieties differ by more than the LSD for individual traits, genetic difference for that trait should not be considered. The coefficient of variation (CV) is a statistical tool to be use as an estimate of the precision of the test. In general, a CV of less than 10% for yield data is indicative of a good test. A CV between 10% and 15% is considered to be an acceptable test.

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Table 1: 2009 Early Maturity Soybean Variety Test, Columbia Basin College, Pasco, WA

Planted: May 7, 2009

Harvested: October 19, 2009

Variety	Company Name	Maturity Group	Yield 13 % moisture (bu/acre)	Percent Moisture	Test Weight	Mature Plant Height (in)	Lowest Pod Height (in)	Lodging	Maturity on 9/10	Percent Protein	Percent Oil
AG1702 RR	Asgro	1.7	82.1	14.4	52.9	40.7	7.9	2.7	6.2	43.1	21.0
CSR1520	Wilbur-Ellis	1.5	76.3	14.9	53.9	40.3	5.7	1.8	6.5	40.0	22.3
30M09	Dyna-Gro	0.9	69.3	14.8	53.3	38.2	4.3	1.2	8.0	43.7	21.7
AG1403 RR	Asgro	1.4	67.6	14.9	52.7	41.4	6.7	2.8	6.3	41.1	21.2
AG0808 RR	Asgro	0.8	67.5	14.6	52.5	49.3	4.8	3.0	6.2	40.3	21.3
33T06	Dyna-Gro	0.6	66.9	15.2	53.3	41.8	3.2	2.3	7.0	42.8	21.3
AG0803 RR	Asgro	0.8	66.3	14.7	53.2	41.4	6.3	2.3	6.7	41.9	21.5
AG1506 RR	Asgro	1.5	64.5	14.8	54.2	38.9	5.8	3.2	6.0	40.8	22.4
AG0401 RR	Asgro	0.4	62.5	15.1	53.3	44.3	5.3	3.3	7.0	41.6	21.8
96081R	Wilbur-Ellis	0.8	62.4	14.4	53.2	37.1	4.8	2.7	6.7	43.1	21.2
AG00901 RR	Asgro	0.0	62.3	14.9	53.1	34.1	4.0	1.5	8.0	42.5	21.4
AG0604 RR	Asgro	0.6	59.1	14.9	53.0	44.8	5.6	1.8	7.8	42.1	22.4
AG0103 RR	Asgro	0.1	57.4	14.9	52.8	36.6	4.3	2.2	7.7	43.6	21.9
32T03	Dyna-Gro	0.3	57.4	14.8	53.5	40.8	5.0	2.8	6.7	42.0	21.9
AG00501RR	Asgro	0.0	57.0	15.3	53.0	32.2	4.7	1.0	8.0	41.9	21.6
109R001	Wilbur-Ellis	0.0	44.9	15.3	52.8	29.6	3.4	1.2	8.0	42.3	22.1
		Average	64.0	14.9	53.2	39.5	5.1	2.2	7.0	42.0	21.7
		CV	8.2	2.7	1.6	9.0	20.5	36.2	7.6	1.0	1.1
		LSD.05	7.48	0.58	NS	5.08	1.49	1.16	0.77	0.62	0.35

Table 2: 2009 Early Maturity Soybean Variety Test, Columbia Basin College, Pasco, WA

Planted: May 29, 2009

Harvested: October 20, 2009

Variety	Company Name	Maturity Group	Yield (bu/acre)	Percent Moisture	Test Weight	Mature Plant Height (in)	Lowest Pod Height (in)	Lodging	Maturity on 9/10	Percent Protein	Percent oil
91Y20	Pioneer	1.20	74.7	14.1	54.2	41.0	6.3	1.2	6.0	42.6	20.7
90Y42	Pioneer	0.40	73.5	14.6	53.5	41.2	5.3	1.7	7.0	41.6	21.4
90M02	Pioneer	0.00	73.5	15.8	54.0	42.5	5.7	3.3	7.0	43.2	21.0
90M60	Pioneer	0.60	71.9	14.2	53.8	40.8	5.5	2.8	6.0	42.5	20.5
90Y80	Pioneer	0.80	71.7	15.2	53.7	44.8	6.0	2.7	6.0	42.3	21.4
AG0604 RR	Asgro	0.60	71.0	14.4	53.5	44.5	4.8	2.8	6.0	40.7	22.4
32T03	Dyna-Gro	0.30	69.6	15.0	53.7	47.8	6.5	2.7	6.0	40.9	21.5
AG0401 RR	Asgro	0.40	69.3	14.9	53.0	49.7	4.8	3.0	6.0	40.4	21.7
AG00901 RR	Asgro	0.09	68.6	14.9	53.5	41.1	5.7	2.3	7.3	42.0	21.0
AG0808 RR	Asgro	0.80	68.6	14.9	53.8	51.7	5.7	3.0	6.0	39.4	21.3
90Y20	Pioneer	0.20	67.5	15.3	53.8	44.3	4.7	2.8	6.3	42.7	20.7
AG0103 RR	Asgro	0.10	64.7	16.1	53.3	42.5	5.0	3.2	6.3	42.7	21.6
30M09	Dyna-Gro	0.90	63.4	14.5	54.0	43.1	3.5	4.0	6.5	43.9	21.2
AG00501RR	Asgro	0.05	63.0	14.8	53.7	42.5	4.7	2.7	7.0	41.5	21.2
109R001	Wilbur-Ellis	0.00	62.9	15.7	53.2	35.9	4.2	3.0	7.5	41.5	21.9
AG0803 RR	Asgro	0.80	59.4	14.2	53.8	50.5	5.3	2.5	6.2	41.1	21.3
		Average	68.3	14.9	53.7	44.0	5.2	2.7	6.4	41.8	21.3

CV	12.3	5.8	1.3	11.2	25.9	26.6	6.0	0.9	1.0
LSD.05	NS	1.23	NS	7.07	1.94	1.04	0.55	0.53	0.29

Table 3: 2009 Early Maturity Soybean Variety Test, Columbia Basin College, Connell, WA

Planted: May 12, 2009

Harvested: October 29, 2009

Variety	Company Name	Maturity Group	Yield (bu/acre)	Percent Moisture	Test Weight	Mature Plant Height (in)	Lowest Pod Height (in)	Lodging	Maturity on 9/15	Percent Protein	Percent Oil
CSR1520	Wilbur-Ellis	1.5	42.5	14.6	53.8	30.1	5.2	1.0	6.2	33.8	23.8
AG1702 RR	Asgro	1.7	40.9	14.8	53.0	33.3	5.7	1.0	6.2	35.7	23.2
AG1506 RR	Asgro	1.5	39.1	15.1	54.0	28.8	4.8	1.0	6.0	34.3	23.8
AG00501RR	Asgro	0.0	39.0	13.7	53.0	27.9	3.6	1.0	7.8	38.3	21.9
33T06	Dyna-Gro	0.6	37.7	14.8	53.0	32.8	4.9	1.0	7.4	38.0	21.9
AG1403 RR	Asgro	1.4	37.7	14.8	53.6	29.2	5.4	1.0	6.2	35.0	22.9
96081R	Wilbur-Ellis	0.8	37.7	14.4	52.8	32.4	5.0	1.0	7.2	37.4	22.5
109R001	Wilbur-Ellis	0.0	36.9	15.1	52.2	23.2	2.8	1.0	8.0	38.2	23.2
AG0604 RR	Asgro	0.6	36.1	14.7	53.8	31.8	5.3	1.0	7.4	36.2	23.8
AG0103 RR	Asgro	0.1	35.9	14.9	53.4	26.1	4.5	1.0	7.6	39.6	22.4
AG0401 RR	Asgro	0.4	35.5	14.9	52.6	32.4	4.8	1.2	7.0	36.8	22.7
AG0808 RR	Asgro	0.8	35.0	15.0	53.0	29.7	5.3	1.0	6.8	36.5	22.3
AG00901RR	Asgro	0.0	34.8	14.5	52.6	27.5	4.2	1.0	7.6	38.0	21.6
32T03	Dyna-Gro	0.3	34.4	14.8	52.2	31.6	5.6	1.6	6.4	38.6	21.8
AG0803 RR	Asgro	0.8	34.2	14.9	54.0	30.6	4.4	1.2	6.8	37.3	22.6
30M09	Dyna-Gro	0.9	32.8	14.8	53.0	22.2	3.6	1.0	8.0	39.2	23.0
		Average	36.9	14.8	53.1	29.4	4.7	1.1	7.0	37.1	22.7
		CV	15.9	3.7	1.4	12.9	23.7	25.6	5.7	3.5	2.5
		LSD.05	NS	NS	1.04	5.40	1.59	NS	0.57	1.83	0.80

Table 4: 2009 Single Rep Soybean Strip Test, Columbia Basin College, Pasco, WA

Planted: June 8, 2009

Harvested: November 4, 2009

Entries	Company	Mature Plant Height (in)	Lowest pod height	Lodging	Yield (bu/A)	Moisture	Test weight	Percent oil	Percent Protein
33T06	DynaGro	47.0	4	1	57.5	12.5	53.3	23.7	33.7
90Y80	Pioneer	45.0	4	2	63.8	12.6	54.3	23.9	33.8
30M09	DynaGro	42.5	5	1	56.3	12.2	54.0	23.3	37.8
32T03	DynaGro	44.0	6	2	58.4	12.6	54.7	24.3	31.9
AG0808	Asgro	46.0	9	2	65.1	12.3	55.7	22.1	35.6
109R001	Wilber-Ellis	36.0	5	1	66.0	13.0	54.0	24.2	34.5
Ag1403	Asgro	41.0	6	1	64.7	12.7	54.7	23.4	32.1
Ag1506	Asgro	44.0	6	3	58.8	12.8	54.0	23.7	33.4
Ag0401	Asgro	40.0	7	1	62.6	12.6	55.7	22.4	33.7
Ag1702	Asgro	40.0	4	1	64.3	12.7	56.3	24.4	31.5

data is an average of three samples

Attachment 7

2010 Soybean Performance Tests

William T. W. Woodward[7]

INTRODUCTION

Since 2006, Columbia Basin College (CBC) has run tests on soybean to provide information on the relative performance of varieties under irrigated conditions. Of the oilseed crops, soybean appears to have the best potential to be grown at a profit in Washington when considering the high input costs for irrigated crops. Information on yield potential and maturity of varieties continues to be limited when making a choice of which variety to grow.

Monsanto submitted 22 Roundup®-resistant soybean varieties ranging in maturity from 0.0 to 2.5. Locations for the tests included: Columbia Basin College in Pasco (Test 1), a private farm near Walla Walla (Test 2), and Magden farms near Othello (Test 3). Test 3 failed due to irrigation difficulties. Results for Test 1 and 2 are presented in Table 1 and 2, respectively.

Entries were planted in five-row plots with rows 15 inches apart. Plots were 5 x 17 feet and replicated four times. Seeding rates were at 175,000 seeds per acre with each of the 24 entries adjusted for seed size. The entire plot was harvested for yield.

DATA INTERPRETATION

Yields were recorded as bushels per acre (60 pounds per bushel) adjusted to 13% moisture content. Moisture was measured using a Dickey-john Tri-Grain™ moisture tester. Test weight was measured using a Quart Cup 26 weighing apparatus sold by Seedburo Equipment Co. Percent protein and oil was measured using pre-calibrated near infrared reflectance spectroscopy (NIRS) by Monsanto.

[7] Dean of Agriculture Education, Research and Development Columbia Basin College, Pasco, WA, December 14, 2009. CBCAG1101

Mature Plant Height and **Lowest Pod Height** were measured in inches. Mature plant height is the average length from the soil surface to the top of the main stem. Lowest pod height is a measure from ground to the lowest pod on the stem and can give an indication of harvest loss during combine operations. Varieties which produce pods lower to the ground are more susceptible to yield loss during harvest.

Lodging was rated at maturity as follows:

1. Most plants erect
2. Plants slightly leaning
3. All plants moderately leaning
4. All plants severely leaning
5. Most plants down

Maturity is the average of the following scores:

6. Full seed – pod containing a green seed that fills the pod capacity at one of the four uppermost nodes on the main stem.
7. Beginning maturity – one normal pod on the main stem has reached it's mature pod color
8. Full maturity – 95% of the pods have reached their full mature color

Statistics

For each trait measured, LSD (least significant difference) was calculated. The significance level used to calculate the LSD was 5%. Unless two varieties differ by more than the LSD for individual traits, genetic difference for that trait should not be considered. The coefficient of variation (CV) is a statistical tool to be use as an estimate of the precision of the test. In general, a CV of less than 10% for yield data is indicative of a good test. A CV between 10% and 15% is considered to be an acceptable test.

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Table 1: 2010 Soybean Variety Test (Test 1 Pasco)
Columbia Basin College

Seeded: 05/05/10

Variety	Harvest Date	Maturity Group	Yield 13% moisture (bu/acre)	Percent Moisture	Test Weight	Mature Plant Height (in)	Lowest Pod Height (in)	Lodging	Maturity on 9/10	Percent Protein	Percent Oil
AG1702	9/24/10	1.70	53.1	12.9	55.3	46.8	8.3	1.5	8.0	42.5	19.9
AG0430	9/24/10	0.43	52.0	11.0	56.3	43.5	6.0	2.8	8.0	42.7	19.6
AG1702	10/22/10	1.70	51.4	12.7	54.5	45.8	8.0	2.0	7.8	42.1	19.7
AG0808	9/24/10	0.08	50.2	11.2	56.5	48.8	5.5	3.0	8.0	41.1	20.0
AG2130	10/22/10	2.13	50.0	14.4	54.8	49.0	8.0	3.5	7.0	40.7	19.2
AG1931	10/22/10	1.93	50.0	12.4	55.5	44.5	8.8	1.8	8.0	39.8	19.7
AG2530	10/22/10	2.53	49.8	13.6	54.5	49.3	7.5	3.5	7.0	43.2	18.4
AG0730	9/24/10	0.73	48.9	10.7	55.8	42.5	6.5	2.0	8.0	42.4	19.1
AG1403	10/22/10	1.40	46.6	13.1	54.0	43.5	8.5	2.3	8.0	42.5	19.7
AG1230	10/22/10	1.23	45.7	12.4	55.0	45.3	7.3	2.3	8.0	42.6	19.3
AG1831	10/22/10	1.83	45.5	13.0	54.5	52.8	8.0	4.0	7.5	41.8	20.4
AG00931	9/24/10	0.09	45.3	10.9	56.3	40.3	4.5	3.3	8.0	40.6	19.5
AG0401	9/24/10	0.40	45.2	11.0	55.8	46.8	5.5	3.0	8.0	40.9	21.0
AG0803	9/24/10	0.80	44.9	11.0	56.3	51.0	6.0	2.8	8.0	42.3	20.2
AG1730	10/22/10	1.73	44.6	12.3	55.5	46.8	7.8	3.3	8.0	41.3	19.8
AG00603	9/24/10	0.06	44.0	11.4	56.0	34.8	5.0	1.5	8.0	42.1	19.8
AG1431	10/22/10	1.43	43.8	12.8	55.3	51.5	6.5	4.5	7.8	42.3	20.0
AG2002	10/22/10	2.00	43.7	13.0	54.8	48.8	8.0	1.8	7.5	43.0	19.9
AG0231	9/24/10	0.20	42.0	10.8	56.3	36.8	4.3	1.0	8.0	41.3	19.3
AG1730	9/24/10	1.73	41.6	13.3	55.8	44.8	5.8	2.5	8.0	40.3	20.4
AG2430	10/22/10	2.43	41.1	13.5	55.0	50.5	7.0	3.5	7.3	41.9	19.7
AG00901	9/24/10	0.09	41.0	11.0	56.0	34.8	7.0	1.3	8.0	41.7	19.5
AG1530	10/22/10	1.53	39.2	12.0	54.8	51.5	6.0	4.3	7.8	40.7	19.2
AG00501	9/24/10	0.05	37.0	10.2	56.0	34.8	5.3	1.3	8.0	41.5	20.0
Mean			45.7	12.1	55.4	45.2	6.7	2.6	7.8	41.7	19.6
LSD 5%			NS	1.1	1.1	8.4	2.4	1.22	0.5	0.71	0.4
CV %			21.3	6.4	1.3	13.1	24.8	32.8	4.4	1.19	1.3

Table 2: 2010 Soybean Variety Test (Test 2 Walla Walla)

Seeded: 05/11/10 Harvest: 10/13/10

Variety	Maturity Group	Yield 13 % moisture (bu/acre)	Percent Moisture	Test Weight	Percent Protein	Percent Oil
AG0730	0.73	50.7	13.3	52.8	39.0	20.3
AG1230	1.23	49.0	13.0	54.8	38.8	20.1
AG1730	1.73	48.6	13.5	54.5	39.4	20.3
AG1403	1.40	48.1	14.1	53.5	36.4	20.9
AG1730	1.73	46.7	13.9	55.0	39.4	20.4
AG1831	1.83	46.5	12.3	54.0	39.4	20.2
AG2002	2.00	45.5	13.5	54.5	39.2	19.9
AG1530	1.53	45.1	13.1	53.8	39.5	20.2
AG0803	0.80	44.1	13.0	53.8	37.6	21.1
AG00931	0.09	43.8	13.1	52.8	39.1	20.3
AG1702	1.70	42.4	13.6	54.8	39.3	20.3
AG0808	0.08	41.6	12.9	54.3	37.8	20.4
AG1431	1.43	41.1	12.6	54.0	40.0	20.4
AG1931	1.93	40.0	13.1	55.0	40.0	19.6
AG0231	0.20	37.8	12.8	54.0	39.6	19.3
AG2530	2.53	37.3	12.6	54.8	40.9	17.9
AG0430	0.43	36.6	13.4	52.8	38.7	20.8
AG1702	1.70	35.7	13.6	53.5	38.8	20.5
AG0401	0.40	35.6	13.0	53.3	37.8	21.9
AG2430	2.43	35.3	13.4	54.0	40.3	19.2
AG2130	2.13	30.6	12.6	55.5	42.2	18.2
AG00603	0.06	27.9	12.8	52.8	40.5	19.6
AG00501	0.05	27.0	12.3	52.8	40.0	19.4
AG00901	0.09	25.4	12.9	53.0	39.3	19.2
Mean		40.1	13.1	53.9	39.3	20.0
LSD 5%		12.51	0.95	1.01	1.2	0.7
CV %		21.8	5.1	1.3	2.1	2.5

Attachment 8

The Potential of Alfalfa, Switchgrass and Miscanthus As Biofuel Crops in Washington

William T. W. Woodward[8]

ABSTRACT

The need for a billion tons of biomass to produce enough biofuel to replace 30 percent of USA petroleum consumption has been reported by the United States Department of Energy (DOE). The high biomass yield of alfalfa in the state of Washington along with its perennial nature and ability to produce its own nitrogen provides considerable potential for the crop as a feedstock for the production of ethanol.

Switchgrass has been identified by the DOE as a primary crop for development because of its potential for high fuel yields and its ability to grow on marginal cropland without intensive management. Breeding efforts for biomass production in the western part of the US for both switchgrass and alfalfa have been non-existent. Better adapted varieties are needed to meet the need of Washington's growers for economically producing products for cellulosic ethanol production.

Giant Miscanthus (Miscanthus x giganteus) is a tall perennial grass that is being grown experimentally in numerous European countries. It can be burned directly or with coal for the generation of electricity and used as a fuel for direct heating of homes and businesses. ZeaChem is in the planning stages of building a 50 million dollar cellulosic ethanol plant near the Port of Morrow in Oregon. Miscanthus could be the primary feedstock for that industry.

[8] Dean of Agriculture Education, Research & Development, Columbia Basin College, 2600 North 20th Ave, Pasco, WA 99301. January 3, 2008. In 2008 Proceedings Washington State Hay Growers Assiciation Annual Conference & Trade Show, January 16-17, 2008. CBCAG802

Columbia Basin College (CBC) is developing a program to conduct multi-year research for the development of high biomass alfalfa and switchgrass varieties for cellulosic ethanol production. In addition, CBC plans to work in the development and testing of Miscanthus as a biofuel.

Introduction

With Washington State's renewable fuel standard designed to increase biofuel use with standards that start at 2% and ramp up to 5% for biodiesel and 10% for ethanol, investments in the design of the agricultural plant in addition to the bio-diesel plant (refinery) need to be considered. Since Washington State has suggested that the ramp up will come from feedstock produced from Washington's growers, then research is needed on crops that can be grown for biofuel at a profit. Ethanol from cellulose should be a primary consideration. Domestic ethanol as an alternative fuel can decrease dependence on foreign oil, create jobs, and reduce air pollution, trade deficits, and carbon dioxide buildup.

About one third of the harvested irrigated acres in the Columbia Basin are made up of forage crops with the majority in alfalfa. There are about 500,000 acres of alfalfa in Washington of which over 75% of the production is in the Columbia Basin (1). In the state of Washington, there are about 1.5 million acres of land in the Conservation Reserve Program (CRP) (2), almost 5 million acres in pasture or rangeland and another 2.5 million in summer fallow or idled. Much of that land could be used for the production of switchgrass or another suitable grass for biomass production.

If all the corn and soybean grown in the U.S. were dedicated to producing biofuels, they would meet just 12 percent of the nation's demand for gasoline according to Kate VanderBosch, professor of plant biology at the University of Minnesota. However, a report from the U. S. Department of Agriculture and U. S. Department of Energy indicated the production of cellulosic ethanol could displace at least 30 percent of the nation's petroleum consumption by 2030 (4).

Brazil has made ethanol from switchgrass which is more efficient than corn and Iogen Corp., in Ottawa, Canada is the first business to commercially sell cellulosic

ethanol. ZeaChem is in the planning stages of building a 50 million dollar cellulosic ethanol plant at the Port of Morrow in Oregon.

ENERGY FROM ALFALFA

Because of its high biomass production, perennial nature, its symbiotic relationship with specific bacteria for producing its own nitrogen, and valuable co-products, alfalfa (*Medicago sativa L.)* has the potential of being a leading crop in the production of cellulosic ethanol. Due to the increase in the refining of corn and soybeans for biofuels, an increase in continuous row cropping with little rotation to perennial crops could increase.

The result would likely be an increased risk of soil erosion, contamination of surface and groundwater by nitrate and pesticides, and loss of valuable organic matter. More alfalfa acres for biofuel production would reduce greenhouse gas emissions, protect water quality, and improve our soils as a resource. Most importantly, it would contribute to making the United States more energy independent.

In the Columbia Basin, it is not uncommon to obtain yields of alfalfa above 10 tons per acre which are the highest yields in Northern Latitudes in the United States. When alfalfa is grown strictly for biomass with two to three cuts rather than four to five as compared to standard practices for producing dairy hay, total yield of alfalfa can increase as much as 42% and potential ethanol yield from stems doubles (7).

To maximize energy yield by reducing transportation costs, cellulosic biomass production and processing from alfalfa will need to be local. The fit is natural for the Columbia Basin when considering the high yield production by local growers. When located within 15 miles from a processing facility, the efficiency of energy production by alfalfa is 2 to 3 times that of corn grain or soybeans (Table 2).

Table 2: Comparison of Soybean, Corn Grain, Corn Stover and Alfalfa for Energy

Crop (yield)	Energy input	Delivered energy	Ratio of output:input
	Million BTU/acre		
Soybean (40 bu/a)	2.3	18.3	7.1
Corn grain (180 bu/a)	6.0	59.0	8.8
Corn stover (3.6 tons/a)	2.6	51.1	19.7
Alfalfa (6 tons/a)	3.0	78.2	25.0

Hans Jung – University of Minnesota

Although the USDA/ARS at the University of Minnesota is breeding alfalfa for ethanol production, the Midwest environment is much different from that of the Pacific Northwest (PNW). Yield potential is half of what it is in the Columbia Basin and it is grown under non-irrigated conditions. An alfalfa designed to fit a two or three cut system in the Columbia Basin will need to have large strong stems to avoid lodging under sprinkler irrigation and will need to have resistance to a number of pests that are not a problem in the mid-west.

ENERGY FROM SWITCHGRASS

Switchgrass (*Panicum virgatum L.*) is a perennial native grass adapted to the prairies of North America. The Department of Energy identified switchgrass as a primary species for development as an energy crop. It has the ability to grow well on marginal cropland without heavy fertilization or intensive management and has a potential for high fuel yields.

A recent review of the initial DOE program to evaluate and develop switchgrass as a bio-energy crop has shown its potential as an alternative to corn for ethanol production (5). The program developed a research base for improvement of switchgrass through breeding. Yield gains for switchgrass were found to exceed that of corn. In addition, the energy ratio is more favorable for switchgrass than for corn (Table 1). Although switchgrass has been grown for seed in the Pacific Northwest, breeding efforts for biomass production have been limited to the central and eastern parts of the United States. Yield gains through breeding in Washington could be even more significant.

Table 1: Comparison of Corn and Switchgrass for Energy

Component	Corn	Switchgrass
Ethanol Production	2.6 gal/bushel	80 gal/ton
Energy ratio	1.21	4.43
Net energy gain	21%	343%

McLaughlin and Kazos

In response to research needs on switchgrass in Washington, studies on switchgrass adaptability and biomass production were initiated by Washington State University in Prosser (6). Switchgrass was shown to yield over 8 tons of dry matter in young stands. Higher yields can be expected as the stands get older.

ENERGY FROM MISCANTHUS

Giant Miscanthus (*Miscanthus x giganteus)* is a tall perennial grass that reproduces by underground rhizomes and has been evaluated in Europe during the past 10 years as a bioenergy crop. Miscanthus stems may be used as fuel for production of heat and electric power and as a feedstock for the production of cellulosic ethanol. Since the plant can get taller than 14 feet, it is speculated that 10 to 15 tons of dry matter could be harvested in one harvest in the fall, winter or early spring after dry down.

In the United States, the University of Illinois has been researching Miscanthus for about five years. The reasons for their interest are:

- Greater yields than switchgrass
- Sterile and propagated by rhizomes
- Low maintenance, perennial grass
- Long-life expectancy
- Hardy
- Nitrogen and other nutrients are moved into the rhizomes during the growing season for next year's growth
- 80 to 120 gallons of ethanol per ton of dry matter
- Energy ratio of input to output is expected to be less than 0.2
- Heat and power generation in Europe for over two decades
- Yields obtained in the U of I trials indicate that growing Miscanthus in 10% of Illinois farmland would provide sufficient fuel to produce 50% of the

states electricity needs and significantly reduce carbon and sulfur dioxide emissions into the air. (8)

Research and Discussion

Alfalfa

Columbia Basin College has begun an alfalfa breeding program for both standard varieties for dairy forage and germplasm for biomass types. One advanced variety was harvested for foundation seed production in 2007 while breeder seed was produced on eight more experimental varieties. Selections for non-lodging and biomass yield were made in the field and crossed in the greenhouse. Seven thousand progeny from this cross were planted in a spaced plant nursery. Selections for tall, upright growth habit suitable for infrequent cutting management were made from the nursery and are being crossed this winter for potential new varieties targeted as feedstock for cellulosic ethanol production. Alfalfa varieties for the Columbia Basin, regardless of their use, will be selected for resistance to blue aphid, clover root curculio, Verticillium wilt, stem nematode, and root knot nematode to enhance persistence.

Switchgrass

Breeding research is currently underway at CBC to develop adapted, high-yielding switchgrass experimental cultivars for the Columbia Basin. Five thousand switchgrass plants from four high yielding germplasm were started in the greenhouse and transplanted to the field in 2007.
Because the genetics of switchgrass are such that the phenotype of the parent plant is not a good indicator of the genotype, a progeny row experiment is planned for the selection of high biomass parents for the development of a suitable high yielding adapted variety. Upland and lowland types were observed in the field in 2007. Results showed that the lowland types were variable but higher yielding. Therefore, we will focus on breeding lowland types for Washington's environment.

Establishing a good stand of switchgrass has always been a problem. The productivity in the first year is poor. Management research is needed to better establish switchgrass on non-irrigated lands. Investigation of the establishment

through the use of rhizomes or tillers might prove useful for higher yields in the first year and the establishment of non-irrigated lands.

Because of its dry conditions during seed maturation, eastern Washington is known for its excellent production of vegetable, legume and grass seeds. If switchgrass becomes the grass of choice for cellulosic ethanol production, the Columbia Basin would be perfect area for producing seed. Research in methods of seed production for switchgrass is needed to capture that potential.

Miscanthus

In 2007 a single plant of Giant Miscanthus was obtained from Minnesota. The rhizomes were split to produce over 100 plants in the greenhouse and planted in the field. CBC will harvest the plants this winter and produce enough rhizomes to establish a nursery field in the spring of 2008.

CBC plans to establish a large field test to evaluate the potential of Miscanthus to utilize potato waste water. The experiment would require the cooperation of the Port of Pasco, Lamb Weston and CBC. A possible future collaboration would be with a cellulosic ethanol producer such as the planned cellulosic plant slated to be built at the Port of Morrow by ZeaChem. CBC sent samples of selected alfalfa, Miscanthus and switchgrass to ZeaChem in November of 2007 for evaluation as a cellulosic ethanol feedstock under their system of production. Their plan to build the $50 million facility is based on the production system which utilizes an enzyme that has been isolated from termites. Their goal is to produce 150 gallons of ethanol from each ton of dry matter.

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Cellulosic Ethanol from Alfalfa, Switchgrass and Miscanthus

Research Proposal
Columbia Basin College
Department of Agriculture Research & Development
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ABSTRACT

The need for a billion tons of biomass to produce enough biofuel to replace 30% of USA petroleum consumption has been reported by the United States Department of Energy (DOE). The high biomass yield of alfalfa in the state of Washington along with its perennial nature and ability to produce its own nitrogen provides considerable potential for the crop as a feedstock for the production of ethanol. Switchgrass has been identified by the DOE as a primary crop for development because of its potential for high fuel yields and its ability to grow on marginal cropland without intensive management. Breeding efforts for biomass production in the western part of the US for both switchgrass and alfalfa have been non-existent. Better adapted varieties are needed to meet the need of Washington's growers for economically producing products for cellulosic ethanol production. Giant Miscanthus (Miscanthus x giganteus) is a tall perennial grass that is being grown experimentally in numerous European countries. It can be burned directly or with coal for the generation of electricity and used as a fuel for direct heating of homes and businesses. ZeaChem is in the planning stages of building a 50 million dollar cellulosic ethanol plant near the Port of Morrow in Oregon. Miscanthus could be the primary feedstock for that industry. Columbia Basin College (CBC) proposes to develop a program to conduct multi-year research for the development of high biomass alfalfa and switchgrass varieties for cellulosic ethanol production. In addition it plans to work cooperatively with the University of Illinois in the development and testing of Miscanthus as a biofuel. CBC has invested over $300,000 in operating funds for staff salaries and administrative support as well as building facilities, farmland, greenhouses, and limited equipment to meet that goal. This proposal requests $453,300 to move from initial testing to a full-scale breeding and testing program for the development of feedstock needed for the production of cellulosic ethanol.

Introduction

With Washington State's renewable fuel standard designed to increase biofuel use with standards that start at 2% and ramp up to 5% for biodiesel and 10% for ethanol, investments in the design of the agricultural plant in addition to the bio-diesel plant (refinery) need to be considered. Since Washington State has suggested that the ramp up will come from feedstock produced from Washington's growers, then research is needed on crops that can be grown for bio-fuel at a profit. Ethanol from cellulose should be a primary consideration. Domestic ethanol as an

alternative fuel can decrease dependence on foreign oil, create jobs, and reduce air pollution, trade deficits, and carbon dioxide buildup.

About 1/3 of the harvested irrigated acres in the Columbia Basin are made up of forage crops with the majority in alfalfa. There are about 500,000 acres of alfalfa in Washington of which over 75% of the production is in the Columbia Basin (1). In the state of Washington, there are about 1.5 million acres of land in the Conservation Reserve Program (CRP) (2), almost 5 million acres in pasture or rangeland and another 2.5 million in summer fallow or idled. Much of that land could be used for the production of switchgrass or another suitable grass for biomass production.

Due to the high input costs for irrigated land, it will be difficult for growers to show a profit by growing most oilseed crops. CBC has run yield trials for sunflower and soybean. The yield on the best sunflower variety was less than 2000 lbs/acre without bird damage. Seventy to 80% of the crop was lost due to birds and the remaining harvested crop had to be further dried after 6 weeks of excellent field drying conditions. The top soybean variety yielded about 80 bushels giving it some potential for the Columbia Basin. With the price for canola at 10-15 cents a pound, an excellent yield of 4000 lbs. would not fit a grower's enterprise budget when the crop is under irrigation. A preliminary study on peanuts in cooperation with Washington State University and a private grower, showed a potential of 5000 lbs. per acre. At 50% oil, peanuts may have some potential.

If all the corn and soybean grown in the U.S. were dedicated to producing biofuels, they would meet just 12 percent of the nation's demand for gasoline according to Kate VanderBosch, professor of plant biology at the University of Minnesota. However, a report from the U. S. Department of Agriculture and U. S. Department of energy indicated the production of cellulosic ethanol could displace at least 30 percent of the nation's petroleum consumption by 2030 (4).

Brazil has made ethanol from switchgrass which is more efficient than corn and Iogen Corp., in Ottawa, Canada is the first business to commercially sell cellulosic ethanol. ZeaChem is in the planning stages of building a 50 million dollar cellulosic ethanol plant near the Tri-cities.

ENERGY FROM SWITCHGRASS

Switchgrass (*Panicum virgatum L.*) is a perennial native grass adapted to the prairies of North America. The Department of Energy identified switchgrass as a

primary species for development as an energy crop. It has the ability to grow well on marginal cropland without heavy fertilization or intensive management and has a potential for high fuel yields.

A recent review of the initial DOE program to evaluate and develop switchgrass as a bio-energy crop has shown its potential as an alternative to corn for ethanol production (5). The program developed a research base for improvement of switchgrass through breeding. Yield gains for switchgrass were found to exceed that of corn. In addition, the energy ratio is more favorable for switchgrass than for corn (Table 1). Although switchgrass has been grown for seed in the Pacific Northwest, breeding efforts for biomass production have been limited to the central and eastern parts of the United States. Yield gains through breeding in Washington could be even more significant.

Table 1: Comparison of Corn and Switchgrass for Energy

Component	Corn	Switchgrass
Ethanol Production	2.6 gal/bushel	80 gal/ton
Energy ratio	1.21	4.43
Net energy gain	21%	343%

McLaughlin and Kazos

In response to research needs on switchgrass in Washington, studies on switchgrass adaptability and biomass production were initiated by Washington State University in Prosser (6). Switchgrass was shown to yield over 8 tons of dry matter in young stands. Higher yields can be expected as the stands get older.

ENERGY FROM ALFALFA

Because of its high biomass production, perennial nature, its symbiotic relationship with specific bacteria for producing its own nitrogen, and valuable co-products, alfalfa (*Medicago sativa L.)* has the potential of being a leading crop in the production of cellulosic ethanol. Because of the increase in the refining corn and soybeans for biofuels, an increase in continuous row cropping with little rotation to

perennial crops could increase. The result would likely be an increased risk of soil erosion, contamination of surface and ground water by nitrate and pesticides, and loss of valuable organic matter. More alfalfa acres for biofuel production would reduce greenhouse gas emissions, protect water quality, and improve our soils as a resource. Most importantly, it would contribute to making the United States more energy independent.

In the Columbia Basin, it is not uncommon to get yields of alfalfa above 10 tons which are the highest yields in Northern Latitudes in the United States. When alfalfa is grown strictly for biomass with two to three cuts rather than four to five as compared to standard practices for producing dairy hay, total yield of alfalfa can increase as much as 42% and potential ethanol yield from stems doubles (7).

To maximize energy yield by reducing transportation costs, cellulosic biomass production and processing from alfalfa will need to be local. The fit is natural for the Columbia Basin when considering the high yield production by local growers. When located within 15 miles from a processing facility, the efficiency of energy production by alfalfa is 2 to 3 times that of corn grain or soybeans (Table 2).

Table 2: Comparison of Soybean, Corn Grain, Corn Stover and Alfalfa for Energy

Crop (yield)	Energy input	Delivered energy	Ratio of output:input
	Million BTU/acre		
Soybean (40 bu/a)	2.3	18.3	7.1
Corn grain (180 bu/a)	6.0	59.0	8.8
Corn stover (3.6 tons/a)	2.6	51.1	19.7
Alfalfa (6 tons/a)	3.0	78.2	25.0

Hans Jung – University of Minnesota

Although the USDA/ARS at the University of Minnesota is breeding alfalfa for ethanol production, the Midwest environment is much different from that of the Pacific Northwest (PNW). Yield potential is half of what it is in the Columbia Basin and it is grown under non-irrigated conditions. An alfalfa designed to fit a two or three cut system in the Columbia Basin will need to have large strong stems to avoid lodging under sprinkler irrigation and will need to have resistance to a number of pests that are not found in the mid-west.

ENERGY FROM MISCANTHUS

Giant Miscanthus (*Miscanthus x giganteus)* is a tall perennial grass that reproduces by underground rhizomes and has been evaluated in Europe during the past 10 years as a bioenergy crop. Miscanthus stems may be used as fuel for production of heat and electric power and as a feedstock for the production of cellulosic ethanol. Since the plant can get taller than 14 feet, it is speculated that 10 to 15 tons of dry matter could be harvested in one harvest in the fall, winter or spring after dry down.

In the United States, the University of Illinois has been researching Miscanthus for about 5 years. The reasons for their interest are:

- Produces greater yields than switchgrass
- Is sterile and propagated by rhizomes
- Low maintenance, perennial grass
- Long life expectancy
- Hardy
- Nitrogen and other nutrients are moved into the rhizomes during the growing season for next years growth
- Can produce 80 to 120 gallons of ethanol per ton of dry matter
- Energy ratio of input to output is expected to be less than 0.2
- Has been grown in Europe for over two decades for heat and power generation
- Yields obtained in the U of I trials indicate that growing Miscanthus in 10% of Illinois farmland would provide sufficient fuel to produce 50% of the states electricity needs and significantly reduce carbon and sulfur dioxide emissions into the air. (8)

Proposed Research

Alfalfa

Columbia Basin College has already begun an alfalfa breeding program for both standard varieties for dairy forage and germplasm for biomass types. One advanced variety will be harvested for foundation seed production in 2007 while eight more experimental varieties were placed in breeder seed blocks. Selections for non-lodging and biomass yield were made in the field and crossed in the

greenhouse. 7,000 progeny from this cross were planted in a spaced plant nursery. Selections for tall, upright growth habit suitable for cellulosic feedstock have been made from the nursery and will be crossed this winter for potential new varieties targeted as feedstock for cellulosic ethanol production. Alfalfa varieties for the Columbia Basin, regardless of their use, will need to be selected for resistance to blue aphid, clover root curculio, Verticillium wilt, stem nematode, and root knot nematode to enhance persistence. Because industry focuses on traits required for the large profit margin mid-west market, many traits needed for the PNW have been overlooked.

CBD will develop alfalfa varieties with a high level of resistance to root knot nematode to provide a rotation crop with potato that would eliminate the need for fumigation prior to potato establishment. Root knot nematode is detrimental to potato in both appearance and yield and significantly reduces yield and persistence of alfalfa.

The blue alfalfa aphid stunts new alfalfa seedlings when planted in late summer or fall and reduces regrowth of established stands. The result is a decreased yield the following spring due to lowered carbohydrate reserves in the crown. CBC will develop varieties for resistance to the blue alfalfa aphid that often overwinters in the Columbia Basin and is present in the late summer and fall. This will reduce the need for using pesticides on alfalfa and allow for a full yield the following spring.

Stem nematode is a problem throughout irrigated areas in the PNW and is especially severe in the Yakima River Valley. The nematode will enter new crown buds in the fall and reduce regrowth. Often they will over winter in the crown buds and severely reduce spring growth. Although many alfalfa varieties have claims of having high resistance to the pest, experience in Washington alfalfa fields has not shown positive results. CBC will develop a selection scheme to enhance the development of higher levels of resistance to the nematode. Plants that appear to have excellent resistance to the pest have been selected and are currently being crossed in the greenhouse and field.

Verticillium Wilt was first identified in Washington in 1976. It has since spread throughout the United States and Canada. Most of the breeding industry has done an excellent job of developing varieties with high resistance to the disease. However, there are still some new proprietary varieties that start losing stand in the second year of production. The continued testing of newly release varieties is essential for monitoring yield declines due to Verticillium Wilt. Plants used in the CBC research program will be selected for resistance to the disease.

The clover root curculio is a weevil that lays its eggs on the soil near the crown of an alfalfa plant. When the eggs hatch, the larvae migrate to the root and feed on the outer surface. Stand declines resulting in yield reduction are a result of root and crown rots entering the lesions rather than a direct result of the curculio's feeding. No breeding effort has been made for resistance to the insect as it would be a difficult problem to solve. However, selection of plants for resistance to the secondary diseases is much more feasible. Plants have already been selected that have survived with no apparent disease after three years of feeding by the clover root curculio.

Switchgrass

Breeding research is currently underway at CBC to develop adapted, high-yielding switchgrass experimental cultivars for the Columbia Basin. Five thousand switchgrass plants from four of the higher yielding germplasm were started in the greenhouse and transplanted to the field in 2007.
Because the genetics of switchgrass are such that the phenotype of the parent plant is not a good indicator of the progeny, a progeny row experiment is planned for the selection of high biomass parents for the development of a suitable high yielding adapted variety. Upland and lowland types were observed in the field in 2007. Results showed that the lowland types were variable but higher yielding. Therefore, we will focus on breeding lowland types for Washington's environment.

Establishing a good stand of switchgrass has always been a problem. The productivity in the first year is poor. Management research is needed to better establish switchgrass on non-irrigated lands. Investigation of the establishment through the use of rhizomes or tillers might prove useful for higher yields in the first year and the establishment of non-irrigated lands.

Because of its dry conditions during seed maturation, eastern Washington is known for its excellent production of vegetable, legume and grass seeds. If switchgrass becomes the grass of choice for cellulosic ethanol production, the Columbia Basin would be perfect area for producing seed. Research in methods of seed production for switchgrass is needed to capture that potential.

Miscanthus

In 2007 a single plant of Giant Miscanthus was obtained from Minnesota. The rhizomes were split to produce over 100 plants in the greenhouse and planted in the field. CBC will harvest the plants this winter and produce enough rhizomes to establish a nursery field in the spring of 2008.

CBC plans to initiate work with the University of Illinois to establish a large field test to evaluate the potential of Miscanthus to utilize potato waste water. The experiment would require the cooperation of the University of Illinois, Port of Pasco, Lamb Weston and CBC. A possible future collaboration would be with a cellulosic ethanol producer such as the planned cellulosic plant slated to be built at the Port of Morrow by ZeaChem in the near future. CBC will be sending samples of selected alfalfa, Miscanthus and switchgrass to ZeaChem in November of 2007 for evaluation as a cellulosic ethanol feedstock under their system of production. ZeaChem. Their plan to build the $50 million facility is based on the production system which utilizes an enzyme that has been isolated from termites and is more efficient than others developed to date. Their goal is to produce 150 gallons of ethanol from each ton of dry matter.

Capital Asset Management

Every facet of research and education in alfalfa, switchgrass, and Miscanthus is dependent upon capital equipment. To keep active and viable programs ongoing, a thoughtful approach to equipment needs and replacement must be developed. Many capital equipment items used by forage crop scientists are expensive to the degree that they cannot be purchased from operating budgets of research programs. Often granting sources prohibit the use of grant funds for the purchase of capital equipment, leaving scientists with limited options to acquire or replace worn and failing equipment. For the cellulosic biomass research program, initial capital equipment is necessary to get the program started on the right track.

Capital equipment needs would include:

Capital Assets for Research

Item	Approximate cost/unit	Life expectancy years
Wintersteiger small plot combine	$165,000	10
Forage harvester with weigh system	$75,000	15
Wintersteiger LD 350 thresher	$5,000	10
5' Plot drill (improvements)	$8,000	10
1 meter Plot drill (Hege)	$32,000	10
Pickup	available CBC	4
Trailer for combine, drill and forage harvester	$4,000	15
Computer and hardware	available CBC	3
Plot tractor	available CBC	15
Field tractor	$35,000	15
Plot thresher	$24,000	15
Lab thresher	$4,000	15
South Dakota Seed Blower (small samples)	$2,200	15
Seed counter	$8,500	15
Large lot seed blower	$8,000	15
Tillage equipment	$20,000	15
Roto tiller	available CBC	10
Alley shredder	$2,000	15
Electronic balances	$2,000	10
Plot sprayer	available CBC	15
Bar code reader	$1,000	10
Small plot fertilizer applicator	$2,700	10
Processing/lab space	available CBC	25
Greenhouse space	available CBC	Varies
Refrigerator	$700	10
Freezer	$700	10
Wiley mill	$15,000	15
NIR Spectrometer	WSU collaboration	
Greenhouse rolling benches	available CBC	15
Greenhouse lights	$10,000	10
Bee crossing chamber	$2,500	10
Tools	available CBC	15
Sprinkler heads	$4,000	5

Administration of funds 5%	$22,000
Total	$453,300

A request of $453,300 is respectfully submitted to the Washington State Department of Agriculture for capital improvements to be applied to the Columbia Basin College breeding program for the development of high biomass alfalfa, switchgrass varieties, and Miscanthus for cellulosic ethanol production. Capital improvements can also be used for testing potential oil seed crops.

Columbia Basin College Support -- Equipment, Facilities, and Land

As of August 2007, available equipment includes:

a. 1 older small international tractor useful for spraying and some cultivation. (Currently under repair and maintenance)
b. 1 new Kubota research tractor
c. 1 new roto tiller
d. 1 new sprayer
e. 1 small disk (good for research plots)
f. 1 large cultipacker (good for larger increase blocks)
g. 1 small cultipacker (good for research plots)
h. 1 5' Hege plot planter
i. 1 Computer
j. 1 Printer
k. 1 pickup
l. 1 transplanter (donated by grower in 2007)
m. Sufficient irrigation pipe
n. 1 pivot irrigation system

Facilities include:

a. 30 X 50 foot greenhouse with rolling benches
b. 16 X 38 foot storage garage
c. 29 X 62 foot office and dry lab facility
d. Use of campus facilities including wet lab, science lab, classroom, and meeting rooms

Land includes:

a. 7 acre hand line farm
b. 8 acre ¼ pivot irrigated farm

c. 1.5 acre off-site seed increase block (farmer cooperator)
d. 1 acre stem nematode variety evaluation site (farmer cooperator)
e. 28 acre alfalfa strip test (farmer cooperator)

Experience of the forage breeder (W. T. W. Woodward)

Education

1976 **Ph.D. in Agronomy** Oregon State University, Corvallis OR. Specialization in cytogenetics of forage grasses. Area of research was with meiotic irregularities in tall fescue causing low seed production.

