RESEARCH PROJECT TITLE: Identifying Alternative Rotation Crops for Eastern Oregon

INVESTIGATORS:
Stephen Machado, OSU Agronomist, Pendleton
Christopher Humphreys, OSU Faculty Research Assistant
Brian Tuck, OSU, Extension Agent, Wasco

INTERIM OR FINAL REPORT: Final

PROJECT OBJECTIVES:

1. Obtain alternative crop seed from areas with similar climate to eastern Oregon and from breeders at OSU, WSU and UI.
2. Evaluate the adaptability of alternative crops to growing conditions in eastern Oregon
3. Establish basic agronomic practices of commercially promising alternative crops under reduced tillage systems.

KEYWORDS: Alternative crops, rotation

STATEMENT OF PROBLEM: Detrimental effects of the wheat/fallow rotation can be alleviated by the introduction of alternative crops that reduce or replace the fallow. Research is required to screen and evaluate alternative crops such as chickpeas, winter pea, lentil, faba beans, sunflowers, safflower, soybean, millets, buckwheat, linola, grasses, and other crops with industrial and pharmaceutical uses. These crops have been tried before and screening of some of these crops dates back to the 1930s. However, the screening had problems with stand establishment, agronomy, and other problems associated with vernalization and day-length requirements of some of the crops. Given the improvement in germplasm and the agronomy over the years, it is worthwhile to have another round of screening in eastern Oregon. Benefits of these crops to wheat-based rotations are not fully known and research should be conducted to obtain this information.

AGRONOMIC ZONE OF INTEREST: Research will be targeted for Agronomic zones 3 and 5.

ABSTRACT OF RESEARCH FINDINGS:
Alternative crops that include chickpea, buckwheat, flax, lentils, flax, lupin, millet, mustard, safflower, and sunflower, were evaluated for adaptability to eastern Oregon conditions over three years (2002 to 2004) at the Columbia Basin Agricultural Research Center (CBARC). Chickpea, lentils, winter peas, safflower, and sunflower have the greatest potential for growing in eastern Oregon under the conditions of our study. The rotational benefits of these crops to wheat are now being evaluated.

RESULTS AND INTERPRETATION
Experiments to evaluate alternative crops were conducted at the Columbia Basin Agricultural Research Center (CBARC)'s Pendleton (45ºN, 118º West, elevation 1440 ft) and Moro (45°N, 121°West, elevation 1835 ft) sites. Soils at both sites are Walla Walla silt loams that are 4 to 6 feet deep. Average annual precipitation at the Pendleton and Moro sites is 16 and 11 inches,

respectively. Alternative crop species were evaluated at these sites in 2002, 2003, and 2004. At Pendleton, crop year precipitation was 13, 16, and 20 inches in 2002, 2003, and 2004, respectively. At Moro, crop year precipitation was 8, 9, and 12 inches in 2002, 2003, and 2004, respectively. The crops were grown after fallow at Moro and following wheat at Pendleton. Table 1 shows grain yields of some of the crops evaluated at both stations. More agronomic work was conducted only on chickpeas, lentil, and peas.

Table 1. Grain yield of alternative crops evaluated at the Columbia Basin Agricultural Research Center from 2002 to 2004.

	2002		2003		2004	
Crop	Pendleton	Moro	Pendleton	Moro	Pendleton	Moro
	----------Grain yield (lbs/acre)----------					
Buckwheat (Lind)	61.60	72.46	23.96	79.06	-	-
Buckwheat (A. Lea)	-	-	31.15	71.87	-	-
Chickpeas (Myles)	980.55	912.74	-	-	1450.10	1190.81
Flax (Lind)	331.98	212.90	289.89	83.85	-	-
Flax (Cathay)	-	-	385.72	115.00	336.12	292.90
Flax (Pembina)	-	-	366.56	110.21	-	-
Flax (Omega)	-	-	342.60	189.27	-	-
Lentil	-	-	-	-	1582.15	674.64
Millet (Early Bird)	200.27	121.68	0	0	-	-
Millet (White Wonder)	0	0	0	0	-	-
Mustard (IdaGold)	151.54	590.81	603.74	110.21	909.92	585.80
Safflower (Lind)	839.02	1171.30	1054.15	452.81		
Safflower (MSU)	-	-	996.65	555.83	753.38	743.78
Sunflower (Lind)	307.64	62.53	-	-	-	-
Sunflower (oil)	-	-	620.51	471.97	0	0
Sunflower (Conf)	-	-	752.28	558.22	-	-
$LSD_{0.05}$	86.39	102.29	76.61	106.36	150.24	163.93

Buckwheat (*Fagopyrum esculentum/sagittatum* Moench)
Grain yields of 900 to 1100 lbs/acre for dryland and from 2200 to 3400 lb/a under irrigation have been obtained elsewhere. Grain yield of buckwheat was less than 100 lbs/acre at both Pendleton and at Moro (Table 1). The crop was susceptible to drought and high temperature stress during flowering and grain filling. Considerable grain was also lost through shattering when harvesting was delayed. Because of the difficulty in harvesting buckwheat seed, we recommend that buckwheat should be used only as a cover crop under our conditions. Buckwheat grows very fast and produces considerable biomass in a very short period.

