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ALTERNATIVE CROPS AND CROPPING SYSTEMS IN SOUTHWESTERN NORTH DAKOTA

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SUMMARY

Crop production systems in the southwestern North Dakota are almost exclusively limited to small grains. Average yields reported by Wiyatt and Hamlin (1992) for these crops generally are lower than those required to return an adequate profit margin to producers, if government price supports are not considered (Farm Analysis Center, 1991). Even when government payments are made, in some instances small grain crops cannot profitably be grown in most years.

Expanding cropping choices has been suggested as a possible strategy for profitable crop production (Jolliff, 1989). Crop diversity also can expand market opportunities, improve pest control, and enhance soil conservation (Jolliff and Snapp, 1988). In North Dakota, development of crambe points to the benefits which biological diversity in cropping systems can offer. Crambe is naturally resistant to many pests and can be used to break small grain disease cycles in rotations (Endres and Schatz, 1991). The seed oil is highly-valued by the chemical industry (Van Dyne et al., 1990), opening up new markets to primarily food and feed producers. Crambe also produces considerable amounts of residue and can be managed to protect cultivated fields from wind and water erosion.

Successful production of alternative crops in southwestern North Dakota would provide many benefits to producers. Crambe and other industrial crops could be grown and sold as high-value industrial feedstocks. Pulses like field pea could be intercropped with cereal feed grains to enhance protein content of annual forages. Lupin and other plants

could be grown as high-protein feed grains as well as soil-enhancing crops. This project is directed at evaluating several alternative crops in southwestern North Dakota, and exploring weed management strategies when these crops are grown. This project will collect and publish information on the performance of cereal forage crops and alternative crops and crop management strategies in southwestern North Dakota.

OBJECTIVES

1. Evaluate corn and pulse crops alone and/or in mixtures with one another and small grains for feed and forage in southwestern North Dakota.
2. Explore weed control strategies among alternative crops.

INTRODUCTION

Corn is an important annual forage in southwestern North Dakota. According to Wiyatt and Hamlin (1992), corn was planted on approximately 200,000 acres of cropland in 1991; this represents a 25% increase in corn acreage since 1980 (Carver and Hamlin, 1985). The importance of corn in the region supports adaptation trials of newly developed hybrids. These trials should reflect changes in corn production strategy, including increased planting rates and narrower row spacing.

Conlon and Douglas (1957) reported that corn produced larger yields per acre than any other feed crop grown at the Dickinson Research Extension Center between 1907-57. In summarizing earlier research, Conlon and Douglas (1953) concluded that a corn-wheat-oat rotation generated considerably greater returns than a fallow-wheat-oat rotation on diversified crop-livestock farm operations. The corn produced on the farm was marketed through livestock.

Corn grown as silage is an excellent forage crop. However, soybean meal generally is added to correct protein deficiencies (Goodrich and Meiske, 1976). The soybean meal added to the feed ration is an off-farm cost to producers in southwestern North Dakota, since soybean is not adapted to local growing conditions and little is grown (Wiyatt and Hamlin, 1992). Adaptation screening trials suggest that lupin may successfully be grown in western North Dakota (Carr et al., 1992). If so, lupin could be grown and substituted for soybean meal in livestock rations. Lupin seed is high in protein (35%) and TDN (78%), and unlike soybeans it can be fed directly to livestock without heat treatment (Putnam et al., 1989).

An alternative to growing corn for silage is to grow other cereals like barley or oat as haylage. While past work indicates that both these crops produce less total digestible nutrients than corn grown for either grain or silage (Smith and Stoa, 1944; Wiidakas, 1967), it may be possible to enhance the feed value of barley or oat haylage by growing these cereals together with field pea. Izaurralde et al. (1989) concluded that intercropping barley with field peas significantly increased crude protein content of the hay produced. Similarly, protein yield sometimes was increased when oats were intercropped with field peas in western North Dakota rather than grown alone (Carter and Larson, 1964). While these North Dakota researchers reported that hay yields generally were decreased when oats were intercropped with either field pea or vetch, their data reveal several exceptions. For example, dry matter production of oat-field pea mixtures compared favorably with monocropped oat in recropped environments at Dickinson, Minot, and Williston. Likewise, recent work indicated that dry matter yield was maintained when oats and peas were intercropped at Dickinson (Carr et al., 1992). The influence of intercropping on hay yield and protein content must be established for widespread adoption of this practice in the Southwest. For this to be known, the influence of cereal to pea plant populations on intercrop performance must be established.