1974 **M.S. in Agronomy**, New Mexico State University, Las Cruces, NM. Specialization in cotton breeding. Area of research was association of seed and fiber characteristics with lint percent.

1972 **B.S. in Agronomy**, New Mexico State University, Las Cruces, NM. Specialization in forage breeding; genetics and breeding.

Professional Affiliations

2006 Member, chairman or extension representative for 20 professional affiliations including the Washington State Hay Growers Association, Columbia Basin Hay Growers Association, North American Alfalfa Improvement Conference, Franklin County Crop Improvement Association, American Society of Agronomy, Crop Science Society of Agronomy, Seed Program Advisory Committee, and the Western Alfalfa and Forage Conference.

1985-06 President of the Central Alfalfa Improvement Conference, Vice Chairman of the North American Alfalfa Improvement Conference, officer and board member for other forage organizations, chairman of numerous committees including the alfalfa minimum distance committee of the American Seed Trade Association.

- Authored over 100 publications including 17 alfalfa varieties for crop registration.
- Applied for and received 22 plant variety protection certificates for alfalfa varieties.

- Presented 120 international, regional, and local invited presentations since 2001.
- World Wide Director of Alfalfa Research for a large seed company managing an alfalfa research department, including oversight of operations, administration and establishing direction for the worldwide alfalfa breeding effort.
- Managed seven U.S., three European, one Australian and one South American alfalfa breeding stations.
- Determined annual breeding goals and targeted areas of greatest need for new varieties. Recommended special research projects that supported or enhanced classic and biotechnology breeding efforts.
- Planned and coordinated temperate forage and turf grass research projects; identified parent plants for the development of tall fescue resistance to crown and stem rust.
- Identified grasses and legumes for use as forage and turf in irrigated and non-irrigated areas of Southern Texas and Northern Mexico. Modified and developed selected species into improved varieties; screened varieties and advance lines of forage grasses for overall performance.
- Modified inflorescence of buffelgrass for improved plantability and harvestability creating a potential for wider use of the species in drought stricken areas.

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TITLE: Developing Non-lodging Alfalfa as a Feedstock for Biofuel Production.

ABSTRACT

Alfalfa is a perennial crop that produces high biomass allowing considerable potential as a feedstock for production of ethanol while controlling soil erosion. In addition, it has the ability to produce its own nitrogen through symbiotic relationship with bacteria along with high protein leaf meal and other industrial materials. Since 2006, Columbia Basin College (CBC) has been selecting biomass types of alfalfa that do not lodge at later maturity stages. While working with the green pea aphid on traditional alfalfa, it was found to be a weakness for the non-lodging plant materials. A biomass alfalfa variety needs to have increased pea aphid and lodging resistance. Our objectives are to develop and release lodging and pea aphid resistant germplasm and cultivars; test experimental cultivars for performance under multiple cutting management systems. Preliminary experiments demonstrate the ability for our biomass alfalfa germplasm to stand erect and produce significantly higher yields than traditional varieties under a two cut management system while producing similar yields and forage quality under a five cut system. Our work with the green pea aphid indicates our ability to rapidly increase resistance. We were able to improve germplasm having low resistance to having high resistance in one cycle of selection in a single year. The improved cultivar will not only improve the growers marketing flexibility, it will improve yield. The multi-year cutting management test will demonstrate the effects on forage quality for both traditional and non-lodging types of alfalfa varieties.

1. Introduction

With Washington State's renewable fuel standard designed to increase biofuel use with standards that start at 2% and ramp up to 5% for biodiesel and 10% for ethanol, investments in the design of the agricultural plant in addition to the bio-fuel plant (refinery) need to be considered (14). Since Washington State has suggested that the ramp up will come from feedstock produced from Washington's growers, then research is needed on crops that can be grown for bio-fuel at a profit. Although corn-based ethanol is the national leader in biofuel production in the U.S., ethanol from cellulose should be a primary consideration. Grain-based ethanol cannot meet Washington State's goal of 10% ethanol or the U.S. government's goal of replacing 30% of use of gasoline by 2030. Washington State does not grow enough corn or wheat beyond that needed for food. Domestic ethanol from lignocellulosic biomass crops as an alternative fuel can decrease dependence on foreign oil, create jobs, and reduce air pollution, trade deficits, and carbon dioxide buildup.

About 1/3 of the harvested irrigated acres in the Columbia Basin is comprised of forage crops, the majority of which is alfalfa. Up to 520,000 acres of alfalfa have been grown in Washington of which over 75% of the production is in the Columbia Basin (1). In the state of Washington, there are about 1.5 million acres of land in the Conservation Reserve Program (CRP) (2), almost 5 million acres in pasture or rangeland and another 2.5 million in summer fallow or idled. Much of that land could be used for the production of alfalfa.

A report from the U. S. Department of Agriculture (USDA) and U. S. Department of Energy (DOE) indicated the production of cellulosic ethanol could displace at least 30 percent of the nation's petroleum consumption by 2030 (4). More than 19 million acres of alfalfa was harvested in the United States in 2011. Average yields ranged from 7.9 ton/acre in Arizona to 1.3 tons/acre in Oklahoma. In 2011, Washington ranked fourth among states in yield per acre at 4.8 tons. However, Grant County and Franklin County produce about 6.7 and 7.2 tons/acre respectively on average (12). Many of the growers in these counties have produced more than 10 tons/acre.

Alfalfa has advantages over a grass crop when considered as a biofuel feedstock. As a deep rooted perennial, alfalfa can reduce erosion and nutrient leaching. It will take up available nitrate prior to releasing its unique nitrogen fixation mechanism removing potential ground water contamination and later providing its own nitrogen through fixation. After an average persistence of 4 years, Residual nitrogen is left for the following rotational crop.

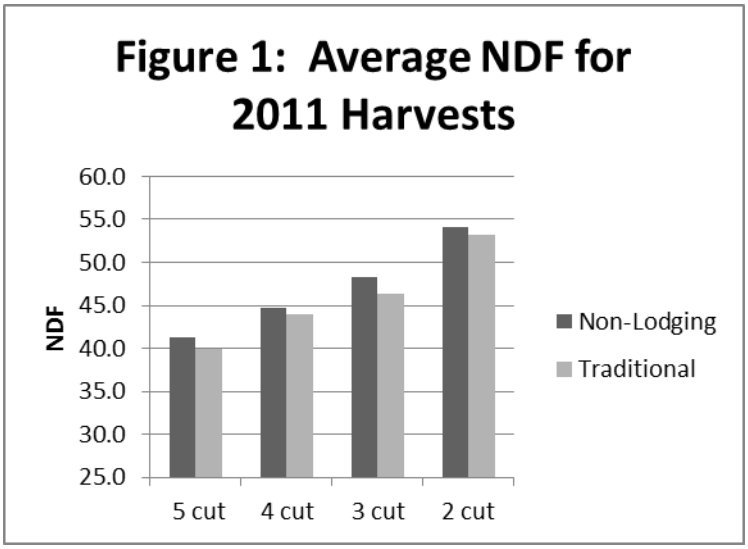
The DOE dismissed alfalfa as a potential biofuel feedstock due to its value as an animal feed. However, if leaves were separated from stems, half of alfalfa could be used as a highly digestible high protein feed. The stems could be used for biofuel. Columbia Basin College (CBC) has been breeding non-lodging germplasm for several years. To be a biomass feedstock, alfalfa will need to have lower input costs. One way to accomplish lower input costs is to allow for fewer cuttings. Because traditional alfalfa varieties lodge in every cut with overhead irrigation, fewer cuts would make harvest more difficult and yields would decline due to leaf and crown diseases that occur in lodged alfalfa. A non-lodging variety would avoid the difficulties of harvest and diseases. A preliminary cutting management experiment was established in the fall of 2010 to evaluate non-lodging germplasm with traditional varieties under 2, 3, 4 and 5 cut systems (16). Results from research indicates that the average of the four CBC non-lodging experimental germplasm (CB9004, CB9005, CB9006, CB9007) in the 2 cut management system over two years yielded an average of 19.4 tons of dry matter per acre (42.7 Mg ha^{-1}) while the five traditional varieties yielded 13.1 tons (28.8 Mg ha^{-1})(Table 1). The other non-lodging variety in the test was 55V12, a commercial non-lodging entry. Neutral Detergent Fiber (NDF), an estimate of structural components in plant cells (i.e. lignin, hemicellulose and cellulose) increased from an average of 40.6 to 53.6 percent from the 5 cut to the 2 cut for all entries (Figure 1).

The USDA-ARS (Agriculture Research Service) Vegetable and Forage Crops Research Unit at Prosser Washington supported green pea aphid experiments to select a traditional germplasm to have high resistance with the goal of releasing the germplasm for public use (17, 18). CBC's non-lodging germplasm and the standard check varieties were included in the experiments to help measure progress. The traditional germplasm performed well in the 2010-2011 aphid

experiment, but it was apparent that the non-lodging germplasm lacked resistance (Table 2). Resistance ranged from 13.5 to 31.9 for non-lodging germplasm CB9005 and CB9007, respectively.

Table 1: Two Year Results of the 2010 Cutting Management Trial (2 cut)

	2011 Harvests		Forage Yield (DM/Ac) 2012 Harvests					
Entry	**2011 Total**	**2011 % mean**	**Cut 1 % mean**	**Cut 2 % mean**	**2012 Total**	**2012 % mean**	**2 year Total**	**2 year % mean**
CB9004	**11.2**	**136.5**	131.1	142.9	**10.3**	**135.3**	**21.6**	**135.9**
CB9005	**9.8**	**119.0**	123.4	130.2	**9.6**	**125.8**	**19.4**	**122.3**
CB9006	**9.8**	**119.4**	111.5	125.7	**8.9**	**116.5**	**18.7**	**118.0**
CB9007	**8.9**	**108.2**	113	128.5	**9.1**	**118.5**	**18.0**	**113.2**
55V12	**8.2**	**99.5**	94.3	101.4	**7.4**	**96.8**	**15.6**	**98.2**
CB001	**6.7**	**81.5**	88.7	73.3	**6.4**	**83.2**	**13.1**	**82.3**
54Q25	**6.5**	**79.3**	74.4	72.0	**5.6**	**73.5**	**12.1**	**76.5**
Masterpiece II	**7.5**	**90.8**	100.6	76.8	**7.0**	**92.1**	**14.5**	**91.4**
Grandstand	**7.1**	**86.7**	86.3	76.2	**6.3**	**82.7**	**13.5**	**84.8**
DKA 42-13	**6.5**	**79.1**	76.7	72.9	**5.8**	**75.4**	**12.3**	**77.3**
Mean	**8.2**	**100**	**100**	**100**	**7.6**	**100**	**15.9**	**100**
LSD 5%	**1.8**	**22.4**	**33**	**28.7**	**2.1**	**22.4**	**3.5**	**22.2**
CV %	**15.6**	**15.6**	**23.1**	**20.1**	**19.5**	**19.5**	**15.5**	**15.5**



Results from a 2011-2012 pea aphid test are presented in Table 3. A traditional germplasm CB11004 was selected from commercial and CBC plant materials and is planned to be the public germplasm release. High resistance with 75.5% resistant plants demonstrates excellent progress considering population genetics and the autotetraploid nature of alfalfa. Similar to CB11004, only the class 1 or the very best plants were used as parents for CB11005 and CB11009. However, both of these were non-lodging plant materials selected from large benches infested with pea aphid. The parents of CB11005 were selected from large population of plants out of CB9009, CB9005 and CB9006. In the 2010-2011 pea aphid experiment (Table 2), these experimentals scored lower in the test with an average percent resistance of 15.5. The method of selection was successful as indicated by the resultant expression of 65% resistant plants for CB11005. On the other hand, CB11009 is an example of the lack of progress when including less than suitable plants among the parents. CB9004 exhibited high resistance among non-lodging plant materials in the 2010-2011 pea aphid experiment. Parents were selected from plots in the test. However, to reach a goal of about 100 parent plants, parents from class 2 and 3 were included. In an autotetraploid species such as alfalfa, it is commonly known "escapes" restrict progress toward improvement for most traits. CB11009 is a good example showing little progress at 38.6 percent resistant plants over CB9004 at 26.3 percent. It should be noted that in both experiments the check varieties PA-1 and Vernal were well within their range of expected resistance according to the standard test for green pea aphid (3). The non-lodging germplasm CB9005 was toward the bottom of both experiments exhibiting low resistance. CBC's breeding and development program significantly increased resistance levels for pea aphid in both traditional and non-lodging plant materials.

Objectives

Germplasm enhancement and cultivar development for alfalfa is the primary objective. We hypothesize that both the germplasm and the cultivar that will be developed will have as much as 40% higher yields than traditional varieties as cutting frequency decreases. We further hypothesize that the same germplasm and cultivar will be suitable for high quality traditional uses when cut at higher frequencies.

The objectives of the proposed research are to: 1) Develop non-lodging alfalfa germplasm and cultivars suitable for marketing for both traditional uses and for biomass. 2) Increase resistance to green pea aphid among the non-lodging germplasm and compare to traditional alfalfa cultivars. 3) Predict forage quality and ethanol differences using Near Infrared Reflectance Spectroscopy (NIRS) among non-lodging, improved non-lodging, and traditional alfalfa cultivars. 4) Release improved alfalfa germplasm and cultivar as dual bioenergy and forage purpose crop.

2. Rationale and Significance

Demand for energy is increasing worldwide while oil supplies are diminishing. In 2012, the U.S. consumed 18.8 million barrels of oil per day or about 21% of the amount produced. World demand is about 90 million barrels per day with only about 88 million barrels being produced (13). Biofuels such as ethanol can be an effective alternative liquid fuel. The need for a billion tons of biomass to produce enough biofuel to replace 30% of USA petroleum consumption has been reported by the DOE. The high biomass yield of alfalfa in the state of Washington along with its perennial nature and ability to produce its own nitrogen provides considerable potential for the crop as a feedstock for the production of ethanol. Our project addresses a solution for the development of a pest resistant alfalfa biomass type variety for use as a quality feed and a feedstock for cellulosic ethanol

Samac, et.al., suggests research is needed to develop alfalfa germplasm and management strategies yielding more biomass (both leaf and stem) with reduced production costs (11). The germplasm would need to be non-lodging to withstand fewer cuts for reduced input costs. Although commercial companies have developed non-lodging varieties primarily for the mid-west market, selection for the trait would be better performed under irrigation due to additional selection pressure. This can be demonstrated by the results shown in Table 1 where all four non-lodging CBC germplasm outperformed 55V12, a newly released non-lodging variety, under a 2 cut management system. Lodging can be forced several times a year under irrigation where little selection pressure would have been available in the mid-west in 2012 due to drought conditions.

CBC research has demonstrated (Table 1 and 2) our methods for selecting for pea aphid resistance are precise. An example of our non-lodging material as compare to a traditional variety in a four cut system is shown in Figure 2. Figure 3 shows a CBC non-lodging germplasm while Figure 4 shows a diseased traditional variety due to ground contact while lodged.

NIRS was introduced as a non-destructive means to predict forage quality by Norris et.al. (9) U.S. Department of Energy estimates one billion tons of dry biomass is required annually to replace 30% of domestic petroleum consumption (DOE, 2005). Feedstock biomass would be derived from wood-based forestry resources and agricultural resources. Identified agricultural resources include perennial crops, crop residues, agricultural wastes and grains. The billion ton report was revised in 2011 (DOE, 2011) defining dedicated bioenergy crops including: switchgrass, miscanthus, sugarcane, sorghum, poplar, willow, eucalyptus and southern pines. Missing is alfalfa, apparently because a narrow view that alfalfa forage biomass is only valued by dairy and animal industries (8). However, Putnam (10) suggests ‘multiple uses’ of higher valued crops such as alfalfa, whereby stem fractions, weather damaged and low quality hay could be used to contribute to the Renewable Fuel Standard (RFS2) with leaf meal used directly by animals. Martin and Jung (6) compare livestock and bioenergy potential of alfalfa-corn to

corn, concluding rotating alfalfa and corn produces less quantities of ethanol but will be more efficient and sustainable than monoculture corn. Nitrogen is a major input cost to growers and if uncontrolled a cost to the environment, which alfalfa mitigates through biological N fixation.

Table 2: 2010-2011 Greenhouse Standard Test for the Green Pea Aphid

Variety	Visual Scores*	ASI	% Resistant Plants
CB8003	7.5	3.3	55.1
PA-1	9.0	3.4	51.7
CB7006	7.3	3.3	48.5
CB7007	8.0	3.4	47.4
CB7005	6.8	3.7	47.0
CB8002	9.0	3.4	46.9
Dura 512	8.0	3.6	42.3
CB7004	6.0	3.5	42.2
CB001	5.3	3.5	40.9
CB8001	7.0	3.8	36.0
54V09	6.3	3.9	34.8
WL 327	4.8	3.9	33.8
Rebound 5.0	7.0	3.9	33.4
**CB9007	4.0	4.0	31.9
CB9002	5.5	3.9	31.7
CB7002	6.3	4.0	31.6
CB7003	5.8	4.0	31.4
DKA 42-15	5.3	3.9	31.0
54H11	3.0	4.1	30.8
CB9001	4.5	4.0	28.8
**CB9004	4.0	4.0	26.3
**CB9003	2.8	4.1	24.8
Masterpiece II	5.3	4.0	23.3
DKA 43-13	7.3	4.1	23.3
**CB9008	3.8	4.0	22.7
DKA 50-18	6.3	4.1	20.1
FSG 351	4.3	4.2	19.2
**CB9006	3.3	4.1	17.1
54Q25	4.5	4.1	16.1
**CB9009	2.3	4.1	15.8
**CB9005	3.0	4.5	13.5
Vernal	2.3	4.6	7.8
Mean	5.4	3.9	31.2
LSD 5%	1.76	0.41	19.51
CV %	23.0	7.4	43.7

* 1 = dead; 9 = Tall, no damage

** non-lodging germplasm

Table 3: 2011-2012 Greenhouse Test for the Green Pea Aphid (Pink Biotype)

Seeded: November 21, 2011
Scored: January 26-27, 2012

Entry	ASI	% resistant plants Class 1-2	% resistant plants Class 1-3
CB11004*	2.5	56.5	75.5
CB11007*	2.9	48.4	66.4
CB11005*	2.9	47.6	65.0
CB11006*	3.0	45.1	62.0
CB11010*	3.0	45.9	61.8
CB11008*	3.1	40.7	59.0
PA-1	3.1	45.6	56.7
CB11001	3.3	34.6	54.0
DKA 42-15	3.4	31.1	51.8
CB11003*	3.3	40.1	49.8
54V09	3.5	31.4	46.9
WT98002	3.5	29.7	42.8
OK 51	3.7	26.0	40.8
CB11009*	3.7	29.4	38.6
CB9002	3.8	27.8	38.4
54Q25	3.9	20.9	35.0
CB11011	4.0	18.6	32.0
CB11012	4.0	18.8	30.7
WT98001	4.0	21.4	30.3
CB001	4.2	13.3	27.1
54H11	4.3	12.9	23.4
CB9005	4.4	11.9	16.8
ARC	4.5	8.4	16.0
Vernal	4.7	4.2	6.5
Mean	3.6	29.6	42.8
LSD 5%	0.66	16.01	20.11
CV %	12.7	37.9	32.9

*****Entries selected for pea aphid

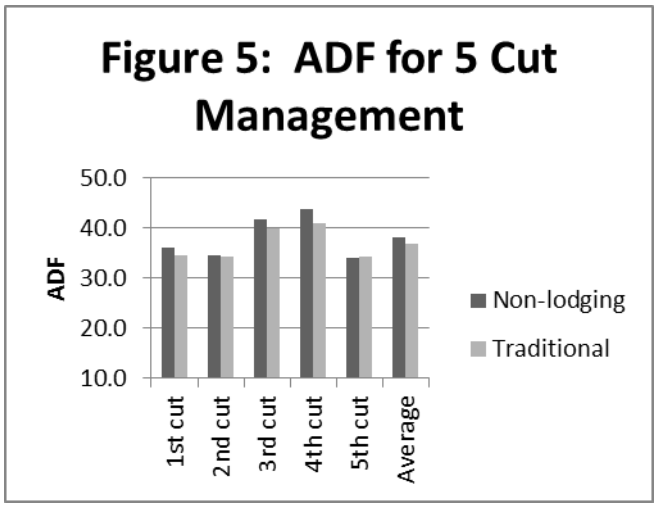
Figure 2: Non-lodging germplasm vs. traditional in the 4 cut management system.

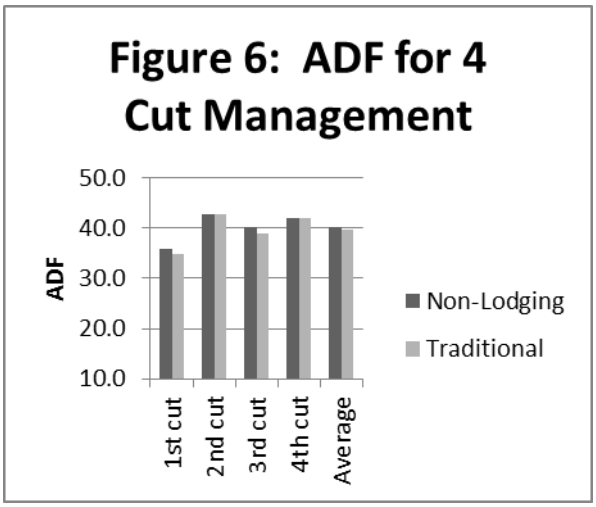
Figure 3: Non-lodging germplasm in 2 cut management system.

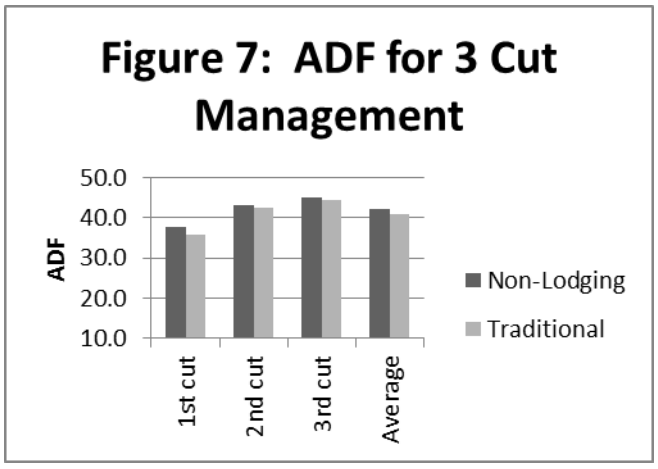
Figure 4: Traditional variety in 2 cut management system.

NIRS technology is widely used by commercial and university/government laboratories in the United States and around the world. An independent group of these labs formed the NIRS Consortium (NIRSC) more than two decades ago (www.nirsc.org). Yearly, new calibrations are published and released, while existing calibrations are constantly upgraded with new spectra for

specific feedstuffs/feedstock products. We control a FOSS 6500 NIRS instrument with membership in NIRSC and access to the latest calibration sets and equations. Previous NIRS results with traditional and non-lodging alfalfa indicated few samples were outside the range of the spectra. Our preliminary results using NIRS on 560 samples resulted in only 11 outside the range. Usually samples were the traditional varieties from the 2 cut management system that showing intensive stem and leaf disease presence. Preliminary data also indicated that non-lodging materials were suitable to traditional uses as represented by acid detergent fiber (ADF) in Figures 5-8.







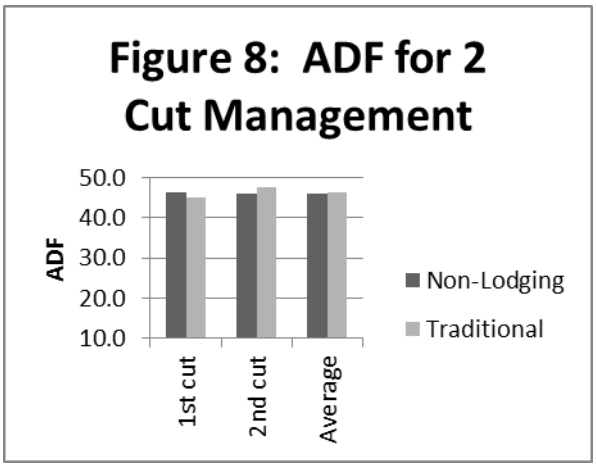


Table 4: First Harvest Year Yield Results of the 2010 Cutting Management Trial (All cuts)

Seeded 8/12/10		Forage Yield (Tons DM/Ac) 2011 Harvests									
Entry	**Company**	**5 cut**	**5 cut % mean**	**4 cut**	**4 cut % mean**	**3 cut**	**3 cut % mean**	**2 cut**	**2 cut % mean**	**Average cuts**	**2011 % mean all cuts**
CB9004	Columbia Basin College	11.4	99.0	12.3	105.0	11.1	115.5	11.2	136.5	11.5	112.1
CB9005	Columbia Basin College	12.1	104.5	12.8	109.7	11.9	124.0	9.8	119.0	11.7	113.5
CB9006	Columbia Basin College	12.1	104.6	12.2	104.4	10.9	113.6	9.8	119.4	11.3	109.6
CB9007	Columbia Basin College	11.9	102.8	11.9	101.5	10.6	110.1	8.9	108.2	10.8	105.2
55V12	Pioneer Hi-bred Int. Inc.	11.3	98.1	11.5	98.0	9.6	100.2	8.2	99.5	10.2	98.9
CB001	Columbia Basin College	11.8	102.3	11.5	98.5	8.8	91.6	6.7	81.5	9.7	94.5
54Q25	Pioneer Hi-bred Int. Inc.	11.1	96.4	11.4	97.4	7.4	77.1	6.5	79.3	9.1	88.8
Masterpiece II	J.R Simplot Company	11.4	99.0	11.2	95.9	9.1	94.3	7.5	90.8	9.8	95.4
Grandstand	Crop Production Services	11.2	96.6	11.0	94.4	8.4	87.0	7.1	86.7	9.4	91.7
DKA 42-13	Dekalb	11.2	96.7	11.1	95.3	8.3	86.5	6.5	79.1	9.3	90.4
	Mean	**11.6**	**100.0**	**11.7**	**100.0**	**9.6**	**100.0**	**8.2**	**100.0**	**10.3**	**100.0**
	LSD 5%	**NS**	**NS**	**1.17**	**10.00**	**1.13**	**11.8**	**1.8**	**22.4**		
	CV %	**6.0**	**6.0**	**7.0**	**7.0**	**8.3**	**8.3**	**15.6**	**15.6**		

Table 5: 2012 Results of the 2010 Cutting Management Trial (all cuts)

Seeded 8/12/10

		Forage Yield (Tons DM/Ac) 2012 Harvests									
Entry	**Company**	**5 cut**	**5 cut % mean**	**4 cut**	**4 cut % mean**	**3 cut**	**3 cut % mean**	**2 cut**	**2 cut % mean**	**Average cuts**	**2012 % mean all cuts**
CB9004	Columbia Basin College	12.5	102.1	9.9	100.9	9.8	111.5	10.3	135.2	**10.6**	**110.6**
CB9005	Columbia Basin College	12.7	103.5	11.3	115.5	10.3	116.3	9.6	125.8	**11.0**	**113.9**
CB9006	Columbia Basin College	11.8	96.7	10.6	108.3	9.7	109.7	8.9	116.5	**10.3**	**106.6**
CB9007	Columbia Basin College	12.4	101.1	10.5	107.6	9.5	107.7	9.1	118.5	**10.4**	**107.7**
55V12	Pioneer Hi-bred Int. Inc.	11.7	95.5	9.6	97.9	9.0	101.7	7.4	96.8	**9.4**	**97.8**
CB001	Columbia Basin College	12.8	104.9	9.0	92.3	8.1	91.8	6.4	83.2	**9.1**	**94.4**
54Q25	Pioneer Hi-bred Int. Inc.	12.2	99.6	9.0	92.2	7.3	82.5	5.6	73.5	**8.5**	**88.6**
Masterpiece II	J.R Simplot Company	12.3	100.7	9.7	98.6	8.9	100.8	7.0	92.1	**9.5**	**98.5**
Grandstand	Crop Production Services	12.1	98.8	9.0	91.4	7.5	84.5	6.3	82.7	**8.7**	**90.5**
DKA 42-13	DeKalb	11.9	97.1	9.3	94.9	8.2	93.1	5.8	75.3	**8.8**	**91.3**
	Mean	**12.2**	**100.0**	**9.8**	**100.0**	**8.8**	**100.0**	**7.6**	**100.0**	**9.6**	**100.0**
	LSD 5%	**NS**	**NS**	**1.1**	**10.0**	**1.5**	**11.8**	**2.1**	**22.4**		
	CV %	**6.7**	**6.0**	**7.8**	**7.8**	**12.2**	**12.2**	**19.5**	**19.5**		

Although only small differences in forage quality were found among entries in our cutting management experiment, large differences were found among entries for yield (Tables 4 and 5). No differences were found for yield among entries in the 5 cut system in both years while significant differences were found among entries in the 4, 3 and 2 cut harvest systems for both years. Yield differences favored the non-lodging entries (top five entries listed on the tables) as harvest systems moved toward fewer cuts.

This project will combines further development of the non-lodging trait with pea aphid resistance along with other pest resistance traits maintained in new alfalfa germplasm for the dual purpose of biomass feedstock for the biorefinery industry plus high quality alfalfa forage for the dairy and livestock producers.. The grower can market each product as a dairy feed or export hay if cut 5 to 6 times a year as high quality forage harvest for biomass with fewer cuts while removing the leaves for high protein leaf meal for dairy feed. Each product allows the grower increased flexibility in the market, produce higher yields of alfalfa, and reduce the need for pesticides to control aphids.

3. Approach

The best performing CBC non-lodging germplasm will be screened for pea aphid in 5 x 12 foot benches in the greenhouse. CB11005, CB11009, CB12005 are non-lodging germplasm that are currently being screened for pea aphid in the greenhouse. In addition, selections from non-lodging germplasm currently in a pea aphid variety test will be planted in breeder seed blocks in the spring of 2013. Resistant plants will be planted in space plant nurseries separated by germplasm sources. Only class 1 plants, based on the standard test, will be used for both breeder seed increase and space plant nurseries. Space plants will be planted 16 inches apart in 22-25 inch rows using a two person transplanter. Plants for breeder seed increase will be planted on 22" centers with 100-200 plants in each block. We expect to produce 3 to 5 lbs of seed for each germplasm. In 2014, selections based on visual scores for lodging, leafiness, color, height, crown width, and spring growth will be removed from the space plant nurseries and planted in isolation for the non-lodging characteristic. Leafcutter bee placement will be timed within 5 to 10 days of flowering. Once seed matures in the fall, blocks will be cut with a sickle bar and allowed to dry on tarps. Tarps containing seed will be moved into the greenhouse for drying in if poor weather occurs. Once the breeder seed plant material is dry, each cage will be threshed through a stationary plot thresher. Immediately following threshing, the resultant seed will be cleaned through a small clipper cleaner. At the end of 2014, basic seed will be ready for testing.

Testing will begin with a replicated 25 entry pea aphid test planted in a single 5' x 12' bench. Plots will be about 5" x 12" planted using 4 rows per entry. Stand counts will be taken at about the unifoliolate stage of growth. The pink biotype of the green pea aphid will be introduced at about the second trifoliolate stage of growth and allowed to multiply. At bud stage, entries will be clipped and allowed to re-grow. When the resistant check variety, PA-1, reaches about 5-6

inches, plants will be lifted and scored individually according the standard test for pea aphid. Vernal will be included in the test as the susceptible check variety and will also be used as the border variety to assure pea aphid multiplication. Plants from each entry will be separated into 5 classes with class 1-3 considered resistant plants. Data will be analyzed as a randomized complete block design with 4 replications. Percent resistant plants will be analyzed using both the 1-2 class and the 1-3 class representing percent resistant plants. Based on previous pea aphid experiments, we expect selected non-lodging germplasm to have high resistance to the insect. Class 1 selections will be made from each non-lodging germplasm to be potted in the greenhouse and planted spring of 2015 in breeder seed increase blocks.

In August of 2015, a cutting management experiment will be established with no less than 10 entries made up of 4 non-lodging CBC experimentals that have high resistance to pea aphid and 55V12 (commercial non-lodging variety) along with 5 high performing traditional commercial varieties sold in the area. The experiment will be planted and analyzed and a spit block design with entries replicated 4 times in each block. In 2016, blocks will be harvested 6 and 5 times to simulate cutting management systems currently in use under irrigation in the Columbia Basin; 4 and 3 times to simulate the expected cutting management for biomass production. Regrowth and lodging notes will be taken along with yield and quality components. Preliminary studies suggest that yields of non-lodging germplasm as compared to traditional commercial varieties will increase as number of cuts become less frequent. Subsamples from a preliminary cutting management test will be used in calibration development for predicting ethanol from alfalfa.

During harvests, forage samples weighing about 400 grams from each plot will be collected and weighed immediately to determine wet weight. The samples will be placed in cloth bags and dried at about 140 degrees F. Once the samples are dry, they will be weighed in the lab to obtain dry weight. Percent moisture will be used to adjust each plot to dry weight for analysis. The dried sample will be stored and later ground through both a Wiley Mill and Udy grinders to 1 mm particle size. In March or April, the ground samples will be scanned with a FOSS 6500 NIRS at the Washington State University (WSU) Irrigated Agriculture Research and Extension Center in Prosser, WA. Alfalfa equations will be confirmed for predicting ethanol using both traditional and non-lodging germplasm. To contribute to the large bioenergy industry, the new equations will be shared with the NIRS Consortium and their national organization of collaborating member laboratories.

In 2017, the pea aphid test will be repeated and second year harvest a quality data will be gathered and analyzed. A 1-2 acre foundation seed field will be established for two non-lodging experimentals based on 1st year yield and pea aphid results. Leafcutter bees will be utilized as pollinators, with seed harvested using a research Hege combine. A pea aphid resistant non-lodging germplasm will be released when characterization data is complete.

Experimental Plan and Timetable

2013

- Screen best performing CBC non-lodging germplasm for pea aphid resistance based on lodging and yield results from previous variety tests (16, 17) and a preliminary cutting management study (19).
- Transplant 2-3 acres with alfalfa plants selected for pea aphid in space plant nurseries.
- Selected non-lodging parents for a minimum of eight experimental cultivars.
- Establish breeder seed blocks for selections from a 2012-2013 pea aphid test.
- December, 2013 – report of progress to granting institution.

2014

- Transplant parents (minimum of 100) into isolation blocks to produce breeder seed.
- Harvest, thresh and condition breeder seed.
- Conduct a 25 entry standard test for pea aphid including resistant and susceptible check varieties. Include known susceptible varieties to help with pea aphid reproduction on the experiment. The test will be planted as a randomized complete block design with 4 replications. Plants will be scored on the basis of regrowth in the presence of high pea aphid populations after clip back.
- December, 2014 – report progress and pea aphid results to granting institution.
- Report results of pea aphid test to the Washington State Hay Growers Association (WSHGA).

2015

- Repeat 25 entry pea aphid test.
- Select plants for pea aphid resistance from non-lodging entries out of the pea aphid test. Only plants scored a 1 will be included in future experimental varieties. No less than 75 plants will be used as parents and will be potted for transplant in the spring.
- Plant a cutting management experiment with no less than 10 entries with 5 non-lodging experimentals and five traditional commercial varieties. The experiment will be planted as a split block design with 4 replications within each block. Blocks will consist of 6, 5, 4, and 3 cutting management systems. A prior cutting management experiment indicated that due to our harvests and immediate removal of hay a 6 cut system would better represent local alfalfa growers 5 cut system. The grower has a dry down delay between cuts. Orthogonal contrasts will be made between non-lodging and traditional varieties.
- Scan samples with NIRS to predict forage bioenergy. Subsamples from a preliminary cutting management test will be used in calibration development for ethanol from alfalfa.
- December, 2015 – Report progress to granting institution.

2016

- Weigh and subsample each plot for determining first year yield, moisture and quality analysis using NIRS. Samples with be dried at 140 degrees F and ground through a Wiley mill; subsequently ground through an Udy mill as suggested for NIRS.

- Produce breeder seed on carryover isolations and new experimentals selected from pea aphid experiment.
- Based on first year results, submit the 3 highest yielding non-lodging experimental to Crop Characteristics, Inc., an independent company that conducts tests according to the Standard Tests to Characterize Alfalfa Cultivars, for classification of other traits including Antracnose, Aphanomyces, bacterial wilt, Fusarium wilt, Phytophthora root rot, Verticillium wilt, stem nematode, and spotted alfalfa aphid.
- Run subsamples of plots through a NIRS to obtain forage quality data such as protein, lignin, NDF, ADF, relative feed value (RFV), dry matter digestibility (DDM) and other quality traits.
- December, 2016—Report progress and first year yield results to granting institution.
- Analyze first year yield data and present results to the WSHGA.

2017

- Plant foundation seed field based on first year yield data by starting plants in greenhouse and transplanting to isolation field. We will try to produce foundation seed under pivot irrigation to determine if seed of non-lodging varieties can be produced under overhead sprinkler irrigation. Standard practices for producing alfalfa seed are with ditch or flood irrigation to keep plants from lodging and destroying the seed.
- Harvest and condition foundation seed.
- Harvest and analyze second year yield data and present 2 year yield data and first year quality data results to the WSHGA.
- Release non-lodging germplasm as a public release when all data for classification is collected. Publishing the release in Crop Science may occur in 2018 due to time restrictions on classification data.
- December, 2017 – Final report of 2 year yield data and first year quality data to granting institution. A third year will be harvested in 2018.

2018

- Release best non-lodging variety for commercial production.

F. FACILITIES AND EQUIPMENT

- Field Plots
  - Carter Forage Harvester with weigh system.
  - Planet Junior for planting plots.
  - Forage dryer for determining plot moisture and sample preparation.
  - Gandy Fertilizer spreader.
  - Avery Berkel scale for weighing samples in field.
  - Hand lines for plot irrigation.
  - Irrigation pump for hand lines.
  - 8 acres of research land on CBC campus.
  - Brillion Pulvi-mulcher M series for soil preparation.

- Kubota tractor with rototiller and packer for soil preparation.
- 10 foot disk.
- Ford 5060 tractor .

- Isolation blocks
  - Domiciles for leaf cutter bee housing.
  - Five foot cycle bar for cutting isolation blocks.
  - LD 180 thresher for smaller samples.
  - Five foot sickle bar for breeder seed harvest.
  - Hege 5 foot research combine for foundation seed harvest.
  - Low profile stationary plot thresher for breeder seed conditioning.
- Dry lab
  - HMC 67 seed Blower for small seed samples.
  - Oahus scale for weighing samples in lab.
  - Stereo microscope.
  - Binocular microscope.
  - Small lab clipper cleaner for breeder seed conditioning.
  - Wiley Mill for rough grind used for preparation of samples for NIRS.
  - Udy grinder for fine grind preparation for NIRS.
  - FOSS 6500 NIRS instrument with membership in NIRSC.
- Greenhouse (30' x 60')
  - Sixteen 5'x12' rolling benches for pea aphid tests and screening.
  - 32 1000 watt combination high pressure sodium and metal halide light fixtures each with timers.
- Pivot irrigation land (1/2 mile from campus).
  - 700 hundred foot span pivot irrigation system.
  - 16 acres under irrigation.
  - Pivot and ditch irrigation available.
  - 7' x 22 ft. trailer for hauling equipment.

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Attachment 11

Cutting Management for Biomass and Traditional Alfalfa Varieties

Progress Report

William T. W. Woodward[10], Steve Fransen, Christopher Lamm,
Eliseo Navarro, David Mitchell, and Cristina Garza

ABSTRACT

In Washington, alfalfa is used for feeding livestock and as an export product in the form of cubes and double compressed bales. Another future market could be alfalfa use as a biofuel. It is a perennial crop that is high yielding, reduces erosion, removes leftover nitrates left by annual crops, requires no additional nitrogen due to its ability to fix nitrogen from the air, and is widely adapted. A non-lodging alfalfa is needed under pivot irrigation if cutting frequency is to be reduced to provide lower input costs. An experiment was established at Columbia Basin College (CBC) to determine yield and quality performance of 5 non-lodging varieties and 5 traditional varieties under 4 cutting management systems (2, 3, 4, and 5 cuts). No significant differences were found among entries for total yield in 2011, 2012 or combined yields for both years in the five cut management system. However, significant differences for total yield in both years and combined years were found among varieties in the 2, 3 and 4 cut systems where non-lodging cultivars showed higher yields than the traditional cultivars. In the 2, 3 and 4 cut systems, three CBC non-lodging entries had significant higher yields than the top yielding traditional variety. In general, yields trended downward for each cultivar from a 5 cut system to a 2 cut system. However, two non-lodging entries maintained over an 11 ton average of dry matter per acre for each system for both years. Quality components including crude protein, acid detergent fiber (ADF), neutral detergent fiber (NDF), lignin, digestible dry matter (DDM), and relative feed value (RFV) were determined for all cuts in the four management systems.

Key Words: alfalfa, cutting management, lodging, crude protein, ADF, NDF, lignin, DDM, RFV.

INTRODUCTION

More than 19 million acres of alfalfa was harvested in the United States in 2011. Average yields ranged from 7.9 ton/acre in Arizona to 1.3 tons/acre in Oklahoma. In 2011, Washington ranked fourth among states in yield per acre at 4.8 tons. However, Grant County and Franklin County produce about 6.7 and 7.2 tons/acre respectively on average. Many of the growers in these counties have produced more than 10 tons/acre.

Alfalfa has some advantages over a grass crop when considered as a biofuel feedstock. As a deep rooted perennial, alfalfa can reduce erosion and nutrient leaching. It will take up available nitrate prior to releasing its unique nitrogen fixation mechanism removing potential ground water contamination and later providing its own nitrogen through fixation. After an average

[10] Dean of Agriculture Education, Research and Development, Columbia Basin College, Steve Fransen, Extension Agronomist, Washington State University Prosser Irrigated Agriculture Research and Extension Center (WSUIAREC) and agriculture interns at CBC, Pasco, WA. December 27, 2012. CBCAG1201. **In:** Proceedings, 2013Washington State Hay Growers Association Northwest Hay Expo.

persistence of 4 years, nitrogen is left behind for the following rotational crop. Alfalfa is one of the few crops that can be considered a friend to the soil.

The DOE dismissed alfalfa as a potential biofuel feedstock due to its value as an animal feed. However, if leaves were separated from stems, half of alfalfa could be used as a highly digestible high protein feed. The stems could be used for biofuel. In order to make this work in Washington, there will be a need to reduce input costs. Reducing the number of cuts and lengthening stand life would help. To reduce the number of cuts an alfalfa variety would need to remain erect to eliminate leaf loss and diseases that occur with lodged alfalfa. The traditional alfalfa varieties tend to lodge under pivot irrigation.

CBC has been working on non-lodging germplasm for several years. A cutting management experiment was established in the fall of 2010 to test non-lodging germplasm with traditional varieties under 2, 3, 4 and 5 cut systems. The experiment will help determine if non-lodging varieties could be used in multiple markets and determine forage quality and yield variation among management systems. In this report forage quality components were determined for only the 2011 harvest year due to forage sample preparation time.

MATERIALS AND METHODS

On August 12, 2010 a cutting management test was planted in a split block design with 4 cutting managements and 10 varieties. Entries were replicated 4 times within cutting managements. For the purposes of this report, each cutting management was analyzed as a randomized complete block. The 10 entries were represented by 5 non-lodging entries including CB9004, CB9005, CB9006, CB9007 (CBC experimental germplasm) and Pioneer's non-lodging variety 55V12; 5 traditional entries included CB001 (CBC experimental), 54Q25, Masterpiece II, Grandstand, and DK42-13.

Dates for the 2011 harvests have previously been reported (1). Dates for the 2012 harvests for the 5 cut system were: May 16, June 21, July 23, August 22 and Sep. 28. For the 4 cut system, the dates were: May 24, June 29, August 10, and Sep. 28. For the 3 cut system, the dates were: June 1, July 29, and Sep. 28. For the 2 cut system, the dates were: June 29, and Sep. 28.

Plots were 3 x 16 feet and were harvested using a carter forage harvester set for about a 2 inch cutting height. Forage yields were obtained by weighing the fresh forage from the entire plot area and converting to tons per acre dry weight. A random subsample of about 400 grams was obtained from each plot as it was harvested. The subsample was dried at about 140 degrees F. and used for the determination of dry matter (DM) and for forage quality analysis.

Samples were prepared for Near Infrared Reflectance Spectroscopy (NIRS) by grinding through a 2-mm screen in a Wiley mill followed by a fine grind using an Udy mill with a 1 mm screen. The samples for the 2011 harvest were run through a NIRS at Washington State University located in Prosser, WA. Data for crude protein, ADF, NDF, lignin, DDM and RFV was analyzed.

RESULTS AND DISCUSSION

Forage Yield

Total yield in the 5 cut system ranged from 11.1 to 12.1 tons DM/acre in 2011 and 11.7 to 12.7 in 2012. However, no significant differences were found among the entries for total yield in 2011, 2012 or combined yields for both years (Table 1). Significant differences were found among varieties in the first and forth cut in the 2012 harvest year. In general, the non-lodging entries had higher yields than the traditional entries in the 1st cut and lower yields in the 4th and 5th cut. There were no differences in average yield between the non-lodging and traditional entries in either harvest years or the combined total as shown by the percent of mean yield in Figure 1.