Chickpea (*Cicer arietinum)*
Cultivar evaluations
In general, grain yield range from 500-1500 lbs/acre; grain yield of 3500 lbs/acre is possible. To determine grain yield potential under eastern Oregon conditions, a cultivar trial was conducted at Pendleton and Moro in the spring of 2002 and 2003. The cultivars were seeded following wheat at Pendleton and following fallow at Moro. Grain yield varied from 300 to 1000 lbs/acre (Table 2). In 2002, the *desi* chickpea, 'Myles', produced the highest yield, followed by 'CA99901604W'

(Table 2). Bean yields of up to 1450 lbs/acre were obtained at Pendleton in 2004 (Table 1). Bean yields from the other cultivars were not significantly different from each other and were about 600 lbs/acre lower than the yield of 'Myles'. Despite being grown following wheat in a drought year, 'Myles' produced more than twice the yield of the other cultivars. At Moro, Myles' produced the highest bean yields (Table 2). The yields of the rest of the cultivars were not significantly different from each other and were about 200 to 300 lbs/acre lower than the yield of 'Myles'. The bean yields of the *kabuli* cultivars were about 200 lbs/acre higher at Moro than at Pendleton, probably because they were grown on previously fallow land at Moro. Sinaloa and CA99901604W, both *kabuli* type chickpeas, consistently produced a high percentage of grade 'A' beans (beans did not pass though a '22/64' sieve) under both dry and wet conditions (Table 2). Dwelley also produced grade 'A' beans under available soil moisture was high (Table 2). *Kabuli* types that produce high percentages of grade 'A' beans dominate American production because of their high value for use as an ingredient in salad bars. On average grade 'A' have recently sold for 18-23c/lb. To obtain both high grain yield and a high percentage of grade 'A' beans under both low and high soil moisture environments, it is recommended to grow Sinaloa. Dwelley should be grown under high soil moisture environments. If grain yield is the only important factor, then Myles should be grown in both low and high yield environments. Myles produces exceptionally high yields in low soil moisture environments. There is a big market for *desi* type chickpeas in India, Pakistan, and North Africa

Table 2. Grain yield (lbs/acre) and size of different chickpea cultivars at CBARC Pendleton and Moro in 2002 and 2003

		Pendleton				Moro			
Cultivar	Type	2002		2003		2002		2003	
		Yield	Size (%A)	Yield	Size (%A)	Yield	Size (%A)	Yield	Size (%A)
Dwelley	*kabuli*	301.9	48	847.9	85	588.1	87	922.9	84
Sinaloa	*kabuli*	408.0	85	1097.8	95	642.1	81	759.6	91
Evans	*kabuli*	400.2	37	765.8	69	716.0	83	811.6	72
Myles	*desi*	1011.2	0	1059.9	0	880.3	0	839.7	0
Sanford	*kabuli*	387.7	29	863.3	75	647.8	88	829.7	70
Sierra	*kabuli*	400.8	58	867.2	80	656.4	89	745.3	82
CA99901604W	*kabuli*	539.4	68	693.7	91	702.6	88	729.7	88
$LSD_{0.05}$	-	223.2	5	257.7	7	195.4	14	207.1	6

Seeding date

Chickpea is normally seeded early in spring when soil temperatures are above 40ºF or warmer. Experiments were conducted to determine the optimum seeding date for Sinaloa and Dwelley chickpeas in 2002 and 2003 in eastern Oregon. The results indicate that, in both years, the highest grain yields were obtained when chickpeas was seeded early in the spring at all sites except at Moro in 2003, where problems associated with plant stand were encountered in the first 3 seeding dates (Tables 3, 4). Despite the reduced plant population, the crop seeded early in mid-March at Moro still produced the highest yield. Based on these results, it is recommended to seed as early as is practically possible in March in areas with similar climatic conditions to the sites used in this

study. Plants seeded early can take advantage of a longer growing period under favorable temperatures and higher available soil moisture. Seeding late shortens the growing period and exposes plants to high temperatures that can rise to more than 90ºF in June and July. Temperatures above 86ºF affect growth and heat stress can cause abortion of buds, flowers, and young pods. Based on our results, it is therefore recommended to plant either Dwelley or Sinoloa when seeding early and Sinaloa when seeding late or in locations that have limited water supply.