Flax and lentil generally are adapted to growing conditions in southwestern North Dakota. However, weed problems can be encountered when growing these crops. Both are poor competitors with weeds, particularly early in the growing season (Martin et al., 1976). Weed control problems encountered when growing these crops may be an obstacle to their wider adoption by producers in the southwestern region of the state.

Harrowing could be effective in reducing stands of common lambsquarters, foxtail, kochia, pigweed, and other small seeded weeds in flax and lentil. However, information is lacking on the effectiveness of harrowing for weed control in flax, and contradictory for lentil. Slinkard and Drew (1988) suggest that postemergent harrowing of lentil can reduce populations of broadleaf weeds, whereas Muehlbauer et al. (1981) indicate that certain weed populations may be enhanced. The effectiveness of harrowing as a weed control strategy must be determined if producers are to have mechanical weed control options when growing these crops.

Preemergent harrowing in flax generally is not recommended because of excessive crop damage (Zollinger, per.

comm.). Preplant tillage can be done to reduce populations of early germinating weeds but seeding generally is delayed and yield reduced (Zollinger, 1992). Use of the rotary hoe may allow preemergent control of early-season weed populations without causing excessive crop losses in flax.

Excellent early-season weed control can result from rotary hoeing corn and other row crops, particularly when combined with herbicides (Gunsolus, 1990; Krause and Burnside, 1992). Using the rotary hoe for weed control in solid seeded crops only recently has been considered (Smolik et al., 1991). Effective use of the rotary hoe to suppress weeds in flax has not been documented, as well as in lentil. This information is important for mechanical weed control options to exist when these crops are grown.

MATERIALS AND METHODS

Objective 1

Cultivar Adaptation Trials. Lupin, fababean, and field pea were evaluated in cultivar comparison trials at the Dickinson. A corn cultivar trial also was conducted. Seed of 18 lupin, 4 fababean, and 6 field pea cultivars or advanced experimentals was provided by the Carrington Research Extension Center. Corn seed was solicited from private seed companies. Cultural practices including tillage and seeding, fertilization, herbicide application, and harvesting followed currently acceptable agronomic procedure in implementing and maintaining cultivar comparison trials.

Cultivars were evaluated using a randomized complete block design with four replicates. Individual plot dimensions were 28 by 6 ft for lupin, fababean, and field pea, and 50 by 6 ft for corn trials. Variables measured on each plot in the lupin, fababean, and field pea trials included: initial date of flowering, rate of plant maturation, grain yield and seed size. In the corn hybrid trial, seedling emergence, date of tasseling, silage yield, grain yield, and test weight were determined.

Data collected from each trial were analyzed by computer using a statistical software program.

Cereal-Pea Intercropping Trial. Dumont and Magnum oats, and Bowman and Horsford barley were sown alone and mixed with Trapper field pea. Seeding rates for monocultures were 325,000, 750,000, and 1,125,000 pure live seed

(PLS) per acre for cereal grains and 162,500, 325,000, and 487,500 PLS per acre for peas. Both crop species were sown at 0.5, 1.0, and 1.5 of a monoculture seeding rate in intercrops and alone. Therefore, fifteen different cereal:pea intercrop treatments were evaluated for each cereal cultivar: 0.5:0.0, 1.0:0.0, 1.5:0,0, 0.5:0.5, 1.0:0.5, 1.5:0.5, 0.5:1, 1:1, 1.5:1, 0.5:1.5, 1:1.5, 1.5:1.5, 0.0:0.5, 0.0:1.0, and 0.0:1.5.

The experiment was arranged in a randomized complete block design in a split split-plot arrangement with four replicates. Cereal crop constituted main plots, cultivar comprised subplots, and seeding rate constituted sub-subplots. The experiment was conducted under dryland conditions in both fallow and recrop environments. Individual plot dimensions were 28 by 6 ft.