There were significant differences among entries for total yield in the four cut system for both harvest years and combined total yield (Table 2). The non-lodging entry CB9005 had significantly higher yields than the highest yielding traditional entry in both years and for combined total yield. In the four cut management system, the non-lodging entries were higher yielding than the traditional entries in both years and for combined total (Figure 2).

The three cut system showed significant differences among varieties for total yield for 2011, 2012 and combined total yields (Table 3). Significant differences among varieties were found within all three cuts in both years. The four non-lodging CBC experimentals had significant higher total yields than all of the traditional varieties in the first year and combined total for the two years. The non-lodging cultivars generally had higher yields than the traditional varieties (Figure 3).

In the 2 cut system, all traditional cultivars lodged severely and lost leaves due to leaf disease. Non-lodging cultivars lost leaves in the lower canopy due to leaf senescence. Significant differences were found among cultivars for total yield in both years and the combined total (Table 4). CB9004 was significantly higher yielding than the rest of the entries in the first year. CB9004 and CB9005 were significantly higher yielding than all of the traditional varieties and the commercial non-lodging variety (55V12) in both years and combined total. The non-lodging varieties as a group were higher yielding in both years and combined total (Figure 4).

Table 5 shows the total yield in tons DM/Ac and percent of mean for all cutting management systems in 2012; total yields for 2011 and 1012 and combined total for both years. The data shows that the fewer the cuts, the more advantage for the non-lodging cultivars. Although the data was not analyzed to detect significant differences among cutting management systems, average total yield trended downward from the 5 cut system to the 2 cut system. CB9004 had about 67% higher yields than the best traditional cultivar (Masterpiece II) in the two cut system in both years.

It is expected that over time the more frequent cuttings will reduce stand and health of the plants causing a reduction in yield. In the Columbia Basin, it is generally known that a 4 cut system will yield more than a five cut system over time. This data shows that reduction in yield in the five cut system vs. the 4 cut system did not happen in the first two years. This may be due to the difference in cutting management of this experiment and the methods used by growers in the

region. In this experiment the forage is harvested and removed from the field with irrigation restored immediately. Growers must remove irrigation for a period of time and harvest. The hay is allowed to dry prior to baling and "dry down" can last a week or more depending on weather. A six cut experimental system would better correlate to a grower 5 cut system in restricting carbohydrate storage to the roots.

Forage Quality

First harvest year results (2011) for crude protein are presented in Tables 6-9. Significant differences were found among entries in the first two cuts of all four management systems. In general, traditional entries had higher crude protein than the non-lodging entries within all cuts and when averaged across cuts in each management system (Figures 6-9).

The ADF (Acid Detergent Fiber) values represent mostly cellulose and lignin. Significant differences for ADF were found among entries in the first two cuts of the 4 and 5 cut management systems and in the 3rd cut of the 3 cut management system while no significant differences were found among entries in the 2 cut system (Tables 10-13). ADF trended lower among the traditional entries within each cut and average of all cuts for each management system with the exception of the 2 cut system (Figures 10-13).

NDF (Neutral Detergent Fiber) values typically represent the total fiber fraction (cellulose, hemicelluloses, and lignin) that make up cell walls (structural carbohydrates or sugars) within the forage tissue. Significant differences were found among entries in the first two cuts of the 5 harvest system, in the first cut of the 4 harvest system and the third cut of the 3 harvest system (Tables 14-17). Generally, the non-lodging entries had higher NDF than the traditional entries among cuts and average of cuts in all four management systems (Figures 14-17).

Digestible dry matter (DDM) is an estimate of the total digestibility of the alfalfa and is calculated from percent acid detergent fiber (ADF). An excellent DDM would be about 67%. DDM for the ten entries is presented in Tables 18-21. Significant differences were found among entries for DDM in the first two cuts of the 4 and 5 harvest systems and in the third cut of the 3 harvest system. Figures 18-21 show the general trend of non-lodging entries having lower DDM than traditional entries.

Relative Feed Value (RFV) is an index representing forage quality and uses NDF and ADF as predictors of forage quality. An excellent RFV index would be 180. Significant differences for RFV among entries were found only in the first two cuts of the 4 and 5 harvest systems with no differences found in the 2 and 3 harvest systems (Tables 22-25). Similar to DDM, non-lodging entries trended lower than traditional entries for RFV within cuts and average across cuts for all harvest systems (Figures 22-25).

Although differences among entries for quality traits within the four harvest management systems are small, the trend is much larger when comparing values across harvest management systems. Crude protein ranged from 20.5 to 12.7 for non-lodging entries and 21.2 to 14.3 for traditional entries for the 5 cut management system and the 2 cut system, respectively (Figure 26). DDM ranged from 60.3 to 52.9 for the traditional entries for the 5 and 2 cut systems, respectively (Figure 30). RFV ranged sharply from 142.6 to 52.9 for the traditional entries in the 5 and 2 cut systems, respectively (Figure 31). Lignin provides strength to a plant and is indigestible. No significant differences were found among entries within cuts on all management

systems. However, lignin percent went up across harvest systems ranging from 6.2 to 9.6 for the five cut and two cut systems, respectively (Figure 29). Both traditional and non-lodging entries showed the same trend. Similar to lignin, ADF and NDF trended up across cutting management systems from 5 cut to 2. The range was 36.7 to 46.2 and 39.9 to 54.1 for ADF (Figure 27) and NDF (Figure 28), respectively.

ACKNOWLEDGMENTS

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Table 1: Two Year Results of the 2010 Cutting Management Trial (5 cut)

Seeded
8/12/10

		2011 Harvests		Forage Yield (Tons DM/Ac) 2012 Harvests												
Entry	**Company**	**2011 Total**	**2011 % mean**	**Cut 1**	**Cut % Mean**	**Cut 2**	**Cut 2 % mean**	**Cut 3**	**Cut 3 % mean**	**Cut 4**	**Cut 4 % mean**	**Cut 5**	**Cut 5 % mean**	**2012 Total**	**2012 % mean**	**2 year Total**	**2 year % mean**
CB9004	Columbia Basin College	**11.4**	**99.0**	3.5	112.1	2.9	107.37	2.9	100.43	1.4	91.05	1.8	90.17	**12.5**	**102.1**	**23.9**	**100.6**
CB9005	Columbia Basin College	**12.1**	**104.5**	3.6	114.5	2.7	100.86	3.0	104.15	1.5	96.16	1.9	94.31	**12.7**	**103.5**	**24.7**	**104.0**
CB9006	Columbia Basin College	**12.1**	**104.6**	3.3	102.8	2.8	106.12	2.6	91.84	1.4	92.06	1.7	84.74	**11.8**	**96.7**	**23.9**	**100.6**
CB9007	Columbia Basin College	**11.9**	**102.8**	3.4	109.0	2.5	91.81	3.0	104.43	1.5	96.28	2.0	100.27	**12.4**	**101.1**	**24.2**	**101.9**
55V12	Pioneer Hi-bred Int. Inc.	**11.3**	**98.1**	2.9	91.2	2.5	92.45	3.1	107.00	1.4	91.84	1.8	92.84	**11.7**	**95.5**	**23.0**	**96.7**
CB001	Columbia Basin College	**11.8**	**102.3**	3.0	96.4	2.8	104.41	3.0	104.72	1.8	118.49	2.1	108.75	**12.8**	**104.9**	**24.6**	**103.6**
54Q25	Pioneer Hi-bred Int. Inc.	**11.1**	**96.4**	3.2	99.7	2.7	99.50	2.7	93.76	1.6	101.56	2.1	106.24	**12.2**	**99.6**	**23.3**	**98.0**
Masterpiece II	J.R Simplot Company	**11.4**	**99.0**	2.9	90.8	2.4	89.57	3.0	103.66	1.7	109.48	2.4	120.18	**12.3**	**100.7**	**23.7**	**99.9**
Grandstand	Crop Production Services	**11.2**	**96.6**	2.8	90.0	2.8	106.20	2.9	100.08	1.5	97.99	2.0	101.94	**12.1**	**98.8**	**23.2**	**97.8**
DKA 42-13	DeKalb	**11.2**	**96.7**	3.0	93.5	2.7	101.71	2.6	89.94	1.6	105.07	2.0	100.55	**11.9**	**97.1**	**23.0**	**96.9**
	Mean	**11.6**	**100.0**	**3.2**	**100.0**	**2.7**	**100.0**	**2.9**	**100.0**	**1.5**	**100.0**	**2.0**	**100.0**	**12.2**	**100.0**	**23.8**	**100.0**
	LSD 5%	**NS**	**NS**	**0.56**	17.6	**NS**	**NS**	**NS**	**NS**	**0.24**	**15.3**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
	CV %	**6.0**	**6.0**	**12.3**	**12.3**	**13.0**	**6.9**	**12.4**	**11.8**	**10.7**	**10.7**	**19.0**	**7.8**	**6.7**	**6.0**	**4.6**	**4.6**

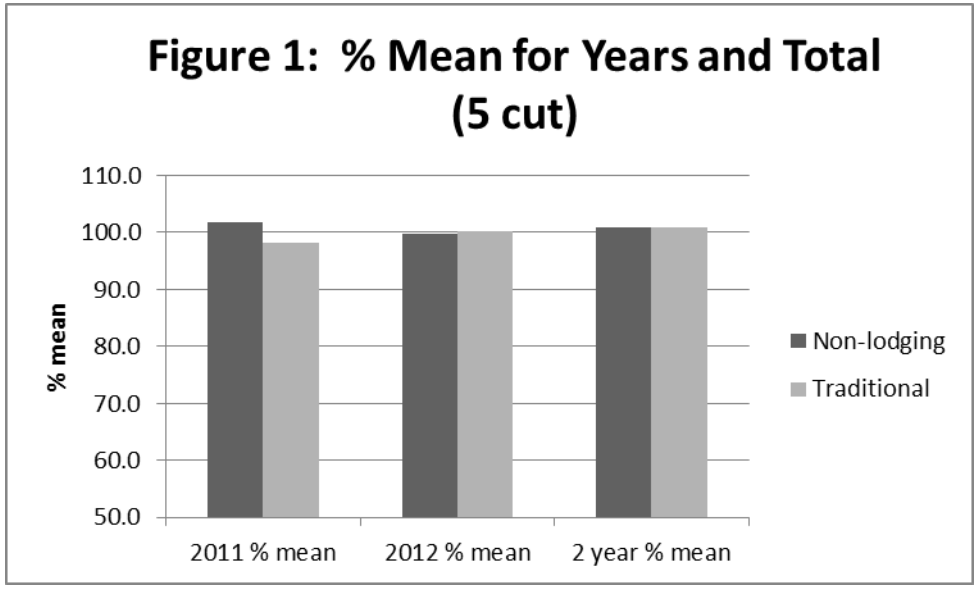


Table 2: Two Year Results of the 2010 Cutting Management Trial (4 cut)

Seeded
8/12/10

		2011 Harvests		Forage Yield (Tons DM/Ac) 2012 Harvests											
Entry	**Company**	**2011 Total**	**2011 % mean**	**Cut 1**	**Cut 1 % mean**	**Cut 2**	**Cut 2 % mean**	**Cut 3**	**Cut 3 % mean**	**Cut 4**	**Cut 4 % mean**	**2012 Total**	**2012 % mean**	**2 year Total**	**2 year % mean**
CB9004	Columbia Basin College	**12.3**	**105.0**	2.7	107.7	2.8	95.45	2.9	102.00	1.5	99.09	**9.9**	**101.0**	**22.2**	**103.2**
CB9005	Columbia Basin College	**12.8**	**109.7**	3.0	122.0	3.4	116.68	3.3	114.88	1.6	104.25	**11.3**	**115.6**	**24.1**	**112.4**
CB9006	Columbia Basin College	**12.2**	**104.4**	2.8	114.9	3.0	99.95	3.0	106.60	1.8	117.05	**10.6**	**108.3**	**22.8**	**106.2**
CB9007	Columbia Basin College	**11.9**	**101.5**	2.9	116.1	3.1	106.28	3.0	104.09	1.6	103.11	**10.5**	**107.6**	**22.4**	**104.3**
55V12	Pioneer Hi-bred Int. Inc.	**11.5**	**98.0**	2.3	92.3	2.9	98.78	3.0	106.10	1.4	90.56	**9.6**	**98.0**	**21.1**	**98.0**
CB001	Columbia Basin College	**11.5**	**98.5**	2.1	83.7	2.7	90.73	2.7	94.09	1.6	105.88	**9.0**	**92.3**	**20.6**	**95.7**
54Q25	Pioneer Hi-bred Int. Inc.	**11.4**	**97.4**	2.2	87.8	2.7	92.97	2.6	90.95	1.5	100.68	**9.0**	**92.3**	**20.4**	**95.0**
Masterpiece II	J.R Simplot Company	**11.2**	**95.9**	2.5	100.2	3.1	105.09	2.6	91.46	1.5	96.76	**9.7**	**98.6**	**20.9**	**97.2**
Grandstand	Crop Production Services	**11.0**	**94.4**	2.1	86.9	2.8	96.35	2.6	92.63	1.3	86.81	**9.0**	**91.4**	**20.0**	**93.0**
DKA 42-13	DeKalb	**11.1**	**95.3**	2.2	88.5	2.9	97.75	2.8	97.21	1.5	95.81	**9.3**	**95.0**	**20.4**	**95.1**
	Mean	**11.7**	**100.0**	**2.5**	**100.0**	**3.0**	**100.0**	**2.8**	**100.0**	**1.5**	**100.0**	**9.8**	**100.0**	**21.5**	**100.0**
	LSD 5%	**1.2**	**10.0**	**0.6**	**24.1**	**NS**	**NS**	**0.5**	**16.5**	**0.2**	**14.8**	**1.1**	**10.0**	**1.8**	**8.2**
	CV %	**7.0**	**5.6**	**16.9**	**16.9**	**11.9**	**11.9**	**11.5**	**11.5**	**6.0**	**6.0**	**7.8**	**7.0**	**5.8**	**5.8**

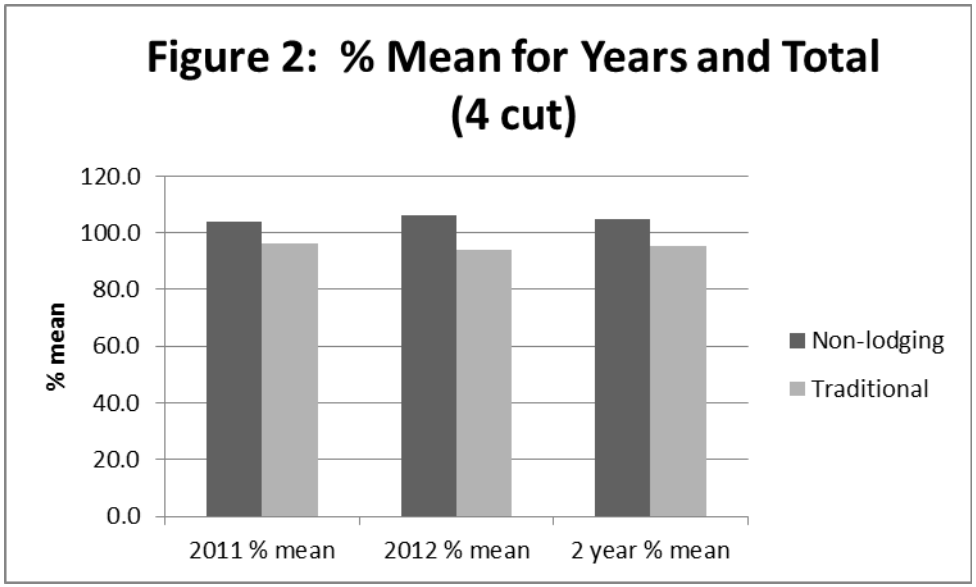


Table 3: Two Year Results of the 2010 Cutting Management Trial (3 cut)

Seeded
8/12/10

		2011 Harvests		Forage Yield (Tons DM/Ac) 2012 Harvests									
Entry	**Company**	**2011 Total**	**2011 % mean**	**Cut 1**	**Cut 1 % mean**	**Cut 2**	**Cut 2 % mean**	**Cut 3**	**Cut 3 % mean**	**2012 Total**	**2012 % mean**	**2 year Total**	**2 year % mean**
CB9004	Columbia Basin College	**11.1**	**115.3**	4.1	107.4	3.3	110.95	2.5	120.29	**9.8**	**111.6**	**20.9**	**113.5**
CB9005	Columbia Basin College	**11.9**	**123.7**	4.4	114.3	3.5	119.13	2.4	116.10	**10.3**	**116.3**	**22.2**	**120.2**
CB9006	Columbia Basin College	**10.9**	**113.4**	4.0	104.8	3.5	117.45	2.2	108.07	**9.7**	**109.8**	**20.6**	**111.6**
CB9007	Columbia Basin College	**10.8**	**112.4**	4.1	105.8	3.1	106.26	2.3	113.41	**9.5**	**107.7**	**20.3**	**110.1**
55V12	Pioneer Hi-bred Int. Inc.	**9.6**	**99.9**	3.8	98.6	3.2	108.70	2.0	97.39	**9.0**	**101.7**	**18.6**	**100.8**
CB001	Columbia Basin College	**8.8**	**91.4**	3.6	93.0	2.6	89.87	1.9	92.56	**8.1**	**91.9**	**16.9**	**91.6**
54Q25	Pioneer Hi-bred Int. Inc.	**7.4**	**76.9**	3.4	89.6	2.2	74.90	1.6	80.38	**7.3**	**82.6**	**14.7**	**79.6**
Masterpiece II	J.R Simplot Company	**9.1**	**94.1**	4.0	103.7	2.9	99.90	2.0	96.78	**8.9**	**100.8**	**18.0**	**97.3**
Grandstand	Crop Production Services	**8.4**	**86.8**	3.2	84.7	2.5	85.07	1.7	83.42	**7.5**	**84.5**	**15.8**	**85.7**
DKA 42-13	DeKalb	**8.3**	**86.3**	3.8	98.1	2.6	87.75	1.9	91.61	**8.2**	**93.2**	**16.5**	**89.6**
	Mean	**9.6**	**100.0**	**3.8**	**100.0**	**2.9**	**100.00**	**2.0**	**100.00**	**8.8**	**100.0**	**18.5**	**100.0**
	LSD 5%	**1.1**	**11.8**	**0.9**	**23.4**	**0.6**	**19.22**	**0.5**	**25.55**	**1.5**	**11.8**	**2.3**	**12.3**
	CV %	**8.1**	**8.3**	**16.4**	**16.4**	**13.5**	**13.5**	**17.9**	**17.9**	**12.2**	**12.2**	**8.6**	**8.6**

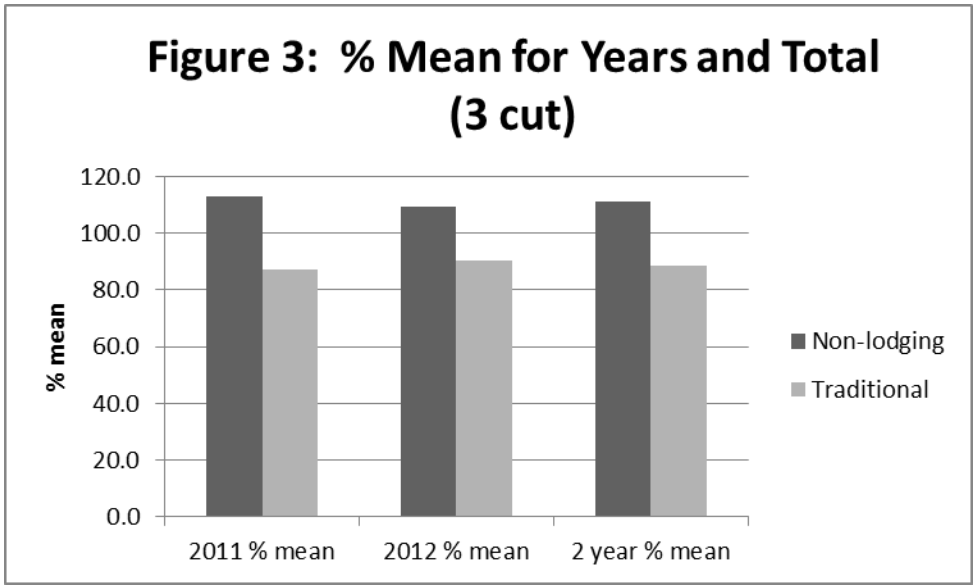


Table 4: Two Year Results of the 2010 Cutting Management Trial (2 cut)

Seeded
8/12/10

		2011 Harvests		——Forage Yield (Tons DM/Ac) 2012 Harvests——							
Entry	**Company**	**2011 Total**	**2011 % mean**	**Cut 1**	**Cut 1 % mean**	**Cut 2**	**Cut 2 % mean**	**2012 Total**	**2012 % mean**	**2 year Total**	**2 year % mean**
CB9004	Columbia Basin College	**11.2**	**136.5**	6.4	131.1	3.9	142.88	**10.3**	**135.3**	**21.6**	**135.9**
CB9005	Columbia Basin College	**9.8**	**119.0**	6.1	123.4	3.5	130.21	**9.6**	**125.8**	**19.4**	**122.3**
CB9006	Columbia Basin College	**9.8**	**119.4**	5.5	111.5	3.4	125.69	**8.9**	**116.5**	**18.7**	**118.0**
CB9007	Columbia Basin College	**8.9**	**108.2**	5.6	113.0	3.5	128.46	**9.1**	**118.5**	**18.0**	**113.2**
55V12	Pioneer Hi-bred Int. Inc.	**8.2**	**99.5**	4.6	94.3	2.8	101.39	**7.4**	**96.8**	**15.6**	**98.2**
CB001	Columbia Basin College	**6.7**	**81.5**	4.4	88.7	2.0	73.30	**6.4**	**83.2**	**13.1**	**82.3**
54Q25	Pioneer Hi-bred Int. Inc.	**6.5**	**79.3**	3.7	74.4	2.0	72.02	**5.6**	**73.5**	**12.1**	**76.5**
Masterpiece II	J.R Simplot Company	**7.5**	**90.8**	4.9	100.6	2.1	76.84	**7.0**	**92.1**	**14.5**	**91.4**
Grandstand	Crop Production Services	**7.1**	**86.7**	4.2	86.3	2.1	76.24	**6.3**	**82.7**	**13.5**	**84.8**
DKA 42-13	DeKalb	**6.5**	**79.1**	3.8	76.7	2.0	72.98	**5.8**	**75.4**	**12.3**	**77.3**
Mean		**8.2**	**100.0**	**4.9**	**100.0**	**2.7**	**100.00**	**7.6**	**100.0**	**15.9**	**100.0**
LSD 5%		**1.8**	**22.4**	**1.6**	**33.0**	**0.8**	**28.73**	**2.1**	**22.4**	**3.5**	**22.2**
CV %		**15.6**	**15.6**	**23.1**	**23.1**	**20.1**	**20.1**	**19.5**	**19.5**	**15.5**	**15.5**

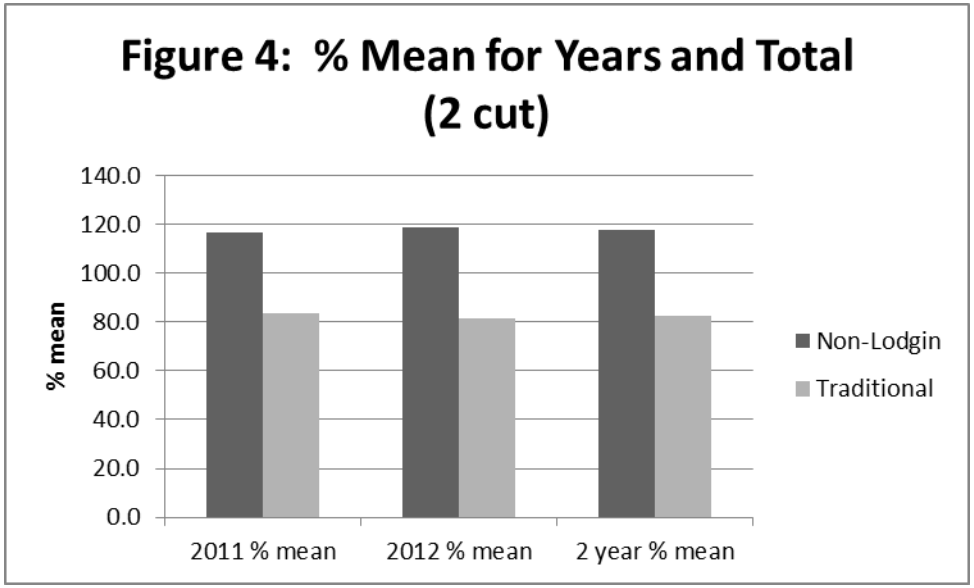


Table 5: Two Year Results of the 2010 Cutting Management Trial (all cuts)

Seeded
8/12/10

		2011 Harvests		Forage Yield (Tons DM/Ac) 2012 Harvests											
Entry	**Company**	**Average cuts**	**2011 % mean all cuts**	**5 cut**	**5 cut % mean**	**4 cut**	**4 cut % mean**	**3 cut**	**3 cut % mean**	**2 cut**	**2 cut % mean**	**Average cuts**	**2012 % mean all cuts**	**2 year Total**	**2 year % mean**
CB9004	Columbia Basin College	**11.5**	**112.1**	12.5	102.1	9.9	100.99	9.8	111.57	10.3	135.28	**10.6**	**110.6**	**22.2**	**111.3**
CB9005	Columbia Basin College	**11.7**	**113.5**	12.7	103.5	11.3	115.55	10.3	116.34	9.6	125.82	**11.0**	**113.9**	**22.6**	**113.6**
CB9006	Columbia Basin College	**11.3**	**109.6**	11.8	96.7	10.6	108.31	9.7	109.77	8.9	116.54	**10.3**	**106.6**	**21.5**	**108.1**
CB9007	Columbia Basin College	**10.8**	**105.2**	12.4	101.1	10.5	107.62	9.5	107.70	9.1	118.55	**10.4**	**107.7**	**21.2**	**106.4**
55V12	Pioneer Hi-bred Int. Inc.	**10.2**	**98.9**	11.7	95.5	9.6	97.99	9.0	101.70	7.4	96.85	**9.4**	**97.8**	**19.6**	**98.3**
CB001	Columbia Basin College	**9.7**	**94.5**	12.8	104.9	9.0	92.31	8.1	91.86	6.4	83.21	**9.1**	**94.4**	**18.8**	**94.4**
54Q25	Pioneer Hi-bred Int. Inc.	**9.1**	**88.8**	12.2	99.6	9.0	92.27	7.3	82.55	5.6	73.54	**8.5**	**88.6**	**17.6**	**88.7**
Masterpiece II	J.R Simplot Company	**9.8**	**95.4**	12.3	100.7	9.7	98.60	8.9	100.81	7.0	92.13	**9.5**	**98.5**	**19.3**	**96.8**
Grandstand	Crop Production Services	**9.4**	**91.7**	12.1	98.8	9.0	91.40	7.5	84.53	6.3	82.73	**8.7**	**90.5**	**18.1**	**91.1**
DKA 42-13	DeKalb	**9.3**	**90.4**	11.9	97.1	9.3	94.95	8.2	93.16	5.8	75.35	**8.8**	**91.3**	**18.1**	**90.8**
	Mean	**10.3**	**100.0**	**12.2**	**100.0**	**9.8**	**100.0**	**8.8**	**100.0**	**7.6**	**100.0**	**9.6**	**100.0**	**19.9**	**100.0**
	LSD 5%			**NS**	**NS**	**1.1**	**10.0**	**1.5**	**11.8**	**2.1**	**22.4**				
	CV %			**6.7**	**6.0**	**7.8**	**7.8**	**12.2**	**12.2**	**19.5**	**19.5**				

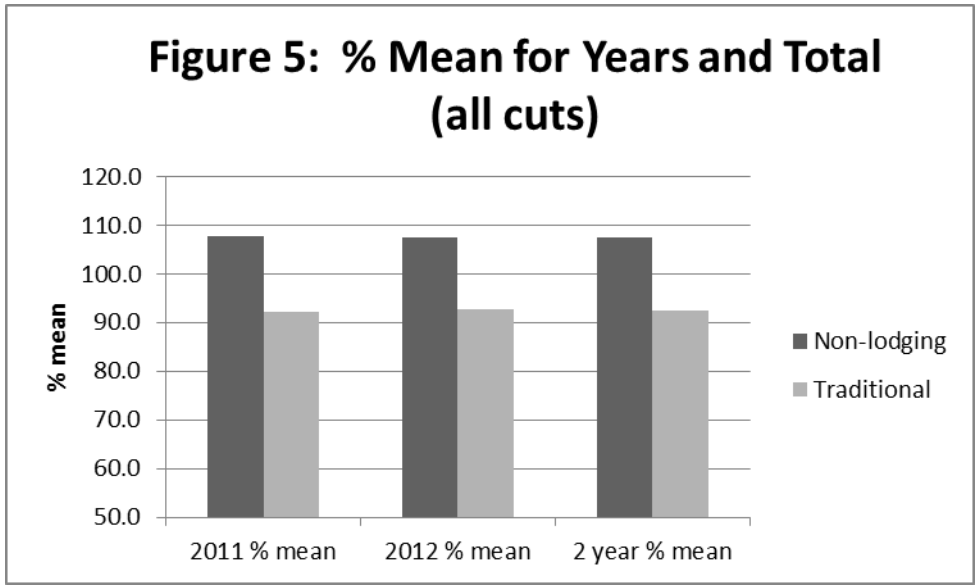


Table 6: First Harvest Year Results for Protein (5 cut)

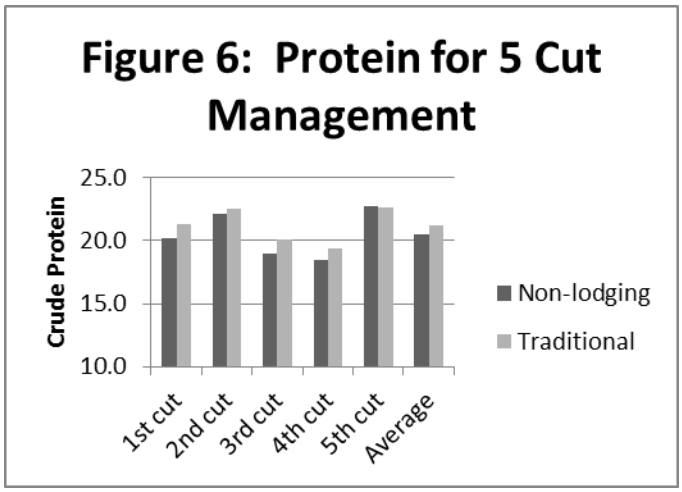
Seeded 8/12/10

		2011 Harvests						
Entry	Company	Cut 1	Cut 2	Cut 3	Cut 4	Cut 5	Total	Average
CB9004	Columbia Basin College	19.9	21.4	18.7	19.4	22.5	101.9	20.4
CB9005	Columbia Basin College	20.0	22.4	18.9	18.2	22.4	101.8	20.4
CB9006	Columbia Basin College	20.0	23.0	18.8	18.2	22.4	102.3	20.5
CB9007	Columbia Basin College	20.8	21.8	19.1	18.1	23.3	102.9	20.6
55V12	Pioneer Hi-bred Int. Inc.	20.6	22.1	19.2	18.2	22.8	102.8	20.6
CB001	Columbia Basin College	20.9	22.8	19.3	19.2	22.7	105.0	21.0
54Q25	Pioneer Hi-bred Int. Inc.	21.4	21.9	20.1	19.2	22.6	105.2	21.0
Masterpiece II	J.R Simplot Company	21.1	22.2	20.3	18.9	22.5	105.0	21.0
Grandstand	Crop Production Services	21.4	22.9	20.7	19.9	22.9	107.8	21.6
DKA 42-13	DeKalb	21.4	22.9	19.8	19.7	22.5	106.3	21.3
	Mean	**20.7**	**22.3**	**19.5**	**18.9**	**22.6**	**104.1**	**20.8**
	LSD 5%	**1.28**	**0.89**	**1.32**	**NS**	**NS**		
	CV %	**4.3**	**2.8**	**4.7**	**11.1**	**3.0**		

Table 7: First Harvest Year Results for Protein (4 cut)

Seeded 8/12/10

		2011 Harvests					
Entry	Company	Cut 1	Cut 2	Cut 3	Cut 4	Total	Average
CB9004	Columbia Basin College	19.2	17.6	18.1	17.1	71.9	18.0
CB9005	Columbia Basin College	19.8	18.6	18.1	17.1	73.7	18.4
CB9006	Columbia Basin College	19.1	17.8	19.2	17.8	73.8	18.4
CB9007	Columbia Basin College	20.1	18.0	18.2	17.8	74.2	18.5
55V12	Pioneer Hi-bred Int. Inc.	20.4	18.1	18.2	18.4	75.0	18.7
CB001	Columbia Basin College	20.3	16.2	19.3	19.6	75.4	18.9
54Q25	Pioneer Hi-bred Int. Inc.	19.6	18.1	18.2	18.4	74.3	18.6
Masterpiece II	J.R Simplot Company	19.8	18.6	18.5	17.6	74.4	18.6
Grandstand	Crop Production Services	20.6	19.7	19.6	19.1	78.8	19.7
DKA 42-13	DeKalb	19.5	18.1	18.9	19.3	75.7	18.9
	Mean	**19.8**	**18.1**	**18.6**	**18.2**	**74.7**	**18.7**
	LSD 5%	**1.11**	**1.71**	**NS**	**0.99**		
	CV %	**3.9**	**6.6**	**6.2**	**3.8**		



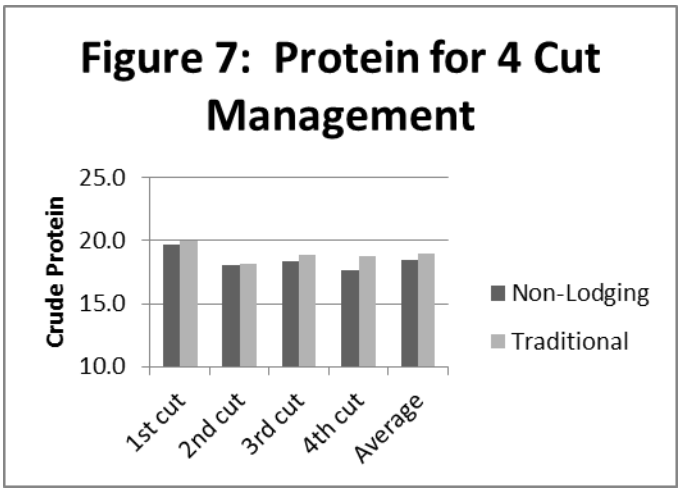


Table 8: First Harvest Year Results for Protein (3 cut)

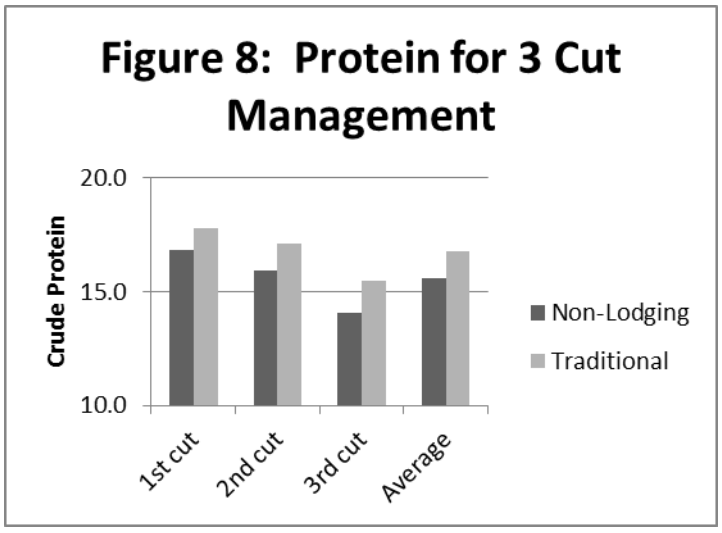
Seeded 8/12/10 — 2011 Harvests

Entry	Company	Cut 1	Cut 2	Cut 3	Total	Average
CB9004	Columbia Basin College	16.8	15.8	14.1	46.6	15.5
CB9005	Columbia Basin College	16.5	16.0	14.0	46.5	15.5
CB9006	Columbia Basin College	16.9	16.1	13.1	46.0	15.3
CB9007	Columbia Basin College	17.0	15.7	14.2	46.9	15.6
55V12	Pioneer Hi-bred Int. Inc.	16.9	16.2	15.0	48.1	16.0
CB001	Columbia Basin College	17.9	17.2	15.3	50.4	16.8
54Q25	Pioneer Hi-bred Int. Inc.	17.8	17.5	15.0	50.3	16.8
Masterpiece II	J.R Simplot Company	17.4	16.2	16.0	49.5	16.5
Grandstand	Crop Production Services	17.7	17.0	15.1	49.8	16.6
DKA 42-13	DeKalb	18.2	17.6	15.9	51.7	17.2
Mean		**17.3**	**16.5**	**14.8**	**48.6**	**16.2**
LSD 5%		**NS**	**1.07**	**1.26**		
CV %		**6.3**	**4.5**	**6.0**		

Table 9: First Harvest Year Results for Protein (2 cut)

Seeded 8/12/10 — 2011 Harvests

Entry	Company	Cut 1	Cut 2	Total	Average
CB9004	Columbia Basin College	12.2	13.6	25.8	12.9
CB9005	Columbia Basin College	11.2	12.8	24.0	12.0
CB9006	Columbia Basin College	12.1	12.8	24.9	12.4
CB9007	Columbia Basin College	12.1	13.8	25.9	12.9
55V12	Pioneer Hi-bred Int. Inc.	12.7	14.3	27.0	13.5
CB001	Columbia Basin College	15.2	15.5	30.7	15.4
54Q25	Pioneer Hi-bred Int. Inc.	13.4	14.4	27.8	13.9
Masterpiece II	J.R Simplot Company	13.9	13.8	27.6	13.8
Grandstand	Crop Production Services	14.3	14.8	29.1	14.5
DKA 42-13	DeKalb	13.9	14.3	28.2	14.1
Mean		**13.1**	**14.0**	**27.1**	**13.5**
LSD 5%		**2.03**	**1.64**		
CV %		**10.8**	**8.2**		



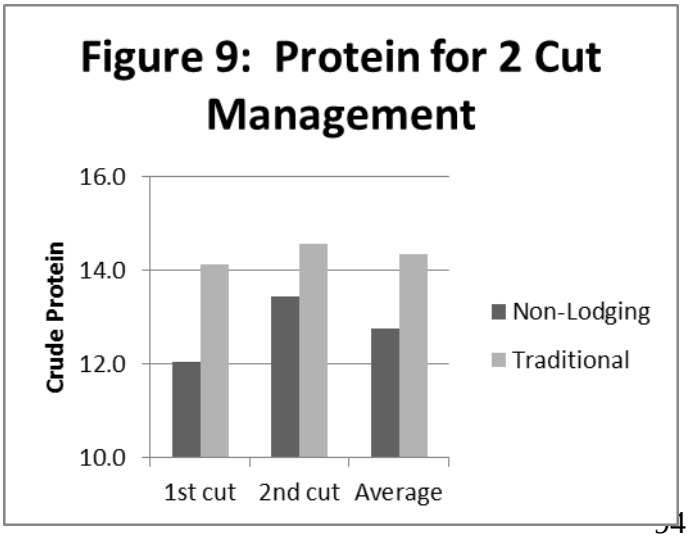
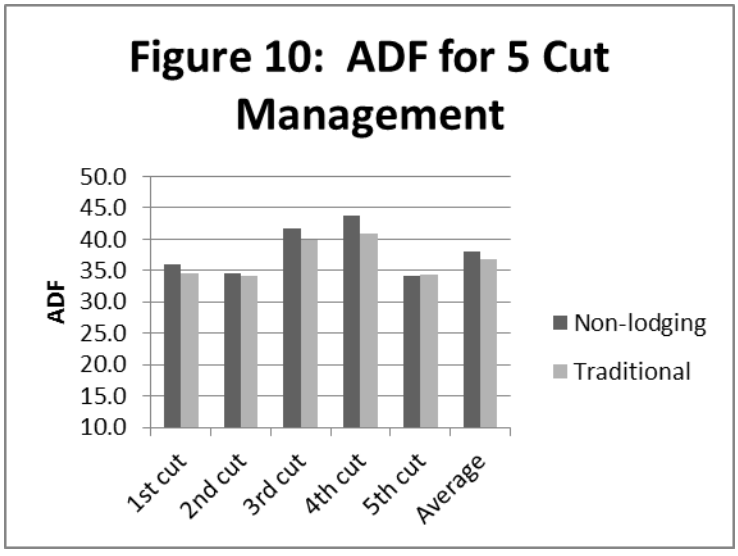


Table 10: First Harvest Year Results for ADF (5 cut)

Seeded 8/12/10		2011 Harvests						
Entry	Company	Cut 1	Cut 2	Cut 3	Cut 4	Cut 5	Total	Average
CB9004	Columbia Basin College	37.1	36.1	42.4	41.7	34.2	191.5	38.3
CB9005	Columbia Basin College	36.2	34.9	41.5	44.5	34.4	191.4	38.3
CB9006	Columbia Basin College	37.4	33.4	41.5	45.3	36.1	193.7	38.7
CB9007	Columbia Basin College	35.0	35.5	42.6	44.4	33.0	190.6	38.1
55V12	Pioneer Hi-bred Int. Inc.	34.2	33.2	40.2	43.1	32.7	183.5	36.7
CB001	Columbia Basin College	36.4	33.8	41.5	40.8	34.8	187.4	37.5
54Q25	Pioneer Hi-bred Int. Inc.	34.1	35.7	40.2	42.1	35.3	187.4	37.5
Masterpiece II	J.R Simplot Company	34.2	34.5	39.2	42.5	35.1	185.4	37.1
Grandstand	Crop Production Services	34.4	33.6	38.0	39.9	33.0	179.0	35.8
DKA 42-13	DeKalb	33.5	33.2	40.2	39.2	33.2	179.2	35.8
	Mean	**35.2**	**34.4**	**40.7**	**42.4**	**34.2**	**186.9**	**37.4**
	LSD 5%	**2.57**	**1.80**	**NS**	**NS**	**NS**		
	CV %	**5.1**	**3.7**	**5.8**	**11.2**	**5.3**		

Table 11: First Harvest Year Results for ADF (4 cut)

Seeded 8/12/10		2011 Harvests					
Entry	Company	Cut 1	Cut 2	Cut 3	Cut 4	Total	Average
CB9004	Columbia Basin College	37.0	43.2	40.6	43.8	164.6	41.1
CB9005	Columbia Basin College	36.3	42.4	40.3	41.4	160.3	40.1
CB9006	Columbia Basin College	38.2	43.8	39.1	42.5	163.6	40.9
CB9007	Columbia Basin College	33.8	42.7	40.6	42.7	159.8	39.9
55V12	Pioneer Hi-bred Int. Inc.	33.6	41.9	39.7	39.4	154.5	38.6
CB001	Columbia Basin College	34.4	46.6	37.5	39.5	157.9	39.5
54Q25	Pioneer Hi-bred Int. Inc.	35.6	42.1	40.3	43.1	161.0	40.3
Masterpiece II	J.R Simplot Company	35.0	42.1	40.0	43.5	160.5	40.1
Grandstand	Crop Production Services	33.8	39.7	38.2	41.3	153.0	38.2
DKA 42-13	DeKalb	35.2	42.6	38.4	43.0	159.1	39.8
	Mean	**35.3**	**42.7**	**39.5**	**42.0**	**159.4**	**39.9**
	LSD 5%	**2.46**	**3.66**	**NS**	**NS**		
	CV %	**4.9**	**6.0**	**5.3**	**6.3**		



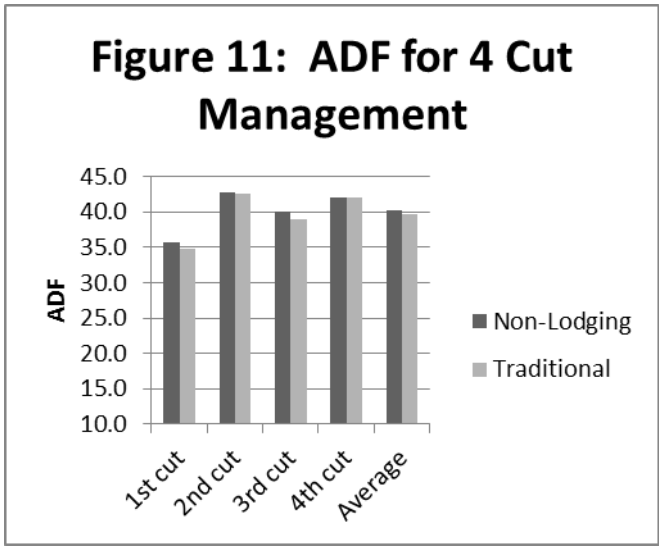
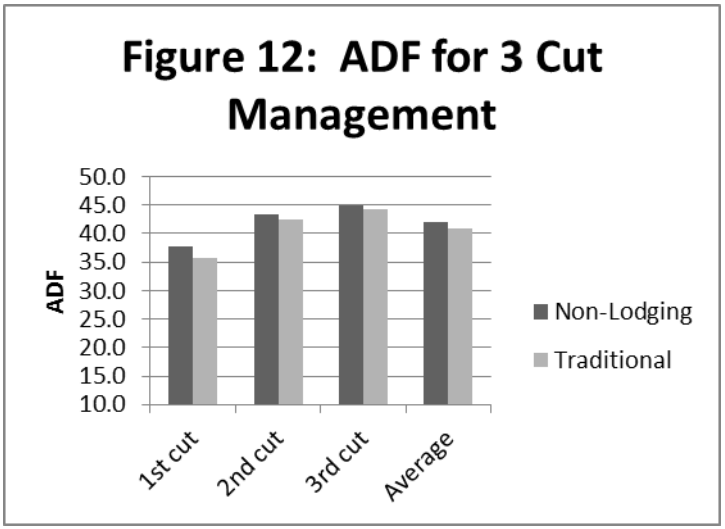


Table 12: First Harvest Year Results for ADF (3 cut)