Table 3. Seeding date effects on grain yield (lbs/acre) of chickpea cultivars at different sites in 2002

Seeding date	Milton Freewater		Pendleton		Moro	
	Dwelley	Sinaloa	Dwelley	Sinaloa	Dwelley	Sinaloa
	----------†Grain yield (lbs/acre)----------					
Early April	1119a†	927a	400a	562a	819a	961a
Mid April	913b	886a	367b	476b	626b	775b
Late April	853b	914a	107c	425c	363c	594c

† means with the same letter within a column are not significantly different ($p<0.05$)

Table 4. Seeding date effects on grain yield (lbs/acre) of chickpea cultivars at different sites in 2003

Seeding date	Pendleton		Moro	
	Dwelley	Sinaloa	Dwelley	Sinaloa
	----------†Grain yield (lbs/acre)----------			
Mid March	1036a	1014a	823a	845a
Early April	794b	932b	591c	661c
Mid April	721c	728c	642b	686c
Late April	652d	744c	822a	758b

† means with the same letter within a column are not significantly different ($p<0.05$)

Seeding rate, depth and Row spacing

Seeding rates range from 80 lb/acre for *desi* to 160 lb/acre for *kabuli* chickpea; the recommendation is to germinate about 3 plants/ft^2. Seed must be inoculated with appropriate bacteria to enhance N fixation. Results from our experiments involving Sinaloa and Dwelley indicate that increasing seeding rates generally increased grain yields at all the sites and in both years (Table 5, 6). The effect of seeding rate on grain yield was, however, influenced by seeding date. Increasing seeding rates significantly increased grain yield when chickpeas were seeded in early spring. The magnitude of the increase in grain yield with increase in seeding rates was significantly reduced when chickpea was seeded later in the season. The results at Moro, although confounded with plant population problems, still showed the same response. It is therefore recommended that higher seeding rates be used when planting is done early in the spring.

Although high grain yields were produced at high seeding rates late in the season, the yield increase was small relative to early seeded crop and profitability may not justify the use of high seeding rate late in the season. Optimum seeding rate was cultivar dependent. The optimum seeding rate for Dwelley was 3.0 seeds/ft^2. Increasing seeding rate to 4.5 seed/ft^2 did not result in significant yield increase and could be uneconomical. In contrast the optimum seeding rate for Sinoloa is 4.5 seeds/ft^2 in both years under both low and high soil moisture conditions. It is therefore recommended to seed Dwelley at 3.0 seeds/ft^2 and Sinaloa at 4.5 seeds/ft^2 if it is economical to do so. Row spacing had no significant effect on grain yield for either cultivar. Row spacings of 6 or 12 inches are recommended.

Table 5. Seeding rate effects on grain yield (lbs/acre) of chickpea cultivars at different sites in 2002

Seeding rate (seeds/ft^2)	Milton Freewater		Pendleton		Moro	
	Dwelley	Sinaloa	Dwelley	Sinaloa	Dwelley	Sinaloa
1.5	806c†	786c	256b	388c	534b	640c
3.0	1071a	931b	313a	513b	633a	802b
4.5	1008b	1010a	306a	563c	641a	888a

† means with the same letter within a column are not significantly different ($p<0.05$)

Table 6. Seeding rate effects on grain yield (lbs/acre) of chickpea cultivars at different sites in 2003

Seeding rate (seeds/ft^2)	Pendleton		Moro	
	Dwelley	Sinaloa	Dwelley	Sinaloa
1.5	689c	680c	591b	659c
3.0	821b	872b	769a	745b
4.5	893a	1012a	799a	838a

† means with the same letter within a column are not significantly different ($p<0.05$)

Corn (*Zea mays* L.)

Average yields for silage corn is about 35,000 lbs/acre. Our results indicate that about 11,000 to 15,000 lbs/acre of fresh biomass (4,000 to 6,000 lbs/acre dry matter) can be produced under dryland conditions (Table 7). Grain weight ranged from 2,000 to 3,000 lbs/acre (Table 7). Grain yields of up to 18,000 lbs/acre have been produced elsewhere. The average US yields are about 5,000 lbs/acre. In our experiment plant population was rather high due to planter calibration problems. High plant population probably decreased grain yield by increasing competition for water and nutrients between plants. The suggested plant population for dryland corn for grain is 12,000 to 18,000 plants/acre. The population can be increased if the corn is grown for silage.

Table 7. Biomass and grain yield of dryland corn, CBARC, Moro, 2004

Cultivar	Plant/acre	Biomass (lbs/acre)		Grain yield (lbs/acre)
		Fresh	Dry	
39F59	64,062	12,404	5,244	2,753
39T71	51,531	11,380	4,872	3,097
DKC26-75	44,823	12,520	5,228	2,036
DKC33-10	33,759	15,077	6,041	2,612
$LSD_{0.05}$	14,496	2,438	960	1,463

Flax (*Linum usitatissimum*)
Average flax yield is 1000 lb/acre (20 bu/acre). In our evaluations grain yields of flax varied from 80 to 390 lbs/acre (Table 1). Grain yields were higher in Pendleton than at Moro. Grain yields can be improved if more agronomic work is done to determine the optimum seeding rates, row spacing, and fertilizer rates for flax grown under eastern Oregon Conditions.