Variables measured in each plot included: plant populations at establishment, plant height, distance of lowermost pea pods from the soil surface, dry matter yield at early heading to late milk grain development stage (Zadoks 77), grain yield, kernel size, grade of peas, and Land Equivalent Ratios. Crude protein, acid- and neutral detergent fiber content will be determined if funding is available for dry matter samples harvested from each plot, as will grain N content of both cereal and pea crops. Field pea grade also will be determined.

Data were analyzed by computer using a statistical software program.

Objective 2

Mechanical Weed Control Study. A field experiment was conducted under dryland conditions. The experiment was arranged in a randomized complete block design in a split-plot arrangement with four replicates. Crop species comprised main plots and included flax, lentil, and hard red spring wheat.

Weed control treatments comprised subplots. These were oriented at right angles to main plots and included: (1) rotary hoeing at three to five days after seeding; (2) rotary hoeing at three to five days after seeding and again when plants were 2-5 in. tall; (3) harrowing with a spring tooth harrow at three to five days after seeding; (4) harrowing at three days after seeding and again when seedlings were 2-5 in tall; (5) rotary hoeing at three to five days after seeding plus herbicides; (6) harrowing at three to five days after seeding plus herbicides; and (7) herbicides alone. Herbicide treatments included a postemergent application of 0.25 lb a.i./ac Buctril for flax when rotary hoed or harrowed and 0.4 lb a.i./ac Poast plus 0.25 lb a.i.ac Buctril when not hoed or harrowed; a postemergent application of 0.38 lb a.i./ac Sencor for lentil when rotary hoed or harrowed and 0.4 lb a.i./ac Poast plus 0.38 lb a.i./ac Sencor when not hoed or harrowed; and a postemergent application of 0.25 lb a.i./ac Buctril for wheat when rotary hoed or harrowed and 0.9 lb a.i./ac Hoelon plus 0.25 lb a.i.ac Buctril when not hoed or harrowed. A check (no weed control) treatment was included in each replicate.

Variables measured on each plot included: plant population at establishment or approximately 2 days after last tillage pass, whichever was later, dry matter production of grass and broadleaf weeds, and seed yield of each crop. Weed control within each plot was visually rated as percent control compared to the check subplot.

Data were analyzed by computer using a statistical software program.

LITERATURE CITED

Carr, P., E. Eriksmoen, G. Martin, B. Melchior, R. Olson, and M. Hinrichs. 1992. Ninth annual western dakota crops day research report. Dickinson Res. Ctr., Dickinson, ND. 71 p.

Carter, J.F., and K.L. Larson. 1964. Oats, peas, and vetch for hay and silage in North Dakota. North Dak. Agric. Exp. Stat. Bull. No. 447. Fargo, ND. 8 p.

Carver, R.F., and W.G. Hamlin. 1985. North Dakota agricultural statistics. Agric. Stat. No. 54. North Dakota State University, Fargo, ND.

Conlon, T.J., and R.J. Douglas. 1957. Corn for silage. North Dak. Farm Res. 19(4): 107-114.

Conlon, T.J., and R.J. Douglas. 1953. Rotation and tillage investigations at the Dickinson Experiment Station. North Dak. Agric. Exp. Stat. Bul. No. 383. 126 p.

Endres, G., and B. Schatz. 1991. Crambe production. North Dak. State Univ. Ext. Circ. A-1010. Fargo, ND. 4 p.

Farm Analysis Center. 1991. North Dakota farm and range business management: region 4 averages. Ann. Rep.

Center for Farm Financial Management, Univ. Minn., St. Paul. MN. 75 p.

Goodrich, R.D., and J.C. Meiske. 1976. High-energy silage. p. 569-580. *In* M.E. Heath, D.S. Metcalfe, and R.F. Barnes (eds.) Forages: the science of grassland agriculture. The Iowa State Univ. Press, Ames, IA.

Gunsolus, J.L. 1990. Mechanical and cultural weed control in corn and soybeans. Amer. J. Alt. Agric. 5:114-119.

Izaurralde, R.C., N.G. Juma, and W.B. McGill. 1990. Plant and nitrogen yield of barley-field pea intercrop in cryoboreal-subhumid central Alberta. Agron. J. 82:295-301.