Seeded 8/12/10		2011 Harvests				
Entry	Company	Cut 1	Cut 2	Cut 3	Total	Average
CB9004	Columbia Basin College	37.0	43.4	45.6	126.0	42.0
CB9005	Columbia Basin College	37.6	43.4	44.0	124.9	41.6
CB9006	Columbia Basin College	38.6	43.6	49.1	131.3	43.8
CB9007	Columbia Basin College	38.6	43.3	43.8	125.7	41.9
55V12	Pioneer Hi-bred Int. Inc.	37.2	42.5	42.3	122.0	40.7
CB001	Columbia Basin College	36.4	42.8	43.9	123.0	41.0
54Q25	Pioneer Hi-bred Int. Inc.	36.7	41.3	45.4	123.4	41.1
Masterpiece II	J.R Simplot Company	36.2	45.1	43.7	124.9	41.6
Grandstand	Crop Production Services	35.5	42.3	44.5	122.3	40.8
DKA 42-13	DeKalb	34.1	41.0	44.0	119.0	39.7
	Mean	**36.8**	**42.9**	**44.6**	**124.3**	**41.4**
	LSD 5%	**NS**	**NS**	**3.60**		
	CV %	**6.7**	**4.8**	**5.6**		

Table 13: First Harvest Year Results for ADF (2 cut)

Seeded 8/12/10		2011 Harvests			
Entry	Company	Cut 1	Cut 2	Total	Average
CB9004	Columbia Basin College	46.9	47.4	94.3	47.1
CB9005	Columbia Basin College	48.0	46.6	94.7	47.3
CB9006	Columbia Basin College	46.6	48.0	94.7	47.3
CB9007	Columbia Basin College	45.1	43.8	88.9	44.4
55V12	Pioneer Hi-bred Int. Inc.	44.6	44.2	88.8	44.4
CB001	Columbia Basin College	44.2	46.1	90.3	45.1
54Q25	Pioneer Hi-bred Int. Inc.	45.8	48.8	94.6	47.3
Masterpiece II	J.R Simplot Company	45.1	47.9	93.0	46.5
Grandstand	Crop Production Services	45.3	46.8	92.1	46.1
DKA 42-13	DeKalb	44.2	47.7	91.9	46.0
	Mean	**45.6**	**46.7**	**92.3**	**46.2**
	LSD 5%	**NS**	**NS**		
	CV %	**5.9**	**7.8**		



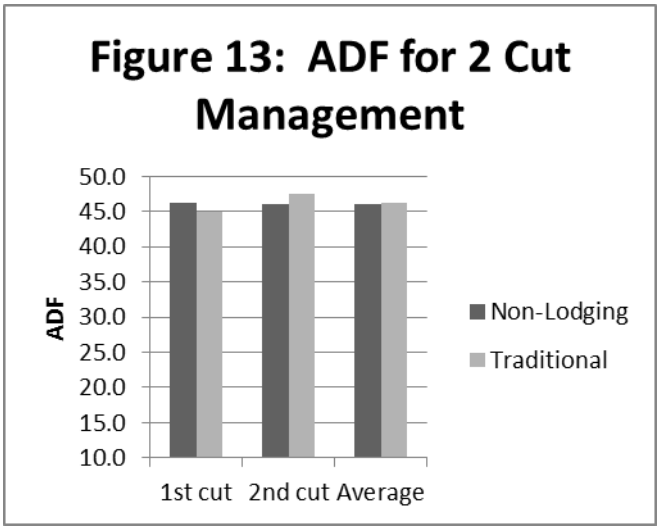
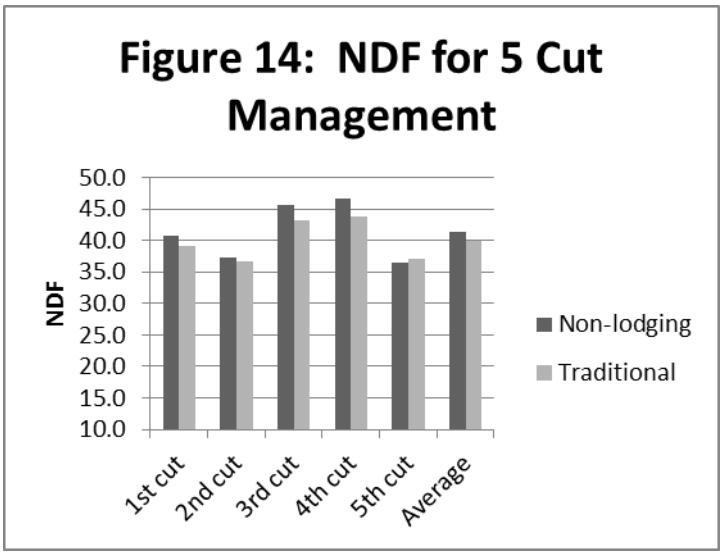


Table 14: First Harvest Year Results for NDF (5 cut)

Seeded 8/12/10		2011 Harvests						
Entry	**Company**	**Cut 1**	**Cut 2**	**Cut 3**	**Cut 4**	**Cut 5**	**Total**	**Average**
CB9004	Columbia Basin College	41.8	38.7	46.4	44.9	36.7	208.6	41.7
CB9005	Columbia Basin College	41.2	37.9	45.8	47.9	36.7	209.4	41.9
CB9006	Columbia Basin College	42.1	35.7	44.8	47.9	38.5	208.8	41.8
CB9007	Columbia Basin College	39.6	38.2	46.7	47.0	35.4	206.8	41.4
55V12	Pioneer Hi-bred Int. Inc.	38.7	35.7	44.2	45.7	35.5	199.8	40.0
CB001	Columbia Basin College	41.6	36.7	45.3	43.9	37.8	205.2	41.0
54Q25	Pioneer Hi-bred Int. Inc.	38.6	38.1	43.4	44.1	37.9	202.2	40.4
Masterpiece II	J.R Simplot Company	38.7	36.6	42.7	45.4	38.4	201.8	40.4
Grandstand	Crop Production Services	38.6	35.7	41.6	43.1	35.3	194.3	38.9
DKA 42-13	DeKalb	37.8	35.7	43.3	42.1	35.9	194.9	39.0
	Mean	**39.9**	**36.9**	**44.4**	**45.2**	**36.8**	**203.2**	**40.6**
	LSD 5%	**3.00**	**2.31**	**NS**	**NS**	**NS**		
	CV %	**5.3**	**4.4**	**6.4**	**10.6**	**5.5**		

Table 15: First Harvest Year Results for NDF (4 cut)

Seeded 8/12/10		2011 Harvests					
Entry	**Company**	**Cut 1**	**Cut 2**	**Cut 3**	**Cut 4**	**Total**	**Average**
CB9004	Columbia Basin College	41.9	47.5	45.1	47.6	182.0	45.5
CB9005	Columbia Basin College	41.4	46.7	45.0	45.8	178.8	44.7
CB9006	Columbia Basin College	43.4	48.0	43.3	46.8	181.4	45.4
CB9007	Columbia Basin College	38.5	47.4	45.1	47.4	178.4	44.6
55V12	Pioneer Hi-bred Int. Inc.	38.2	46.4	44.1	44.2	172.9	43.2
CB001	Columbia Basin College	39.0	51.6	41.4	44.3	176.3	44.1
54Q25	Pioneer Hi-bred Int. Inc.	40.7	46.5	44.9	46.8	178.8	44.7
Masterpiece II	J.R Simplot Company	39.8	45.8	44.5	47.5	177.6	44.4
Grandstand	Crop Production Services	38.3	43.8	42.5	44.9	169.5	42.4
DKA 42-13	DeKalb	40.0	46.9	42.6	46.4	175.8	44.0
	Mean	**40.1**	**47.1**	**43.8**	**46.1**	**177.1**	**44.3**
	LSD 5%	**2.75**	**NS**	**NS**	**NS**		
	CV %	**4.8**	**6.6**	**5.5**	**5.5**		



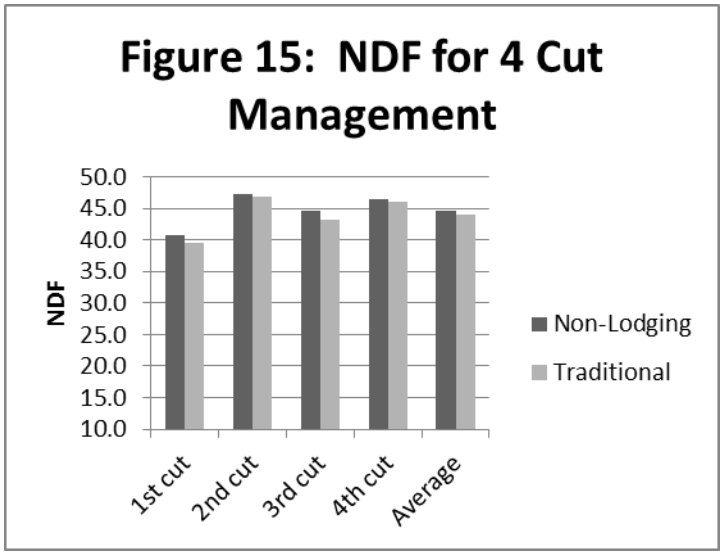
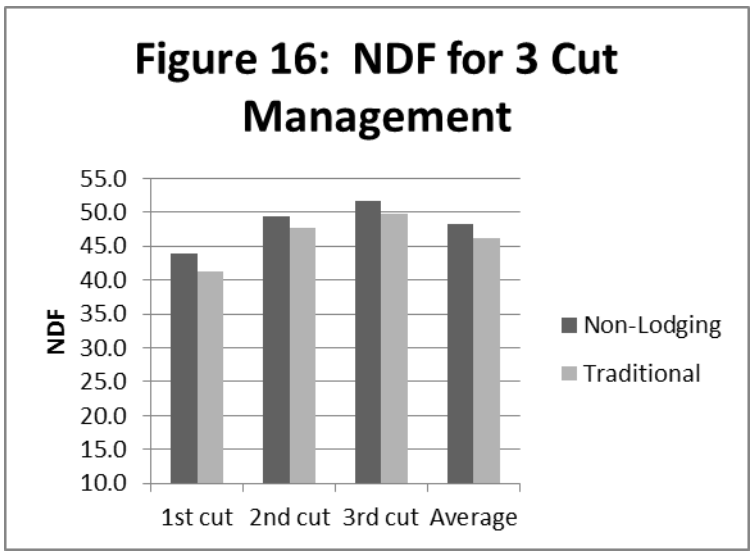


Table 16: First Harvest Year Results for NDF (3 cut)

Seeded 8/12/10		2011 Harvests				
Entry	**Company**	**Cut 1**	**Cut 2**	**Cut 3**	**Total**	**Average**
CB9004	Columbia Basin College	43.2	49.3	52.6	145.0	48.3
CB9005	Columbia Basin College	43.9	49.6	50.7	144.2	48.1
CB9006	Columbia Basin College	44.7	49.6	57.2	151.4	50.5
CB9007	Columbia Basin College	45.1	49.7	49.9	144.7	48.2
55V12	Pioneer Hi-bred Int. Inc.	43.1	48.5	48.5	140.0	46.7
CB001	Columbia Basin College	41.8	48.2	49.0	138.9	46.3
54Q25	Pioneer Hi-bred Int. Inc.	42.2	46.8	51.9	140.8	46.9
Masterpiece II	J.R Simplot Company	41.8	50.4	48.9	141.1	47.0
Grandstand	Crop Production Services	41.1	47.7	50.2	138.9	46.3
DKA 42-13	DeKalb	39.1	45.8	49.5	134.3	44.8
	Mean	42.6	48.5	50.8	141.9	47.3
	LSD 5%	**NS**	**NS**	**4.28**		
	CV %	**7.1**	**5.0**	**5.9**		

Table 17: First Harvest Year Results for NDF (2 cut)

Seeded 8/12/10		2011 Harvests			
Entry	**Company**	**Cut 1**	**Cut 2**	**Total**	**Average**
CB9004	Columbia Basin College	55.3	54.9	110.1	55.1
CB9005	Columbia Basin College	57.2	54.0	111.2	55.6
CB9006	Columbia Basin College	55.0	56.1	111.2	55.6
CB9007	Columbia Basin College	53.6	51.0	104.6	52.3
55V12	Pioneer Hi-bred Int. Inc.	52.5	51.3	103.8	51.9
CB001	Columbia Basin College	51.2	52.4	103.7	51.8
54Q25	Pioneer Hi-bred Int. Inc.	53.5	55.7	109.2	54.6
Masterpiece II	J.R Simplot Company	52.4	54.8	107.2	53.6
Grandstand	Crop Production Services	52.5	53.1	105.6	52.8
DKA 42-13	DeKalb	51.6	54.3	105.9	53.0
	Mean	**53.5**	**53.8**	**107.3**	**53.6**
	LSD 5%	**NS**	**NS**		
	CV %	**6.2**	**7.8**		



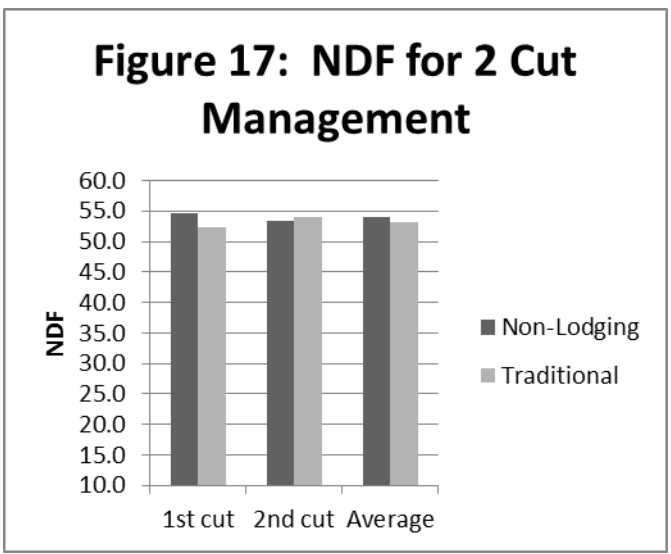


Table 18: First Harvest Year Results for DDM (5 cut)

Seeded 8/12/10

2011 Harvests

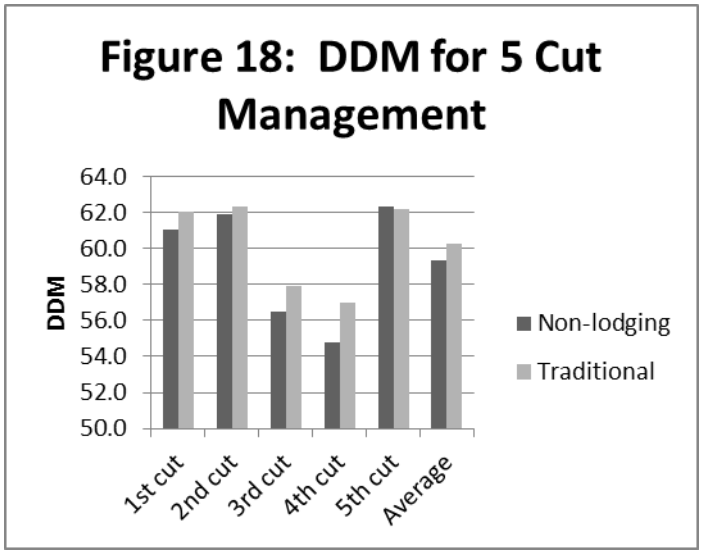
Entry	Company	Cut 1	Cut 2	Cut 3	Cut 4	Cut 5	Total	Average
CB9004	Columbia Basin College	60.8	60.8	55.9	56.4	62.2	296.1	59.2
CB9005	Columbia Basin College	60.8	61.7	56.6	54.2	62.1	295.4	59.1
CB9006	Columbia Basin College	59.8	62.9	56.6	53.6	60.7	293.6	58.7
CB9007	Columbia Basin College	61.6	61.2	55.7	54.3	63.2	296.1	59.2
55V12	Pioneer Hi-bred Int. Inc.	62.3	63.0	57.6	55.3	63.4	301.6	60.3
CB001	Columbia Basin College	60.6	62.5	56.6	57.1	61.8	298.6	59.7
54Q25	Pioneer Hi-bred Int. Inc.	62.4	61.1	57.6	56.1	61.4	298.5	59.7
Masterpiece II	J.R Simplot Company	62.3	62.1	58.4	55.8	61.5	300.0	60.0
Grandstand	Crop Production Services	62.2	62.7	59.3	57.8	63.2	305.1	61.0
DKA 42-13	DeKalb	62.8	63.1	57.6	58.4	63.1	304.9	61.0
	Mean	**61.5**	**62.1**	**57.2**	**55.9**	**62.3**	**299.0**	**59.8**
	LSD 5%	**1.41**	**1.41**	**NS**	**NS**	**NS**		
	CV %	**2.5**	**1.6**	**3.2**	**6.6**	**2.3**		

Table 19: First Harvest Year Results for DDM (4 cut)

Seeded 8/12/10

2011 Harvests

Entry	Company	Cut 1	Cut 2	Cut 3	Cut 4	Total	Average
CB9004	Columbia Basin College	60.1	55.2	57.3	54.8	227.4	56.8
CB9005	Columbia Basin College	60.7	55.9	57.5	56.7	230.7	57.7
CB9006	Columbia Basin College	59.2	54.8	58.5	55.8	228.2	57.1
CB9007	Columbia Basin College	62.6	55.7	57.3	55.7	231.2	57.8
55V12	Pioneer Hi-bred Int. Inc.	62.8	56.3	58.0	58.2	235.3	58.8
CB001	Columbia Basin College	62.2	52.6	59.7	58.1	232.6	58.1
54Q25	Pioneer Hi-bred Int. Inc.	61.2	56.2	57.5	55.4	230.2	57.6
Masterpiece II	J.R Simplot Company	61.7	56.1	57.8	55.1	230.6	57.6
Grandstand	Crop Production Services	62.6	58.0	59.2	56.7	236.5	59.1
DKA 42-13	DeKalb	61.5	55.7	59.0	55.4	231.6	57.9
	Mean	**61.4**	**55.6**	**58.2**	**56.2**	**231.4**	**57.9**
	LSD 5%	**1.9**	**2.9**	**NS**	**NS**		
	CV %	**2.2**	**3.6**	**2.8**	**3.6**		



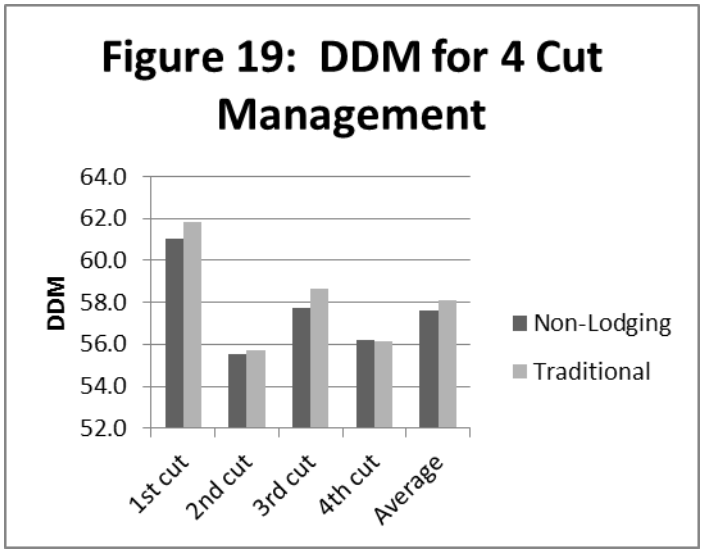
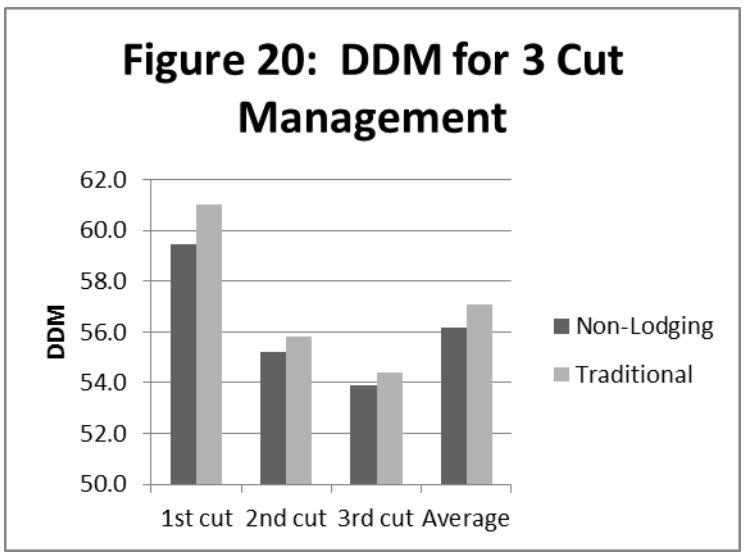


Table 20: First Harvest Year Results for DDM (3 cut)

Seeded 8/12/10		2011 Harvests				
Entry	**Company**	**Cut 1**	**Cut 2**	**Cut 3**	**Total**	**Average**
CB9004	Columbia Basin College	60.1	55.1	53.4	168.5	56.2
CB9005	Columbia Basin College	59.6	55.1	54.7	169.4	56.5
CB9006	Columbia Basin College	58.8	54.9	50.7	164.4	54.8
CB9007	Columbia Basin College	58.9	55.2	54.8	168.8	56.3
55V12	Pioneer Hi-bred Int. Inc.	59.9	55.8	55.9	171.6	57.2
CB001	Columbia Basin College	60.6	55.6	54.7	170.9	57.0
54Q25	Pioneer Hi-bred Int. Inc.	60.3	56.7	53.5	170.6	56.9
Masterpiece II	J.R Simplot Company	60.7	53.8	54.9	169.4	56.5
Grandstand	Crop Production Services	61.2	56.0	54.3	171.5	57.2
DKA 42-13	DeKalb	62.4	57.0	54.6	174.0	58.0
	Mean	**60.2**	**55.5**	**54.1**	**169.9**	**56.6**
	LSD 5%	**NS**	**NS**	**2.80**		
	CV %	**3.2**	**2.9**	**3.6**		

Table 21: First Harvest Year Results for DDM (2 cut)

Seeded 8/12/10		2011 Harvests			
Entry	**Company**	**Cut 1**	**Cut 2**	**Total**	**Average**
CB9004	Columbia Basin College	52.4	52.0	104.4	52.2
CB9005	Columbia Basin College	51.5	52.6	104.1	52.0
CB9006	Columbia Basin College	52.6	51.5	104.1	52.0
CB9007	Columbia Basin College	53.8	54.8	108.6	54.3
55V12	Pioneer Hi-bred Int. Inc.	54.2	54.4	108.6	54.3
CB001	Columbia Basin College	54.5	53.0	107.5	53.7
54Q25	Pioneer Hi-bred Int. Inc.	53.2	50.9	104.1	52.0
Masterpiece II	J.R Simplot Company	53.7	51.6	105.3	52.7
Grandstand	Crop Production Services	53.6	52.4	106.0	53.0
DKA 42-13	DeKalb	54.4	51.8	106.2	53.1
	Mean	**53.4**	**52.5**	**105.9**	**52.9**
	LSD 5%	**NS**	**NS**		
	CV %	**3.9**	**5.4**		



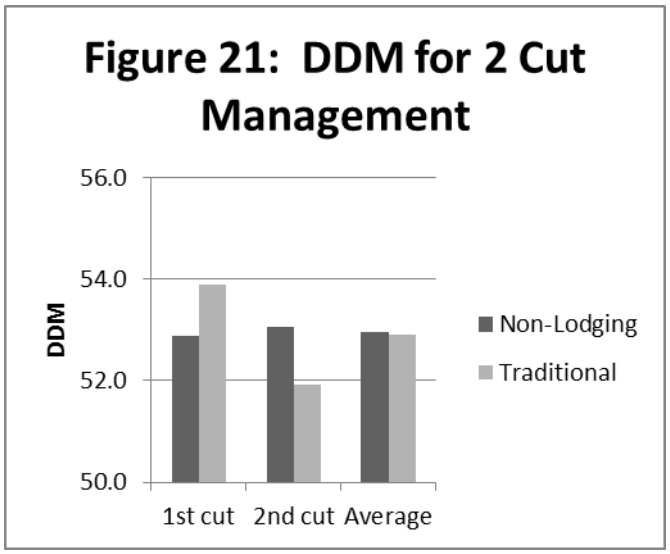
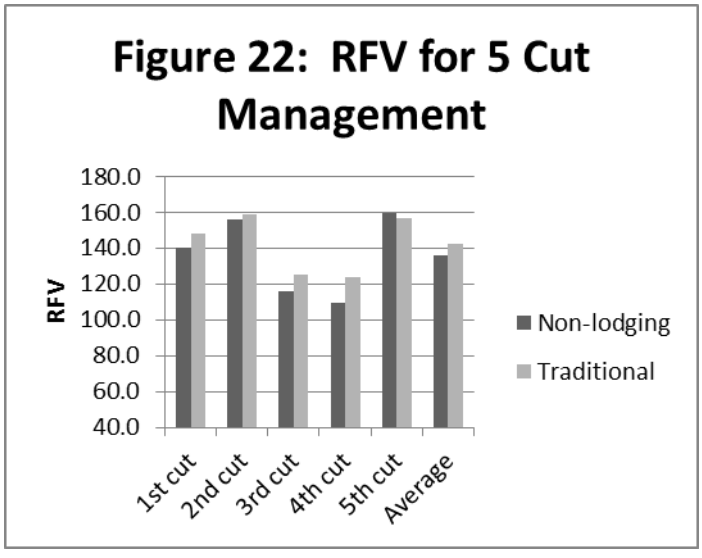


Table 22: First Harvest Year Results for RFV (5 cut)

Seeded 8/12/10		2011 Harvests						
Entry	**Company**	**Cut 1**	**Cut 2**	**Cut 3**	**Cut 4**	**Cut 5**	**Total**	**Average**
CB9004	Columbia Basin College	133.8	147.3	112.5	117.1	158.6	669.2	133.8
CB9005	Columbia Basin College	137.4	152.0	116.0	105.8	158.9	670.1	134.0
CB9006	Columbia Basin College	132.6	165.1	118.4	104.2	148.7	668.9	133.8
CB9007	Columbia Basin College	145.7	149.6	111.1	108.7	166.6	681.6	136.3
55V12	Pioneer Hi-bred Int. Inc.	150.4	164.4	121.6	113.1	166.6	716.0	143.2
CB001	Columbia Basin College	135.8	159.3	116.4	121.2	153.0	685.6	137.1
54Q25	Pioneer Hi-bred Int. Inc.	150.5	149.1	123.8	121.6	151.5	696.5	139.3
Masterpiece II	J.R Simplot Company	150.3	157.8	127.7	117.0	149.3	702.0	140.4
Grandstand	Crop Production Services	150.3	163.6	133.0	126.8	166.7	740.3	148.1
DKA 42-13	DeKalb	154.9	164.2	124.1	133.8	164.4	741.5	148.3
	Mean	**144.1**	**157.2**	**120.5**	**116.9**	**158.4**	**697.2**	**139.4**
	LSD 5%	**13.06**	**13.06**	**NS**	**NS**	**NS**		
	CV %	**7.4**	**5.8**	**9.5**	**17.5**	**7.4**		

Table 23: First Harvest Year Results for RFV (4 cut)

Seeded 8/12/10		2011 Harvests					
Entry	**Company**	**Cut 1**	**Cut 2**	**Cut 3**	**Cut 4**	**Total**	**Average**
CB9004	Columbia Basin College	133.5	108.6	118.5	107.7	468.3	117.1
CB9005	Columbia Basin College	136.3	111.5	118.8	115.3	481.9	120.5
CB9006	Columbia Basin College	127.0	106.9	126.5	111.1	471.5	117.9
CB9007	Columbia Basin College	152.0	109.6	118.2	109.9	489.6	122.4
55V12	Pioneer Hi-bred Int. Inc.	145.2	113.3	122.3	122.7	503.5	125.9
CB001	Columbia Basin College	148.6	95.4	134.4	122.5	500.8	125.2
54Q25	Pioneer Hi-bred Int. Inc.	140.6	113.4	120.1	111.2	485.3	121.3
Masterpiece II	J.R Simplot Company	144.3	114.3	121.1	108.0	487.6	121.9
Grandstand	Crop Production Services	152.2	124.8	131.4	118.0	526.4	131.6
DKA 42-13	DeKalb	144.1	111.0	129.4	111.5	495.9	124.0
	Mean	**142.4**	**110.9**	**124.1**	**113.8**	**491.1**	**122.8**
	LSD 5%	**1.9**	**2.9**	**NS**	**NS**		
	CV %	**6.4**	**10.2**	**8.6**	**8.8**		



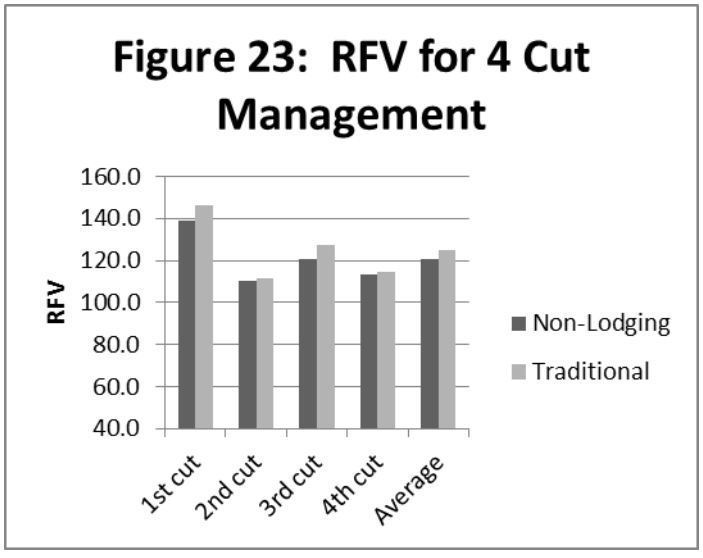
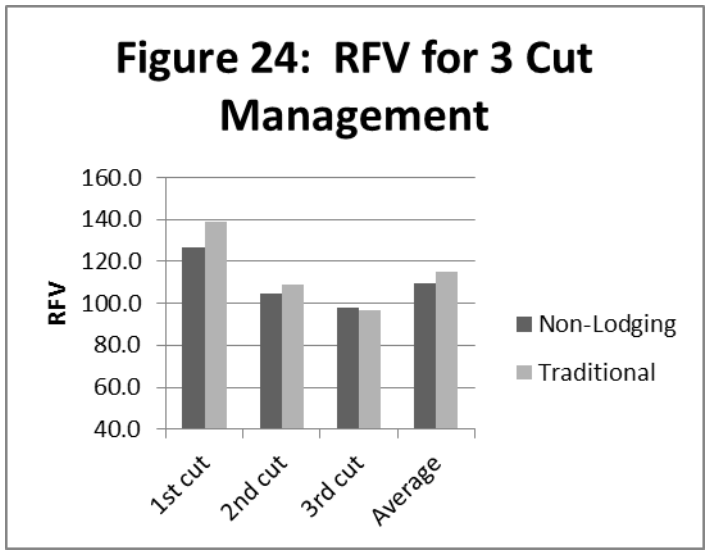


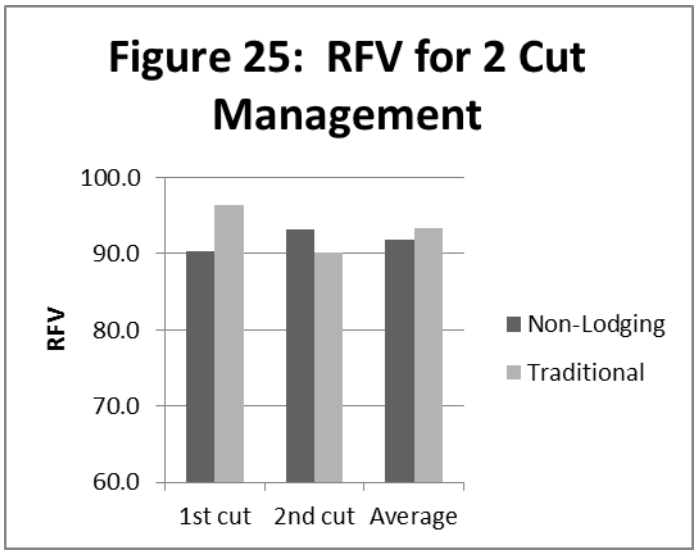
Table 24: First Harvest Year Results for RFV (3 cut)

Seeded 8/12/10		2011 Harvests				
Entry	**Company**	**Cut 1**	**Cut 2**	**Cut 3**	**Total**	**Average**
CB9004	Columbia Basin College	129.7	104.2	95.2	329.0	109.7
CB9005	Columbia Basin College	127.2	103.7	101.1	332.0	110.7
CB9006	Columbia Basin College	122.5	103.2	83.0	308.7	102.9
CB9007	Columbia Basin College	121.9	103.9	102.4	328.1	109.4
55V12	Pioneer Hi-bred Int. Inc.	130.9	107.4	107.9	346.1	115.4
CB001	Columbia Basin College	136.3	107.6	104.4	348.3	116.1
54Q25	Pioneer Hi-bred Int. Inc.	134.0	113.0	96.2	343.2	114.4
Masterpiece II	J.R Simplot Company	135.4	99.3	104.6	339.4	113.1
Grandstand	Crop Production Services	138.5	109.6	100.8	348.9	116.3
DKA 42-13	DeKalb	148.9	116.2	76.7	341.8	113.9
	Mean	**132.5**	**106.8**	**97.2**	**336.5**	**112.2**
	LSD 5%	**NS**	**NS**	**NS**		

Table 25: First Harvest Year Results for RFV (2 cut)

Seeded 8/12/10		2011 Harvests			
Entry	**Company**	**Cut 1**	**Cut 2**	**Total**	**Average**
CB9004	Columbia Basin College	88.6	88.4	177.0	88.5
CB9005	Columbia Basin College	84.2	91.1	175.3	87.6
CB9006	Columbia Basin College	89.2	86.0	175.3	87.6
CB9007	Columbia Basin College	93.5	101.2	194.7	97.3
55V12	Pioneer Hi-bred Int. Inc.	96.1	99.3	195.5	97.7
CB001	Columbia Basin College	99.1	94.8	193.9	97.0
54Q25	Pioneer Hi-bred Int. Inc.	93.4	85.1	178.5	89.2
Masterpiece II	J.R Simplot Company	95.7	89.0	184.7	92.4
Grandstand	Crop Production Services	95.9	92.0	187.9	94.0
DKA 42-13	DeKalb	98.2	89.6	187.8	93.9
	Mean	93.4	91.7	**185.0**	**92.5**
	LSD 5%	**NS**	**NS**		
	CV %	**9.7**	**13.2**		





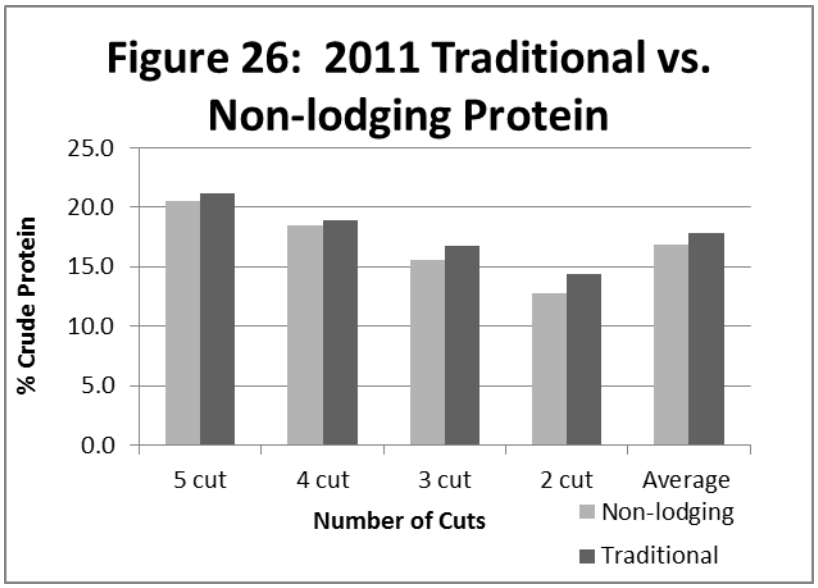


Figure 26: 2011 Traditional vs. Non-lodging Protein
% Crude Protein
25.0
20.0
15.0
10.0
5.0
0.0
5 cut
4 cut
3 cut
2 cut
Average
Number of Cuts
Non-lodging
Traditional

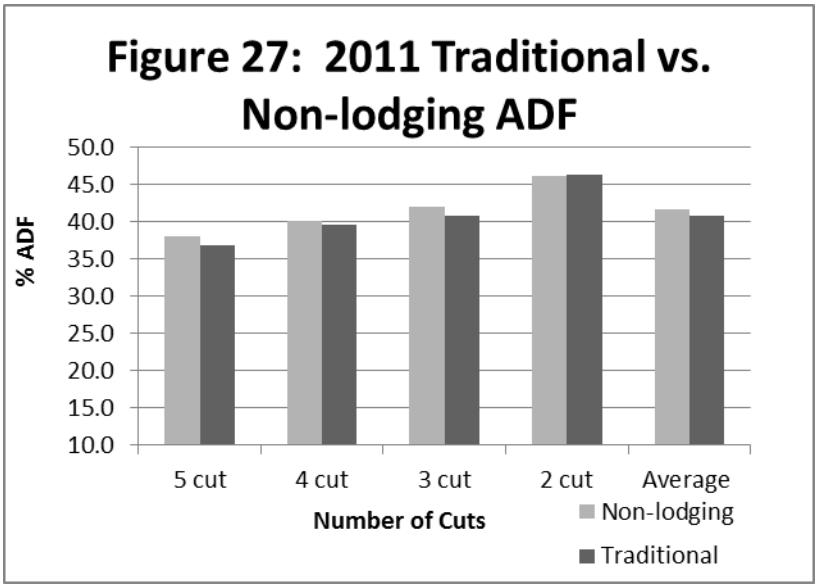


Figure 27: 2011 Traditional vs. Non-lodging ADF
% ADF
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5 cut
4 cut
3 cut
2 cut
Average
Number of Cuts
Non-lodging
Traditional

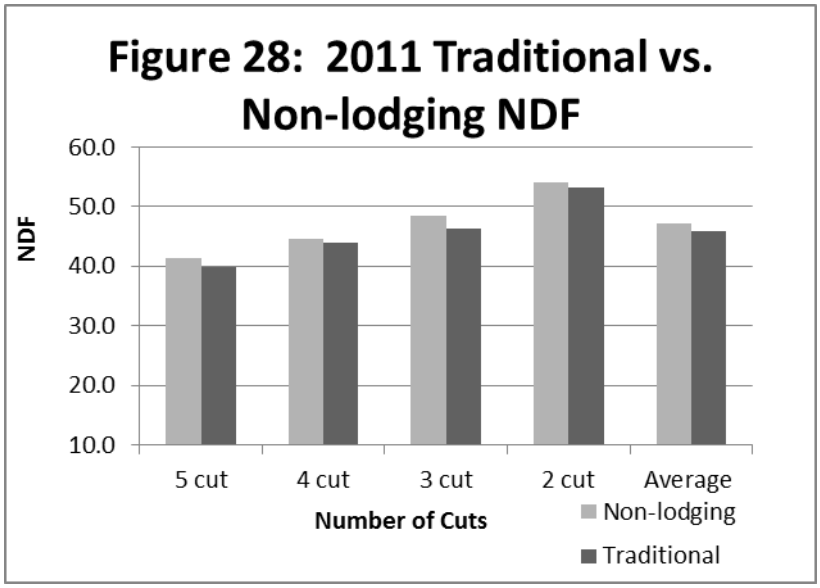


Figure 28: 2011 Traditional vs. Non-lodging NDF
NDF
60.0
50.0
40.0
30.0
20.0
10.0
5 cut
4 cut
3 cut
2 cut
Average
Number of Cuts
Non-lodging
Traditional

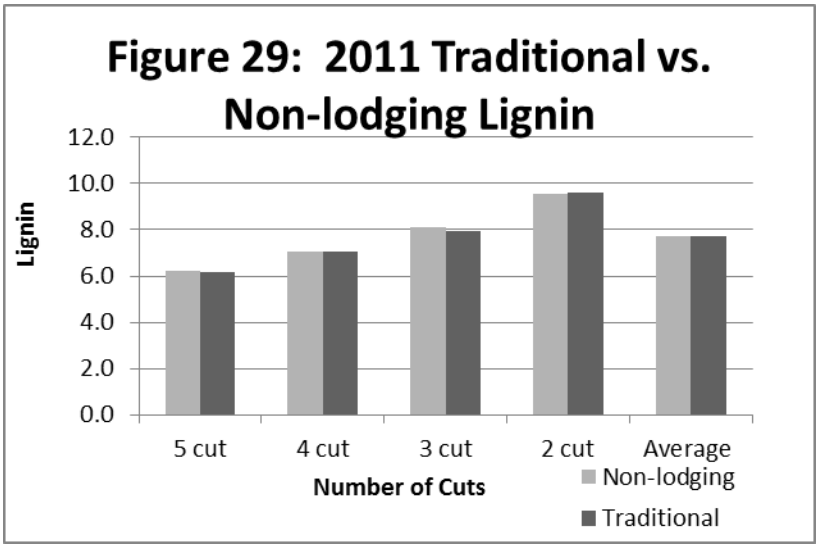


Figure 29: 2011 Traditional vs. Non-lodging Lignin
Lignin
12.0
10.0
8.0
6.0
4.0
2.0
0.0
5 cut
4 cut
3 cut
2 cut
Average
Number of Cuts
Non-lodging
Traditional

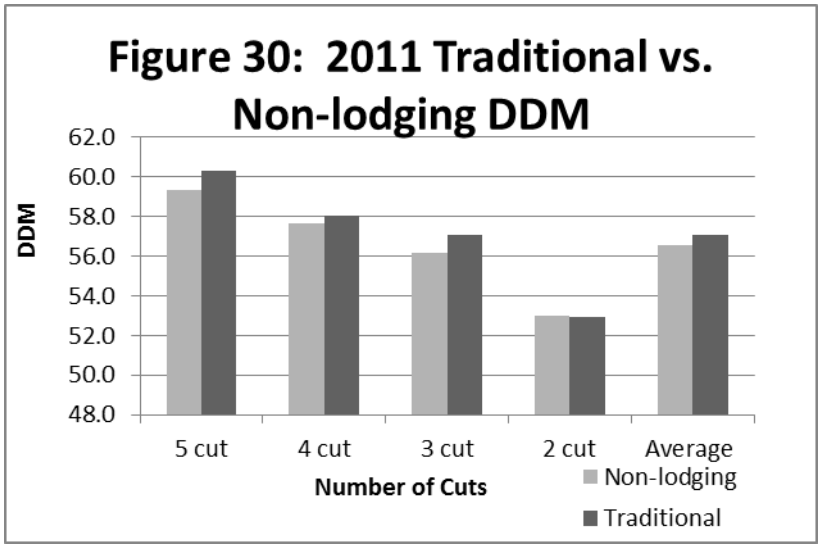


Figure 30: 2011 Traditional vs. Non-lodging DDM
DDM
62.0
60.0
58.0
56.0
54.0
52.0
50.0
48.0
5 cut
4 cut
3 cut
2 cut
Average
Number of Cuts
Non-lodging
Traditional

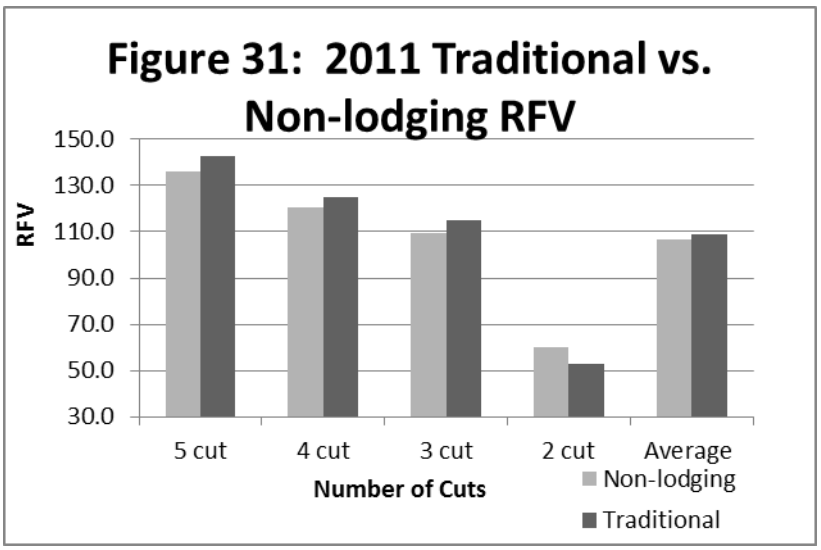


Figure 31: 2011 Traditional vs. Non-lodging RFV
RFV
150.0
130.0
110.0
90.0
70.0
50.0
30.0
5 cut
4 cut
3 cut
2 cut
Average
Number of Cuts
Non-lodging
Traditional

Attachment 12

A PLAN FOR ALFALFA RESEARCH AND DEVELOPMENT

COLUMBIA BASIN COLLEGE

William T. W. Woodward

A. Introduction

Because of the impact of alfalfa as a forage crop on society, improvement of the crop and production systems by researchers and educators has been superior. Public research and education for the crop was strong until the early 80's and has declined since. A good example of this can be found in the state of Washington with the loss of forage positions and focus on forages at both USDA and WSU in Prosser. Recently, WSU asked the extension forage specialist to focus on crops that would provide funding rather than continue research on forage crops. In the last ten years, WSU extension as lost more than half of their faculty and currently only one faculty member focuses on forage crops. It has been left up to industry to determine economic traits eligible for improvement. Industry decisions are based on return on investment with research focused on traits that could add to the bottom line. In recent years the focus has been on patentable value added traits such has herbicide resistance. Because higher sales with better margins occur in the Midwest and Eastern parts of the United States, traits that are important in the Pacific Northwest have been ignored unless they are also important to the high margin areas.