Faba bean (*Vicia faba*)
Faba bean grain yields vary from 500 to 1500 lbs/acre; 2000 up to 4000 lbs/acre are possible (with 27 to 32% crude protein) under ideal conditions. Grain yield obtained from our trials at CBARC Pendleton were very low and ranged from 8 to 11 lbs/acre (Table 8). Low yields were attributed to poor stands and severe disease incidences. Results indicate that the cultivars

Table 8. Faba bean grain yield at CBARC, Pendleton, 2002

Cultivar	Grain yield (lbs/acre)
Melody	10.7
Devine	16.3
Cresta	10.5
CDC Fatima	11.6
CDC Blitz	11.0
Quattro	10.8
Compass	8.8
Scirocco	10.7
$LSD_{0.05}$	6.8

evaluated, most from Canada, were not adapted to eastern Oregon conditions. Breeding work is needed to develop faba bean cultivars adapted to eastern Oregon conditions. Up to 4370 lb/acre dry forage with 10.5% protein can be produced under ideal conditions. Faba bean should be grown once in every 4 years in the same field. It has the same diseases as rapeseed, sunflower, and other specialty crops. Faba bean is an excellent N fixing crop and can leave as much as 150 lb/acre for subsequent crops.

Lentil (*Lens culinaris*)
Cultivar evaluations
Winter and spring lentils were evaluated at CBARC from 2002 to 2004. In addition a seeding date experiment involving three winter lines was conducted. Winter lentils were seeded in October and spring lentils were seeded in March to May at a seeding rate of 20 seeds/ft^2. Data obtained from these experiments are presented below (Table 9-13). Grain yields were generally low for both

winter and spring lentils in the 2002-03 crop-year probably due to low precipitation. Seeding the spring lentils as late as May probably reduced the grain further. Grain yields of winter lentils ranged from 300 to 700 lbs/acre (Table 9). Spring lentil yields ranged from 100 to 500 lbs/acre (Table 11). Grain yields of both winter and spring lentils improved in the 2003-04 crop-year due to high precipitation and early seeding of spring lentils. Winter lentil yields ranged from 900 to 1800 lbs/a (Table 10, 12) and the spring lentil grain yields ranged from 1100 to 1600 lbs/acre (Table 13). Of the spring lentil commercial cultivars, Merrit produced the highest yield followed by Athena and Pardina (Table 13). Skyline produced the lowest yields. High yields in 2004 were attributed to high and well distributed precipitation and timely seeding. Pendleton received about 20 inches of precipitation that was 4 inches above the 73-yr average. Winter types normally yield from 30 to 50% more than spring types but this was not the case in 2004 because of broadleaf weed problems in winter lentils.

Table 9. Site and cultivar effects on winter lentil grain yield at CBARC, 2002-03

	Pendleton			Moro		
Accession No.	†Grain yield (lbs/acre)	†Plant/ft^2	†Plant height (in)	†Grain yield (lb/a)	†Plant/ft^2	†Plant height (in)
WA8649041	323.9c	5.4a	13.7a	87.7c	4.6a	11.7a
WA8649090	700.4a	5.1a	13.0a	314.4b	5.43a	8.2d
LC9440070	456.1b	5.4a	13.2a	431.2a	5.9a	10.3b
LC9979010	471.7b	4.9a	13.2a	425.5a	5.6a	9.2c

†means with same letters are not significantly different at 0.05 probability level.

Table 10 . Site and cultivar effects on winter lentil grain yield at CBARC, 2003-04

	Pendleton			Moro		
Accession No.	†Grain yield (lbs/acre)	†Plant/ft^2	†Plant height (inches)	†Grain yield (lbs/acre)	†Plant/ft^2	†Plant height (inches)
WA8649041	1071.1c	17.3a	16.9a	1081.4a	23.3a	9.9a
WA8649090	1639.4a	14.5a	15.5a	1015.0a	21.4a	11.3a
LC9440070	1100.1c	13.1b	15.0b	986.0a	21.2a	11.0a
LC9979010	1405.1b	11.2b	16.6a	1151.9a	19.8a	10.3a

†means with same letters are not significantly different at 0.05 probability level.