Jolliff, G.D. 1989. Strategic planning for new-crop development. J. Prod. Agric. 2:6-13.

Jolliff, G.D., and S.S. Snapp. 1988. New crop development: opportunity and challenges. J. Prod. Agric. 1:83-89.

Krause, N., and O.C. and Burnside. 1992. Alternative systems of dry bean production. MN Agric. Exp. Stn. Paper No. 20,036, Misc. Journ. Series, Univ. Minn., St. Paul, and Irrigation Res. Ctr., Staples, MN.

Martin, J.H., W.H. Leonard, and D.L. Stamp. 1976. Principles of field crop production. Third Ed. Macmillan Pub. Co., New York, NY. 1118 p.

Muehlbauer, F.J., R.W. Short, R.J. Summerfield, K.J. Morrison, and D.G. Swan. 1981. Description and culture of lentils. Washington State Univ. Ext. Circ. EB 0957. 8 p.

Putnam, D.H., E.S. Oplinger, L.L. Hardman, and J.D. Doll. 1989. Lupine. In Alternative field crops manual. Ctr. Alt. Plant and Animal Products., Univ. Minn., St. Paul, MN.

Slinkard, A.E., and B.N. Drew. 1988. Lentil production in western Canada. Division of Extension and Community Relations Pub. No. 413. Univ. Saskatchewan, Saskatoon, Canada. 6 p.

Smith, R.W., and T.E. Stoa. 1944. A comparison of different grains for feed production in North Dakota. North Dak. Agric. Exp. Stat. Bimon. Bul. 6(4): 13-17.

Smolik, J., L. Evjen, K. Lewis, and P. Wieland. 1991. Mechanical and chemical weed control in spring wheat. p. 36-37. In Northeast Res. Stat. Annual Progress Report. Plant Sci. Pamphlet No. 43. South Dak. State Univ., Brookings, SD.

Van Dyne, D.L., M.G. Blase, and K.D. Carlson. 1990. Industrial feedstocks and products from high erucic acid oil: crambe and industrial rapeseed. Univ. Missouri-Columbia, Columbia, MO.

Wiyatt, S.D., and W.G. Hamlin. 1992. North Dakota Agricultural Statistics. North Dak. State Univ., Fargo.

Wiidakas, W. 1967. Adapted corn hybrids are more dependable. North Dak. Agric. Exp. Stat. Bimonthly Bull. Farm Res. 25(1): 13-15.

Zollinger, R.K. 1992. Agricultural weed control guide. North Dak. State Univ. Ext. Circ. W-253 (rev.) 66 p.

RESULTS

OBJECTIVE 1

Corn

Average yield of corn silage yield was 3.7 tons of dry matter per acre among the nine hybrids evaluated in 1994. Significant differences in silage yield were not observed among the hybrids, in part because of soil and other uncontrolled variability. Silage yield for the two hybrids included in the corn trial at Dickinson over the last three years has been around 4 tons/acre.

For the first time in three years, corn produced grain at Dickinson. Grain yield ranged from 43 bushels per acre for Pioneer 3963 to 62 bushels per acre for Pioneer 3905, though significant differences in grain yield among hybrids were not observed. Test weight was light (<56 lbs/bu), with the exception of grain produced by Cargill 1077 (58.6 lbs/bu).

Lupin

Grain yield varied from 313 to 1415 pounds per acre among the entries in the

lupin nursery in 1994. Primorski produced the greatest amount of seed. Seedling blight and rodent feeding were observed in several plots at the time of seedling emergence and shortly thereafter. The Anthracnose pathogen was observed among white lupin varieties in certain plots at the onset of bloom. These factors probably explain the relatively high variability in yield (indicated by the high CV[%]) which could not be explained by cultivar differences.

Of the lupin cultivars evaluated at Dickinson between 1992 and 1994, RSI 2085 produced the most grain. Grain yield of this cultivar during this period was 116% that of Primorski, another white lupin. Grain yield of yellow lupin cultivars evaluated over this time have been considerably less than that of the white lupin cultivars, suggesting that yellow lupin is not adapted to growing conditions in the southwest.