Alfalfa research and education programs within Columbia Basin College along with collaborative efforts with WSU could be a local, state, regional, national and international source of knowledge, education, and training. Goals include: (1) Develop superior plant materials for local, state, national and international use; (2) Develop, assimilate and disseminate science-based information for the production of alfalfa; and (3) Integrate alfalfa research and development into student learning.

B. BACKGROUND INFORMATION

According to the USDA National Agricultural Statistics Service, the value of all hay in Washington in 2016 was about $976 million while the value of alfalfa hay was about $311 million. Among agricultural commodities, hay value ranks sixth in Washington. In 2016 there were 870 thousand acres of hay harvested with alfalfa making up 440 thousand of those acres. Grant and Franklin counties grow about 43 percent of all hay acres and 45 percent of the alfalfa acreage in the state. The two counties produce 60% of the alfalfa hay in Washington with the Columbia Basin Counties producing about 75% of the alfalfa. The major Washington ports have stated that forage crops which include alfalfa and timothy grass hay is the number one export crop by volume and third by value. The export hay products are processed by over 25 processor businesses in the state with the majority exported to China, Japan, Korea and Taiwan.

C. GOALS AND OBJECTIVESf

Goal 1. Develop superior plant materials for local, state, national and international use.

- Develop high-yielding, disease and insect resistant, excellent quality varieties of alfalfa
- Focus on traits important to the PNW and ignored by industry. The traits include the blue alfalfa aphid, clover root curculio, root knot and stem nematode.
- Develop an alfalfa variety for use in cellulosic ethanol production.

Goal 2. Develop, assimilate and disseminate science-based information for the production of alfalfa.

- Through timely knowledge transfer and dissemination, improve the capability for forage alfalfa producers to be successful
- Utilize all research information available to develop recommendations for optimizing economic returns from alfalfa production.
- Expand public knowledge of alfalfa production to help create an informed citizenry.

Goal 3. Integrate alfalfa research and development into student learning.

- Provide students with the opportunity to combine research with entomology by providing hands-on experience with selecting and evaluating resistant plants and alfalfa varieties for insect resistance.
- Provide students with the opportunity to learn experimental design from the planning stage to report writing and presentation to an audience.
- Provide students with the opportunity to combine product development with nematology by selecting alfalfa plants resistant to stem and/or root knot nematode.
- Provide students with business learning opportunities by following a product through development, production, marketing and sales.

D. CURRENT ALFALFA PROGRAM

1. Faculty, Technical Support and Operating Budget

The Columbia Basin College alfalfa program is beginning to mature with 1 FTE and support from the maintenance and grounds department. An operating budget has not been established. A director of Agriculture Education, Research and Development was hired in 2017 to potentially replace the 1 FTE currently running the program. Support with a research technician will be needed to continue the program.

2. Equipment, Facilities, and Land

As of July 2017, available equipment includes:

o. 1 5060 New Holland tractor
p. 1 Case tractor with front end loader
q. 1 small Kubota tractor
r. 1 small plot combine (donated)

s. 1 Carter Forage Harvester (for harvesting small forage plots)
t. 1 forage drier (for drying forage sample and pepper pods)
u. 2 rotovators
v. 1 sprayer
w. 1 seed bed preparation attachment
x. 1 small disk (good for research plots)
y. 1 10 ft. disk for larger fields
z. 1 large cultipacker (good for larger increase blocks)
aa. 1 small cultipacker (good for research plots)
bb. 1 Hege plot planter (good for planting research and increase blocks). The planter needs cone and seed monitor.
cc. 2 Computers and a lap top
dd. 2 Printers
ee. 1 pickup (a new one purchased with agriculture sales in 2017)

Facilities include:

e. 30 X 60 foot greenhouse with head house
f. 30 X 40 foot greenhouse (to be completed in 2018)
g. 16 X 38 foot storage garage (increased to encompass the entire K building)
h. 29 X 62 foot Office and dry lab facility
i. Use of campus facilities including wet lab, science lab, classroom, and meeting rooms.

Land includes:

f. 8 acre hand line farm on campus
g. 15 acre under pivot irrigation
h. 1 acre under flood irrigation
i. 1.5 acre off-site stem nematode test (farmer cooperator)
j. 42 acre alfalfa strip test (farmer cooperator) no longer in production
k. 28 acre alfalfa strip test (farmer cooperator) no longer in production

E. VARIETY AND GERMPLASM DEVELOPMENT

Figure 1 outlines components of a successful plant improvement program, and program steps are described below.

1. General Plant Improvement Program

a) Conventional Germplasm Modification and Development – The definition of germplasm is a pool of genetic diversity of a crop species which includes wild relatives, plant introductions, intermating populations, breeding lines and developed varieties. When considering biotechnology, tissue culture lines, cell lines, molecular genetic libraries of genes and gene constructs can be part of the genetic germplasm pool. Conventional germplasm modifications include the use of genes from wild relatives; identifying adapted genotypes from unadapted lines, increasing gene frequency of desirable genes, and development of lines and varieties for specific traits. Variety development for alfalfa typically

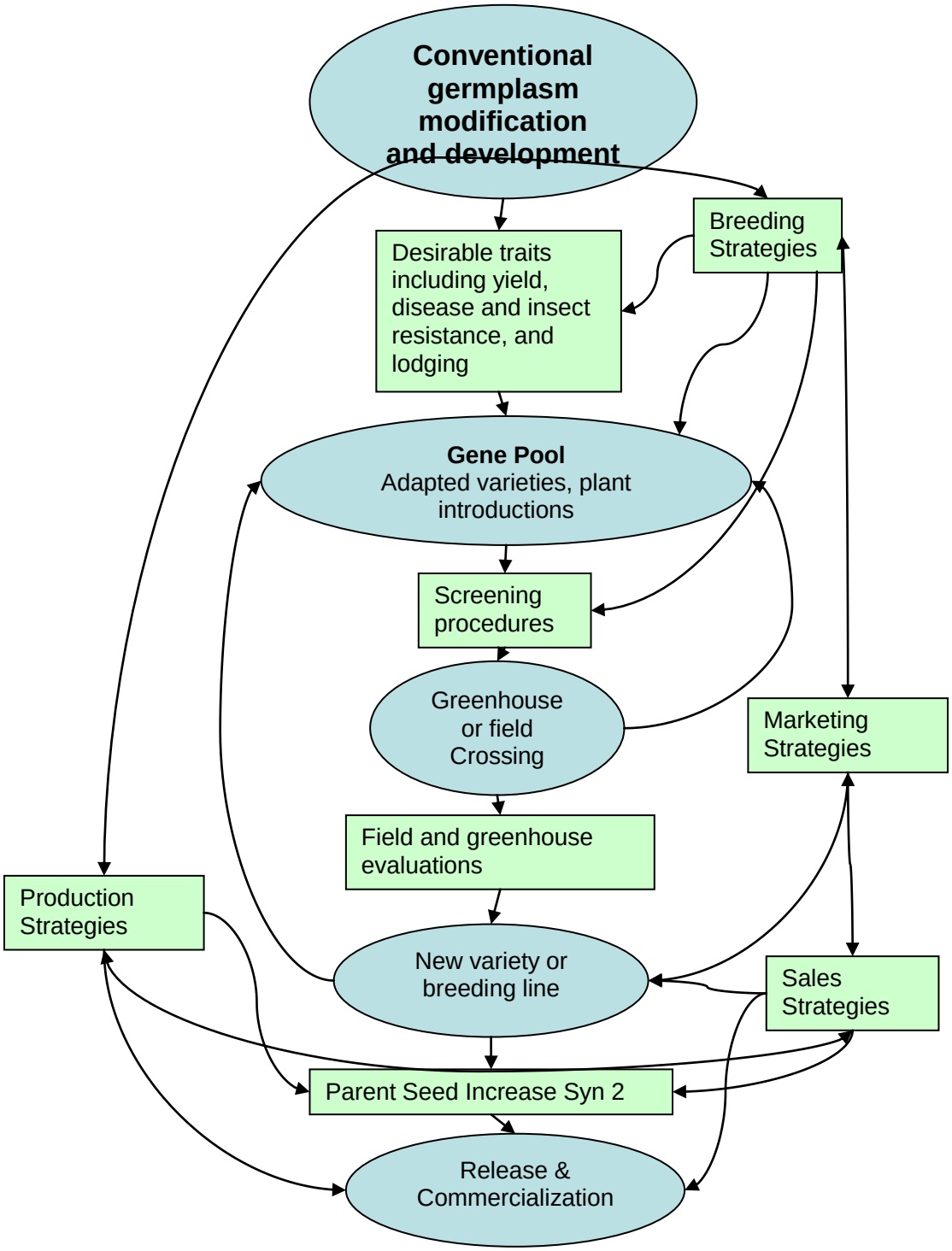
involves populations or individual plants altered in one or more of five broad categories.

- Yield – Changes in the ability to produce increase biomass.
- Physiological traits – Modifying characteristics such and height, winter hardiness, lodging, multifoliolate leaves, regrowth.
- Disease resistance – Developing varieties or germplasm with improvements in resistance to pathogens or pathogenesis-related processes.
- Insect resistance – Developing varieties or germplasm with improvements in resistance to insects.
- End-use traits – Modifying germplasm to produce improved quality. In the case of cellulosic ethanol, increase production of cellulose.

b) Crossing Block – Crossing is the process of hybridizing selected trait specific plants. For alfalfa it typically involves effort of the plant breeder or geneticist. Breeding strategies used in crossing include the clonal and progeny evaluation, population breeding, strain crossing, and backcrossing methods. Crossing blocks can be in the field or greenhouse using bees or hand crossing. Screening procedures vary and differ with individual traits and desired population outcomes. Typically, alfalfa lines are intercrossed among 75- 200 plants to avoid inbreeding or from 4 to 16 clones that have been tested using progeny row evaluation. Lines are tested for desirable traits and if deficient are placed back into the gene pool.

c) Field and Greenhouse evaluations – Plant breeders are involved in evaluating numerous agronomic, pathological, and entomological traits in the field. In addition, greenhouse evaluations for pest traits are often a more precise and economical way to handle larger numbers of lines. For example the screening and testing for the blue alfalfa aphid can be done in an isolated greenhouse avoiding the contamination by other aphids that could impact the outcome.

Figure 1. COMPONENTS OF A SUCCESSFUL ALFALFA BREEDING PROGRAM



d) Multiplication and Variety Release – Promising lines that the plant breeder has identified as potential varieties go through three stages of seed increase. They include breeder, parent (foundation seed), and commercial seed. Breeder seed is the result of a small increase block that range in size but typically about 2000 sq. ft. Parent seed is the generation of seed that will be used by the farmer to establish commercial seed fields and range in size from 1 acre to 10 depending on the size of the market. Breeder seed is used for evaluation purposes as well as for seed increase. Breeder seed is stored until the evaluation process is complete and if the line is acceptable as a new variety release, the stored breeder seed is used for the production of parent seed. If the line is unacceptable, then it goes back to the germplasm pool.

2. Breeding

Plant breeding is the science and art of the genetic improvement of plants. The breeding program at Columbia Basin College is familiar with all steps necessary for developing improved varieties of alfalfa. Specifically, it recognizes phenotypes of genetic traits, and also the physiological, pathological, and entomological responses important for adaptation, yield, and forage quality. The CBC breeding program is also familiar with the techniques required for evaluating genetic potential for all traits of interest. Knowledge of the requirements for variety naming, certification, plant variety protection, and review board applications is available.

3. Entomology and its role in the CBC alfalfa improvement program

Major areas to be addressed in alfalfa entomology research include blue alfalfa aphid, spotted alfalfa aphid, green pea aphid, cow pea aphid, alfalfa weevil, clover root curculio, lygus bug and thrips. Techniques are available and facilities are available for the selection of all of the aphid species. Selection among glandular hair genotypes could provide a solution for weevil control. It would be difficult to select for clover root curculio resistance per se, however, selection for crown rot resistance caused by the insect could provide beneficial results. Although most entomologists have stated that there is no yield decline due to thrip infestations, many of the growers in the Columbia Basin have stated that they see a significant alteration of plant growth causing reduced yield. Selecting for resistance to thrips may be difficult as there does not seem to be variation for resistance among alfalfa germplasm.

Economic threshold and economic injury levels have been developed for aphids and the alfalfa weevil. In addition, there is good resistance in current varieties for pea and spotted aphid. In Washington, there is evidence that resistance to the blue alfalfa aphid and the cowpea aphid is either non-existent or at a low level. Many growers routinely spray pesticides for aphid control on alfalfa in the fall. The reason is due to past experience with stunted plants and slow regrowth the next spring. The primary culprit is the blue alfalfa aphid as it injects a toxin into the plants that causes stunting and reduced carbohydrate reserves for the following

regrowth of the crop. Blue aphid resistance would eliminate the need for fall pesticide applications.

The cowpea aphid has recently moved into the state of Washington and many other states from the PSW. In 2005, it became severe enough to warrant the use of pesticides for control. Little research has been done on the insect and no varieties have been developed that have resistance. The development of resistant varieties for the PNW would help eliminated the need for pesticide use.

The clover root curculio has been identified in field throughout Washington and part of Oregon. Idaho entomologists have indicated that it is also present in their state. It has been determined that a rotation with a grass species will help control curculio for a short period of time. However, alfalfa yield declines occur in the third year of the crop due to crown and root diseases that infest after damage by the clover root curculio. Selection for germplasm that have better resistance to the root and crown damaging organisms would allow for a better yield potential for the third and forth production years of alfalfa. Field screenings appear to be the best method for better alfalfa performance in the presence of clover root curculio.

4. **Nematology and its role in the CBC alfalfa improvement program**

There are a number of plant parasitic nematodes that affect alfalfa. They include the alfalfa stem nematode (*Ditylenchus dipsaci)*, root knot nematodes *(Meloidogyne species)*, and root lesion nematodes *(Pratylenchus species)*. In addition the stubby root nematode has been observed to remove enough nodules and root hairs to reduce spring growth. Because these nematodes are present under irrigated condition and not considered to be economically damaging to the major part of the alfalfa seed market, little effort is made by industry to breed for high levels of resistance.

A root knot nematode resistant variety with a high level of resistance would not only allow for higher yields for the alfalfa crop, but, would allow the potato grower to rotate with alfalfa without the need for fumigation of the field. Potato and alfalfa are a common rotation in the PNW.

Although work is currently being done on stem nematode resistance, there seems to be a problem with the screening techniques and the evaluation procedures. It is possible to develop a variety with high enough levels of resistance to prevent economic damage. A non-dormant variety (GT13R+) has demonstrated economic levels of resistance in Spain, Chili and California. However, it is only one of the many non-dormant varieties released that has passed the test. In the Yakima River Basin and during cool wet springs in the Columbia Basin, stem nematode can be devastating. There is a need for a dormant alfalfa variety with economic resistance to the nematode.

5. **Plant Pathology and its role in the CBC alfalfa improvement program**

Diseases can be a major factor in alfalfa production in the PNW. The common diseases that occur on alfalfa in the PNW include bacterial wilt *(Clavibacter*

michiganense subsp insidiosum), Fusarium wilt *(Fusarium oxysporum f.sp. medicaginis)*, anthracnose *(Colletotrichum trifolii)*, Phytopthora root rot *(Phytophthora megasperma f. sp. medicaginis)*, Verticillium Wilt (*Verticillium albo-atrum)*, Schlerotinia sp., Aphanomyces *(Aphanomyces euteiches)*, downy mildew *(Peronospora trifoliorum)*, Crown rot complex *(Complex of various pathogens: Fusarium, Pythium, Rhizoctonia, Phoma & Stagonospora)*and numerous leaf diseases.

Verticillium wilt was first identified in Washington in 1976. Since then it has spread through the rest of the US. Most proprietary varieties on the market today have excellent resistance to the disease. However, older and some newer varieties are susceptible. Verticillium wilt can cause sever stand loss and yield declines, thus, new varieties must have a high level of resistance to the disease. Excellent resistance to anthracnose, Phytophthora, bacterial wilt and Fusarium wilt has been bred into most proprietary alfalfa varieties. Resistance to the crown rot complex accelerated by clover root curculio damage still remains a problem.

6. **Major Breeding Focus**

   The major thrust for the CBC alfalfa breeding program will be directed at traits that are major problems for the PNW and largely ignored by industry. They would include:

   a) Enhanced stem nematode resistance
   b) Enhanced root knot nematode resistance
   c) Stand and yield decline due to clover root curculio
   d) Blue alfalfa aphid resistance
   e) Cowpea aphid resistance
   f) Enhanced varieties for cellulosic ethanol production
   g) Maintenance of resistance to major diseases such as Verticillium Wilt

F. PROGRESS IN REACHING GOALS AND OBJECTIVES

1. 65 experimental varieties or germplasms have been developed utilizing both recurrent selection and half sib selection using progeny rows. Varieties and germplasms were selected for one or more of the following traits:
   a) Clover root curculio
   b) Stem nematode
   c) Root knot nematode
   d) Yield utilizing progeny rows
   e) Pink biotype of the green pea aphid
   f) Non-lodging for biomass potential
2. 4 foundation seed increase fields for advanced varieties
3. 1 small commercial field with seed sold to local growers
4. Over 75 presentations related to outreach to growers, students, legislators and others.
5. 14 student workers of which 10 have jobs and 4 continuing their education at Eastern Oregon.

Attachment 13

EFFECTS OF CUTTING MANAGEMENT ON FORAGE YIELD OF TRADITIONAL AND NON-LODGING ALFALFA CULTIVARS
Progress Report

William T. W. Woodward[11], Christopher Lamm,
Eliseo Navarro, and David Mitchell

ABSTRACT

In Washington, alfalfa is used for feeding livestock and as an export product in the form of cubes and double compressed bales. Another future market could be alfalfa use as a biofuel. It is a perennial crop that is high yielding, reduces erosion, removes leftover nitrates left by annual crops, requires no additional nitrogen due to its ability to fix nitrogen from the air, and is widely adapted. A non-lodging alfalfa is needed under pivot irrigation if cutting frequency is to be reduced to provide lower input costs. An experiment was established at Columbia Basin College (CBC) to determine yield and quality performance of 5 non-lodging varieties and 5 traditional varieties under 4 cutting management systems (5, 4, 3, and 2 cuts). In the first year of the experiment, no differences were found for total yield among cultivars in the 5 cut or 4 cut system. However, significant differences were found among varieties in the 3 and 2 cut systems where the trend for the non-lodging cultivars to yield more than the traditional cultivars was observed. In the 2 cut system, one non-lodging cultivar (CB9004) yielded 67% more than the highest yielding traditional cultivar. In general, yields trended downward for each cultivar from a 5 cut system to a 2 cut system. However, one cultivar maintained over 11 tons of dry matter for each system. Due to sample preparation time, forage quality components have not been determined.

Key Words: alfalfa, cutting management, lodging

INTRODUCTION

More than 19 million acres of alfalfa was harvested in the United States in 2011. Average yields ranged from 7.9 ton/acre in Arizona to 1.3 tons/acre in Oklahoma. In 2011, Washington ranked fourth among states in yield per acre at 4.8 tons. However, Grant County and Franklin County produce about 6.7 and 7.2 tons/acre respectively on average. Many of the growers in these counties have produced more than 10 tons/acre.

Alfalfa has some advantages over a grass crop when considered as a biofuel feedstock. As a deep rooted perennial, alfalfa can reduce erosion and nutrient leaching. It will take up available nitrate prior to releasing its unique nitrogen fixation mechanism removing potential ground water contamination and later providing its own nitrogen through fixation. After an average persistence of 4 years, nitrogen is left behind for the following rotational crop. Alfalfa is one of the few crops that can be considered a friend to the soil.

[11] Dean of Agriculture Education, Research and Development, Columbia Basin College and agriculture students attending CBC, Pasco, WA, December 14, 2011. CBCAG1104. **In:** Proceedings, 2012 Washington State Hay Growers Association Annual Conference & Trade Show.

The DOE dismissed alfalfa as a potential biofuel feedstock due to its value as an animal feed. However, if leaves were separated from stems, half of alfalfa could be used as a highly digestible high protein feed. The stems could be used for biofuel. In order to make this work in Washington, there will be a need to reduce input costs. Reducing the number of cuts and lengthening stand life would help. To reduce the number of cuts an alfalfa variety would need to remain erect to eliminate leaf loss and diseases that occur with lodged alfalfa. The traditional alfalfa varieties tend to lodge under pivot irrigation.

CBC has been working on non-lodging varieties for several years. A cutting management experiment was established in the fall of 2010 to test non-lodging varieties with traditional varieties under 2, 3, 4 and 5 cut systems. The experiment will help determine if non-lodging varieties could be used in multiple markets and determine forage quality and yield variation among management systems. In this report forage quality components have not been determine due to forage sample preparation time.

MATERIALS AND METHODS

On August 12, 2010 cutting management test was planted in a split block design with 4 cutting managements and 10 varieties. Entries were replicated 4 times within cutting managements. For the purposes of this report, each cutting management was analyzed as a randomized complete block. The 10 entries were represented by 5 non-lodging cultivars including CB9004, CB9005, CB9006, CB9007 (CBC experimental cultivars) and Pioneer's non-lodging variety 55V12; 5 traditional cultivars including CB001 (CBC experimental), 54Q25, Masterpiece II, Grandstand, and DK42-13.

Dates for cutting for the 5 cut system were: May 16, June 16, July 19, August 22 and Sep. 26. For the 4 cut system, the dates were: May 20, July 1, August 15, and Sep. 26. For the 3 cut system, the dates were: May 31, July 29, and Sep. 26. For the 2 cut system, the dates were: July 1, and Sep. 26.

Plots were 3 x 16 feet and were harvested using a carter forage harvester set for about a 2 inch cutting height. Forage yields were obtained by weighing the fresh forage from the entire plot area and converting to lbs. per acre dry weight. A random subsample of about 400 grams was obtained from each plot as it was harvested. The subsample was dried at about 140 degrees F. and used for the determination of dry matter (DM) and for future quality analysis.

Samples are currently being prepared for Near Infrared Reflectance Spectroscopy (NIRS) by grinding through a 2-mm screen in a Wiley mill followed by a fine grind using an Udy mill. Once prepared, the samples will be run through NIRS at Washington State University at Prosser in Steve Fransen's lab.

RESULTS AND DISCUSSION

Total yield in the 5 cut system ranged from 11.1 tons/acre to 12.1 tons/acre. However, no significant differences were found among the entries (Table 1). No significant differences were found within cuts with the exception of the first and second. Three of the non-lodging cultivars showed higher yields than all of the commercial traditional varieties in the first cut while 54Q25 was lower yielding than many of the entries in the second cut. There were no significant

differences among the cultivars for total yield in the four cut system even though there were significant differences within the 1st, 2nd and 4th cuts (Table 2). The three cut system showed significant differences among varieties for total yield and within cuts (Table 3). All four of the non-lodging CBC experimentals had significant higher total yields than all of the traditional varieties. The non-lodging cultivars generally had higher yields in each cut than the traditional varieties. In the 2 cut system, all traditional cultivars lodged severely and lost leaves due to leaf disease. Non-lodging cultivars lost leaves in the lower canopy due to leaf senescence. Significant differences were found among cultivars for total yield (Table 4). CB9004 was significantly higher yielding than the rest of the entries. CB9004, CB9005, and CB9006 were significantly higher yielding than all of the traditional varieties. Table 5 shows the total yield in tons and percent of mean for all cutting management systems. The data shows that the fewer the cuts, the more advantage for the non-lodging cultivars. Although the data was not analyzed to detect significant differences among cutting management systems, average total yield trended downward from the 5 cut system to the 2 cut system. However, one variety (CB9004) yielded over 11 tons in all four cutting systems. CB9004 had about 67% higher yields than the best traditional cultivar (Masterpiece II) in the two cut system.

It is expected that over time the more frequent cuttings will reduce stand and health of the plants causing a reduction in yield. In the Columbia Basin, it is generally known that a 4 cut system will yield more than a five cut system over time. This data shows that reduction in yield doesn't happen in the first year.

In most cases there were no significant differences in dry weight among cultivars. However, there were significant differences in cut 1 of the 5 cut system and cut 1 of the 2 cut system. In both cases it appeared that the non-lodging varieties had a higher percent dry matter than the traditional cultivars.

ACKNOWLEDGMENTS

The support of the Washington State Hay Growers Association is greatly appreciated. We would like the thank Wilber-Ellis for providing fertilizer and First Line Seeds for providing seed inoculants.

Table 1: First Harvest Year Results of the 2010 Cutting Management Trial (5 cut)

Seeded 8/12/10

Forage Yield (Tons DM/Ac)

2011 Harvests

Entry	Company	Cut 1	Cut 1 % dry weight	Cut 2	Cut 2 % dry weight	Cut 3	Cut 3 % dry weight	Cut 4	Cut 4 % dry weight	Cut 5	Cut 5 % dry weight	2011 Total	2011 % mean
CB9004	Columbia Basin College	3.4	0.20	1.7	0.17	2.4	0.20	2.4	0.22	1.5	0.19	11.4	99.04
CB9005	Columbia Basin College	3.8	0.20	1.9	0.17	2.5	0.20	2.5	0.23	1.4	0.18	12.1	104.54
CB9006	Columbia Basin College	3.5	0.21	1.7	0.17	2.5	0.21	2.9	0.24	1.5	0.18	12.1	104.65
CB9007	Columbia Basin College	3.5	0.21	1.8	0.17	2.4	0.20	2.7	0.24	1.5	0.18	11.9	102.76
55V12	Pioneer Hi-bred Int. Inc.	3.2	0.21	1.9	0.18	2.2	0.21	2.5	0.23	1.4	0.18	11.3	98.06
CB001	Columbia Basin College	3.2	0.19	2.0	0.16	2.5	0.21	2.6	0.22	1.6	0.17	11.8	102.26
54Q25	Pioneer Hi-bred Int. Inc.	3.0	0.19	1.7	0.16	2.3	0.20	2.7	0.22	1.5	0.17	11.1	96.42
Masterpiece II	J.R Simplot Company	2.9	0.19	1.9	0.17	2.4	0.20	2.7	0.23	1.5	0.17	11.4	99.00
Grandstand	Crop Production Services	3.0	0.19	1.8	0.17	2.3	0.20	2.5	0.21	1.5	0.17	11.2	96.60
DKA 42-13	Dekalb	3.0	0.19	1.9	0.16	2.4	0.21	2.3	0.21	1.6	0.18	11.2	96.67
Mean		**3.3**	**0.20**	**1.8**	**0.17**	**2.4**	**0.20**	**2.6**	**0.22**	**1.5**	**0.18**	**11.6**	**100.00**
LSD 5%		**0.37**	**0.01**	**0.18**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
CV %		**8.1**	**4.8**	**6.7**	**4.0**	**9.6**	**6.7**	**18.8**	**13.5**	**9.9**	**5.2**	**6.0**	**6.0**

Table 2: First Harvest Year Results of the 2010 Cutting Management Trial (4 cut)

Seeded 8/12/10

Forage Yield (Tons DM/Ac)

2011 Harvests

Entry	Company	Cut 1	Cut 1 % dry weight	Cut 2	Cut 2 % dry weight	Cut 3	Cut 3 % dry weight	Cut 4	Cut 4 % dry weight	2011 Total	2011 % mean
CB9004	Columbia Basin College	3.2	0.21	3.4	0.24	2.8	0.22	2.8	0.26	12.3	104.97
CB9005	Columbia Basin College	3.5	0.21	3.5	0.23	3.1	0.23	2.7	0.25	12.8	109.72
CB9006	Columbia Basin College	3.3	0.22	3.3	0.24	2.8	0.22	2.8	0.26	12.2	104.38
CB9007	Columbia Basin College	3.0	0.21	3.4	0.23	2.8	0.23	2.6	0.25	11.9	101.45
55V12	Pioneer Hi-bred Int. Inc.	3.0	0.21	3.5	0.23	2.7	0.22	2.2	0.25	11.5	98.04
CB001	Columbia Basin College	2.8	0.21	3.5	0.24	2.8	0.24	2.4	0.24	11.5	98.46
54Q25	Pioneer Hi-bred Int. Inc.	3.1	0.21	3.0	0.22	2.8	0.23	2.5	0.24	11.4	97.38
Masterpiece II	J.R Simplot Company	2.8	0.21	3.2	0.23	2.8	0.22	2.4	0.24	11.2	95.95
Grandstand	Crop Production Services	3.0	0.21	3.1	0.21	2.7	0.22	2.2	0.24	11.0	94.39
DKA 42-13	Dekalb	2.9	0.21	3.3	0.22	2.8	0.24	2.1	0.25	11.1	95.27
Mean		**3.1**	**0.21**	**3.3**	**0.23**	**2.8**	**0.23**	**2.5**	**0.25**	**11.7**	**100.00**
LSD 5%		**0.47**	**NS**	**0.38**	**NS**	**NS**	**NS**	**0.36**	**NS**	**1.17**	**10.00**
CV %		**10.8**	**4.3**	**7.9**	**6.0**	**10.6**	**5.8**	**10.1**	**7.0**	**7.0**	**5.6**

Table 3: First Harvest Year Results of the 2010 Cutting Management Trial (3 cut)

Seeded 8/12/10

Forage Yield (Tons DM/Ac)

2011 Harvests

Entry	Company	Cut 1	Cut 1 % dry weight	Cut 2	Cut 2 % dry weight	Cut 3	Cut 3 % dry weight	2011 Total	2011 % mean
CB9004	Columbia Basin College	4.1	0.24	3.7	0.27	3.3	0.29	11.1	115.54
CB9005	Columbia Basin College	4.2	0.26	4.0	0.28	3.7	0.29	11.9	123.98
CB9006	Columbia Basin College	4.0	0.26	3.7	0.27	3.2	0.29	10.9	113.64
CB9007	Columbia Basin College	3.8	0.24	3.6	0.27	3.1	0.30	10.6	110.14
55V12	Pioneer Hi-bred Int. Inc.	4.1	0.24	3.3	0.27	2.3	0.28	9.6	100.19
CB001	Columbia Basin College	3.7	0.23	3.0	0.25	2.2	0.27	8.8	91.60
54Q25	Pioneer Hi-bred Int. Inc.	3.0	0.22	2.5	0.26	1.9	0.29	7.4	77.10
Masterpiece II	J.R Simplot Company	3.9	0.23	3.3	0.26	1.9	0.27	9.1	94.30
Grandstand	Crop Production Services	3.4	0.24	2.9	0.27	2.0	0.29	8.4	87.00
DKA 42-13	Dekalb	3.5	0.24	3.0	0.26	1.9	0.29	8.3	86.51
	Mean	**3.8**	**0.24**	**3.3**	**0.27**	**2.6**	**0.28**	**9.6**	**100.00**
	LSD 5%	**0.59**	**NS**	**0.51**	**NS**	**0.56**	**NS**	**1.13**	**11.80**
	CV %	**10.9**	**9.3**	**10.9**	**6.9**	**15.5**	**6.3**	**8.3**	**8.3**

Table 4: First Harvest Year Results of the 2010 Cutting Management Trial (2 cut)

Seeded 8/12/10

Forage Yield (Tons DM/Ac)

2011 Harvests

Entry	Company	Cut 1	Cut 1 % dry weight	Cut 2	Cut 2 % dry weight	2011 Total	2011 % mean
CB9004	Columbia Basin College	6.1	0.33	5.1	0.32	11.2	136.5
CB9005	Columbia Basin College	4.9	0.33	4.9	0.33	9.8	119.0
CB9006	Columbia Basin College	5.3	0.32	4.5	0.32	9.8	119.4
CB9007	Columbia Basin College	4.9	0.33	4.0	0.33	8.9	108.2
55V12	Pioneer Hi-bred Int. Inc.	4.9	0.31	3.3	0.31	8.2	99.5
CB001	Columbia Basin College	3.7	0.28	3.0	0.32	6.7	81.5
54Q25	Pioneer Hi-bred Int. Inc.	3.5	0.30	3.0	0.34	6.5	79.3
Masterpiece II	J.R Simplot Company	4.0	0.30	3.5	0.34	7.5	90.8
Grandstand	Crop Production Services	4.2	0.31	3.0	0.34	7.1	86.7
DKA 42-13	Dekalb	4.0	0.30	2.5	0.35	6.5	79.1
	Mean	**4.6**	**0.310**	**3.7**	**0.330**	**8.2**	**100.00**
	LSD 5%	**0.92**	**0.035**	**1.07**	**NS**	**1.84**	**22.43**
	CV %	**14.1**	**9.3**	**20.4**	**6.9**	**15.6**	**15.6**

Table 5: First Harvest Year Yield Results of the 2010 Cutting Management Trial (All cuts)

Seeded
8/12/10

Forage Yield (Tons DM/Ac)
2011 Harvests

Entry	Company	5 cut	5 cut % mean	4 cut	4 cut % mean	3 cut	3 cut % mean	2 cut	2 cut % mean	Average cuts	2011 % mean all cuts
CB9004	Columbia Basin College	11.4	99.0	12.3	105.0	11.1	115.5	11.2	136.5	11.5	112.1
CB9005	Columbia Basin College	12.1	104.5	12.8	109.7	11.9	124.0	9.8	119.0	11.7	113.5
CB9006	Columbia Basin College	12.1	104.6	12.2	104.4	10.9	113.6	9.8	119.4	11.3	109.6
CB9007	Columbia Basin College	11.9	102.8	11.9	101.5	10.6	110.1	8.9	108.2	10.8	105.2
55V12	Pioneer Hi-bred Int. Inc.	11.3	98.1	11.5	98.0	9.6	100.2	8.2	99.5	10.2	98.9
CB001	Columbia Basin College	11.8	102.3	11.5	98.5	8.8	91.6	6.7	81.5	9.7	94.5
54Q25	Pioneer Hi-bred Int. Inc.	11.1	96.4	11.4	97.4	7.4	77.1	6.5	79.3	9.1	88.8
Masterpiece II	J.R Simplot Company	11.4	99.0	11.2	95.9	9.1	94.3	7.5	90.8	9.8	95.4
Grandstand	Crop Production Services	11.2	96.6	11.0	94.4	8.4	87.0	7.1	86.7	9.4	91.7
DKA 42-13	Dekalb	11.2	96.7	11.1	95.3	8.3	86.5	6.5	79.1	9.3	90.4
	Mean	**11.6**	**100.0**	**11.7**	**100.0**	**9.6**	**100.0**	**8.2**	**100.0**	**10.3**	**100.0**
	LSD 5%	**NS**	**NS**	**1.17**	**10.000**	**1.13**	**11.8**	**1.8**	**22.4**		
	CV %	**6.0**	**6.0**	**7.0**	**7.0**	**8.3**	**8.3**	**15.6**	**15.6**		

Attachment 14

COLUMBIA BASIN COLLEGE 2011 ALFALFA VARIETY TRIALS

William T. W. Woodward,[12] Christopher Lamm and
Eliseo Navarro

INTRODUCTION

Hay is the sixth most valuable commodity produced in Washington with alfalfa making up about 65% of the total hay grown in the state. The value of alfalfa hay approached $292 million in 2010 with alfalfa making up 69% of the total hay tonnage produced. The average alfalfa yield for the state in 2010 was 4.5 tons/acre while Franklin County the averaged 7.15 tons/acre. Some growers in Franklin County have produced as much as 11 tons/acre. Franklin County harvested 84,000 acres of alfalfa and produced about 600,000 tons.

Principal markets for Washington alfalfa include 263,000 dairy cows on about 460 licensed herd operations in the state. About 25% of Washington's alfalfa production is processed into compressed bales or cubes for export to Japan, Korea, Taiwan, China, United Arab Emirates (UAE) and Saudi Arabia. Alfalfa that has lower quality due to rain or weeds is feed to beef cows. Alfalfa prices in 2011 began the year in January with an average price of $130 per ton growing each month until the price reached an average of $240 per ton for the last three month of the year.

Columbia Basin College (CBC) is breeding alfalfa for traditional uses and for biomass production. The Columbia Basin and surrounding area have pests that negatively affect an alfalfa stand and yield more intensely than other parts of the United States. They include aphids, clover root curculio, stem nematode and root knot nematode. These pests have not been a major focus for most alfalfa breeders due to small markets and lower margins on seed sales. The breeding program at CBC has a focus on these traits as well as attention to other traits for the improvement of alfalfa performance.

MATERIALS AND METHODS

Alfalfa variety tests were planted on August 7th, 2008 and on August 6th, 2010 to determine yield and regrowth of experimental varieties selected at CBC. Entries were selected individually or in combination for stem nematode, clover root curculio, pea aphid, root knot nematode, and non-lodging. Commercial varieties were entered as checks.

[12] Dean of Agriculture Education, Research and Development, Columbia Basin College and agriculture students attending CBC, Pasco, WA, December 14, 2011. CBCAG1105.

Plots were 3 x 16 feet and were harvested using a carter forage harvester set for about a 2 inch cutting height. Forage yields were obtained by weighing the fresh forage from the entire plot area and converting to tons per acre dry matter (DM). Spring growth and regrowth was scored 1-9 with 1 = no regrowth and 9 = tallest plot on a visual basis.

RESULTS AND DISCUSSION

Results of the 2008 alfalfa variety test are shown in Table 1. No significant differences were found for yield among varieties in 2009 or 2010. Significant differences were found in 2011 with stem nematode selected CB7006 and CB7007 among the top varieties. Three of the entries were greenhouse crossed germplasm selected for non-lodging. Non-lodging CBG703 performed better than the other two non-lodging entries, CBG701 and CBG702. The three non-lodging germplasm were used to plant spaced plant nurseries in 2007 and 2008 for further selection. Table 2 shows the first year results of the 2011 alfalfa variety test. The test will be harvested for two additional years to determine differences among varieties.

Table 1: 2008 Alfalfa Variety Trial, Columbia Basin College, Pasco, WA

	Forage Yield (Tons DM/Ac)														
Seeded 8/07/08					2011 Harvest										
	2009	2009%	2010	2010%	19-May	1-Jul	11-Aug	22-Sep	2011	2011%	3 year	3 year	06/18/09	2010 spg	2011 Spg
Entry	Total	mean	Total	mean	Cut 1	Cut 2	Cut 3	Cut 4	Total	mean	Total	mean	regrowth*	growth*	growth*
CB7006	9.26	103.8%	10.1	103.1	3.3	3.5	3.4	2.2	12.5	107.2	31.9	104.9	7.5	6.8	8.0
54H11	8.77	98.4%	10.2	104.5	3.3	3.6	3.1	2.2	12.2	105.1	31.3	102.9	5.8	6.3	6.5
CB7002	8.78	98.4%	10.0	102.1	3.6	3.4	3.2	2.2	12.4	106.5	31.2	102.7	7.3	6.5	7.8
CB7007	8.87	99.4%	9.7	99.2	3.4	3.3	3.6	2.2	12.5	107.4	31.1	102.4	8.3	6.5	7.3
CBG703	9.15	102.6%	9.7	99.0	3.6	3.5	3.2	2.0	12.2	105.1	31.1	102.4	6.8	6.3	7.5
Artisan	8.93	100.1%	10.0	101.9	3.3	3.3	3.3	2.2	12.1	104.2	31.1	102.2	8.5	6.5	7.8
Mountaineer 2.0	9.12	102.3%	10.1	103.0	3.2	3.3	3.0	2.2	11.7	100.5	30.9	101.9	8.3	5.5	6.5
CB7003	8.95	100.4%	10.1	102.8	3.1	3.1	3.4	2.3	11.8	101.4	30.8	101.6	8.5	6.0	6.0
CB001	8.83	99.0%	10.2	104.1	3.1	3.2	3.3	2.1	11.7	100.3	30.7	101.1	7.8	7.8	6.3
Rebound 5.0	9.30	104.2%	9.9	100.6	3.2	3.3	2.9	2.0	11.5	98.4	30.6	100.8	7.3	5.5	6.5
CB7008	9.08	101.8%	9.5	97.0	3.0	3.3	3.3	2.3	11.8	101.4	30.4	100.1	8.0	4.3	5.8
CB7005	8.56	95.9%	10.3	105.5	3.0	3.2	3.0	2.2	11.5	98.7	30.4	100.1	7.0	6.0	5.5
54Q25	8.61	96.5%	10.3	104.7	2.9	2.9	3.2	2.5	11.5	98.4	30.3	99.9	6.3	6.0	6.0
CB7009	8.93	100.2%	9.7	98.8	3.0	2.9	3.0	2.2	11.0	94.6	29.6	97.6	7.5	5.8	4.8
CB7004	9.06	101.6%	9.2	93.9	3.1	2.9	3.1	2.3	11.3	97.4	29.6	97.5	7.3	6.0	6.3
CBG702	8.65	97.0%	9.1	93.0	3.1	3.4	3.0	1.9	11.4	98.2	29.2	96.2	8.0	4.5	6.5
DKA42-15	9.23	103.5%	9.4	95.7	2.8	2.7	2.4	1.9	9.8	84.5	28.4	93.7	6.8	4.8	5.5
CBG701	8.48	95.0%	8.9	91.0	2.9	3.2	2.7	1.8	10.6	90.8	28.0	92.1	6.8	4.0	5.8
Mean	**8.9**	**100.0%**	**9.81**	**100.0**	**3.2**	**3.2**	**3.1**	**2.1**	**11.64**	**100.0**	**30.37**	**100.0**	**7.4**	**5.8**	**6.4**
LSD 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**0.44**	**0.36**	**NS**	**1.20**	**10.3**	**NS**	**NS**	**1.02**	**1.91**	**1.80**
CV %	**6.8**	**6.8**	**7.9**	**7.9**	**12.1**	**9.5**	**8.0**	**14.5**	**7.2**	**7.2**	**5.2**	**5.2**	**9.7**	**22.9**	**19.6**

* 9=12 inches
2= 4 inches

Table 2: One-Year Forage Yield: 2010 Alfalfa Variety Trial, Columbia Basin College. Pasco, WA.

	Forage Yield (Tons DM/Ac)						
Seeded 8/06/10							
	19-May	1-Jul	11-Aug	22-Sep	2011	2011%	2-May
Entry	Cut 1	Cut 2	Cut 3	Cut 4	Total	mean	Spring Growth*
CB9003	3.5	3.4	3.4	2.7	13.0	108.7%	8.5
54H11	3.4	3.2	3.3	2.7	12.6	105.5%	6.5
CB9005	3.3	3.3	3.3	2.6	12.5	104.7%	8.5
CB9004	3.2	3.3	3.2	2.7	12.4	104.0%	8.5
CB9007	3.2	3.3	3.2	2.7	12.4	103.6%	6.8
CB9008	3.3	3.3	3.2	2.6	12.4	103.5%	5.8
CB9006	3.3	3.2	3.2	2.6	12.3	103.0%	6.8
CB7007	3.0	3.3	3.5	2.3	12.1	101.5%	5.5
CB7003	3.3	3.1	3.2	2.5	12.0	100.7%	7.3
CB8002	3.1	3.2	3.3	2.4	12.0	100.4%	5.8
CB8001	2.8	3.2	3.6	2.5	12.0	100.4%	5.3
CB8003	2.8	3.2	3.4	2.5	11.9	99.8%	5.5
CB001	3.0	2.9	3.3	2.4	11.7	97.6%	6.0
CB7002	3.0	3.1	3.2	2.4	11.7	97.5%	6.0
CB7004	2.9	3.2	3.3	2.2	11.6	97.3%	5.3
CB9009	3.0	3.2	3.2	2.3	11.6	97.3%	6.3
CB9001	3.0	3.1	3.1	2.4	11.6	97.0%	7.0
CB7005	3.0	3.0	3.2	2.4	11.6	96.7%	5.8
DKA 43-13	3.1	2.9	3.2	2.3	11.5	96.5%	5.3
CB7006	2.8	3.2	3.2	2.2	11.5	95.8%	5.8
CB9002	2.9	3.1	3.2	2.2	11.3	94.6%	6.0
54Q25	3.2	2.9	2.8	2.3	11.2	93.6%	5.8
Mean	**3.1**	**3.2**	**3.3**	**2.4**	**11.96**	**100.0%**	**6.3**
LSD 5%	**0.47**	**0.26**	**0.43**	**0.35**	**0.79**	**6.6%**	**1.47**
CV %	**10.6**	**5.9**	**9.2**	**10.0**	**4.6**	**4.6**	**16.2**

*** 9=12 inches**
2= 4 inches

Attachment 15

Economic Thresholds – Weevils and Aphids

William T. W. Woodward[13]

Key Words: alfalfa, cowpea aphid, *Aphis craccivora*, spotted alfalfa aphid, *Therioaphis maculata*, pea aphid, *Acyrthosiphon pisum*, blue alfalfa aphid, *Acyrthosiphon kondoi, alfalfa weevil, Hypera postica,* Gyllenhal.

Alfalfa Weevil

The alfalfa weevil (*Hypera postica* Gyllenhal) is one of the more important insect pests of alfalfa in Washington. Both adults and larvae can cause damage. However, the larvae chewing on the plant terminals do the most frequent damage. Depending on larvae population, damage can range from terminal leaf skeletonization to complete defoliation of the first growth of the season leaving fields with a grayish cast. When weevil populations are high in the first cut, delay in regrowth can occur in subsequent harvests. Yield and stand loss can be significant.

In Washington, the alfalfa weevil overwinters as adults and become active in the spring as temperatures exceed 60 F. In the spring, the adults will lay their eggs within the alfalfa stem and upon hatching move up the stem to the plant terminal where they feed on newly initiated leaves. As the larvae get older they will move out from the terminal end and feed on the more exposed alfalfa foliage.

Once the larvae have finished feeding they drop to the ground and form a cocoon. After pupation (10 to 14 days), they emerge as adults, feed briefly on alfalfa foliage and leave the field to hibernate for the rest of the summer and following winter.

[13] Dean of Agriculture Education, Research and Development Columbia Basin College, Pasco, WA. January 13, 2010. CBCAG1001

Adults measure about 3/8 of an inch in length, are light brown with a darker brown stripe in the middle of the back. Larvae are pale yellow to light green when small and turn bright green with a white stripe down the middle of their back when older. A characteristic black head is evident. Eggs are laid inside the stem, in groups of 5 to 15. They are bright yellow and turn darker as they near hatching.