Table 11 Grain yield and height of Western Regional Lentil lines (0398) evaluated in 2003

Entry No.	Accession No.	Pendleton		Moro	
		Grain yield (lbs/acre)	Plant height (in)	Grain yield (lbs/acre)	Plant height (in)
1	LC460197L	356.2	12.8	362.4	9.3
2	LC860359L	366.9	15.5	350.6	9.4
3	LC9960273L	247.2	15.13	244.8	9.6
4	LC99602075L	352.3	16.3	251.9	9.3
5	LC460266B	470.1	13.6	197.0	9.3
6	LC760209C	397.6	14.3	148.7	9.4
7	LC99602712T	318.3	10.6	117.6	9.6
8	LC99602724T	334.4	10.6	132.1	9.4
9	LC00600831E	347.7	12.3	212.9	9.5
10	LC00600854E	256.6	13.4	176.7	9.6
11	LC99602427P	429.8	10.6	120.7	9.6
12	LC00600812P	478.7	11.4	103.0	9.4

Table 12 Grain yield and height of Elite Winter Lentil lines evaluated in 2003-04 crop-year at CBARC, Pendleton, Oregon.

Entry #	Accession #	Grain yield (lbs/acre)	Plant height (in)
1	WA-041	1098.5	17.4
2	LC-062	1531.3	16.6
3	LC-079	961.9	15.3
4	LC-120	1642.6	15.9
5	LC-057	1124.9	14.1
6	LC-094	1426.8	15.6
7	LC-010	1825.9	14.8
8	LC-065	1657.5	15.8
$LSD_{0.05}$	-	508.6	1.7

Table 13. Grain yields of spring lentil cultivars at Pendleton, OR, 2004

	Grain yield	
	----------Lbs/acre----------	
Cultivar	Unadjusted	†Adjusted (18%)
Regular	1426.33	1697.33
Skyline	1131.68	1346.70
Pardina	1428.90	1700.39
Eston	1362.92	1621.88
Athena	1445.85	1720.57
Merrit	1661.11	1976.71
$LSD_{0.05}$		

† means adjusted for losses by 18%

Seeding date: Winter lentils are seeded in the fall (October to November) and spring lentils are seeded early in spring when soil temperatures are above 50ºF from April 15 to May 15 to avoid

seedling diseases. A seeding date experiment was conducted during the 2002-03 and 2003-04 crop-years at CBARC in Pendleton and Moro. In the 2002-03 crop-year, higher grain yields were produced when lentils were seeded in November compared to October in Pendleton (Table 14). Planting in October reduced plant stands due to lack of soil moisture (crop 'dusted' in). The opposite was true at Moro (Table 14). Grain yields were reduced when lentils were seeded in November primarily due to grassy weeds. Herbicide (Assure®) application was delayed due to practical problems. WA8649090 produced the highest yields at both seeding dates at Pendleton. In Moro LC9440070 produced the highest yields at both seeding dates. The experiment was repeated in the 2003-04 crop-year at both sites (Table 15). On average higher yields were produced when lentils were seeded in November than in October at Pendleton. At Moro, there were no significant differences in grain yields of lentils seeded in October and November. WA8649090 and LC999010 produced higher yields than the other lines at both seeding dates at Pendleton. WA869041 and LC999010 produced the highest yields at Moro. Broadleaf weeds were a major problem this past season and may have reduced grain yields. Better control of the broadleaf weeds is needed before winter lentils can be grown on a larger scale.

Seeding rate, depth and Row spacing

Lentil is planted at a seeding rate of 40 lbs/acre for small-seeded Spanish brown and red lentil types and 60 to 80 lbs/acre for large Brewer types. Target plant population is 15 to 20 plants/ft^2. Our data indicate that high yields were obtained at a seeding rate of 20 plants/ft^2 (Table 16, 17). It is recommended to seed at a row spacing of 6 inches in higher rainfall areas and at 12 inches in lower rainfall areas. The recommended seeding depth is 1 to 2 inches.

Table 14. Site and seeding date effects on winter lentil grain yield at CBARC, 2002-03

		Pendleton	Moro
Planting date	Breeders lines	----------Grain yield (lbs/acre) †----------	
October 15	WA8649041	270.9	119.8
	WA8649090	608.4	583.4
	LC9440070	454.7	631.2
	LC999010	281.1	620.2
	mean	**403.8b**	**488.6a**
November 12	WA8649041	461.4	86.7
	WA8649090	891.9	237.6
	LC9440070	564.0	427.5
	LC999010	797.7	280.2
	mean	**678.8a**	**258.0b**
$LSD_{0.05‡}$	-	255.8	175.8

†means with same letters are not significantly different at 0.05 probability level.
‡LSD compares means of cultivars

Table 15. Grain yield of Winter lentil lines at CBARC, Pendleton, OR, 2003-04

		Pendleton	Moro
Planting date	Breeders lines	----------Grain yield (lbs/acre)----------	
October 20	WA8649041	1076.3	1101.9
	WA8649090	1464.2	1017.3
	LC9440070	1151.7	1072.9
	LC999010	1477.1	1301.2
	mean	**1158.6a**	**1032.0a**
November 11	WA8649041	999.6	1211.3
	WA8649090	1873.0	1171.4
	LC9440070	1102.8	950.9
	LC999010	1771.6	1232.6
	mean	**1449.3b**	**1085.2a**
$LSD_{0.05}$	-	255	255