Fababean

Grain yield was low for the four varieties evaluated at Dickinson in 1994. Yield ranged from 383 lbs per acre for Aladin to 630 lbs per acre for Encore. These low yields can partially be explained by field conditions at seeding. Heavy wheat stubble was disked into the soil prior to planting. The stubble interfered with the planter's ability to sow seed at a uniform depth. Seeding depth ranged from 0.25 inches to 1.5 inches. As a result, uneven and, in some plots, poor crop stands developed. Results of this trial are insufficient to determine if fababean is adapted to growing conditions in western North Dakota.

Field Pea

Average grain yield for the six field pea varieties evaluated in 1994 was 1606 lbs per acre. Yields would have been much higher if crop stand had been better than what was achieved. As in the case of fababean, wheat stubble interfered with planting of field pea seed and, in some plots, a poor crop stand resulted. Compared to fababean, however, field pea seems adapted to growing conditions in southwestern North Dakota. Yield of field pea varieties evaluated at Dickinson in 1992 and 1994 has averaged around 2000 lbs per acre.

Cereal-pea Intercrops

Consistent trends have not been observed among cereal-pea mixtures evaluated at Dickinson during 1993 and 1994. In 1993, oat-pea mixtures generally produced more hay than barley-pea mixtures, regardless of whether the oat was a conventional (Dumont) or forage (Magnum) type. In 1994, hay yield of cereal-pea mixtures was higher when a forage-type cereal was grown, regardless of whether the cereal crop was barley or oat.

Hay yield of cereal crops grown alone at 750,000 PLS per acre was generally greater than any cereal-pea mixture when the cereal crop was sown at 375,000 PLS per acre. When the cereal was sown at 750,000 or 1,125,000 PLS per acre in combination with pea, some cereal-pea mixtures produced more hay than the cereal crops grown alone at 750,000 PLS per acre, depending on the year, tillage environment, and cereal cultivar considered. These data indicate that further work is needed to determine if hay production of cereal-pea intercrops at selected seeding rates is consistently greater than that produced by the cereal crop when grown alone. Still, it seems that sowing oat or barley at 375,000 PLS per acre along with pea at 375,000 PLS per acre, as has been suggested by some proponents of cereal-pea mixtures in North Dakota, may produce less hay than a sole cereal crop. This may be an acceptable trade-off for some livestock producers if the quality of the cereal-pea hay is improved compared to that of the cereal crop when grown alone. This project will continue so that the influence of intercropping on hay quality, and the impact of seeding rates on cereal-pea hay yield, can be better quantified.

Objective 2

Most effective control of weeds resulted when herbicides were used alone or in combination with either the harrow or rotary hoe. Without herbicides, single or multiple cultivations using a harrow or rotary hoe failed to control weeds as effectively as any control treatment including herbicides. When used alone, however, both the harrow and rotary hoe reduced weeds compared to the check (no control) treatment.

Seed yield was comparable between plots in which weeds were mechanically controlled and plots in which only herbicides were used to control weeds, regardless of which crop was grown. Greatest amounts of seed were produced when a preemergent mechanical cultivation was combined with a postemergent application of herbicide, though yield generally was not significantly greater than that for the treatment including only herbicides. An exception occurred with flax, where yield was significantly greater for the harrow + herbicide treatment than the herbicide treatment.

Crop stand was reduced by both pre- and postemergent cultivation with either the harrow or rotary hoe. Greatest reductions occurred when the rotary hoe was used compared to the harrow. Of the crops evaluated, flax stand was reduced most dramatically and wheat the least.

Evaluation of mechanical and chemical control methods in flax, lentil, and wheat will be continued in 1995. This evaluation will be expanded to include safflower and either mustard or crambe as well.

Dryland Corn Hybrid Trial - Recrop -- Dickinson, ND, 1994									
			Yield						Test weight lbs/bu
			Silage					Grain 1994 bu/ac	
			70%	DM basis					
Brand	Hybrid	RM days	Moisture	1994	1993	1992	Avg		
			tons/ac						
Cargill	1077	75	14.4	4.3	2.9	----	----	44.7	58.6
Cargill	2037	80	12.8	3.8	3.3	4.7	3.9	46.5	50.4
Dekalb	DK 343	84	12.1	3.6	3.1	----	----	50.6	52.0
Dekalb	DK 401	90	10.3	3.1	----	4.7	----	46.9	49.4
Pioneer	3905	87	13.7	4.1	----	----	----	62.0	55.0
Pioneer	3917	87	11.6	3.5	3.2	----	----	49.7	51.1
Pioneer	3921	86	10.5	3.1	----	----	----	56.4	51.4
Pioneer	3963	79	12.3	3.7	3.3	4.9	4.0	43.0	55.5
Pioneer	3979	76	12.9	3.9	----	5.1	-----	55.3	54.9
Mean			12.3	3.7				50.6	53.1
CV(%)			24.6	24.6				20.6	2.9
LSD .05			NS	NS				NS	2.2