Monitoring

In order to detect weevil population increases, an alfalfa field should be sampled on a weekly basis beginning in the spring. Monitoring would be especially important if there is a history of weevil damage or damage the previous year due to a potentially higher over wintering population. When alfalfa is 8 inches or less, a random sample of 25 stems per site can be collected and then vigorously shaken within a container. An economic threshold will be between 1.5 to 2 larvae per stem. At the same time, damaged terminals can be determined by examining 50 random plant terminals in each location. Twenty damaged terminals or 40 % would indicate an economic threshold. When the alfalfa plants are 8 –10 inches tall a standard sized sweep net (15 inches) can be used to determine the larvae population. A swing of the net through the top of the canopy for 180 degrees would represent one sample. In fields larger than 30 acres, a minimum of 5 sweep samples should be taken with an average of 20 larvae per sweep indicating the economic threshold. This method may underestimate the true population, as small larvae are difficult to dislodge from the plant terminals.

A forth method was developed by D. G. Harcourt at an Ottawa research station in Canada. It is based on counting puncture wounds on stems early in the growing season to give up to 10 days lead time in making management decisions. The procedure requires taking a bouquet of three alfalfa stems cut at ground level when the crop is 10 to 12 inches tall.

1. Visually divide the field into quarters and collect bouquets at random by walking through each quarter in a diagonal path (Figure 1).
2. Collect 40 bouquets (10 per quarter) and place in bags separated by quarter.
3. Examine the stems in sets of three and count the number of puncture wounds using a magnifier. The bouquets should be from different bags.
4. Enter the total number of punctures in the sampling chart (Table 1).
5. Examine more bouquets if the running total lies between the two limits shown on the sampling chart.
6. If the running total reaches the upper or lower limit, a decision can be reached.

7. Exceeding the upper limit means a treatment is required. Below the lower limit means no treatment required.

Table 1: Sampling Chart

	NUMBER OF PUNCTURES		
Total numbers of bouquets	Running total	Lower limit	Upper limit
12		4	16
14		6	18
16		7	20
18		9	21
20		11	23
22		12	25
24		14	26
26		16	28
28		17	30
30		19	31
32		21	33
34		22	35
36		24	36
38		26	38
40		27	40

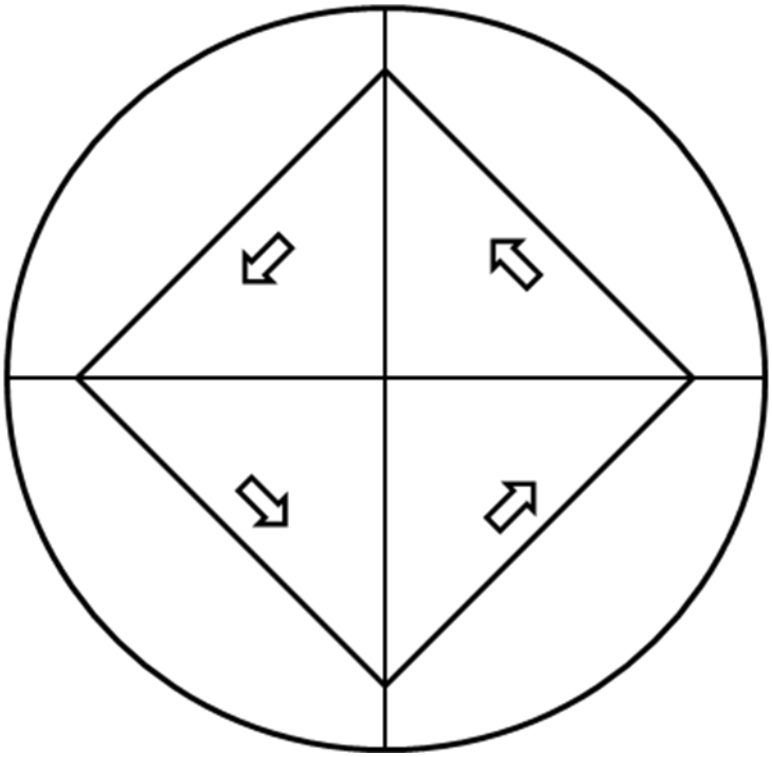


Figure 1

Controls

Cultural

In Washington, the alfalfa weevil population makes its largest increase near harvest. Cutting the crop when most of the plants are at bud stage can prevent serious damage. Early cutting reduces weevil larvae populations by exposing them to the sun and wind. If this practice is used in place of a chemical control, the fields should be monitored for regrowth and larvae numbers. Check the stubble for signs of feeding damage to new growth. In severe cases, green up may be slowed because of the rapid consumption of new crown buds. Examine under the windrows for regrowth and larvae numbers. No regrowth or damaged regrowth (50 % of the plants) and/or a count of 8 or more larvae per square foot would indicate a need for chemical treatment.

Although there have been efforts to breed for resistance to the alfalfa weevil, there has been no significant progress. However, because of the great genetic diversity in alfalfa the future shows promise.

Biological

The parasitic wasp (*Bathyplectes curculionis*) is present throughout the range of the alfalfa weevil. However, parasitism rates can vary greatly causing cultural and chemical the primary methods of control.

Aphids

Four aphid species have been known to damage alfalfa in Washington. They include pea aphid, blue alfalfa aphid, spotted alfalfa aphid and the cowpea aphid. All four of these species have multiple generations each year; the females can produce live offspring at birth allowing aphid populations to build up quickly if conditions are favorable. Weather conditions have a great effect on the likelihood of aphid outbreaks. Mild weather in the fall can be ideal for aphid build-up. All four feed with piercing-sucking mouthparts and remove sap from the terminal leaves and stems of the host plant. They also inject toxins while feeding that further stunt and sicken plants. The toxin levels injected vary among species. Those secreted by the spotted alfalfa aphid, blue alfalfa aphid, and the cowpea aphid are the most damaging. Feeding can result in wilting, stunting, deformation and in sever infestations, death of the plant. Plants can appear short and bunch with terminals more lightly colored. Often plants can be coated with honeydew secreted by the aphids. Honeydew can also hinder the baling process, and promote the growth of a black fungus that can reduce hay quality. The molds growing on the honeydew reduce palatability, hold soil and dust on the forage, and may be toxic.

Cowpea Aphid

Since 1999 there have been concerns with a new black aphid that infests alfalfa. The aphid has been identified as the cowpea aphid or by other names such as the black legume aphid and the groundnut aphid. The cowpea aphid has been know to occur in the southwest for about a hundred years and was rarely found invading alfalfa without causing economic damage. In 1998, cowpea aphid built to economically damaging levels on alfalfa in California and intensified in 1999. It is has now spread throughout the United States and in parts of Canada. It was first observed in Washington in the fall of 2001 but did not reach economic thresholds until the fall of 2005. The aphid has not been found on new growth in the spring indicating that it does not over winter well in Washington. The insect is most likely carried to Washington by winds from the south in late summer causing infestation

on the last cut and regrowth following the last cut. Yield losses would occur the following spring due to restricted carbohydrate reserves in the alfalfa plant. The new pest behaves differently from previously known populations of cowpea aphid. In general, it is a relatively small aphid, less than 2 mm long usually shiny black while the smaller nymphs may appear to be a dull gray to black. The first half of the antennae is white, and the legs are usually a creamy white color with blackish tips. Colonies start on the growing points of the host plant and can quickly infest the entire plant. Cowpea aphid has a broad host range and is found on both weed and crop species. The aphid is known to transmit nearly 30 virus strains. Because the cowpea aphid has been a warm weather pest often found on cotton and is now found damaging alfalfa during the cooler parts of the year, it is suspected that it is a new biotype.

Blue Alfalfa Aphid

Blue alfalfa aphids (BA) are very similar in appearance to pea aphids; they are slightly smaller and have a waxy, darker green color than pea aphid. However, the antennae must be examined under magnification to discriminate these species. The third antennal segment (from the base) of the pea aphid has a dark brown narrow band of pigment at the tip; the segment on the blue alfalfa aphid is uniformly brown. Its life history is similar to the pea aphid. Cool, dry conditions favor the aphid's development, and populations decrease quickly when temperatures reach 85° F. The blue alfalfa aphid has not been known to be a large problem in the Columbia Basin. However, it appeared to be very damaging this fall and may not have been studied enough in Washington to know the extent of potential damage. Typically, it is not observed or a problem in the spring but shows up in the late summer probably riding on winds from the South. In the spring of 2005 after a mild winter, a field near Boardman Oregon was devastated due to blue aphid. Over wintering hot spots were observed in several locations in the infested field with extremely high populations occurring in the rest of the field.

Pea Aphid

Pea aphids (PA) are comparatively large (3/16 long), bright green aphids, with long cornicles (paired "tails" near the end of the body). They over-winter as eggs, which are glued on fallen stems and leaves of alfalfa in the fall. After hatching in the early spring, the nymphs feed on the first growth, usually found on the growing tips of the plants. After one or two generations, winged forms are produced which colonize other fields. Asexual reproduction continues through the summer. Later, males are produced, and sexual reproduction produces the over-wintering eggs.

Dry, cool conditions (55 to 60° F.) favor the development of dense populations. Infestations in the Columbia Basin may occur at any time but are most likely to occur during spring or late summer and fall.

Spotted Alfalfa Aphid

Spotted alfalfa aphid (SAA) is smaller (1/10 inch long) than the pea aphid. It is pale very light yellow with four to six rows of darker spots on the upper abdomen that can be seen only on close inspection with a hand lens. This species is so small and light colored that care must be taken when checking the sweep net for its presence. It can be easily overlooked.

Development of spotted alfalfa aphid is optimal when temperatures are warm and humidity is low, with peak populations tending to develop late in the summer. Dry weather, with mild temperatures, increases the chances for damaging infestations of the spotted alfalfa aphid. Besides drawing photosynthetic material from the plant, this species injects a toxic substance into the plant, causing veins to yellow. This species feeds preferentially on older leaves lower on the plant, moving up as leaves die.

Economic Thresholds

On seedlings, an average of one aphid (any species, pea, blue and spotted) per plant can be economical if the short-term weather forecasts predict conditions that favor population build up. However, 1 spotted or blue alfalfa aphid per plant warrants treatment. Treatment thresholds change with plant growth stage and vary by aphid species (Table 1).

Because the cowpea aphid has only recently become a problem in alfalfa, no monitoring guidelines or economic thresholds have been developed for this aphid. Because it appeared to cause stunting and yellowing of leaves in the fall of 2005, thresholds should follow the advice given for the blue alfalfa aphid.

Table 2. Suggested Economic Thresholds for Pea, Blue, Spotted and Cowpea Aphids at Seedling and Three Growth Stages.

Growth Stage	Pea aphid	Blue alfalfa aphid	Spotted alfalfa aphid	Cowpea aphid[1]
Seedling	5	1	1	1
<10 inch	40	10	10	10
> 10 inches	75	30	30	30
20 inches	100	50	50	50

[1]Blue aphid thresholds are used at this time.

Control

Cultural

It is possible to control aphids by harvesting when thresholds are reached at or near bud stage or later. It is most effective when followed by hot, dry weather. However, sampling following harvest is necessary to assure adequate control has been obtained following large numbers of aphids at harvest time.

Biological

Aphid populations in most of Washington seldom require treatment because of predators such as parasites and fungi. Consideration of beneficial insect populations should be made prior to treatment with an insecticide. Common predators include lady beetles, green lacewings, bigeyed bugs, and damsel bugs. Two wasp species are parasitic on aphids and can be seen as active when large golden-brown aphid mummies are found on the upper surfaces of the leaves.

Resistant Cultivars

Fortunately, alfalfa breeders have kept up by releasing pea and spotted aphid resistant varieties. In most cases there is enough resistance to keep levels of aphids below economic threshold levels. Because the spotted alfalfa aphid is such a problem with seed production on alfalfa, breeders must have acceptable levels of resistance thus benefiting those that grow the crop for forage.

Chemical

Even though there are good cultural and biological controls along with resistant varieties, aphid population explosions can occur. Chemical control may be required.

Attachment 16

Optimum Planting Date for Alfalfa Grown in the Columbia Basin

William T. W. Woodward[14] and John Kugler[15]

The production potential and profitability of an alfalfa field can be strongly influenced by planting dates. Seedling development, stand density and forage yield can be negatively affected. The risk of late-summer planting occurs when fields are planted too late for proper plant development. Planting should be completed at least 30 to 45 days prior to the first killing frost. Large plants with a developing crown are able to withstand harsher conditions and provide a higher yield potential the following spring. Both photoperiod and temperature affect the growth and development of seedling alfalfa. Photoperiod may have a larger effect than temperature for dormant alfalfa in the Columbia Basin because of its northern location. Insufficient information on optimum planting dates for alfalfa development is available for the Columbia Basin.

PROCEDURES

Field studies were conducted between 2002 and 2005 near Pasco and Othello, Washington. The variety Columbia 2000 was used in all experiments. Plots were arranged in a randomized complete block design with four replications. The planting date treatments for the year 2002 were August 3, 13, 23 and September 2, 12, 22. For the year 2003, planting dates were August 6, 16, 26 and September 5, 15 and 25. The plots seeded in 2002 were cut 5 times in Pasco and 4 in Othello in 2003 and 2004. Plots seeded in 2003 were cut 5 times in Pasco in 2004 and 3 times in 2005 while plots in Othello were cut 4 times each year. Plot size was 4 x 14 feet seeded at about 15 lbs. per acre.

RESULTS

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The 2003 harvest of the 2002 seeded plots in Pasco showed significant yield declines among planting dates (Table 1). The September planting dates had significant lower yields than the planting dates for August. Total yield for the first harvest year ranged from 9.5 tons/acre to 6.2 tons/acre for the first planting date in August and the last planting date in September, respectively.

Table 1: Pasco Date of Seeding Study (2002 seeding)
Forage Yield (Tons DM/Ac)

Year 2003	2003 Harvests							
Entry	15-May Cut 1	16-Jun Cut 2	24-Jul Cut 3	20-Aug Cut 4	24-Sep Cut 5	2003 Total	Percent mean	3-Jun Regrowth
08/03/02	2.9	2.4	2.0	1.5	0.7	9.5	116.3%	8.5
08/13/02	2.9	2.2	2.0	1.6	0.7	9.4	115.8%	7.8
08/23/02	2.7	1.9	1.8	1.6	0.6	8.6	106.2%	6.8
09/02/02	2.2	1.6	1.8	1.4	0.5	7.6	93.1%	5.5
09/12/02	2.3	1.6	1.6	1.5	0.5	7.5	91.9%	4.8
09/22/02	1.5	1.2	1.8	1.3	0.4	6.2	76.6%	3.5
Mean	**2.5**	**1.8**	**1.8**	**1.5**	**0.6**	**8.1**	**100.0%**	**6.1**
LSD 5%	**0.42**	**0.23**	**0.24**	**0.18**	**NS**	**0.79**	**9.68%**	**1.06**
CV %	**12.0**	**9.0**	**9.1**	**8.7**	**26.2**	**6.7**	**6.7**	**12.0**

Table 2 shows the results for the second harvest year on the 2002 Pasco seeding. Although the trend was lower yields for the September planting dates as compared to the August planting dates, there were no significant differences found among planting dates in 2004. However, the combined analysis for the two harvest years showed significant differences between the August and September planting dates.

Table 2: Pasco Date of Seeding Study (2002 seeding)
Forage Yield (Tons DM/Ac)

	2004 Harvests							Yield		
Entry	6-May Cut 1	11-Jun Cut 2	14-Jul Cut 3	16-Aug Cut 4	12-Oct Cut 5	2004 Total	Percent mean	2-Year Total	2-Yr % mean	06/03/03 Regrowth
08/03/02	2.2	1.5	1.6	1.6	0.8	7.7	106.6%	17.2	111.8%	8.5
08/13/02	2.1	1.7	1.5	1.7	0.9	7.9	109.8%	17.3	113.0%	7.8
08/23/02	1.9	1.5	1.6	1.6	0.8	7.4	102.7%	16.1	104.6%	6.8
09/02/02	2.1	1.3	1.3	1.4	0.7	6.8	94.1%	14.4	93.6%	5.5
09/12/02	2.0	1.2	1.4	1.5	0.6	6.7	92.3%	14.1	92.1%	4.8
09/22/02	2.0	1.2	1.3	1.5	0.7	6.8	94.4%	13.0	85.0%	3.5
Mean	**2.0**	**1.4**	**1.4**	**1.5**	**0.8**	**7.2**	**100.0%**	**15.4**	**100.0%**	**6.1**
LSD 5%	**NS**	**0.30**	**NS**	**NS**	**0.23**	**NS**	**NS**	**1.59**	**10.34%**	**1.06**
CV %	**10.0**	**14.8**	**11.9**	**16.1**	**20.7**	**9.9**	**9.9**	**7.2**	**7.2**	**12.0**

No visual differences in regrowth on 5/20/04

The first cut of the 2003 harvest of the 2002 seeded plots in Othello was harvested with a 10 day delayed harvest of the September planting dates. Due to the delay, significant differences occurred only in the first cut and total yield (Table 3). There was a trend for yield decline among August planting dates and September planting dates with the last planting date of September 22 being significantly lower yielding than the first two planting dates in August.

Table 3: Othello Date of Seeding Study (2002 seeding)
Forage Yield (Tons DM/Ac)

Year 2003	2003 Harvests					
	20-May	24-Jun	29-Jul	5-Sep	2003	Percent
Entry	Cut 1	Cut 2	Cut 3	Cut 4	Total	mean
08/03/02	3.2	2.7	2.5	2.1	10.6	111.3%
08/13/02	2.9	2.4	2.6	2.4	10.3	108.9%
08/23/02	2.2	2.2	2.4	2.2	8.9	94.2%
09/02/02	2.9	2.5	2.5	2.2	10.1	105.9%
09/12/02	2.2	2.6	2.5	1.7	9.0	94.5%
09/22/02	1.8	2.3	2.3	1.7	8.1	85.3%
Mean	**2.5**	**2.4**	**2.5**	**2.0**	**9.5**	**100.0%**
LSD 5%	**0.59**	**NS**	**NS**	**NS**	**1.20**	**12.60%**
CV %	**16.1**	**9.6**	**8.5**	**20.3**	**8.8**	**8.8**

Table 4 shows the results for the second harvest year on the 2002 Othello seeding. No significant differences were observed among planting dates for cuts or for total yield in 2004. However, the combined analysis for the two harvest years showed significant differences between the first two August and last two September planting dates. Two-year yields ranged from 19 tons per acre for the August 3 planting date to 16.2 tons for the September 22 planting date.

Table 4: Othello Date of Seeding Study (2002 seeding)
Forage Yield (Tons DM/Ac)

	2004 Harvests							Yield
	13-May	17-Jun	19-Jul	27-Aug	2004	Percent	2-Year	2-Yr %
Entry	Cut 1	Cut 2	Cut 3	Cut 4	Total	mean	Total	mean
08/03/02	2.9	1.6	1.8	2.2	8.5	103.0%	19.0	107.5%
08/13/02	2.9	1.7	1.9	2.3	8.8	107.6%	19.2	108.3%
08/23/02	2.4	1.4	1.5	2.0	7.3	89.2%	16.3	91.9%
09/02/02	2.8	1.6	1.8	2.3	8.6	104.0%	18.6	105.0%
09/12/02	2.7	1.5	1.7	2.0	8.0	97.2%	17.0	95.7%
09/22/02	2.7	1.5	1.8	2.2	8.1	98.9%	16.2	91.6%
Mean	**2.7**	**1.6**	**1.7**	**2.2**	**8.2**	**100.0%**	**17.7**	**100.0%**
LSD 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**1.83**	**10.34%**
CV %	**11.6**	**11.2**	**12.1**	**10.0**	**9.0**	**9.0**	**7.2**	**7.2**

The 2004 harvest of the 2003 seeded plots in Pasco showed significant differences within cuts and total yield (Table 5). Total yields for 2004 ranged from 8.5 tons per acre to 5.7 tons per acre for the August 6 and September 25 planting dates, respectively. Significant differences were found between the first two planting dates in August and the last two planting dates in September. The yield decline was similar to the previous Pasco study.

Table 5: Pasco Date of Seeding Study (2003 seeding)
Forage Yield (Tons DM/Ac)

	2004 Harvests						
Entry	7-May Cut 1	11-Jun Cut 2	14-Jul Cut 3	16-Aug Cut 4	12-Oct Cut 5	2004 Total	Percent mean
08/06/03	2.5	1.5	1.5	1.8	1.2	8.5	117.8%
08/16/03	2.2	1.4	1.5	1.8	1.1	8.0	110.1%
08/26/03	2.1	1.1	1.6	1.7	1.1	7.6	105.1%
09/05/03	1.9	0.9	1.4	1.6	1.1	7.0	96.9%
09/15/03	1.6	0.8	1.5	1.6	1.1	6.7	91.9%
09/25/03	1.0	0.6	1.4	1.5	1.1	5.7	78.2%
Mean	**1.9**	**1.1**	**1.5**	**1.7**	**1.1**	**7.3**	**100.0%**
LSD 5%	**0.25**	**0.29**	**0.13**	**0.17**	**NS**	**0.65**	**8.9%**
CV %	**9.1**	**19.2**	**6.1**	**7.0**	**9.4**	**6.2**	**6.2**

Table 6 shows the results for the second harvest year on the 2003 Pasco seeding. No significant differences were found among planting dates among cuttings or total yield indicating that there is little carryover of the effects of planting dates after the first year. However, the combined analysis for the two harvest years showed significant differences between the first two planting dates in August and the last two planting dates in September. These significant differences can be attributed to the yield declines in the first harvest year after planting.

Table 6: Pasco Date of Seeding Study (2003 seeding)
Forage Yield (Tons DM/Ac)

	2005 harvests					Yield		
Entry	6-May Cut 1	7-Jun Cut 2	12-Jul Cut 3	2005 Total	Percent mean	2-Year Total	2-Yr % mean	05/20/04 Regrowth
08/06/03	3.2	1.8	1.1	6.2	105.8%	14.7	112.4%	9.0
08/16/03	3.1	1.9	1.0	6.1	103.7%	14.0	107.2%	7.8
08/26/03	2.8	1.7	1.1	5.6	95.8%	13.2	101.0%	6.8
09/05/03	2.7	1.7	1.0	5.4	92.8%	12.4	95.0%	5.3
09/15/03	3.0	1.9	1.1	6.0	102.2%	12.6	96.5%	4.3
09/25/03	2.8	1.9	1.1	5.8	99.6%	11.5	87.8%	3.0
Mean	**2.9**	**1.8**	**1.1**	**5.8**	**100.0%**	**13.1**	**100.0%**	**6.0**
LSD 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**1.12**	**8.57%**	**0.88**
CV %	**8.7**	**11.9**	**16.1**	**7.3**	**7.3**	**6.0**	**6.0**	**10.2**

Table 7 shows the yield results for the 2004 harvest on the 2003 seeding in Othello. Significant differences for planting dates were found within all cuts and for total yield. Yields ranged from 10 tons per acre for the August 6 planting date to 5.3 tons per acre for the September 25 planting date. The August planting date treatments were significantly higher yielding than the September planting dates. These results were similar to what was found in the Pasco studies.

Table 7: Othello Date of Seeding Study (2003 seeding)
Forage Yield (Tons DM/Ac)

		2004 Harvests					
Entry	Final %Stand	13-May Cut 1	17-Jun Cut 2	19-Jul Cut 3	27-Aug Cut 4	2004 Total	Percent mean
08/06/03	99.0	3.0	2.1	2.3	2.6	10.0	131.7%
08/16/03	98.3	2.6	2.0	2.2	2.4	9.2	121.3%
08/26/03	96.3	2.0	1.8	2.2	2.6	8.6	113.3%
09/05/03	99.0	1.1	1.2	1.7	2.0	6.0	78.8%
09/15/03	93.3	0.2	1.6	2.1	2.6	6.5	85.6%
09/25/03	91.3	0.1	1.2	1.6	2.4	5.3	69.3%
Mean	**96.2**	**1.5**	**1.6**	**2.0**	**2.4**	**7.6**	**100.0%**
LSD 5%	**7.83**	**0.41**	**0.40**	**0.37**	**0.17**	**0.69**	**9.0%**
CV %	**5.7**	**18.9**	**16.9**	**12.7**	**5.0**	**6.3**	**6.3**

Table 8 shows the results for the second harvest year on the 2003 Othello seeding. No significant differences were observed among planting dates for cuts or for total yield in 2004 indicating recovery of plants after the first harvest year. However, the combined analysis for the two harvest years showed significant differences between the first three August and last three September planting dates. Two-year yields ranged from 16.8 tons per acre for the August 6 planting date to 11.7 tons for the September 25 planting date.

Table 8: Othello Date of Seeding Study (2003 seeding)

Forage Yield (Tons DM/Ac) (2003 seeding)

	2005 harvests							Yield
	12-May	20-Jun	26-Jul	8-Sep	2005	Percent	2-Year	2-Yr %
Entry	Cut 1	Cut 2	Cut 3	Cut 4	Total	mean	Total	mean
08/06/03	2.2	1.7	1.5	1.4	6.8	100.9%	16.8	117.2%
08/16/03	2.2	1.8	1.5	1.4	6.9	102.9%	16.1	112.7%
08/26/03	2.2	1.9	1.5	1.3	6.9	102.2%	15.5	108.1%
09/05/03	2.1	1.8	1.4	1.3	6.5	97.0%	12.5	87.4%
09/15/03	2.3	1.8	1.5	1.3	6.8	101.5%	13.3	93.1%
09/25/03	2.1	1.6	1.5	1.3	6.4	95.4%	11.7	81.6%
Mean	**2.2**	**1.8**	**1.5**	**1.3**	**6.7**	**100.0%**	**14.3**	**100.0%**
LSD 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**1.13**	**7.88%**
CV %	**8.9**	**10.8**	**6.3**	**8.0**	**6.5**	**6.5**	**5.5**	**5.5**

DISCUSSION

The data in this study indicated that the best time to plant alfalfa is during the first two to three weeks in August. Although a good stand can be established in September, yield may not be as desirable the following year. In Othello, the delayed harvest of the September planted plots in 2002 indicated that if a late planting is unavoidable, it would be advisable to not cut on a calendar schedule until a delayed first cut is taken. Growers that like to take a fall cut on new seedings would need to plant no later than the first two weeks of August. The plots were trimmed in November of each year; however, the data was not used in these analyses. The August seedings were observed to have significantly more growth than the September seedings in the fall (Figures 1 & 2). Figure 3 shows the difference in spring growth. The difference in planting the first week in August and the last week in September is a yield difference of about 3 tons the first harvest year and 4 tons over two years for both the mid and lower Columbia Basin in Washington.

Figure 1: October 10, 2003. Pasco 2003 seeded study.

Figure 2: Growth differences in plants in the fall of 2003 on the Pasco 2003 seeding. Large plant on left is from the first seeding in August. Small plant on right is from the last seeding in September.

Figure 3: Spring growth of seeding date treatments in Othello.

Attachment 17

Stem Nematode: Can It Be Defeated

Christopher A. Lamm[16], William T. W. Woodward[17], Cristina Garza[18], Eliseo Navarro[19]

INTRODUCTION

Alfalfa stem nematode, *Ditylenchus dipsaci,* sometimes referred to as "bulb and stem nematode", live in affected soil areas as well as the plant tissues of alfalfa. The destruction caused by this parasitic roundworm can greatly reduce the profitability of an alfalfa stand. Out of the many different types of plant parasitic nematodes, this one lives by feeding in the "stems" and crowns of alfalfa plants, while many other species of nematodes feed on the roots. In Washington State, alfalfa is the only major crop that is seriously damaged by this pest, though it affects other crops.

KEY WORDS: alfalfa, stem nematode, *Ditylenchus dipsaci*

SOME PUBLIC CONTRIBUTIONS

O.F. Smith (Nevada) was the first to compare levels of stem nematode resistance in several alfalfa cultivars. G. Thorne (Iowa State University) was the first person in the USA to identify that alfalfa has stem nematode resistance from a Turkestan variety FC 19304. Out of that plant introduction, Nemastan, Lahontan and Washoe alfalfa varieties were developed in Nevada. The variety Vernema was developed by Dick Peaden at Prosser, WA and is considered to be a resistant check variety. The standard test was developed and revised by Peaden, Griffin and Kugler at Washington State and Utah State University.

SYMPTOMS

Although stem nematode is not a major problem in the Columbia Basin, it is a serious problem in the Yakima Valley as well as farm lands that irrigated from the Umatilla Water Shed. The nematode can devastate fields throughout the Pacific Northwest. However, in the Columbia Basin, stem nematode can be reduced due to fumigation when potatoes are used in a rotation. The number of fields with symptoms of stem nematode varies each year based on weather conditions that occur during late winter and early spring, which is when the symptoms can be easily observed. During the growing year the stand will continue to have poor growth and lower economic benefit. One of the more recognizable symptoms of infected plants is the discoloration of the leaves. This is called "white flagging", which occurs when the nematodes begin to move to the leaf tissue and destroy the chloroplasts. This results in yellowing and white leaves, which is more prevalent on spring growth and regrowth following the first cutting. With the presence of nematodes, the nodes of the plant become swollen and the internodes become shorter producing a shorter growing alfalfa stand. This gives the impression that the field has been grazed. Once

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infected the alfalfa plant itself will produce fewer shoots and produce deformed buds and eventually death, reducing the overall profitability of the stand.

DISEASE CYCLE

Plant parasitic nematodes like stem nematodes are a microscopic roundworm. To feed on the plant they have a hollow, needle shaped stylet that is used to puncture the plant tissue. Stem nematode can survive on seed, hay and leave debris. Stem nematodes can easily be spread not just by their own movement, but by either nature or the human factor. It has been estimated that nearly 10 million plant parasitic nematodes are applied with each irrigation cycle in the Yakima Valley. This occurs with water runoff, causing nematodes to be disseminated into adjacent fields or possibly into the water system. After an irrigation cycle when free water is available, stem nematodes move rapidly on the outside of the plant to begin feeding on the buds. During favorable conditions, around 59-70°F, stem nematodes reproduce at high levels producing about 500 eggs.

RESISTANCE BREEDING

While there are few ways to reduce the impact on infected fields, using alfalfa varieties having resistance or high resistance can improve performance. Unfortunately, growers in the areas infested with stem nematode have not had good experiences with the varieties on the market listed as having resistance to the pest. Columbia Basin College is working on stem nematode resistant varieties through field selections, along with intensive long term greenhouse selection. Although progress has been demonstrated, further selection is required.

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Attachment 18

Stem Nematode and Root Knot Nematode

William T. W. Woodward[20]

Stem Nematode

Introduction

Alfalfa stem nematode, *Ditylenchus dipsaci*, sometimes referred to as "bulb and stem nematode," is one of a few species of nematodes that feed on parts of plants above ground. The race of stem nematode that infests alfalfa has several other hosts where it can survive, but only reproduces on alfalfa in Washington. Alfalfa is the only major crop in Washington that is seriously damaged by this nematode.

Although stem nematode is usually not a widespread problem for alfalfa in the Columbia Basin, it is a serious problem in the Yakima Valley and can be devastating in individual fields throughout the Pacific Northwest. Alfalfa fields irrigated from streams on the Umatilla Basin Watershed have shown severe infestation. The number of fields with symptoms of stem nematode varies from year to year based on the weather conditions that occur during late winter and early spring. Increased populations of stem nematode and feeding activity are favored by cool, wet weather. Damage is most severe under irrigation and in areas associated with early spring rains. A stand of alfalfa can decline rapidly after stem nematodes become established. Production of a stand can be unprofitable after the first year.

Symptoms

Stem nematode symptoms are most readily observed during early spring in established alfalfa stands. A recognizable symptom is stunted plants with white or light yellow leaves. Stunted plants typically have swollen nodes and shortened internodes. Infected stems become brittle and break off easily at the crown. Crowns of severely infected plants are swollen, discolored, spongy, and produce

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few stems. A small percentage of infected plants may have one or more stems that are completely white. This symptom is referred to as "white flagging" and is more prevalent on spring growth and regrowth following the first cutting. In the Yakima Valley white flagging can be observed through the growing season. Severely infected plants eventually die and weeds will begin to establish.

Disease Cycle

Stem nematodes, like other plant parasitic nematodes, are microscopic roundworms with a hollow, needle-shaped stylet used to puncture plant tissue for feeding. Stem nematodes survive unfavorable periods in the crown of infected plants, infested hay and crop debris, seed, and in soil. Long-term survival is possible under very dry conditions in hay, seed, and soil. The nematodes are spread to new areas by surface water runoff, irrigation, wind-blown crop debris, soil and crop debris clinging to equipment, humans and livestock, and with seed. Runoff water is very important in the spread of stem nematodes within a field and to adjacent fields. It has been estimated that as many as 10 million plant parasitic nematodes are applied with each irrigation cycle in the Yakima valley. Stem nematodes ability to withstand desiccation allows for spread by farm machinery. Wind also appears to play a role in dissemination of stem nematodes. When free moisture is present on stems and leaves, the nematode moves rapidly up the outside of a plant and begins feeding in the buds. The nematode reproduces to high levels during periods of favorable temperature and rapidly spreads when plants are wet. Adults are colorless and are about .04 inches long and cannot be seen without magnification. A complete cycle from egg to adult takes between 19 and 23 days when temperatures are around 59-70°F. A single female can lay up to 500 eggs. Because these conditions usually occur during early spring or mild winters, damage is most severe in the first cutting. When moisture is limited and temperatures are high, stem nematode spreads through internal tissues, but at a much slower rate. This slower movement may permit infected plants to outgrow the infestation as the summer progresses. However, damage and resulting spread reappears when conditions again become favorable.

Control

General

Chemical control with nematicides is not an effective management strategy. Some insecticides cleared for use on alfalfa also are nematicides, but they have not been shown to be effective for stem nematode control at the labeled rates. Therefore, the application of economic thresholds for stem nematode is of little value. Decisions on whether to wait or plow up established alfalfa stands are based on the

severity of observed symptoms and yield reduction, rather than nematode populations per gram of forage. Control of stem nematode requires the integrated use of the following cultural practices:

Prevention

Efforts should be made to prevent the introduction and limit the spread of stem nematodes into new areas. When working in an infested field, clean crop debris and soil from equipment before entering a clean field. Remove all dry hay and dust clinging to balers or other equipment because stem nematodes have the ability to withstand very dry conditions. Where possible, situate new fields upwind of infested fields and where runoff is not received from an infested field. Because stem nematode is most severe in the first cutting, harvest when the top two to three inches of the soil is dry to reduce infection of new growth. Rainfall or irrigation before or soon after cutting promotes invasion of new buds. In the Yakima valley, irrigate with well water if possible.

Crop Rotation

Rotation with crops such as small grains and forage grasses for two to four years will reduce stem nematode populations. The greatest benefits can be expected from longer rotations. However, low numbers of the nematode may survive during the rotation period and begin to increase when alfalfa is reintroduced. Volunteer plants must be controlled during the rotation period.

Resistant Varieties

Several alfalfa varieties are reported to have some level of resistance to stem nematode. Planting a resistant variety should be considered where stem nematodes persist as a problem. Unfortunately, the level of resistance to stem nematode in currently available varieties is not very high. Therefore, even the best varieties may become infected and develop symptoms during years with extended periods of wet, cool conditions. Columbia Basin College is breeding for resistance to stem nematode. This breeding is being done by selecting plants in the field rather than under laboratory or greenhouse conditions. GT 13R Plus is a class 8 non-dormant variety that has shown exceptional resistance to stem nematode in both Chile and Spain under heavy pressure. The breeding background on GT 13R Plus indicated that surviving plants were selected in an old field that was infested with stem nematode. Even though recurrent selection in the field is a slower process than greenhouse or laboratory procedures, it may be the best screening method for producing resistant varieties.

Root Knot Nematode

Introduction

Root knot nematodes (*Meloidogyne* species) are among the most widespread and economically important of plant parasitic nematodes. In Washington, two species of economic concern are the Northern root knot nematode (*M. hapla*) and the Columbia root knot nematode (*M. chitwoodi*). The Northern root knot nematode is distributed throughout Washington and the United States while the Columbia root knot nematode occurs in the Columbia River Basin of Washington and Oregon. Though found in most soil types, they are most abundant in sandy loam soils. Root knot nematodes on alfalfa are of economic concern because of the direct damage they can cause and for the serious damage they inflict on susceptible crops that are grown in rotation with alfalfa. The Northern root knot nematode attacks more than 550 different hosts, including alfalfa. Grain crops are poor hosts for the Northern root knot nematode. However, commonly grown grains in the Basin are hosts for the Columbia root knot nematode. Two races of the Columbia root knot nematode occur in Washington, but only one of them is able to reproduce on susceptible alfalfa varieties.

Life Cycle

Unlike the stem nematode which infects plant tissue during all stages in its life cycle, root knot nematodes are infectious only when they are newly hatched second stage juveniles. After entering the root, second stage juveniles undergo three more molts. As the alfalfa seedling develops, second stage juveniles that penetrated root tissue become established and sedentary in the cortical tissue. Feeding of the nematode initiates a series of host responses, culminating in the formation of galls, and giant plant cells within the galls provide food for the nematodes. As females mature, their bodies swell and they remain immobile. White swollen females, about the size of a pinhead, can be seen. Root knot nematodes reproduce sexually and mature females deposit 50 to 1,000 eggs in a gelatinous matrix within root tissue. Males maintain their long and slender body, and after the fourth molt, they are once again mobile. Under ideal conditions, the life cycle of root knot nematodes is usually completed in 20 to 25 days, and four to five generations may occur in one growing season. For *M. hapla*, the life cycle on alfalfa takes approximately 30 days at 77°F. Root knot nematodes overwinter as second stage juveniles and as eggs in the soil. They may also survive as egg masses in root tissue from the previous crop.

Symptoms

Infections of alfalfa by *Meloidogyne* species may be confined to localized areas of a field or extend throughout an entire field. The extent of the damage depends on several factors, including initial nematode population level, alfalfa variety, and soil temperature at planting time. High initial populations and warm soil temperatures may cause serious injury to seedlings, resulting in stunting. The Northern root knot nematode infects and parasitizes roots of alfalfa plants and causes the plant cells to enlarge into small oval galls on the roots that can be seen with the naked eye. Galls caused by root knot nematodes are accompanied by lateral root growth. In a heavily infested field, young seedlings may be killed by this nematode, even though roots may not display galls. The Columbia root knot nematode produces similar symptoms as the Northern root knot nematode, but it is less pathogenic to alfalfa, and cause tiny galls that can easily be missed if roots are not examined carefully. Root knot nematodes, like stem nematodes, are implicated in interactions with other pathogens. Bacterial wilt, Phytophthora root rot, Fusarium wilt, and damage by the alfalfa stem nematode may be enhanced on alfalfa when the Northern root knot nematode is present.

Management

1. Resistant varieties.
   Use of resistant alfalfa varieties is probably the most practical means of managing root knot nematodes. A number of resistant varieties are now commercially available.
2. Crop rotation.
   Crop rotation to manage the root knot nematode is often not successful because of the wide host range of these nematodes. However, wheat and Barley are a good rotation if only the Northern root knot nematode is present in the field.
3. Chemical control.
   Soil fumigation before planting can be effective against the Northern root knot nematode. However, fumigants are expensive and they are generally not economically feasible on alfalfa.

Attachment 19

RETHINKING THE STANDARD TEST FOR ALFALFA STEM NEMATODE

William T. W. Woodward[21], Christopher A. Lamm[22], Cheriese Moon[23], Eliseo Navarro[24], and Jon Dunn[25]

ABSTRACT

A greenhouse test was conducted to evaluate alfalfa entries for resistance to the alfalfa stem nematode under a 12 month incubation period. Significant differences were found among entries for ASI (average severity index) and percent resistant plants. No significant differences were found between Vernema, the resistant check variety, and Ranger, the susceptible check variety. Poor performance of Vernema and other commercial alfalfa varieties in the greenhouse and stem nematode infested fields in Washington and Oregon indicate a need for a reevaluation of the standard test and check varieties for alfalfa stem nematode.

Key Words: alfalfa, stem nematode, *Ditylenchus*, standard test

INTRODUCTION

Alfalfa stem nematode, *Ditylenchus dipsaci*, sometimes referred to as "bulb and stem nematode," feed on parts of plants above ground. Stem nematode as multiple hosts, but reproduces on alfalfa in Washington. Alfalfa is the only major crop in Washington that is seriously damaged by this nematode.

Although stem nematode is usually not a widespread problem in the Columbia Basin, it is a serious problem in the Yakima Valley and can be devastating in individual fields throughout the Pacific Northwest. Alfalfa fields irrigated from streams on the Umatilla Basin Watershed have shown severe infestation. The number of fields with symptoms of stem nematode varies from year to year based on the weather conditions that occur during late winter and early spring. Increased populations of stem nematode and feeding activity are favored by cool, wet weather. Damage is most severe under irrigation and in areas associated with early spring rains. A stand of alfalfa can decline rapidly after stem nematodes become established. Production of a stand can be unprofitable after the first year.

Stem nematode symptoms are most readily observed during early spring in established alfalfa stands. A recognizable symptom is stunted plants with white or light yellow leaves. Stunted plants typically have swollen nodes and shortened internodes. Infected stems become brittle and break off easily at the crown. Crowns of severely infected plants are swollen, discolored, and produce few stems. A small percentage of infected plants may have one or more stems that are

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completely white. This symptom is referred to as "white flagging" and is more prevalent on spring growth and regrowth following the first cutting. In the Yakima Valley white flagging can be observed through the growing season. Severely infected plants eventually die and weeds will begin to establish.

Stem nematodes, like other plant parasitic nematodes, are microscopic roundworms with a hollow, needle-shaped stylet used to puncture plant tissue for feeding. Stem nematodes survive unfavorable periods in the crown of infected plants, infested hay and crop debris, seed, and in soil. In Washington, stem nematode can survive in crown buds even when the ground is frozen. Long-term survival is possible under very dry conditions in hay, seed, and soil. The nematodes are spread to new areas by surface water runoff, irrigation, wind-blown crop debris, soil and crop debris clinging to equipment, humans and livestock, and with seed. Runoff water is very important in the spread of stem nematodes within a field and to adjacent fields. It has been estimated that as many as 10 million plant parasitic nematodes are applied with each irrigation cycle in the Yakima Valley (1). The nematode reproduces to high levels during periods of favorable temperature and rapidly spread when plants are wet. Adults are colorless and are about .04 inches long and cannot be seen without magnification. A complete cycle from egg to adult takes between 19 and 23 days when temperatures are around 59-70°F. A single female can lay up to 500 eggs. Because these conditions usually occur during early spring or mild winters, damage is most severe in the first cutting.

Over the past 11 years, a field infested with stem nematode has been observed. The field had been established with Vernema, the resistant stem nematode check for dormant alfalfa varieties. Although Vernema is listed as having high resistance with 60% resistant plants, the field was devastated and had no growth in the spring due to stem nematode. After Vernema was removed, the field was left fallow for one year and a modern variety classified as having high resistance to stem nematode was planted. Because the modern variety failed within two years, inexpensive seed (variety not stated) was planted. Due to reoccurring experience with shorted stand life, the non-stated variety was removed the fall of 2011.

Due to the lack of success of varieties classified as having resistance to stem nematode, an experiment was established in a greenhouse at Columbia Basin College (CBC). The standard test for stem nematode was developed in 1995 (2) and suggested the time for incubation after inoculation as 12 weeks. Because of delayed occurrence of symptom in the field, a longer incubation period of 12 months was used.

MATERIALS AND METHODS

Alfalfa entries were planted in a 5' x 12' bench in a greenhouse. Plots were 5" x 12" consisting of 4 rows planted with about 100 seeds per entry. At the cotyledon stage of growth, stand counts of each entry were recorded. Stem nematodes were collected from a field near Prosser, Washington and introduced to the bench in September 2010 to conduct germplasm screening. Following the screening, entries were seeded in the same soil. Plots were maintained for a full year with clipping at or just prior to bud stage when observed on the healthiest plants. In October 2011, the plots were dug and individual plants scored based on regrowth and plant health: 1 = Tall; healthy regrowth, 2 = Medium height; healthy regrowth, 3 = short regrowth; plant with moderate necrosis, 4 = plant alive; severe necrosis, 5 = dead or missing based on stand counts.

2011 Greenhouse Test for Stem Nematode

The test included 35 alfalfa entries with 4 replications and was analyzed as a randomized complete block design. ASI, percent resistant plants using number of plants in class 1 and 2, and percent resistant plants using number of plants in class 1, 2 and 3 were analyzed.

RESULTS AND DISCUSSION

Although selection for resistance to stem nematode has occurred for decades, results under field conditions have not shown as much progress as other pests. For example, the improvement of screening and testing for Anthracnose, Verticillium Wilt and Phytophthora root rot over the last 25 years have correlated well with performance in the field. In most cases, modern varieties classified as having resistance or high resistance to these diseases have not had problems. On the other hand, problems with stem nematode have continued.

Results from a long term stem nematode greenhouse test are shown in a table on page 4. Significant differences among varieties were found for ASI and for % resistant plants. However, there was not a significant difference between the resistant check variety Vernema and the susceptible check Ranger. The standard test suggests that the top two classes of plants be considered resistant. In this test, Vernema would be considered susceptible and when considering the top three classes, it would be considered as having low resistance at best. Observations in Washington over the last decade have confirmed that Vernema does not perform well in fields with the presence of stem nematode. The standard test for stem nematode calls for the evaluation of plants after 12 weeks in the greenhouse. Perhaps a longer duration test would be more appropriate for a pest such as stem nematode. Parents of the top five experimentals in the test were selected from older fields irrigated from the Yakima River in Washington and from fields irrigated from the Umatilla water shed in Oregon. Both areas have had long term problems with stem nematode. Based on this test, these experimentals would be classified as having moderate resistance at best. If this test was submitted to the National Alfalfa & Misc. Legumes Variety Review Board, it would not be accepted. The resistant check variety must be within an acceptable range of reaction of 45-70 % for Vernema. If resistance were adjusted to Vernema at the expected resistance level of 60%, then most of the entries in the test would be considered as having high resistance. The data suggests that it is time to rethink the standard test for alfalfa stem nematode.