†means with same letters are not significantly different at 0.05 probability level.
‡LSD compares means of cultivars

Table 16. Seeding rate effects on winter lentil grain yield at CBARC, 2002-03

	Pendleton			Moro		
Seeding rate	†Grain yield (lbs/acre)	†Plant/ft^2	†Plant height (in)	†Grain yield (lbs/acre)	†Plant/ft^2	†Plant height (in)
10 seeds/ft^2	434.8b	4.0b	13.1a	256.1b	3.7b	9.8a
20 seeds/ft^2	541.3a	6.4a	13.5a	373.3a	6.9a	9.9a

†means with same letters are not significantly different at 0.05 probability level.

Table 17. Seeding date and seeding rates effects on winter lentil grain yields, CBARC, 2003-04.

		Grain yield	
		Pendleton	Moro
Seeding date	Seeding rate	----------lbs/acre†----------	
October 21	10	1024.9b	940.7c
	20	1292.3a	1123.3a
November 10	10	1464.8a	1028.8ac
	20	1436.7a	1141.6a

†means with same letters are not significantly different at 0.05 probability level.

Millet (*Panicum miliaceum* L.)
Grain yields of up to 2,800 lbs/acre have been obtained. In our evaluation in 2002 and 2003, grain yields ranged from 0 to 200 lbs/acre (Table 1). The cultivars used were not adapted to eastern Oregon conditions.

Mustard (*Brassica* spp.)
Experimental yields in the PNW range from 560 to 2,200 lbs/acre. Mustard, together with other alternative crops, was evaluated for suitability to eastern Oregon conditions at CBARC Pendleton

and Moro Centers from 2002 to 2004. Grain yields of mustard varied from 100 to 900 lbs/acre at Pendleton and from 100 to 600 lbs/acre at Moro (Table 1).

Peas (*Pisum sativum*)

The yield potential of peas varies greatly depending on site and environmental factors. Yields range from 900 to 3500 lbs/acre. We evaluated 12 lines of spring peas at CBARC in Pendleton and at Moro and six lines of winter peas at CBARC in Pendleton in the 2002-03 crop-year. We also evaluated commercial cultivars in 2001-02, 2002-03 and 2003-04 crop-years at Pendleton. Winter peas and spring peas were planted in October and March, respectively, at a seeding rate of 7 seeds/ft^2. The crops were grown after winter wheat at Pendleton and after fallow at Moro. Spring peas produced about 700 to 1100 lbs/acre at Pendleton and 300 to 600 lbs/acre at Moro (Table 18). Grain yields of the winter pea lines ranged from 1900 to 3000 lbs/acre (Table 19). Winter pea lines yield 1200 to 1900 lbs/acre more than spring types. The effect of precipitation is clearly demonstrated in Table 20. Grain yields of commercial spring cultivars increased by 3 to 4 times in 2003-04 crop-year compared to yields in the previous years. Precipitation at Pendleton was 20 inches in 2003-04 crop-year compared to 16 inches and 13 inches in 2002-03 and 2001-02 crop-years, respectively. Grain yields ranging from 2700 to 3200 lbs/acre were obtained in the 2003-04 crop-year. The cultivar 'Universal' yields well under both dry and wet years but the yield was not significantly different from Badminton and Mozart under dry and wet conditions. We therefore recommend all the three cultivars to growers.

Table 18 Grain yield and height of Western Regional Dry Pea lines evaluated in 2002-03

Entry No.	Accession No.	Pendleton		Moro	
		†Grain yield (lbs/acre)	Plant height (inches)	†Grain yield (lbs/acre)	Plant height (inches)
1	PS610152	1162.8	9.6	475.1	8.1
2	PS710048	1027.3	9.8	482.6	8.1
3	PS810162	735.5	9.8	370.4	7.5
4	PS810191	1122.0	10.4	431.0	8.3
5	PS810240	1243.8	9.4	718.8	7.0
6	PS9910346	1001.7	9.8	574.1	7.9
7	PS9910592	977.0	9.9	431.0	8.3
8	PS710909	801.7	9.9	311.9	8.1
9	PS99101364	793.6	10.4	287.2	8.4
10	PS99101381	835.2	10.0	308.3	7.9
11	PS9910140	1066.4	9.9	646.8	7.9
12	PS9910188	1319.0	10.3	679.3	7.5
$LSD_{0.05}$		320.5	0.8	173.4	0.8

†Similar letters to the right of the numbers indicate that the means are not significantly different ($P<0.05$)

Table 19 Grain yield and height of Elite Winter Pea lines evaluated in 2003-04 crop-year at CBARC, Pendleton, Oregon.