Dryland Peal Variety Trial - Recrop -- Dickinson, ND, 1994						
Variety	Height inches	Test weight lbs/bu	Grain yield			% of Trapper
			1994	1992	Avg	
			lbs/ac			
Century	15.1	64.4	1678.1	2152.2	1,915.15	0.83
Emerald	13.3	63.7	1523.9	----	----	----
Express	14.3	62.1	1611.1	----	----	----
Profi	16.2	63.1	1699.0	----	----	----
Sirius	16.2	64.1	1692.8	1767.6	1,730.20	0.75
Trapper	14.1	64.6	1429.8	3208.0	2,318.90	1.00
Mean	14.9	63.7	1605.8			
CV(%)	18.9	0.54	11.01			
LSD .05	NS	0.5	NS			

Dryland Lupin Nursery - Fallow -- Dickinson, ND, 1994								
Entry	Type	Days to bloom	Height inches	Seed yield				% of Primorski %
				1994	1993	1992	Avg	
				lbs/ac				
Borluta	Y	46.0	26.7	331.5	----	----	----	----
Chinette	W	30.2	25.5	648.8	----	----	----	----

Danja	B	29.2	19.2	1263.3	2126.8	----	----	----
Gungurru	B	29.5	16.0	1012.6	1756.8	----	----	----
Jenny	W	30.5	27.7	1058.4	----	----	----	----
Juno	Y	41.5	24.0	596.7	1438.1	679.0	904.60	0.50
Manru	Y	51.2	32.0	313.1	835.3	420.9	523.10	0.29
Merrit	B	30.0	15.5	1150.2	1449.3	----	----	----
Primavera	W	30.0	23.5	1163.4	----	----	----	----
Primorski	W	29.0	27.2	1415.5	1455.8	2507.7	1,793.00	1.00
Progress	W	32.2	28.2	831.8	2007.0	----	----	----
RSI 2085	W	35.0	26.0	957.7	2564.5	2728.3	2,083.50	1.16
RSI 1013NH	W	31.0	23.5	1022.2	----	----	----	----
RSI 2019	W	33.7	26.7	731.2	2394.9	----	----	----
Ultra	W	33.5	27.0	939.2	2262.8	2226.3	1,809.43	1.01
Vegus-W	Y	40.0	25.5	443.2	1151.4	----	----	----
Yandee	B	29.5	19.5	947.6	1806.9	----	----	----
Yorrel	B	29.7	19.2	1348.8	1510.5	----	----	----
Mean		33.6	24.5	898.6				
CV(%)		4.8	9.0	20.7				
LSD .05		2.3	3.1	263.8				

Dryland Fababean Trial - Recrop -- Dickinson, ND, 1994		
Variety	Height inches	Seed yield lbs/acre
Aladin	26.0	383.4
Encore	23.7	630.0
Outlook	24.0	364.4
Pegasus	25.2	437.5
Mean	24.7	453.8
CV(%)	6.6	17.9
LSD .05	NS	130.0

Cereal/Pea Intercropping Study										
Cereal			harvest moisture				Hay yield			
Variety	seeding rate		fallow		recrop		fallow		recrop	
	cereal	pea	1993	1994	1993	1994	1993	1994	1993	1994
	PLS/acre		%				DM/acre			
Bowman			71	77	72	77	4.1	2.4	2.7	2.5
Dumont			79	79	75	80	4.2	2.7	3.0	2.5
Horsford			70	71	74	62	4.3	3.2	2.6	4.2
Magnum			77	69	75	63	4.4	3.6	3.0	3.9