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Entry	ASI	% Resistant plants Class 1-2	% Resistant plants Class 1-3
CB7006	4.3	15.0	23.8
CB8002	4.3	16.5	23.0
CB8003	4.3	14.0	21.8
CB9002	4.3	13.0	21.5
CB7007	4.3	14.8	21.0
54Q25	4.4	11.8	19.8
CB9001	4.4	11.3	18.5
Grandstand	4.4	10.5	18.5
Rebound 5.0	4.4	9.0	18.5
PGI427	4.4	10.8	18.0
CB001	4.4	9.8	17.8
DKA 43-13	4.4	11.5	17.5
DKA 50-18	4.4	11.0	16.3
54V09	4.5	8.3	15.8
CB7002	4.5	10.0	15.0
DKA 42-15	4.5	10.3	14.5
CB9007	4.6	6.3	13.0
CB8001	4.6	7.3	12.8
13RSupreme	4.6	7.5	12.8
Masterpiece II	4.6	8.3	11.3
Mountaineer 2.0	4.6	7.0	11.3
CB7003	4.7	5.5	11.0
Pillar	4.6	8.5	10.8
55V12	4.7	5.5	10.5
Vernema	4.7	5.3	10.5
CB7005	4.7	7.0	9.8
CB7004	4.7	5.3	9.3
CB9009	4.7	4.5	8.0
CB9008	4.8	3.3	6.5
CB9004	4.8	4.0	6.0
CB9003	4.8	3.0	5.8
54H11	4.8	2.5	5.8
CB9006	4.8	2.0	4.5
CB9005	4.9	1.8	4.0
Ranger	4.9	1.0	1.5
Mean	4.6	8.1	13.3
LSD 5%	0.32	6.8	10.01
CV %	4.9	59	52.7

Attachment 20

UNDERSTANDING RESISTANCE CLASSIFICATIONS FOR PEA APHID ON ALFALFA

William T. W. Woodward[26], Jon Dunn, Christopher Lamm,
Eliseo Navarro, and Cheriese Moon

ABSTRACT

A greenhouse test at Columbia Basin College (CBC) was conducted to evaluate alfalfa entries for resistance to the pink biotype of the pea aphid that regularly infests alfalfa in the Columbia Basin in Washington. Significant differences were found among entries for visual scores, ASI (average severity index), and percent resistance. Only 3 of 12 commercial varieties in the test scored similar to their resistance level claimed when submitted to the National Alfalfa & Misc. Legumes Variety Review Board. Both the resistant and susceptible check varieties were not significantly different than their expected percent resistance indicating the test as acceptable. If only the plants rated 1 & 2 were counted as resistant, no entry in the test would be classified as having higher than moderate resistance. Considering plants rated 1-3 as resistant, about half of the entries would be considered to have resistance or high resistance to the insect. It should be possible to increase the level of resistance to pea aphid and eliminate or at least reduce the amount of chemical control used in the Columbia Basin.

Key Words: pea aphid, alfalfa, standard test, *Acyrthosiphon pisum*, resistance

INTRODUCTION

The pea aphid (*Acyrthosiphon pisum*) is most often found as a large green aphid with long legs allowing it to be very mobile. Its escape response from predators is by leaving the feeding site and dropping off the plant (3). In the greenhouse, disturbance by sprinkler irrigation will cause the same response and is likely to happen under sprinkler irrigation in alfalfa fields allowing for rapid spread of the insect.

During the fall of 2010, the pink biotype of the pea aphid was found to be the most abundant aphid in alfalfa fields located in Franklin County, Washington. Its physical appearance is the same with the exception of color and damage caused by the pink biotype is the same as the green. The reason for color differences within a species of aphid is usually unknown. However, it has been shown that green biotype of the pea aphid is parasitized more often than the pink, while the pink biotype is more prone to predation. The color difference in the pea aphid is controlled by a single gene with two alleles P and p, pink dominant to green (2).

In 1970, due to a need to for a uniform procedure for describing levels of pest resistance for varieties of alfalfa, a North American Alfalfa Improvement Conference (NAAIC) committee on "Standard Tests for Characterizing Disease and Insect Resistance of Alfalfa Cultivars" published procedures that became accepted as standard tests. The publication was revised in 1984. More

[26] Dean of Agriculture Education, Research and Development, Columbia Basin College and agriculture students attending CBC, Pasco, WA, December 14, 2011. CBCAG1102. **In:** Proceedings, 2012 Washington State Hay Growers Association Annual Conference & Trade Show.

recently, standard tests with additions and revisions are available on the NAAIC web site (http://www.naaic.org/). The standard testing procedures for aphids use a 1-5 scoring scheme. Plants rated 1-2 are considered resistant for the cowpea aphid and spotted alfalfa, while a less stringent 1-3 is used for the blue alfalfa aphid and pea aphid.

A pea aphid test, based on the standard test, was initiated to determine resistant levels of CBC experimentals, selected commercial varieties, and appropriate resistant and susceptible check varieties. This type of test can classify varieties and be a tool to determine the need for further selection on experimentals. Because many alfalfa growers in the state of Washington routinely use a pesticide in the fall to control aphids, it is possible that varieties are misclassified due to the less stringent scoring system for the pest. Selection of only class 1 plants was made from numerous varieties and experimentals in the test. Seed will be produced on the population of plants and released as a resistant pink aphid biotype germplasm pending further test results.

MATERIALS AND METHODS

Alfalfa entries were planted in a 5' x 12' bench in a greenhouse. Plots were 5" x 12" consisting of 4 rows planted with about 100 seeds per entry. Germination tests were run on all entries to determine the need for scarification. Some of the entries, including checks, needed scarification. At the cotyledon stage of growth, stand counts of each entry were recorded. Pea aphids (pink biotype) were introduced to the bench at about the second trifoliolate emergence. The aphids were allowed to multiply until plants were near bud stage. Observations of 3 to 4 inch colonies on stems were not uncommon. Visual scores were taken on regrowth on a 1-9 scale with 1 = dead plot and 9 = tall resistant appearing plots. When the regrowth of the resistant check (PA-1) was about 5 inches tall with little growth on the susceptible check (Vernal), plots were dug and scored according the standard test with differentiation for plant height. Plants rated a 1 were about 5 inches tall, 2 about 3 inches, and 3 about 1 inch. Plants rated 4 were short with little regrowth and chlorotic while ratings of 5 were either dead or missing based on stand count. The test included 35 entries with 4 replications and was analyzed as a randomized complete block design.

The pink biotype of the pea aphid was collected in alfalfa fields in Franklin County, WA. The collection was isolated from the greenhouse on potted alfalfa plants for about 2 months to eliminate parasites and assure a pure pea aphid population. The collection was transferred to the greenhouse where benches containing experimental varieties had been planted for selection purposes. The test was planted in an isolated bench with aphid introduction upon second trifoliolate initiation. A pesticide was not applied to reduce aphid population prior to scoring. To simulate fall condition, greenhouse temperature was regulated between 60 and 70 degrees F while 12 hour daylight was maintained.

RESULTS AND DISCUSSION

Results of the pea aphid test are shown in Table 1. When classifying varieties according to the standard test using the 1-3 plant ratings, the resistant check variety, PA-1, showed 52% resistance and was well within its range of resistance and close to its expected percent resistance at 55% resistant plants. The susceptible check variety, Vernal, was within its range and close to its expected % resistant plants. Correlations among ratings and ASI were high indicating all scoring techniques could be used to classify varieties (Table 2). Negative correlations between

ASI and other scoring techniques were negative due to lower ASI scores indicating higher resistance. This test would be acceptable for submission to the National Alfalfa & Misc. Legumes Variety Review Board. When observing commercial varieties, 3 of the 12 were correctly classified when considering ratings 1-3. When considering the ratings 1-2, none of the entries would be considered as having resistance or high resistance to the pink biotype of the green pea aphid. Many of the alfalfa growers in Washington spray a pesticide to control aphids in the fall of the year. It is possible that varieties do not have as high a level of resistance as reported. Plants rated as a 1 were selected from commercial and experimental varieties and crossed in the field during the summer of 2011. A greenhouse experiment has been planted for the 2011-2012 winter to determine selection progress. The CBC greenhouse test differs from the standard test in the time allowed for aphid buildup, scoring on regrowth after cutting, and terminating infestation after 21 to 28 days.

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Table 1: 2011 Greenhouse Test for the Green Pea Aphid (Pink Biotype)

Variety	Class	Visual Scores*	ASI	% resistant plants Class 1-2	% resistant plants Class 1-3
CB8003		7.5	3.3	25.6	55.1
OK 51		6.8	3.5	15.4	54.5
PA-1	HR	9	3.4	28.2	51.7
CB7006		7.3	3.3	16.7	48.5
CB7007		8	3.4	24.3	47.4
CB7005		6.8	3.7	16.2	47
CB8002		9	3.4	25.5	46.9
Dura 512	R	8	3.6	18.2	42.3
CB7004		6	3.5	23.1	42.2
CB001		5.3	3.5	18.9	40.9
CB8001		7	3.8	14	36
54V09	HR	6.3	3.9	10.8	34.8
WL 327	R	4.8	3.9	9.9	33.8
Rebound 5.0	HR	7	3.9	11.1	33.4
CB9007		4	4	5.3	31.9
CB9002		5.5	3.9	9.8	31.7
CB7002		6.3	4	9.6	31.6
CB7003		5.8	4	7.8	31.4
DKA 42-15	HR	5.3	3.9	9.7	31
54H11	MR	3	4.1	4.6	30.8
CB9001		4.5	4	10	28.8
Unknown		4	3.9	11.3	27.9
CB9004		4	4	9.9	26.3
CB9003		2.8	4.1	6.4	24.8
Masterpiece II	HR	5.3	4	5	23.3
DKA 43-13	R	7.3	4.1	8.1	23.3
CB9008		3.8	4	5.4	22.7
DKA 50-18	R	6.3	4.1	6	20.1
FSG 351	HR	4.3	4.2	3.9	19.2
CB9006		3.3	4.1	3.9	17.1
54Q25	R	4.5	4.1	5.9	16.1
CB9009		2.3	4.1	2.9	15.8
CB9005		3	4.5	1.5	13.5
Vernal	S	2.3	4.6	0	7.8
Mean		5.4	3.9	11	31.2
LSD 5%		1.76	0.41	10.22	19.51
CV %		23	7.4	65.1	43.7

* 1 = dead; 9 = Tall, no damage

Table 2: Correlations for ASI, Ratings 1-2 and Ratings 1-3

	Visual scores	ASI	Class 1,2
ASI	-0.79		
Class 1,2	0.83	-0.93	
Class 1,2,3	0.80	-0.95	0.90

Attachment 21

PROGRESS IN BREEDING FOR PEA APHID RESISTANCE

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Eliseo Navarro

ABSTRACT

In December 2010, a greenhouse test at Columbia Basin College (CBC) was conducted to evaluate alfalfa entries for resistance to the pink biotype of the green pea aphid that regularly infests alfalfa in the Columbia Basin in Washington. Significant differences were found among entries for visual scores, ASI (average severity index), and percent resistance (6). Only 3 of 12 commercial varieties in the test scored similar to their resistance level claimed when submitted to the National Alfalfa & Misc. Legumes Variety Review Board. Both the resistant and susceptible check varieties were not significantly different than their expected percent resistance indicating the test was acceptable. In November 2011, a second test was planted to determine progress after selection for pea aphid in the greenhouse. Significant differences were found among entries for ASI and percent resistant plants. Significant progress was made selecting resistant plants based on regrowth after clipping and general health of the plant with no clipping.

Key Words: pea aphid, alfalfa, standard test, *Acyrthosiphon pisum*, resistance

SOME PUBLIC CONTRIBUTIONS

In 1957, Dr. Bill Melton at New Mexico State University began breeding alfalfa for resistance to pests in the southern New Mexico area. The breeding effort resulted in the release of the variety Mesilla in 1967 which had moderate resistance to the green pea aphid (4). The variety Washoe and Apex were released in 1966 while Dawson was released in 1967 (3). The variety "Kanza" was released in 1969 and serves as a resistant check variety for pea aphid to this day. All of these varieties were developed for pea aphid resistance by scientists at public institutions for different environments in the United States. They were widely grown as varieties and served alfalfa breeders as germplasm for the development of modern multiple pest resistant varieties developed by the public and industry. Many methods of selecting resistant plants for pea aphid have been developed by various universities. The standard test for pea aphid was developed by Dr. R. C. Berberet at Oklahoma State University and is used by all alfalfa breeders as a tool to classify new varieties for their level of resistance to the insect (1).

INTRODUCTION

The pea aphid (*Acyrthosiphon pisum*) is most often found as a large green aphid with long legs allowing it to be very mobile. Its escape response from predators is by leaving the feeding site and dropping off the plant (2). In the greenhouse, disturbance by sprinkler irrigation will cause the same response and is likely to happen under sprinkler irrigation in alfalfa fields allowing for rapid spread of the insect.

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[27] Dean of Agriculture Education, Research and Development, Columbia Basin College and agriculture students attending CBC, Pasco, WA, December 28, 2012. CBCAG1202. **In:** Proceedings, 2013Washington State Hay Growers Association Northwest Hay Expo.

During the fall of 2010, the pink biotype of the pea aphid was found to be the most abundant aphid in alfalfa fields located in Franklin County, Washington. Its physical appearance is the same with the exception of color and damage caused by the pink biotype is the same as the green. The reason for color differences within a species of aphid is usually unknown. However, it has been shown that green biotype of the pea aphid is parasitized more often than the pink, while the pink biotype is more prone to predation. The color difference in the pea aphid is controlled by a single gene with two alleles P and p, pink dominant to green (2).

In 1970, due to a need of a uniform procedure for describing levels of pest resistance for varieties of alfalfa, a North American Alfalfa Improvement Conference (NAAIC) committee on "Standard Tests for Characterizing Disease and Insect Resistance of Alfalfa Cultivars" published procedures that became accepted as a method to classify varieties. The publication was revised in 1984. More recently, standard tests with additions and revisions are available on the NAAIC web site (http://www.naaic.org/). The standard testing procedures for aphids use a 1-5 scoring scheme. Plants rated 1-2 are considered resistant for the cowpea aphid and spotted alfalfa, while a less stringent 1-3 is used for the blue alfalfa aphid and pea aphid.

A pea aphid test, based on the standard test, was initiated to determine resistant levels of CBC experimentals, commercial varieties grown in the area, and appropriate resistant and susceptible check varieties. This type of test can classify varieties and be a tool to determine the need for further selection on experimentals. Because many alfalfa growers in the state of Washington routinely use a pesticide in the fall to control aphids, it is possible that varieties are misclassified due to the less stringent scoring system for the pest.

MATERIALS AND METHODS

Alfalfa entries were planted in a 5' x 12' bench in a greenhouse on November 21, 2011 and scored on January 26-27, 2012. Plots were 5" x 12" consisting of 4 rows planted with about 100 seeds per entry. Germination tests were run on all entries to determine the need for scarification. Some of the entries, including checks, needed scarification. At the cotyledon stage of growth, stand counts of each entry were recorded. Pea aphids (pink biotype) were introduced to the bench at about the second trifoliolate emergence. The aphids were allowed to multiply until plants were near bud stage. Observations of 3 to 4 inch colonies on stems were not uncommon. When the regrowth of the resistant check (PA-1) was about 5 inches tall with little growth on the susceptible check (Vernal), plots were dug and scored according the standard test with differentiation for plant height. Plants rated 1 were about 5 inches tall, 2 about 3 inches, and 3 about 1 inch. Plants rated 4 were short with little regrowth and chlorotic while ratings of 5 were either dead or missing based on stand count. The test included 24 entries with 4 replications and was analyzed as a randomized complete block design.

The pink biotype of the pea aphid was collected in alfalfa fields in Franklin County, WA. The collection was isolated in the greenhouse on alfalfa plants started in a bench for about 2 months. A pesticide was not applied to reduce aphid population prior to scoring. To simulate fall condition, greenhouse temperature was regulated between 60 and 70 degrees F while 12 hour daylight was maintained.

Out of the 2010-2011 pea aphid variety test, parents of four experimentals were selected for resistance to the pea aphid while scoring the test. Parents for CB11003 were selected from 8 CBC entries that had been previously selected for stem nematode. The parents were made up of plants score as 1 and 2. The second (CB11004) was selected from 10 commercial entries, one CBC experimental, and from the resistant check and was intended as a potential germplasm release. All of these parents scored a 1 in the test. The parents of CB11009 were selected from the test using parents scored from 1-3. The parents of CB11005 were selected from a large number of plants from non-lodging germplasm planted in 5'x12' benches. The source for CB11006 was previously selected for stem nematode resistance and parents were selected from a large number of plants planted in a bench. CB11007 and CB11008 were selected from the same germplasm using different methods of selection. Selections for CB11007 were made by identifying plants in the bench population that retained their green color with no chlorotic symptoms. Selections for CB11008 were made based on the selections ability to recover under severe aphid pressure after clip back. Selections were maintained in the greenhouse and planted in the field for breeder seed production in 2011. The 2011-2012 test included these entries.

RESULTS AND DISCUSSION

Results and discussion of the 2010-2011 pea aphid test (Table 1) are reported in a previous Washington State Hay Growers Association proceedings article (6) Results from the 2011-2012 pea aphid test are shown in Table 3. When classifying varieties according to the standard test using the 1-3 plant ratings, the resistant check variety, PA-1, showed 56.7% resistant plants and was well within its range of resistance and close to its expected percent resistance at 55% resistant plants. The susceptible check variety, Vernal, was within its range and close to its expected percent resistant plants. Correlations among ratings and ASI were high indicating all scoring techniques could be used to classify varieties (Table 4). Negative correlations between ASI and other scoring techniques were negative due to lower ASI scores indicating higher resistance. This test would be acceptable for submission to the National Alfalfa & Misc. Legumes Variety Review Board. When considering the accepted resistant classes of plants of scores 1-3, 9 of the entries would be considered as having high resistance to the green pea aphid. When considering the ratings 1-2, only one of the entries would be considered as having high resistance to the pink biotype of the green pea aphid. Eleven entries would be considered to have resistance to the insect. Entries that were selected for pea aphid resistance in 2010-2011 are followed by an asterisk in the entry column. Six of the top performing entries in the test were experimentals selected the previous year for resistance to pea aphid.

CB11004 was selected from 12 sources including CB8002, 54Q25, DKA42-13, WL327, Masterpiece II, Rebound 5.0, 512, DKA42-15, DKA50-18, 54V09, FSG351, and the resistant check variety PA-1. Only class 1 plants were used as parents for the germplasm. CB11004 had the highest percent resistant plants in the test at 75.5 % when classified using the standard test with plants scored 1-3 considered resistant. It was the only entry to be considered as having high resistance when considering only plants scored 1 and 2. CB11004 was not significantly different than the resistant check variety but was significantly higher than all commercial varieties in the test. CB11004 may be released as a germplasm once it is classified for other pests. The average percent resistance for the varieties that were sources for parent plants was 33%. The improvement resulting in CB11004 indicates that further improvement for pea aphid resistance can be made for commercial varieties.

CB11007 and CB11008 were selected from the same original germplasm (CB9002) under two different selection methods. Parents of CB11007 were selected from a large population of plants from CB9002 that had not been clipped and showed healthy green growth under heavy pea aphid infestation. Parents of CB11008 were selected for their ability to recover after clipping under heavy infestation of pea aphid. Both methods of selection appeared to be successful as there was no significant difference between the two experimentals. Both would be considered as having high resistance to pea aphid.

CB11005 and CB11009 were selected from non-lodging germplasm. CB11005 was selected from large population of plants out of CB9009, CB9005 and CB9006. In the 2010-2011 pea aphid test, these experimentals were near the bottom of the test with an average percent resistance of 15.5. The method of selection appeared to be successful as indicated by the resultant expression of 65% resistant plants for CB11005. On the other hand, CB11009 is an example of the lack of progress when including less than suitable plants among the parents. CB9004 exhibited one of the highest levels of resistance among non-lodging plant materials in the 2010-2011 pea aphid experiment. Parents were selected from plots in the test. However, to reach a goal of about 100 parent plants, parents from class 2 and 3 were included. In an autotetraploid species such as alfalfa, it is commonly know that escapes while selecting can "kill" progress toward improvement for most traits. CB11009 is a good example showing little progress at 38.6 percent resistant plants over CB9004 at 26.3 percent.

Parents of CB11003 were selected from plots from germplasm that had been previously selected for stem nematode resistance. Class 1 and 2 plants were included in the parent population resulting in only a small advance in pea aphid resistance. However, the experimental just missed the classification of having high resistance by about one percentage point.

Parents of CB11006 and CB11010 were selected out of single germplasm sources planted in benches infested with pea aphid. Both improved from the classification of having resistance to having high resistance to the insect.

The experiment shows that when precision of parent selection is utilized, excellent progress can be made for pea aphid resistance.

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Seeded: 12-10-2010 Harvest: 2-18-11

Variety	Class	Visual Scores*	ASI	% resistant plants Class 1-2	% resistant plants Class 1-3
CB8003		7.5	3.3	25.6	55.1
OK 51		6.8	3.5	15.4	54.5
PA-1	HR	9	3.4	28.2	51.7
CB7006		7.3	3.3	16.7	48.5
CB7007		8	3.4	24.3	47.4
CB7005		6.8	3.7	16.2	47
CB8002		9	3.4	25.5	46.9
512	R	8	3.6	18.2	42.3
CB7004		6	3.5	23.1	42.2
CB001		5.3	3.5	18.9	40.9
CB8001		7	3.8	14	36
54V09	HR	6.3	3.9	10.8	34.8
WL 327	R	4.8	3.9	9.9	33.8
Rebound 5.0	HR	7	3.9	11.1	33.4
CB9007		4	4	5.3	31.9
CB9002		5.5	3.9	9.8	31.7
CB7002		6.3	4	9.6	31.6
CB7003		5.8	4	7.8	31.4
DKA 42-15	HR	5.3	3.9	9.7	31
54H11	MR	3	4.1	4.6	30.8
CB9001		4.5	4	10	28.8
Unknown		4	3.9	11.3	27.9
CB9004		4	4	9.9	26.3
CB9003		2.8	4.1	6.4	24.8
Masterpiece II	HR	5.3	4	5	23.3
DKA 43-13	R	7.3	4.1	8.1	23.3
CB9008		3.8	4	5.4	22.7
DKA 50-18	R	6.3	4.1	6	20.1
FSG 351	HR	4.3	4.2	3.9	19.2
CB9006		3.3	4.1	3.9	17.1
54Q25	R	4.5	4.1	5.9	16.1
CB9009		2.3	4.1	2.9	15.8
CB9005		3	4.5	1.5	13.5
Vernal	S	2.3	4.6	0	7.8
Mean		5.4	3.9	11	31.2
LSD 5%		1.76	0.41	10.22	19.51
CV %		23	7.4	65.1	43.7

* 1 = dead; 9 = Tall, no damage

Table 2: 2010-2011 Correlations for ASI, Ratings 1-2 and Ratings 1-3

	Visual scores	ASI	Class 1,2
ASI	-0.79		
Class 1,2	0.83	-0.93	

Class 1,2,3	0.80	-0.95	0.90

Table 3: 2011-2012 Greenhouse Test for the Green Pea Aphid (Pink Biotype)

Seeded: November 21, 2011
Scored: January 26-27, 2012

Entry	ASI	% resistant plants Class 1-2	% resistant plants Class 1-3
CB11004*	2.5	56.5	75.5
CB11007*	2.9	48.4	66.4
CB11005*	2.9	47.6	65.0
CB11006*	3.0	45.1	62.0
CB11010*	3.0	45.9	61.8
CB11008*	3.1	40.7	59.0
PA-1	3.1	45.6	56.7
CB11001	3.3	34.6	54.0
DKA 42-15	3.4	31.1	51.8
CB11003*	3.3	40.1	49.8
54V09	3.5	31.4	46.9
WT98002	3.5	29.7	42.8
OK 51	3.7	26.0	40.8
CB11009*	3.7	29.4	38.6
CB9002	3.8	27.8	38.4
54Q25	3.9	20.9	35.0
CB11011	4.0	18.6	32.0
CB11012	4.0	18.8	30.7
WT98001	4.0	21.4	30.3
CB001	4.2	13.3	27.1
54H11	4.3	12.9	23.4
CB9005	4.4	11.9	16.8
ARC	4.5	8.4	16.0
Vernal	4.7	4.2	6.5
Mean	3.6	29.6	42.8
LSD 5%	0.66	16.01	20.11
CV %	12.7	37.9	32.9

*****Entries selected for pea aphid

Table 4: 2010-2011 Correlations for ASI, Ratings 1-2 and Ratings 1-3

ASI vs. Class 1,2		-0.99
ASI vs. Class 1,2,3		-0.99
Class 1,2 vs. Class 1,2,3		0.97

Attachment 22

CAGES FOR 2013

Greenhouse selections for 2013

CB13001--CBG1201—(Traditional) Selections out of CB11003 after 10 months in stem nematode bench. Selections were made on root examination for Fusarium wilt. 92 parent plants were selected with 56 surviving in pots through the winter. CB11003 – 97 plants selected for the pink biotype of the green pea aphid. Germplasm sources include: CB001 (16 plants), CB7002 (10), CB7004 (12), CB7005 (9), CB7007 (14), CB8001 (5), CB8002 (5), and CB8003 (26). Planted: first one north.

CB13002 -- CBG1202 – (traditional) out of CB11001 after 10 months in stem nematode bench. Selections were made on root examination for Fusarium wilt. 92 parent plants with 48 lost in pots in greenhouse winter of 2013. CB11001 – Selections from Greenhouse stem nematode bench after 12 months of pressure. Cage is made up of 26 plants from CB8001, 15 plants from CB8002, 63 plants from CB001 and 36 plants from CB9002. Second one from north

CB13003 -- CBG1205 – (traditional) 55 parent plants from traditional experimental CB12003 (selected from commercial varieties for stem nematode) selected from 2012 pea aphid test. Should be good yielding and have resistance to stem nematode and pea aphid. Third one from north

CB13004 -- CBG1206 – Traditional experimental with 72 parent plants from CB11004. This is a second cycle for pea aphid from commercial types. Selected from the 2012-2013 pea aphid test. 4th one from north

CB13005 -- CBG1203 – Non-lodging experimental selected out of CB11005 from 2012 small pea aphid test that wasn't scored. Long term 12 month screening. 75 parent plants. 24 plants from CB11009 to make 99 plants for cage isolation. Parent plants from CB11009 were from the same screening. PA-1, CB11005, CB11009 and CB11004 had the best growth and survival in the test.

CB13006 -- CBG1204—Non-lodging experimental with 106 parents selected from CB12005 (38 plants), CB11005 (38), and CB11009 (32) from 2012 pea aphid test. 10 parents were scored 2 with the rest as a 1. Should have excellent pea aphid resistance.

CB13007 – Traditional variety with parents selected from 2012 small pea aphid test from CB11004 (74) and CB11006 (30). Previous selection was from stem nematode with final selection from pea aphid test after 10 months in bench. CB11004 was from multiple commercial varieties for pea aphid. CB11006 traces back to CB001 selected for pea aphid resistance. Fifth one from north

Attachment 23

TITLE: Developing Alfalfa Germplasm for Resistance to Stem Nematode-disease Complex.

ABSTRACT

The alfalfa stem nematode (SN), *Ditylenchus dipsaci* (Kühn) Filipjev, is the most important plant-parasitic nematode associated with alfalfa (*Medicago sativa* L.) throughout the western United States (US) and most parts of the world where irrigation is necessary. Even though most alfalfa varieties sold in the western US are rated as having high resistance, stand decline due to SN has been observed in both the Pacific Northwest (PNW) and the Pacific Southwest (PSW). In 2009, scientists in California called the outbreak of SN damage "devastating" and even linked the event to climate change. Because HR alfalfa varieties have failed in the field, there is a significant possibility that the problem is due to a complex association between SN and disease. Because a long duration test may be more appropriate to simulate field conditions, Columbia Basin College (CBC) established a greenhouse test that was scored after a12 month exposure to SN. Entries included commercial varieties, standard checks and germplasm developed by CBC. Although the germplasm lines showed significantly higher resistance levels than Vernema, the HR check variety, none of the entries were classified as having better than moderate resistance to SN. Roots of subsequent screening were scored for selection purposes and plants were discarded due to Fusarium wilt (*Fusarium oxysporum* f. sp. *medicagininis*). There is a strong need to develop germplasm that can persist in the field under sever SN pressure. However, success may depend on selecting for the stem nematode-disease complex (SNDC).

1. Introduction

Alfalfa (*Medicago sativa* L.) is a polymorphic species adapted to most parts of the world and grown under a wide range of climatic conditions. Plant breeders have used the vast genetic diversity within the species to release numerous varieties selected for improved winter hardiness, enhanced yield under specific conditions, and large efforts on multiple pest resistance. Because other methods of control for many of the diseases, insects, and nematodes are ineffective, unavailable or too expensive for the crop, plant resistance has been used successfully over biological, cultural, chemical or mechanical control. Alfalfa is a cross-pollenated autotetraploid species that is considered to be a heterogeneous population (4). An alfalfa variety would be made up of plants that are genetically different but have characteristics that are in common. Pest resistance for an alfalfa variety is characterized by the frequency of resistant plants in a population. Most often it is expressed as percent resistant plants or as average severity index (ASI) which is calculated by averaging the numerical severity rating for individual plants tested. Most often both are reported and the CV (coefficient of variation) for ASI is used to determine the comparisons of results among experiments.

The alfalfa stem nematode (SN), *Ditylenchus dipsaci* (Kuhn) Filipjev, is considered to be the most important plant-parasitic nematode associated with alfalfa. I have personally observed the pest in various parts of the world including Chile, Spain, Champaign Valley of France, Italy

(near Parma), California, Arizona, Idaho, Oregon and Washington. Most of the observations were associated with irrigation where water was derived from mountain water sheds. The exception was in the Champaign Valley in France were the nematode was associated with natural low undulation in the soil. The infestation in Italy was on irrigated alfalfa intended for feeding dairy animals for the production of Parmesan cheese. At $2.5 billion in annual revenues for Italy, parmesan is a big business (19). Severe damage caused by SN on alfalfa in the Sacramento and Northern San Joaquin valley in the spring of 2009-2010 was widely reported. (1, 2, 3, 8, 18). The University of California at Davis suggested the cause to be warmer winter temperatures and stating that "if climate change causes winter temperatures to rise further, outbreaks of alfalfa SN may become more frequent in the region"(1). Alfalfa is the only major crop in Washington that is seriously damage by SN. Although SN is usually not a widespread problem in the Columbia Basin due to rotation with high value crops like onion and potato where fumigation is used to lower the population of nematodes, it is serious where those crops cannot be grown such as under wheel lines. In addition, SN is a serious problem in the Yakima Valley and can be devastating in individual fields throughout the Pacific Northwest. Alfalfa fields irrigated from streams on the Umatilla Basin Watershed have shown severe infestation. A stand of alfalfa can decline rapidly after SN becomes established causing production to be unprofitable after the first year.

SN symptoms are most readily observed during early spring in established alfalfa stands. A recognizable symptom is stunted plants with white or light yellow leaves. Stunted plants typically have swollen nodes and shortened internodes. Infected stems become brittle and break off easily at the crown. Crowns of severely infected plants are swollen, discolored, and produce few stems. A small percentage of infected plants may have one or more stems that are completely white. This symptom is referred to as "white flagging" (Figure 1) and is more prevalent on spring growth and regrowth following the first cutting. In the Yakima Valley white flagging can be observed through the growing season (Figure 2). Severely infected plants eventually die and weeds will begin to establish.

Figure 1: Alfalfa white flagging in the Yakima valley.

Figure 2: White flagging throughout an alfalfa field in the Yakima valley

SNs, like other plant parasitic nematodes, are microscopic roundworms with a hollow, needle-shaped stylet used to puncture plant tissue for feeding. SN survives unfavorable periods in the crown of infected plants, infested hay and crop debris, seed, and in soil. In Washington, SN can survive in crown buds even when the ground is frozen. Long-term survival is possible under very dry conditions in hay, seed, and soil. The nematodes are spread to new areas by surface water runoff, irrigation, wind-blown crop debris, soil and crop debris clinging to equipment, humans and livestock, and with seed. Runoff water is very important in the spread of SN within a field and to adjacent fields. It has been estimated that as many as 10 million plant parasitic nematodes are applied with each irrigation cycle in the Yakima Valley (5). The nematode reproduces to high levels during periods of favorable temperature and rapidly spread when plants are wet. Adults are colorless and are about .04 inches long and cannot be seen without magnification. A complete cycle from egg to adult takes between 19 and 23 days when temperatures are around 59-70°F. A single female can lay up to 500 eggs. Because these conditions usually occur during early spring or mild winters, damage is most severe in the first cutting.

Over the past 11 years, a field infested with SN has been observed. The field had been established with Vernema, the resistant SN check for dormant alfalfa varieties. Although Vernema is listed as having high resistance with 60% resistant plants, the field was devastated and had no growth in the spring due to SN. After Vernema was removed, the field was left fallow for one year and a modern variety classified as having high resistance to SN was planted. Because the modern variety failed within two years, inexpensive seed (variety not stated) was planted. Due to reoccurring experience with shorted stand life, the non-stated variety was removed the fall of 2011.

Due to the lack of success of varieties classified as having resistance to SN, an experiment was established in a greenhouse at Columbia Basin College (CBC). The standard test for SN was developed in 1995 (9) and suggested the time for incubation after inoculation as 12 weeks. Because of delayed occurrence of symptom in the field, a longer incubation period of 12 months was used. Although selection for resistance to SN has occurred for decades, results under field conditions have not shown as much progress as other pests. For example, the improvement of screening and testing for Anthracnose caused by *Colletotrichum trifolii*, Verticillium Wilt caused by *Verticillium albo-atrum* and Phytophthora root rot caused by *Phytophthora megasperma* over the last 25 years have correlated well with performance in the field. In most cases, modern varieties classified as having resistance or high resistance to these diseases have not had problems. On the other hand, problems with SN have continued.

Results from a long term SN greenhouse test are shown in Table 1. Significant differences among varieties were found for ASI and for % resistant plants. However, there was not a

significant difference between the resistant check variety Vernema and the susceptible check Ranger. The standard test suggests that the top two classes of plants be considered resistant. In this test, Vernema would be considered susceptible and when considering the top three classes, it would be considered as having low resistance at best. Observations in Washington over the last decade have confirmed that Vernema does not perform well in fields with the presence of SN. The standard test for SN calls for the evaluation of plants after 12 weeks in the greenhouse. Perhaps a longer duration test would be more appropriate for a pest such as SN. Parents of the top five experimentals in the test were selected from older fields irrigated from the Yakima River in Washington and from fields irrigated from the Umatilla water shed in Oregon. Both areas have had long term problems with SN. Based on this test, these experimentals would be classified as having moderate resistance at best. If this test was submitted to the National Alfalfa & Misc. Legumes Variety Review Board, it would not be accepted. The resistant check variety must be within an acceptable range of reaction of 45-70 % for Vernema. If resistance were adjusted to Vernema at the expected resistance level of 60%, then most of the entries in the test would be considered as having high resistance. The results of a second long term SN test are reported in Table 2. The resistant and susceptible check varieties, Vernema and Ranger, respectively, performed about the same as in the 2010-2011 test. In addition, four varieties (CB7006, CB9002, 54V09 and 55V12) were tested again in the 2012-2014 experiment. All four of the varieties had similar results with the CBC experimentals showing promise and the commercial varieties performing poorly. Most of the CBC experimental varieties in the test have been selected through one or two cycles for SNDC in the greenhouse. One of the obvious exceptions is the experimental CB11011 which is a non-lodging germplasm that has not been selected for SN. An interesting observation is CB12001 which was selected out of CB11011 in a SNDC screening. Although it appears that some progress was made, it is difficult to make early progress with susceptible germplasm in an autotetraploid species like alfalfa. The data suggests that it is time to rethink the standard test for alfalfa SN or consider selecting for SNDC. The second test for SNDC indicates that recurrent selection for SN and the disease complex found in greenhouse benches could solve the negative correlation of greenhouse testing and field performance with alfalfa varieties.

In plant pathology and nematology, there have been significant findings of nematode and fungal disease complexes (13, 14, 15, 16). In addition, nematode and bacterial disease complexes have been demonstrated (10, 11, 12). Carefully controlled experiments have proved that plant-parasitic nematodes increase the development of diseases cause by fungi and bacteria. Figure 3 shows the crowns of alfalfa plants lifted from the 2012-2014 SNDC test clearly showing crown rots due to Fusarium wilt (FW) caused by *Fusarium oxysporum*. Plants dug in stem nematode infested fields clearly show the same symptoms (Figure 4). It was demonstrated that the transmission of bacterial wilt (BW) of alfalfa cause by *Corynebacterium insidiosum* was due to SN (6). The development of bacterial wilt was stimulated because SN reduced the resistance of the alfalfa plant to BW (7).

Table 1: 2010-2011Greenhouse Test for Stem Nematode

Entry	ASI	% Resistant plants Class 1-2	% Resistant plants Class 1-3
CB7006	4.3	15.0	23.8
CB8002	4.3	16.5	23.0
CB8003	4.3	14.0	21.8
CB9002	4.3	13.0	21.5
CB7007	4.3	14.8	21.0
54Q25	4.4	11.8	19.8
CB9001	4.4	11.3	18.5
Grandstand	4.4	10.5	18.5
Rebound 5.0	4.4	9.0	18.5
PGI427	4.4	10.8	18.0
CB001	4.4	9.8	17.8
DKA 43-13	4.4	11.5	17.5
DKA 50-18	4.4	11.0	16.3
54V09	4.5	8.3	15.8
CB7002	4.5	10.0	15.0
DKA 42-15	4.5	10.3	14.5
CB9007	4.6	6.3	13.0
CB8001	4.6	7.3	12.8
13RSupreme	4.6	7.5	12.8
Masterpiece II	4.6	8.3	11.3
Mountaineer 2.0	4.6	7.0	11.3
CB7003	4.7	5.5	11.0
Pillar	4.6	8.5	10.8
55V12	4.7	5.5	10.5
Vernema	4.7	5.3	10.5
CB7005	4.7	7.0	9.8
CB7004	4.7	5.3	9.3
54H11	4.8	2.5	5.8
CB9006	4.8	2.0	4.5
CB9005	4.9	1.8	4.0
Ranger	4.9	1.0	1.5
Mean	4.6	8.1	13.3
LSD 5%	0.32	6.8	10.01
CV %	4.9		

Table 2: 2012-2014 Greenhouse Test for Stem Nematode

Seeded:11-8-2012 Harvest: 4-11-2014

Entry	ASI	% resistant plants Class 1-2	% resistant plants Class 1-3
CB12004	4.0	22.7	28.1
CB11003	4.0	23.1	27.7
CB12006	4.1	20.4	27.3
CB11008	4.1	18.1	26.5
CB11006	4.2	19.2	23.5
CB12003	4.3	12.3	21.9
CB12002	4.3	13.1	21.9
CB7006	4.3	14.2	20.8
CB9002	4.3	14.6	20.4
CB10001	4.4	10.8	20.4
CB11001	4.3	14.2	20.0
CB11010	4.3	13.5	19.6
CB11005	4.4	15.4	19.2
CB10002	4.4	11.5	18.8
CB11004	4.4	13.5	18.5
CB11007	4.4	12.3	18.5
54V09	4.5	8.8	14.6
CB11009	4.5	10.0	13.8
CB11012	4.6	6.9	12.3
55V12	4.6	8.8	11.5
Vernema	4.6	6.9	10.8
Grandstand	4.6	8.1	10.8
CB12001	4.7	5.8	10.4
CB11011	4.9	1.2	5.0
Ranger	4.8	2.7	5.8
LSD 5%	0.33	8.90	9.87
CV %	5.3		

Figure 3:

Figure 4

It is suggested that SN as a primary pathogen induce the establishment of secondary pathogens like bacteria which may not be able to infect the plant by itself. The inability for modern alfalfa varieties to persist under infestation of SN even though they have been classified as having high resistance the nematode is either due to misclassification of the varieties or to a more complex association of the SN and root and crown diseases of alfalfa.

Objectives

Germplasm enhancement and cultivar development for alfalfa is the primary objective. We hypothesize that both the germplasm and the cultivars that will be developed will have as much as 50% better stands after three years than current commercial varieties classified as HR for SN. We further hypothesize that the same germplasm and cultivars will have significant higher yields due to improved persistence under SN pressure.

The objectives of the proposed research are to: 1) Develop alfalfa germplasm and cultivars suitable for marketing in SN infested areas. 2) Increase resistance to SN along with a disease complex consisting of FW, BW, and VW.

2. Rationale and Significance

Demand for alfalfa forage is increasing worldwide as demonstrated by the increase in export hay by 64% since 2007 (17). Two markets that have caused the increase are China and the United Arab Emirates. US hay exports were valued at $1.2 billion in 2012. Currently about 12% of alfalfa hay is exported out of 7 western states (AZ, CA, OR, WA, NV, UT, ID) which are also the primary states that have problems with SN. When severe SN infestations in California cause yield losses of 100% in the first cutting and 50% in the second cutting (3), dollars are lost. Considering alfalfa is going for more than $300 a ton in 2014, 4 tons in the first and second cutting would be a loss of $1200/acre.

CBC research has demonstrated that phenotypic recurrent selection can improve resistance to the SNDC. There is a need to correlate progress to field performance. The correlation can be made by planting alfalfa variety tests at multiple locations infested with SN and measuring stand decline and yield.

3. Approach

The best performing CBC SN resistant germplasm will be repeatedly screened for SNDC in 5 x 12 foot benches in the greenhouse. CB12002, CB12003, CB12004, CB12006, CB11003, CB11006, and CB11008 are germplasm that are currently being screened for SNDC in the greenhouse. They are also at the top of the 2012-2014 SN test. Selections from the screening will be placed in a breeder seed increase block for further testing and screening. Only class 1

plants, based on the standard test, will be used for breeder seed increase. Plants for breeder seed increase will be planted on 22" centers with 100-200 plants in each block. We expect to produce 3 to 5 lbs of seed for each germplasm. In October of 2015, six greenhouse benches will be dedicated to screening for SNDC. Each bench will be planted to one selected germplasm that scored high for SNDC in 2014 plus the germplasm selected and increased in 2014. Leafcutter bee placement will be timed within 5 to 10 days of flowering on all isolated seed increase blocks in each year. Once seed matures in the fall, blocks will be cut with a cycle bar and allowed to dry on tarps. Tarps containing seed will be moved into the greenhouse for drying if poor weather occurs. Once the breeder seed plant material is dry, each cage will be threshed through a stationary plot thresher. Immediately following threshing, the resultant seed will be cleaned through a small clipper cleaner. At the end of 2015, basic seed will be ready for screening and testing.

In October 2015, testing will begin with a replicated 25 entry SN test planted in a single 5' x 12' bench. Plots will be about 5" x 12" planted using 4 rows per entry. Stand counts will be taken at about the unifoliolate stage of growth. Benches will be pre-infested with SN and diseases that occur locally in SN infested fields. At bud stage, entries will be clipped and allowed to re-grow throughout the screening cycle. In March of 2016, plants will be lifted from the greenhouse benches and scored individually according the standard test for SN. Ranger will be included in the test as the susceptible check variety while Vernema will be the resistant check. Plants from each entry will be separated into 5 classes with class 1-3 considered resistant plants. Data will be analyzed as a randomized complete block design with 4 replications. Percent resistant plants will be analyzed using both the 1-2 class and the 1-3 class representing percent resistant plants along with ASI. Based on previous SN experiments, we expect selected germplasm to have at least a 10% gain in resistant plants per population. Class 1 selections will be made from each of the five germplasm screenings and will be planted spring of 2016 in breeder seed increase blocks.

In August of 2017, variety tests containing the five experimental varieties along with other selected experimentals, commercial varieties and check varieties will be planted at no less than 3 locations with at least 2 of the locations infested with SN. The experiments will be planted and analyzed as a randomized complete block design with 4 replications. Plots will not be harvested for yield at locations with nematode infestation due to inability to coordinate harvests with growers. However, yield will be taken on the plots located on CBC land. Notes such as spring growth, regrowth after cutting, and stand counts will be made at all locations. Harvest at off station locations will be made by the grower as larger strip tests will be planted adjacent to the smaller research plots. The strip tests will include commercial varieties suggested for SN infested areas along with a CBC experimental selected for SN and advanced for foundation seed increase. A foundation seed field for the experimental was planted in the Spring of 2015 with first harvest producing about 20 lbs. of seed. A 38 entry replicated variety trial was planted on

August 27, 2015. Data will be analyzed and reported each year on both greenhouse SNDC tests and field experiments.

As with any phenotypic recurrent selection program, continuous selection and testing occurs each year. The plan is to always have greenhouse benches under SNDC screening and testing and breeder seed increase on selected plant materials each year in the field. Testing at off station location will not happen every year. However, every other or third year is possible.

Experimental Plan and Timetable

2015

- Submit best performing CBC SN germplasm for recurrent selection based on SN resistance and yield results from previous variety tests. Expand number of benches for SN screening to six in new greenhouse.
- Transplant 1 acre with alfalfa plants selected for SN for foundation seed increase.
- Selected SN resistant parents for an experimental cultivar.
- Harvest breeder seed blocks from selections our of a 2012-2014 greenhouse SN test.
- Establish 6 new SNDC 5' x 12' benches with one dedicated to testing and the others for screening.
- In October 2015, inoculate and plant benches.
- In August 2015 plant a small strip test with foundation seed of new experimental variety.
- Plant a variety test with previously SN selected germplasm. This would include about 38 entries including checks.

2016

- Maintain greenhouse screenings.
- Plant variety test on CBC farm including previously selected experimentals.
- Harvest breeder seed.

2017

- Transplant parents (minimum of 100) into isolation blocks to produce breeder seed for five experimentals.
- Harvest, thresh and condition breeder seed.
- Conduct a 25 entry standard test for Sn including resistant and susceptible check varieties. Include known susceptible varieties to help with SN reproduction on the experiment. The test will be planted as a randomized complete block design with 4 replications. Plants will be scored according to the standard test for SN.
- Plant new screenings.
- December, 2017 – report progress and SN results to granting institution.