Entry #	Accession #	Grain yield (lb/a)	Plant height (in)
1	PS-010	2628.0	52.0
2	PS-431	1902.4	42.8
3	PS-448	2367.1	47.3
4	PS-358	2859.3	33.5
5	PS-011	2459.7	33.1
6	PS-009	3136.8	45.8
$LSD_{0.05}$	-	1183	11.0

Table 20. Grain yield and height of commercial spring pea cultivars in 2001-02, 2002-03 and 2003-04 crop-years at CBARC, Pendleton, Oregon.

	2001-02		2002-03		2003-04	
Cultivar	Grain yield (lb/a)	Plant height (in)	Grain yield (lb/a)	Plant height (in)	Grain yield (lb/a)	Plant height (in)
Jasmine	613.5	15.8	-	-	-	-
Badminton	779.7	12.3	797.2	13	2736.1	33.0
Midas	670.7	14.3	-	-	-	-
Eiffel	779.2	16.5	-	-	-	-
Universal	858.0	14.3	767.4	17.8	3267.5	42.8
Mozart	-	-	786.3	11.9	2945.5	37.0
$LSD_{0.05}$	143.5	3.2	166.2		553.6	3.8

Seeding date

Peas are seeded in the fall (winter type) or in spring (spring type). They require 5, 2, or 1 week to emerge at soil temps of 40, 50 or 60ºF, respectively. Because spring peas have been grown for quite some time, growers have determined optimum seeding dates for their respective climatic zones. Winter pea is a new alternative crop and agronomic work is required to determine its optimum growing conditions. To this end we conducted seeding date, seeding rate, and cultivar evaluation experiments in the 2003-03 and 2003-04 crop-years. To determine the optimum seeding date and seeding rate for winter peas two lines of winter pea were grown at CBARC in Pendleton and Moro. The peas were grown at two planting dates and two seeding rates. Data obtained are presented below (Table 21, 22). Unfortunately the winter peas at Pendleton could not be harvested because peas from different plots had grown so big and into each other, we could not distinguish the plots. There were significant interactions between site, planting date and cultivar on grain yield at both sites in both crop-years (Table 21, 22). At Pendleton, grain yield of PS9530726 significantly increased when seeded in November while grain yield of PS9430706 was not influenced by seeding date in the 2002-03 crop-year (Table 21). The yield of PS9430706 was significantly higher than the yield of PS9530726 for both seeding dates. At Moro, there were no significant differences between the cultivars for each seeding date and between the seeding dates (Table 21). Grain yields were, however, much higher during the 2003-04 crop-year than yields in the previous crop-year (Table 22). Both cultivars appear to be adapted to eastern Oregon conditions.

Table 21. Grain yield of Winter Pea lines at CBARC, Pendleton and Moro, OR, 2002-03

		Pendleton	Moro
Planting date	Breeders lines	----------Grain yield (lbs/a) †----------	
October 15-16	PS9530726	1241.4	1140.2
	PS9430706	2050.8	1015.2
		1497.6b	**1030.1a**
November 11-14	PS9530726	1623.7	896.5
	PS9430706	1982.5	1174.2
		1773.4a	**899.0a**
$LSD_{0.05}$		319.5	461.4

†means with same letters are not significantly different at 0.05 probability level.
LSD compares means of cultivars

Table 22 Grain yield of Winter Pea lines at CBARC, Moro, OR, 2002-03

Planting date	Breeders lines	Grain yield (lb/a) †
October 15-16	PS9530726	1787.7
	PS9430706	1930.4
		1859.1a
November 11-14	PS9530726	1879.3
	PS9430706	1606.1
		1742.2a
$LSD_{0.05}$		425.3

†means with same letters are not significantly different at 0.05 probability level.
LSD compares means of cultivars

Seeding rate, depth and Row spacing

Peas are normally seeded at 7 seeds/ft^2 (1400 to 3500 seeds/lb depending on cultivar). Rates vary from 80 to 200 lbs/acre; for grain/pea mixtures, peas should be 60 to 66% of the mixture. We conducted a seeding rate experiment at CBARC Pendleton and Moro in the 2002-03 and 2003-04 crop-years. Peas were seeded at either 5 or 7 seeds/ft^2. On average, there was no significant difference in grain yield between the two seeding rates in the 2002-03 crop-year (Table 22). However, yield of both lines increased with increase in seeding rate. PS9430706 consistently produced higher yields than PS9530726 and this was significantly so at Pendleton. In the 2003-04 crop-year increasing seeding rates significantly increased the average grain yield at Moro (Table 23). There were no data obtained from Pendleton. Based on these results peas should be seeded at 7 seeds/ft^2. The effect of seeding rates higher than 7 seeds/ft^2 was not investigated. Peas are normally seeded in rows 6 to 7 inches apart at a depth of about 2.5 inches; hoe drills are preferred.