2018

- Plant field variety tests with no less than 15 entries consisting of 5 CBC experimentals selected for resistance to SNDC; 5 commercial varieties claiming to have high resistance to SN, FW, VW and BW; standard resistant and susceptible SN check varieties. The experiment will be planted as a randomized complete block design with 4 replications and 3 locations. At least two of the locations will have a history of infestation with SN. Three locations with heavy infestation have already been identified. One has already been planted.
- Report results of SNDC greenhouse test to the Washington State Hay Growers Association (WSHGA).
- December, 2017 – Report progress to granting institution.

2019

- Collect data on the field variety test including scores for spring growth, regrowth after cutting, and yield.
- Produce breeder seed on carryover isolations and new experimentals selected from SNDC greenhouse experiment.
- December, 2018—Report progress and first year yield results to granting institution.

2020

- Analyze first year yield data and present results to the WSHGA.
- Plant foundation seed fields for three of the best performing experimentals based on yield and resistance to greenhouse SNDC.
- Harvest and condition foundation seed.
- Harvest and analyze second year yield data and to the WSHGA.
- Depending on success with selection for SNDC along with persistence results, license an exclusive variety for the market. Publish the release in Crop Science after data collection to accurately describe the variety or varieties.
- December, 2020 – Final report of 2 and 3 year yield data and first year quality data to granting institution and the WSHGA.

F. FACILITIES AND EQUIPMENT

- Field Plots
    - Carter Forage Harvester with weigh system.
    - Planet Junior for planting plots.
    - Forage dryer for determining plot moisture and sample preparation.
    - Gandy Fertilizer spreader.
    - Avery Berkel scale for weighing samples in field.
    - Hand lines for plot irrigation.
    - Irrigation pump for hand lines.
    - 8 acres of research land on CBC campus.
    - Brillion Pulvi-mulcher M series for soil preparation.

- Kubota tractor with rototiller and packer for soil preparation.
- Ford New Holland tractor with rototiller for soil preparation.
- 10 foot disk.
- Ford 5060 tractor .

- Isolation blocks
  - Domiciles for leaf cutter bee housing.
  - Five foot cycle bar for cutting isolation blocks.
  - LD 180 thresher for smaller samples.
  - Five foot cycle bar for breeder seed harvest.
  - Hege 5 foot research combine for foundation seed harvest.
  - Low profile stationary plot thresher for breeder seed conditioning.
- Dry lab
  - HMC 67 seed Blower for small seed samples.
  - Oahus scale for weighing samples in lab.
  - Stereo microscope.
  - Binocular microscope.
  - Small lab clipper cleaner for breeder seed conditioning.
  - Wiley Mill for rough grind used for preparation of samples for NIRS.
  - Udy grinder for fine grind preparation for NIRS.
  - FOSS 6500 NIRS instrument with membership in NIRSC.
- 2 Greenhouses (30’ x 50’). 1 greenhouse 30’ x 40’.
  - 35 5’x12’ rolling benches for testing and screening.
  - 64 1000 watt combination high pressure sodium and metal halide light fixtures each with timers.
- Pivot irrigation land (1/2 mile from campus).
  - 700 hundred foot span pivot irrigation system.
  - 16 acres under irrigation.
  - Pivot and ditch irrigation available.
  - 7’ x 22 ft. trailer for hauling equipment.

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Attachment 24

Germplasm Enhancement for Blue Alfalfa Aphid and Stem Nematode Resistance

Objective:

Screen dormant alfalfa germplasm for resistance to blue alfalfa aphid (*Acyrthosiphon kondoi*) and stem nematode (*Ditylenchus dipsaci*) and release germplasm.

Approach:

Plant selected dormant germplasm in greenhouse for determination of resistance to blue aphid. At the same time, screen large numbers of plants from Columbia Basin College germplasm for selection purposes. Score resistance reaction according to standard tests using known non-dormant resistant varieties as resistant checks. If dormant resistant plants are identified, cross in greenhouse, test and reselect. If no resistance is identified in dormant germplasm, cross with resistant non-dormant germplasm in the greenhouse. Screen seed from dormant germplasm for resistance and plant in the field to select for class four dormant plants. Recombine in greenhouse for germplasm release.

Columbia Basin College has already selected and combined plants selected for resistance to stem nematode from old fields known to be infested. Standard tests developed for screening and testing for stem nematode have failed to produce resistant varieties that will perform well in the field. Observations in Chile and Spain have shown only one non-dormant variety that displays high levels of resistance. The variety is GT-13R+ was selected entirely from a five year old field of AS-13R that had problems with root rot and stem nematode. Eighty-one plants were selected from a stem nematode infested field as parents of AS-13R. This example of recurrent field selection is a good indication that field selection may be better suited than standard screening procedures that have been in use for over 30 years with little or no progress. Columbia Basin College (CBC) will plant experimental varieties selected from infested fields for stem nematode to evaluate

progress for resistance. Additional selections will be made from the field for seed increase and testing. Germplasm will be released based on test results. At the same time a greenhouse screening procedure will be developed that will allow more time for infection of all plants. More precision is necessary for progress toward higher levels of resistance.

Statement of mutual interest:

Both parties have had independent research projects aimed toward the development of resistant germplasm and the development of rapid screening and evaluation techniques for various diseases and insects. Both parties agree that the objectives of this project will strengthen and enhance ongoing research within the scope of this agreement.

The blue alfalfa aphid is an economically important insect on alfalfa in southern areas of the United States and where alfalfa is seeded in late summer or fall. Blue alfalfa aphids inflict serious damage because they inject toxins into the plant as they feed. Toxins injected by the blue alfalfa aphid stunt growth and can kill young seedlings. Growers in Washington State use insecticides to control aphids in the late summer and fall. Resistant varieties would reduce the use of pesticides.

The use of fumigants for the control of stem nematode has not been shown to be economical. Resistant varieties are considered to be the best control measure. However, there are few if any varieties with enough resistance to provide sufficient yields for the perennial crop. Growers in the Pacific Northwest would welcome an alfalfa variety with true high resistance to stem nematode.

Mutual Agreements:

Progress reports are required to be submitted to ARS annually by June 1st. The reports must contain a header or cover page with the following information:

a. A comparison of actual accomplishments with the goals and objectives established for the period and findings of the investigator. Whenever appropriate

and the output of programs or projects can be readily quantified, such quantitative data should be related to cost data for computation of unit costs.

b. Reasons why established objectives were not met, if appropriate.

c. Other pertinent information including, when appropriate, analysis and explanation of cost overruns or high unit costs.

Cooperators shall not be required to submit more than the original and two copies of performance reports. Report submission via electronic mail is allowable.

Cooperators shall immediately notify the USDA, Agricultural Research Service of developments that have a significant impact on the award-supported activities. Also, notification shall be given in the case of problems, delays, or adverse conditions which materially impair the ability to meet the objectives of the award. This notification shall include a statement of the action taken or contemplated, and any assistance needed to resolve the situation.

A final report is to be submitted to ARS within 90 days of completion, expiration, or termination of this Agreement.

Columbia Basin College agrees to:

1. Work closely with ARS in planning and conducting the research outlined herein.

2. Conduct at Cooperator facilities and elsewhere as appropriate, research directed toward developing new screening procedures and germplasm resistant to blue alfalfa aphid and stem nematode. These activities include:

a. Test various dormant germplasm for resistance to blue alfalfa aphid against the accepted non-dormant resistant check variety.

b. Select plants resistant to blue alfalfa aphid and stem nematode for recombination in field or greenhouse.

b. Test existing stem nematode germplasm in the field and greenhouse for resistance using accepted resistant and susceptible check varieties.

b. Develop germplasm by intercrossing resistant selections

ARS agrees to:

1. Work closely with the cooperator in planning and conducting the research outlined herein.

2. Conduct research on the following aspects of the project:

a. Collecting and providing blue aphid population from California if needed.

b. Confirming a non-contaminated collection of blue aphid

c. Help collect and provide resistant and susceptible checks for experiments

d. Help collect and provide released varieties and germplasm for screening and testing

Attachment 25

MANAGEMENT GUIDE

Coexistence and Market Assurance for Production of Non–Genetically Engineered Alfalfa Hay and Forage in a Biotech Era

Daniel H. Putnam,* Tim Woodward, Peter Reisen, and Steve Orloff

Abstract

The introduction of genetically engineered (GE) alfalfa requires a mechanism for producers to successfully grow and market alfalfa (*Medicago sativa* L.) hay destined for GE-sensitive markets such as organic and export. A process of coexistence includes elements of respect for diverse agricultural systems, improved communication, scientific knowledge, and market clarity. A definition for "non-GE alfalfa forage" is proposed, along with suggested production protocols. These protocols include securing non-GE-detect seed, steps to reduce the probability of gene flow in hay fields, equipment sanitation, hay-lot identification, and hay testing for low-level presence. The largest risk for low-level presence in hay is likely to originate from unwanted GE presence in the planting seed. Secondary risks include accidental mixing of hays during harvest or storage, followed by gene flow between forage fields. The tolerance for low-level presence in non-GE hay must meet specific market sensitivities. Promoting absolute zero GE hay (e.g., GMO free) is a practical and analytical impossibility, creates difficulties for farmers, and makes no sense for a nontoxic, unwanted market factor. Regulatory-based tolerances, driven largely by countries that do not permit a GE trait, may require non-GE determination to a limit of detection of approximately 0.1%. Market-based tolerance thresholds may differ greatly depending on the sensitivity of markets. For market purposes, a definition of non-GE alfalfa as having a low-level presence of less than 0.9% of dry matter is suggested. Coexistence strategies for alfalfa forage require an understanding of the sources of low-level presence, market tolerances of diverse markets, and market assurance processes.

GENETICALLY ENGINEERED (GE) traits in crop plants have been commercialized across many crops, including corn (*Zea mays* L.), cotton (*Gossypium hirsutum* L.), canola (*Brassica napus* L.), soybean [*Glycine max* (L.) Merr.], and sugarbeet (*Beta vulgaris* L.) and have very high rates of adoption in North America. The predominant traits are the glyphosate-tolerant trait, or so-called Roundup Ready (RR) trait, which enables broadcast post-emergence applications of glyphosate for weed

Daniel H. Putnam, Dep. of Plant Sciences, MS #1, One Shields Ave., Univ. of California, Davis, CA 95616; Tim Woodward, Columbia Basin College, Pasco, WA 99301; Peter Reisen, Forage Genetics International, Nampa, ID 83563; Steve Orloff, Univ. of California Coop. Ext., Siskiyou County, Yreka, CA 96097. Mention of a trade name or commercial product is solely for purposes of providing specific information and does not imply endorsement of that product nor disparagement of similar products that may serve the same function. Received 14 June 2015. Accepted 10 Dec. 2015. *Corresponding author (dhputnam@ucdavis.edu).

Abbreviations: EIS, environmental impact study; ELISA, enzyme-linked immunosorbent assay; GE, genetically engineered; PCR, polymerase chain reaction; RR, Roundup Ready.

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Attachment 26

2008 Pacific Northwest Hay Market and Export Review and Outlook Report

J. Shannon Neibergs, William T. W. Woodward and Phil J. Peterson

January, 2008

A Community of Learning
Columbia Basin College
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Washington State University
Extension
World Class. Face to Face.

2008 Pacific Northwest Hay Market and Export Review and Outlook Report

J. Shannon Neibergs, William T. W. Woodward and Phil J. Peterson [28]

Introduction

This report presents a summary review of the 2007 hay market and production. This annual report reviews the Pacific Northwest hay market trends in production and hay value. The term hay in general refers to both alfalfa hay and grass hay combined. As appropriate depending on data availability, hay production and value by type is reported separately. Domestic demand for high quality hay is primarily determined by regional dairies. The hay export market is particularly important for Northwest producers. Japan is the largest export market. The interaction of variable and largely uncontrollable hay growing climatic conditions that directly impacts hay quality and yield, the presence of carryover hay stocks, and domestic and export demand factors creates a dynamic hay market. The 2007 hay year started with low carry-over stocks, creating tight supply conditions. In spite of strong 2006 hay prices and generally good growing conditions there was no supply response. In fact the 2007 USDA projected Pacific Northwest all hay production declined by four percent. Tight supply, strong hay demand and high prices of corn and other alternative feedstuffs pushed 2007 hay prices to record highs.

Pacific Northwest All Hay and Alfalfa Hay Production

Tables 1 and 2 present the preliminary 20007 Washington hay production statistics and historic production trends. According to the USDA National Agricultural Statistics Service, Washington's preliminary estimates of all hay harvested acres increased by 20,000 acres in 2007 over 2006 to 790 thousand acres. However harvested alfalfa hay acreage decreased 10 thousand acres to 430 thousand acres between 2006 and 2007. Preliminary yield estimates are higher in 2007 resulting in increased production in 2007 over 2006, but Washington alfalfa production remains historically low. Over the 10 years of historic alfalfa production reported in Table 2, production in 2006 is the lowest production year which is followed by 2007 with 2,236 thousand tons of production.

Tables 3 to 6 reports similar hay production statistics for Oregon and Idaho. Oregon harvested 50 thousand less all hay production acres. Thirty thousand acres of the decrease was in alfalfa production. Idaho was the only Pacific Northwest state that increased alfalfa production acres. Idaho increased alfalfa production acres by 20 thousand acres in 2007 over 2006.

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Due to strong prices the value of hay production has generally increased annually over that past five years for each of the PNW states. Although the 2007 value of production is not reported by the USDA statistics at the time of writing this report, it is almost certain to increase due to strong monthly hay prices reported throughout 2007.

Tables 7 and 8 summarize the Pacific Northwest all hay and alfalfa hay production trend for all three states. The 2007 PNW all hay production is the lowest reported in the table and 2007 alfalfa hay production is the second lowest reported. Table 9 reports farm hay stocks. The end of the year December 2006 hay stocks were 5,754 tons which was relatively low to start the 2007 year. December 2007 stocks are not available at the time of this report. May 1 2007 hay stocks were 740 thousand tons which is the lowest level it has been since 2002. The data on stocks and production are combined to calculate all hay supply as given in Table 10. The 2007 PNW hay supplies, at 12,419 thousand tons is the tightest supply level since 2001.

Domestic Demand for Hay

A primary factor for domestic hay demand is generated from dairy operations. The Pacific Northwest and Washington in particular produces the highest average milk yield per cow in the United States. The PNW's high quality hay is a principle input needed to achieve this high production level. Table 11 presents the PNW's and California's dairy cow numbers. In 2007, Washington increased its dairy cow inventory by 6,000 head from 237 to 243 thousand cows. Oregon's dairy herd decreased by 3,000 head. Idaho is continuing its rapid dairy cow expansion. Idaho's herd grew by 44 thousand head. And California's dairy cow number growth was 25 thousand head.

Figure 1 illustrates a demand index from dairies' for a state's alfalfa hay supply. The index multiplies the size of the state's dairy herd times the daily per head hay consumption of 35 pounds of hay times a 365 day year. This is a rough estimate of the pounds of hay demanded by each state's dairy industry. The estimated hay consumed is divided by each state's hay production to calculate a demand index which is the proportion of the state's alfalfa hay production consumed by dairies. The alfalfa hay demand index is rough estimate because individual dairies may adjust hay consumption to alternative forages as available which would decrease the index, but dairy replacement heifers are not included in the cow population numbers which would increase the consumption of alfalfa hay, thus increasing the index. Dairies replace between 20 and 30 percent of the milking herd annually. The index is useful to illustrate the PNW relative alfalfa hay demand from dairies.

Figure 1 identifies that Washington's demand index is 0.69. This means that using the definition given above, Washington dairies demand 69 percent of the state's alfalfa production. Idaho has a similar proportion at 66 percent, and Oregon is substantially lower at 40 percent. To show Idaho's increase in alfalfa hay demand due to its increasing dairy population, Idaho's alfalfa hay demand index, using 2000 dairy cow numbers and production is 47 percent. The index does well to illustrate California's relative demand for alfalfa hay. California's alfalfa hay demand index is

1.62. The index illustrates the commonly stated fact that California is an alfalfa deficient state, and that hay has to be imported into California to satisfy its hay demands.

In 2006 low dairy profitability due to low milk prices had a limiting effect on hay price increases, because dairy producers lacked the cash flow to pay for escalating prices. In 2007 milk prices increased greatly and provided dairymen some ability to support increasing hay prices. Figure 2 shows the monthly mailbox milk price for the months available at the time of this report. Milk prices increased from the 2006 average milk price of $12.60 per cwt to over $20.00 per cwt in the fall of 2007. These prices represent record high milk prices.

Other livestock, namely cattle and horses demand hay. Tables 12 and 13 present PNW cattle inventories. The cattle and calve inventory has remained fairly steady over the time reported in the table. There are no significant demand trend changes from cattle and calves except to note that there were 30 thousand additional head of cattle and calves in 2007 over 2006. The cattle on feed inventory is harder to evaluate because cattle on feed is a flow inventory and not a static inventory level. Table 13 presents the number of cattle on feed that have gone to market from feedlots with 1,000 head or more capacity. The data shows a steady decline in the number of cattle marketed from feedlots. From 2000 to 2006, the number on fed cattle marketed declined 403 thousand head, or a decline of 32 percent over this period. 2007 is likely to continue this trend. There is not a reported inventory level for horses, but it appears that horses represent a steady to increasing source of hay demand. Horse owners typically have the financial capacity and willingness to pay for high quality two string hay bales.

Export Demand for Hay

The Pacific Rim countries of Japan, Korea and Taiwan are important markets for PNW hay. The Pacific Northwest ports supply about 65 percent of the Pacific Rim forage imports with Pacific Southwest ports supplying the balance. Complete data on 2007 forage exports are not completely available as of the date of this report, but total export data from January to November to Japan and Korea and from January to October to Taiwan are provided in Tables 14 to 16. Total forage exports levels to the Pacific Rim to date are essentially unchanged between 2006 and 2007. Combined forage exports to the Pacific Rim countries for 2006 was 3.32 million metric tons and for 2007 was 3.27 million metric tons. The 2007 Pacific Rim forage export levels are essentially 99 percent of the level of 2006 export levels. Exports to Japan declined 178 thousand metric tons, but total forage exports to Korea increased 132 thousand metric tons. The Japanese milk price was low in 2007 due to an oversupply of Japanese produced milk softening its demand for hay. The decline in exports to Japan represents a relatively small change, but the increase in exports to Korea was a relatively large increase for Korea. The year to date 2006 to 2007 forage exports increase to Korea was almost a 20 percent increase in forage exports, and is the highest tonnage of forage exports to Korea on record. The USA supplied most of the increase in the exports to Korea. Overall, the USA supplies 75 percent of the forage exports to the Pacific Rim Countries.

Tables 17 and 18 identify the waterborne forage exports by west cost port and their trends. The Pacific Northwest ports have consistently provided about 65 percent of the west cost forage exports.

Hay Price Review

Washington's average monthly alfalfa prices for the last 10 years are shown in Table 19. In general, there is a trend for prices to be highest during the months of May, June, and July. However starting in 2006, alfalfa hay prices have generally been increasing on monthly basis. For Washington in 2007, hay prices started the year at $125 dollars per ton and ended the year at $150 dollars per ton. This is the highest USDA average alfalfa price on record for Washington. Table 20 provides monthly prices for California and the PNW states. California prices are about $20 per ton on average higher than Washington prices. Oregon prices are higher than Washington and Idaho's prices. This is probably because of Oregon's proximity to California and California's excess demand for hay.

2008 Hay Acreage and Price Outlook

Tight supplies and strong demand will continue to pressure hay prices. Milk prices are expected to remain strong for 2008 due primarily to increasing exports of non-fat dry milk. With high milk prices, dairies will at least maintain herd levels and there will probably be some herd expansion in the PNW. Idaho has the fastest growing dairy cow herd in the Nation and small increases in California's herd represent a large number of cows.

Due to strong commodity prices from primarily the increased demand for corn from ethanol, there is likely to be limited hay supply expansion. Expanding ethanol plants will demand even more corn in 2008 over 2007. Farmers examining their 2008 crop planting options are looking at high prices for corn, soybeans, wheat and barley. In some cases they are able to double crop these commodities, which provide greater profitability in comparison to establishing a hay crop. In some cases dryland hay may be converted to dryland grain crops to take advantage of high wheat and barley prices. The inability to establish alfalfa using the roundup ready alfalfa seed variety due to export restrictions and the injunction against its use further limits the appeal of establishing expanded hay acreage. California decreased its alfalfa production acreage by 100,000 acres in 2007 and is expected to further decrease its irrigated hay acreage in 2008 due uncertain and decreasing water availability to agricultural crop operations. Instead of expanding hay acreage in response to record high hay prices, it is more likely that hay acreage will decline in 2008.

Exports are likely to remain steady based on Pacific Rim forage demand factors and the value of the dollar that is expected to remain weak due to economic and political factors. One item to be aware of is China may emerge as a forage export destination. China's expanding economy and its expanding demand for nutrition, in particular dairy products, may result in the opportunity to export forages to China. The USDA has sent dairy production technology teams to China and

has produced a report citing China's potential as a forage export destination. When you consider, the potential to back haul empty ocean freighters to China with forage exports, the emergence of China as an export destination seems likely. (http://www.fas.usda.gov/info/fasworldwide/2007/09-2007/ChinaAlfalfaMarket.htm

Hay prices are likely to continue on their record setting pace for 2008. All demand and supply factors are pushing price up. If 2008 is similar to 2006 and 2007, the 2008 alfalfa hay price in Washington will start the year at $150 per ton and increase from that point. In 2006, alfalfa hay price increased $15 per ton over the year, and in 2007 the increase over the year was $25 per ton. In 2008, the price will likely increase at a greater rate. In 2007 the weather was generally good for hay production which benefited dryland production supply. Hopefully 2008 will repeat with good weather for dryland hay production and ease some of the upward pressure on hay prices for livestock producers.

Table 1: Washington All Hay Production

Year	Harvested acres - thousand	Yield tons	Production 1000 tons	Price per Unit dollars/ton	Value of Production 1000 dollars
1997	780	3.95	3,084	$ 115.00	$ 361,824
1998	750	4.21	3,156	$ 97.00	$ 312,588
1999	740	4.13	3,059	$ 98.00	$ 307,027
2000	780	4.17	3,249	$ 107.00	$ 355,261
2001	790	3.91	3,088	$ 120.00	$ 375,328
2002	820	4.07	3,336	$ 111.00	$ 375,366
2003	710	4.45	3,603	$ 93.50	$ 343,610
2004	790	4.29	3,392	$ 108.00	$ 371,040
2005	740	4.34	3,210	$ 113.90	$ 365,610
2006	770	4.04	3,113	$ 127.00	$ 395,824
2007*	790	4.21	3,286		

Table 2: Washington Alfalfa Hay Production

Year	Harvested acres – thousand	Yield tons	Production 1000 tons	Price per Unit dollars/ton	Value of Production 1000 dollars
1997	480	4.80	2,304	$ 111.00	$ 255,744
1998	480	5.00	2,400	$ 91.50	$ 219,600
1999	470	4.90	2,303	$ 89.00	$ 204,967
2000	470	5.00	2,350	$ 98.00	$ 230,300
2001	470	4.80	2,256	$ 114.00	$ 257,184
2002	510	4.90	2,499	$ 107.00	$ 267,393
2003	510	5.30	2,703	$ 86.50	$ 233,810
2004	480	5.00	2,400	$ 105.00	$ 252,000
2005	450	5.20	2,340	$ 112.00	$ 262,080
2006	440	4.90	2,156	$ 125.00	$ 269,500
2007*	430	5.20	2,236		

*Projected
Source: USDA-NASS
http://www.nass.usda.gov/Statistics_by_State/Washington/Publications/Agri-facts/agri2feb.pdf

Table 3: Oregon All Hay Production

Year	Harvested acres - thousand	Yield tons	Production 1000 tons	Price per Unit dollars/ton	Value of Production 1000 dollars
1997	1035	3.16	3,266	$ 117.00	$ 361,020
1998	970	3.48	3,374	$ 104.00	$ 337,698
1999	1100	2.92	3,208	$ 92.00	$ 286,208
2000	1080	2.79	3,018	$ 94.50	$ 278,772
2001	1025	2.98	3,052	$ 112.00	$ 333,626
2002	1115	3.13	3,493	$ 100.00	$ 348,019
2003	1100	3.25	3,572	$ 88.50	$ 313,262
2004	1130	3.21	3,624	$ 105.00	$ 371,892
2005	1000	3.14	3,140	$ 114.00	$ 352,580
2006	1050	3.10	3,256	$ 130.00	$ 411,840
2007*	1,000	3.10	3,100		

Table 4: Oregon Alfalfa Hay Production

Year	Harvested acres - thousand	Yield tons	Production 1000 tons	Price per Unit dollars/ton	Value of Production 1000 dollars
1997	420	4.70	1,974	$ 123.00	$ 242,802
1998	400	4.80	1,920	$ 110.00	$ 211,200
1999	420	4.40	1,848	$ 96.00	$ 177,408
2000	390	4.20	1,638	$ 99.00	$ 162,162
2001	460	4.30	1,978	$ 116.00	$ 229,448
2002	495	4.30	2,129	$ 101.00	$ 215,029
2003	480	4.60	2,208	$ 94.00	$ 207,552
2004	480	4.30	2,064	$ 112.00	$ 231,168
2005	400	4.40	1,760	$ 121.00	$ 212,960
2006	430	4.40	1,892	$ 131.00	$ 244,068
2007*	400	4.60	1,840		

*Projected
Source: USDA-NASS
http://www.nass.usda.gov/Statistics_by_State/Oregon/Publications/Field_Crop_Report
http://www.nass.usda.gov:8080/QuickStats/PullData_US.jsp

Table 5: Idaho All Hay Production

Year	Harvested acres - thousand	Yield tons	Production 1000 tons	Price per Unit dollars/ton	Value of Production 1000 dollars
1997	1300	3.64	4,730	$ 105.00	$ 483,110
1998	1400	3.87	5,420	$ 83.00	$ 441,480
1999	1430	3.59	5,132	$ 83.00	$ 417,788
2000	1390	3.81	5,292	$ 94.50	$ 491,547
2001	1420	3.48	4,938	$ 116.00	$ 565,014
2002	1490	3.55	5,288	$ 95.00	$ 496,612
2003	1500	3.30	4,950	$ 87.50	$ 426,855
2004	1480	3.61	5,350	$ 106.00	$ 552,600
2005	1410	3.82	5,382	$ 111.00	$ 586,782
2006*	1520	3.76	5,720	$ 118.00	$ 666,051
2007*	1500	3.53	5,293		

Table 6: Idaho Alfalfa Hay Production

Year	Harvested acres - thousand	Yield tons	Production 1000 tons	Price per Unit dollars/ton	Value of Production 1000 dollars
1997	1000	4.10	4,100	$ 106.00	$ 434,600
1998	1100	4.30	4,730	$ 84.00	$ 397,320
1999	1150	4.00	4,600	$ 84.00	$ 386,400
2000	1130	4.20	4,746	$ 95.00	$ 450,870
2001	1120	3.90	4,368	$ 118.00	$ 515,424
2002	1170	4.00	4,680	$ 96.50	$ 451,620
2003	1200	3.70	4,440	$ 88.50	$ 392,940
2004	1180	4.00	4,720	$ 108.00	$ 509,760
2005	1140	4.20	4,788	$ 113.00	$ 536,256
2006	1180	4.30	5,074	$ 120.00	$ 608,880
2007*	1200	4.20	5,040		

*Projected
Source: USDA-NASS
http://www.nass.usda.gov/Statistics_by_State/Idaho/Publications/Current_Estimates
http://www.nass.usda.gov/Statistics_by_State/Idaho/Publications/Agriculture_in_Idaho/

Table 7: PNW All Hay Production

Year	State	Harvested acres - thousand	Yield tons	Production 1000 tons	Value of Production 1000 dollars
2003	ID	1,500	3.30	4,950	426,855
2003	OR	1,100	3.25	3,572	313,262
2003	WA	710	4.45	3,603	343,610
2003	**PNW**	**3,310**	**3.66**	**12,125**	**1,083,727**
2004	ID	1,480	3.61	5,350	552,600
2004	OR	1,130	3.21	3,624	371,892
2004	WA	790	4.29	3,392	371,040
2004	**PNW**	**3,400**	**3.64**	**12,366**	**1,295,532**
2005	ID	1,410	3.82	5,382	586,782
2005	OR	1,000	3.14	3,140	352,580
2005	WA	740	4.34	3,210	365,610
2005	**PNW**	**3,150**	**3.72**	**11,732**	**1,304,972**
2006	ID	1,520	3.76	5,720	666,051
2006	OR	1,050	3.10	3,256	411,840
2006	WA	770	4.04	3,113	395,824
2006	**PNW**	**3,340**	**3.62**	**12,089**	**1,473,715**
2007*	ID	1,500	3.53	5,293	na
2007*	OR	1,000	3.10	3,100	na
2007*	WA	790	4.21	3,286	na
2007*	**PNW**	**3,290**	**3.55**	**11,679**	na

Source: USDA-NASS
*Projected

Table 8: PNW Alfalfa Hay Production

Year	State	Harvested acres - thousand	Yield tons	Production 1000 tons	Value of Production 1000 dollars
2003	ID	1,200	3.70	4,440	392,940
2003	OR	480	4.60	2,208	207,552
2003	WA	510	5.30	2,703	233,810
2003	**PNW**	**2,190**	**4.27**	**9,351**	**834,302**
2004	ID	1,180	4.00	4,720	509,760
2004	OR	480	4.30	2,064	231,168
2004	WA	480	5.00	2,400	252,000
2004	**PNW**	**2,140**	**4.29**	**9,184**	**992,928**
2005	ID	1,140	4.20	4,788	536,256
2005	OR	400	4.40	1,760	212,960
2005	WA	450	5.20	2,340	262,080
2005	**PNW**	**1,990**	**4.47**	**8,888**	**1,011,296**
2006	ID	1,180	4.30	5,074	608,880
2006	OR	430	4.40	1,892	244,068
2006	WA	440	4.90	2,156	269,500
2006	**PNW**	**2,050**	**4.45**	**9,122**	**1,122,448**
2007*	ID	1,200	4.20	5,040	na
2007*	OR	400	4.60	1,840	na
2007*	WA	430	5.20	2,236	na
2007*	**PNW**	**2,030**	**4.52**	**9,116**	na

Source: USDA-NASS
*Projected

Table 9: Washington, Oregon and Idaho on Farm Hay Stocks

Year	Washington		Oregon		Idaho		PNW	
	May 1	Dec 1	May 1	Dec 1	May 1	Dec 1	May 1	Dec 1
	1000 tons							
2000	165	1303	128	1766	257	2790	550	5859
2001	195	1513	241	1901	258	2568	694	5982
2002	170	1600	183	2550	444	2824	797	6974
2003	285	1620	340	2357	635	2772	1260	6749
2004	470	1560	371	2366	445	2782	1286	6708
2005	322	1475	362	1790	535	2260	1219	5525
2006	250	1339	210	1840	375	2575	835	5754
2007	240	1385	180	1700	320	2400	740	5485

Source: USDA-NASS
http://www.nass.usda.gov/Statistics_by_State/Washington/Publications/Agri-facts/agri2may.pdf
http://www.nass.usda.gov/Statistics_by_State/Washington/Historic_Data/fieldcrops/allhay.pdf

Table 10: PNW All Hay Supplies

Year	Washington			Oregon			Idaho			PNW		
	May 1	Production	Supply	May 1	Production	Supply	May 1	Production	Supply	May 1	Production	Supply
	1000 tons											
1995	139	3278	**3417**	85	3300	**3385**	222	5080	**5302**	446	11,658	**12,104**
1996	426	3140	**3566**	264	3244	**3508**	660	4760	**5420**	1350	11,144	**12,494**
1997	283	3084	**3367**	97	3266	**3363**	286	4730	**5016**	666	11,080	**11,746**
1998	308	3156	**3464**	621	3374	**3995**	520	5420	**5940**	1449	11,950	**13,399**
1999	410	3059	**3469**	135	3208	**3343**	759	5132	**5891**	1304	11,399	**12,703**
2000	165	3249	**3414**	128	3018	**3146**	257	5292	**5549**	550	11,559	**12,109**
2001	195	3088	**3283**	241	3052	**3293**	258	4938	**5196**	694	11,078	**11,772**
2002	170	3336	**3506**	183	3493	**3676**	444	5288	**5732**	797	12,117	**12,914**
2003	285	3603	**3888**	340	3572	**3912**	635	4950	**5585**	1260	12,125	**13,385**
2004	470	3392	**3862**	371	3624	**3995**	445	5350	**5795**	1286	12,366	**13,652**
2005	322	3210	**3532**	362	3140	**3502**	535	5382	**5917**	1219	11,732	**12,951**
2006	250	3349	**3599**	210	3456	**3666**	375	5702	**6077**	835	12,507	**13,342**
2007*	240	3286	**3526**	180	3100	**3280**	320	5293	**5613**	740	11,679	**12,419**

Source: USDA-NASS

*Projected

http://www.nass.usda.gov/Statistics_by_State/Washington/Publications/Agri-facts/agri2may.pdf

Table 11: Dairy Cow Numbers

Year	Washington	Idaho	Oregon	California
1996	264	256	93	1349
1997	253	272	90	1391
1998	248	292	89	1420
1999	247	318	89	1465
2000	247	347	90	1526
2001	247	366	95	1589
2002	247	388	114	1648
2003	245	404	119	1688
2004	237	424	120	1725
2005	241	455	121	1755
2006	237	478	118	1780
2007	243	522	115	1805

http://www.nass.usda.gov/Statistics_by_State/California/Publications/Livestock/200710lvsrv.pdf

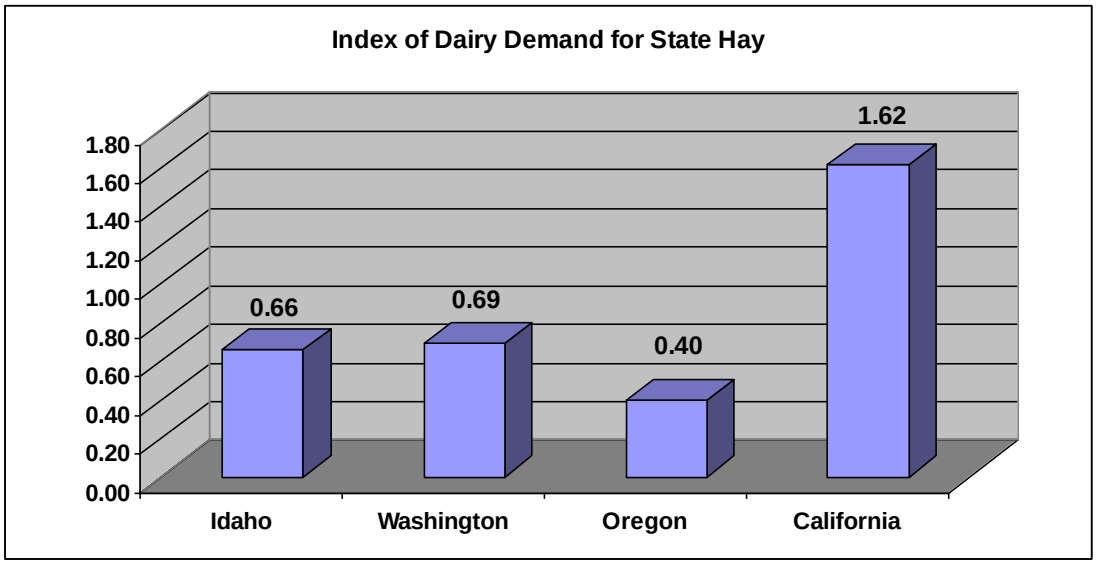

Figure 1: Dairy Demand Index for Alfalfa Hay by State

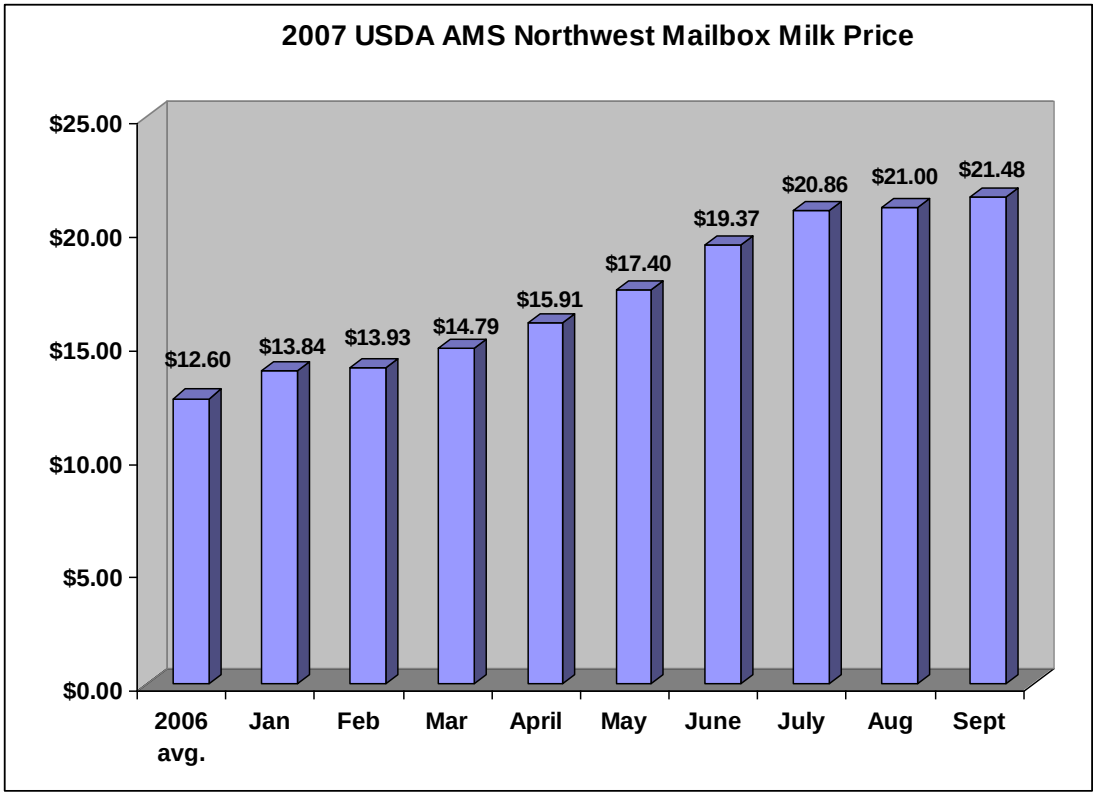

Figure 2. 2007 Dairy Mailbox Milk Price (September last month available).

Table 12: Cattle and Calves All Inventory January 1 in the PNW

	Washington	Oregon	Idaho	PNW
Year	1000 Head			
2000	1,210	1,450	1,950	4,610
2001	1,180	1,360	1,960	4,500
2002	1,130	1,400	1,990	4,520
2003	1,100	1,360	2,000	4,460
2004	1,120	1,440	2,000	4,560
2005	1,080	1,430	2,060	4,570
2006	1,100	1,420	2,110	4,630
2007	1,140	1,340	2,180	4,660

Source: USDA-NASS
http://www.nass.usda.gov/QuickStats/PullData_US.jsp

Table 13: Cattle on Feed Annual Marketings (1,000 head capacity feedlots)

	Washington	Oregon	Idaho	PNW
Year	1000 Head			
2000	560	na	700	1,260
2001	587	na	760	1,347
2002	508	na	726	1,234
2003	443	na	707	1,150
2004	423	na	640	1,063
2005	377	na	616	993
2006	315	na	542	857
2007	Na	na	na	na

Source: USDA-NASS
http://www.nass.usda.gov/QuickStats/PullData_US.jsp

Table 14: Japan Alfalfa Cube and Baled Hay Imports
January to November

	Metric Tons							
Origin	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
USA	1,654,204	1,634,189	1,634,544	1,921,010	1,676,372	1,714,021	1,671,183	1,638,634
CHINA	16,230	414	164	4,862	4,824	2,985	2,907	1,147
AUSTRALIA	168,686	183,094	271,353	329,754	391,230	452,565	456,762	338,264
CANADA	267,124	284,228	268,662	205,748	311,482	267,191	305,271	276,577
OTHERS	15,725	14,727	14,300	11,264	8,105	7,921	14,053	17,059
TOTAL	**2,121,969**	**2,116,652**	**2,189,023**	**2,472,638**	**2,392,013**	**2,444,683**	**2,450,176**	**2,271,681**

Source: Japan Customs
Prepared by William T. W. Woodward, Dean of Agriculture Education, Research and Development, Department of Agriculture, Columbia Basin College, 2600 North 20th Avenue, Pasco, WA 99301
Phone: 509-547-0511 ext. 2915
http://www.columbiabasin.edu/docs/2007_january-november_japan.pdf

Table 15: Korea Alfalfa Meal and Pellets and All Baled Hay Imports
January to November

	Metric Tons							
Origin	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
USA	336,703	348,683	420,284	445,048	446,918	509,315	543,478	664,264
CHINA	23,860	1,795	12,223	52,689	15,264	37,741	29,115	40,214
CANADA	111,327	102,556	41,077	9,602	119,396	39,315	42,856	37,483
AUSTRALIA	2,728	11,557	40,525	6,288	32,748	46,501	55,792	56,451
SPAIN	0	5,764	10,592	3,706	0	1,046	643	2,117
OTHERS	3,075	2,228	10,035	2,818	2,317	1,385	737	4,286
TOTAL	477,693	472,583	534,736	520,151	616,643	635,303	672,621	804,815

Source: Korea Trade Statistics
Prepared by William T. W. Woodward, Dean of Agriculture Education, Research and Development, Department of Agriculture, Columbia Basin College, 2600 North 20th Avenue, Pasco, WA 99301
Phone: 509-547-0511 ext. 2915
http://www.columbiabasin.edu/docs/2007_january-november_korea.pdf

Table 16: Taiwan Total Forage Imports
January to October

	Metric Tons							
Origin	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
USA	149,055	158,919	129,102	147,610	145,693	151,020	160,368	155,558
CANADA	51,837	30,012	23,145	20,393	19,236	20,689	17,927	25,805
AUSTRALIA	67,621	22,636	31,899	12,317	78,054	21,481	21,289	16,118
OTHERS	232	2,390	3,222	1,364	85	1,254	1,654	708
TOTAL	268,745	213,957	187,368	181,684	243,068	194,444	201,238	198,189

Source: Directorate General of Customs, Ministry of Finance, ROC
Prepared by William T. W. Woodward, Dean of Agriculture Education, Research and Development, Department of Agriculture, Columbia Basin College, 2600 North 20th Avenue, Pasco, WA 99301
Phone: 509-547-0511 ext. 2915
http://www.columbiabasin.edu/docs/2007_january-october_taiwan.pdf

Table 17: Waterborne Forage Exports by Port

Ports	2003	2004	2005	2006
	metric tons			
Seattle	554,118	656,407	931,217	790,258
Tacoma	662,875	671,216	859,291	834,432
Portland	553,257	412,675	173,325	201,306
Longview	9,755	1,066	367	-
sub-total	1,782,028	1,743,368	1,966,205	1,828,002
Los Angeles	453,075	402,305	367,056	415,970
Long Beach	545,990	424,184	350,512	359,185
Oakland	231,130	169,453	171,389	196,229
sub-total	1,230,195	995,942	888,957	971,384
Total West	3,012,223	2,739,310	2,855,162	2,799,386
Total All	3,039,548	2,771,818	2,875,811	2,805,980

Source: Port of Portland
Prepared by William T. W. Woodward, Dean of Agriculture Education, Research and Development, Department of Agriculture, Columbia Basin College, 2600 North 20th Avenue, Pasco, WA 99301 Phone: 509-547-0511 ext. 2915

Table 18: West Coast Forage Exports to Pacific Rim

1000 metric tons

	2004		2005		2006	
Origin	**Forage Exports**	**Percent**	**Forage Exports**	**Percent**	**Forage Exports**	**Percent**
PSW	996	36.4%	889	31.1%	971	34.7%
PNW	1742	63.6%	1966	68.9%	1828	65.3%
West Coast	2738	100.0%	2855	100.0%	2799	100.0%

Source: Port of Portland

Prepared by William T. W. Woodward, Dean of Agriculture Education, Research and Development, Department of Agriculture, Columbia Basin College, 2600 North 20th Avenue, Pasco, WA 99301 Phone: 509-547-0511 ext. 2915

Table 19: Washington Alfalfa Monthly Average Prices

Year	Monthly Prices											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	Dollars/Ton											
1996	99	95	98	98	108	112	111	106	108	109	107	113
1997	112	116	110	110	112	110	114	113	116	108	114	110
1998	114	109	100	108	101	103	97	94	91	91	86	88
1999	92	84	74	77	90	95	89	84	86	89	88	87
2000	84	88	89	90	92	101	98	98	96	93	98	95
2001	94	97	99	97	105	120	115	112	114	110	110	112
2002	115	117	115	115	116	115	108	106	106	103	103	104
2003	103	103	103	102	105	113	100	95	90	90	75	85
2004	85	83	80	80	82	90	100	100	110	120	115	105
2005	105	100	100	100	100	110	115	110	110	115	115	115
2006	110	110	110	115	115	120	120	125	130	130	130	125
2007	125	130	130	130	130	140	140	140	140	145	150	150

Source: USDA-NASS
http://www.nass.usda.gov/Statistics_by_State/Washington/Historic_Data/fieldcrops/hayalfprc.pdf
http://www.nass.usda.gov/Statistics_by_State/Washington/Publications/Agri-facts

Table 20: 2007 PNW and California Monthly Alfalfa Prices

Year	Monthly Prices											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	Dollars/Ton											
CA	125	135	150	150	164	166	162	158	156	166	174	170
ID	116	118	121	124	120	140	140	140	137	143	148	142
OR	131	132	135	138	144	148	151	145	145	149	153	159
WA	125	130	125	130	130	140	140	140	140	145	150	150

Source: USDA-NASS
http://www.nass.usda.gov/Statistics_by_State