Table 22. Seeding rate effects on grain yield of Winter Pea lines at CBARC, Pendleton and Moro, OR, 2002-03

		Pendleton	Moro
Seeding rate (seeds/ft^2)	Breeders lines	----------Grain yield (lbs/a) †------	
5	PS9530726	1242.8	848.4
	PS9430706	1866.2	896.9
		1554.5a	**872.6a**
7	PS9530726	1432.5	1018.4
	PS9430706	2000.6	1094.7
		1716.5a	**1056.5a**
$LSD_{0.05}$		338.12	292.5

†means with same letters are not significantly different at 0.05 probability level.
LSD compares means of cultivars

Table 23. Seeding rate effects on grain yield of Winter Pea lines at CBARC, Moro, OR, 2002-03

Seeding rate (seeds/ft^2)	Breeders lines	Grain yield (lb/a) †
5	PS9530726	1705.7
	PS9430706	1739.6
		1722.7b
7	PS9530726	1833.0
	PS9430706	1768.3
		1800.6a
$LSD_{0.05}$		302.5

†means with same letters are not significantly different at 0.05 probability level.
LSD compares means of cultivars

Safflower (*Carthamus tinctorious*)
Grain yields range from 1000 to 1600 lbs/acre (>2000 lbs/acre possible with 15 inches precipitation). In eastern Oregon, safflower grain yields of 544 to 1892 lbs/acre have been obtained. Grain yields of safflower varied from 500 to 1100 lbs/acre (Table 1). Appropriate agronomic practices (seeding rates, row spacing, fertilizer, and cultivars) for safflower should be determined for eastern Oregon conditions. In rotation, safflower stubble provides excellent snow trapping for good soil and water conservation in combination with other conservation practices. However, rotations should be carefully planned to reduce the impacts of a dry soil profile following safflower to the subsequent crop. Safflower has a dense root structure that improves tilth and porosity (break up pan in no-till systems). The crop, however, dries up soil for next crop; therefore plant after fallow or follow with spring cereals. Do not follow safflower with sunflowers, peas, lentils, and canola because they suffer from same diseases.

Sunflower (*Helianthus annus*)
Sunflowers can produce seed yield of 2000 to 3000 lbs/acre and oil yield of 30 to 50%. Sunflower often produces satisfactory yields under drought conditions detrimental to other crops. This is

probably due to its extensively branched taproot that can extract soil water from about 6 to 7 ft in the subsoil. Grain yields of sunflower varied from 300 to 800 lbs/acre at Pendleton and from 80 to 500 lbs/acre at Moro (Table 1). Yields were low due to substantial bird damage; potential yields are higher than the reported yields. Furthermore, appropriate agronomic practices (seeding rates, row spacing, fertilizer, and cultivars) for sunflower have not yet been determined for eastern Oregon conditions.

Summary

After three years of evaluating alternative crops, our results indicate that chickpea, lentils, winter peas, safflower, and sunflower have the greatest potential for growing in eastern Oregon under the conditions of our study. These crops produced high grain yields even under low moisture conditions. A rotation experiment to determine the optimum sequence and benefits of these potential crops to wheat has been initiated at Moro. Lack of markets, however, is the main constraint in growing these crops. However, growing oil seed crops will become profitable as the demand for biodiesel increases. Bird damage is a big problem when growing sunflower. Buckwheat may not be suitable for grain production but can be used as a cover crop; it is fast growing and covers the soil quickly. Flax and linola have the potential to be high value alternative crops but they are poor competitors with weeds. Grain yields can probably be increased by agronomic manipulations (increased seeding rates and narrow row spacing).

INTERACTION WITH OTHER SCIENTISTS CONDUCTING RELATED ACTIVITIES:

The PI is cooperating with: Brian Tuck, Wasco County Extension Agent, OSU, Sandy Macnab, Sherman County Extension Agent, OSU, Jordan Maley, Gilliam County Extension Agent, OSU on evaluating alternative crops in eastern Oregon; ICARDA scientists on the Legume International Nursery, Syria.

PUBLICATIONS AND PRESENTATIONS:

Machado, S. 2004. Potential alternative crops for eastern Oregon. Oregon Agricultural Experiment Station Special Report 1054: 84-102.

Machado, S., Christopher Humphreys, Brian Tuck, and Mary Corp. 2004. Evaluating chickpea (Garbanzo Bean) for adaptability to eastern Oregon. Oregon Agricultural Experiment Station Special Report 1054: 35-43

Machado, S., C. Humphreys, and B. Tuck. 2005. Alternative rotation crops: Peas (*Pisum sativum*). Oregon Agricultural Experiment Station Special Report 1061:66-72.