	0	162,500	----	77	----	72	----	2.1	----	2.7
	0	325,000	----	78	----	71	----	2.2	----	3.2
	0	487,500	----	78	----	73	----	2.4	----	3.0
	375,000	0	79	71	79	89	----	3.2	----	3.0
	375,000	162,500	75	73	75	70	4.1	2.9	2.5	3.1
	375,000	325,000	75	75	77	72	4.1	2.7	2.6	3.1
	375,000	487,500	76	76	77	72	3.9	2.8	2.8	3.3
	750,000	0	74	71	69	69	4.3	3.4	2.8	3.4
	750,000	162,500	73	73	74	71	4.4	3.2	2.7	3.2
	750,000	325,000	74	74	74	71	4.4	3.2	2.9	3.4
	750,000	487,500	74	74	75	71	4.2	3.1	3.0	3.5
	1,125,000	0	----	71	----	67	----	3.5	----	3.5
	1,125,000	162,500	73	71	71	69	4.3	3.6	2.9	3.7
	1,125,000	325,000	73	72	73	69	4.4	3.3	2.9	3.5
	1,125,000	487,500	74	74	74	71	4.5	3.2	----	3.5
Mean			75	74	75	71	4.3	3.0	2.8	3.3
CV(%)			3.5	3.4	2.8	6.6	14.1	10.6	11.6	17.1
LSD			2.0	2.0	2.0	NS	NS	0.2	0.2	0.4

Mechanical/Chemical Weed Control in Flax - Fallow ---- Dickinson, ND, 1994						
Treatment	Stand plants/acre	% of check %	Weed biomass		Crop yield	
			Grass	Broadleaves	Seed bu/ac	Straw lbs/ac
			lbs/ac			
Check (no control)	3,231,132		336.9	2030.9	??	1863.7

Harrow + Herbicide	2,351,795	0.73	229.0	88.6	??	2840.1
Herbicide	2,877,827	0.89	12.6	166.7	??	2420.0
Harrow x 1	2,860,697	0.89	428.4	1049.8	??	2609.6
Harrow x 2	2,473,133	0.77	309.8	1206.8	??	2095.6
Rotary Hoe + Herbicide	2,177,641	0.67	249.1	65.0	??	2402.5
Rotary hoe x 1	2,181,924	0.68	187.4	1758.7	??	2261.3
Rotary hoe x 2	1,718,702	0.53	263.2	1173.5	??	2671.7
Mean	2,484,107		252.0	942.5	??	2496.8
CV(%)	17.1		55.8	60.9	21.7	19.9
$LSD_{0.05}$	623,806		206.7	844.5	??	NS

Mechanical/Chemical Weed Control in Lentil - Fallow -- Dickinson, ND, 1994						
Treatment	Stand plants/acre	% of check %	Weed biomass		Crop yield	
			Grass	Broadleaves	Grain	Straw
			lbs/ac			
Check (no control)	271,224		931.6	4981.6	66.0	129.2
Harrow + Herbicide	266,941	0.98	595.0	597.0	902.6	915.4
Herbicide	289,067	1.07	152.0	1380.8	641.2	833.3
Harrow x 1	217,693	0.80	1520.1	2455.8	123.0	224.8
Harrow x 2	209,127	0.77	1274.2	2429.8	187.9	283.3
Rotary Hoe + Herbicide	216,979	0.80	952.7	251.8	861.9	890.2
Rotary hoe x 1	178,436	0.66	1113.2	2776.5	177.9	281.4
Rotary hoe x 2	165,589	0.61	708.9	4633.5	254.7	215.7

Mean	226,883		906.0	2438.0	402.0	471.7
CV(%)	20.3		73.7	42.4	65.5	42.8
$LSD_{0.05}$	67,625		981.3	1522.0	387.4	297.1

Mechanical/Chemical Weed Control in Hard Red Spring Wheat - Fallow -- Dickinson, ND, 1994						
Treatment	Stand plants/acre	% of check %	Weed biomass		Crop yield	
			Grass	Broadleaves	Grain bu/ac	Straw lbs/ac
			lbs/ac			
Check (no control)	663,070		507.9	2576.7	17.2	1336.9
Harrow + Herbicide	559,577	84.39	388.0	282.6	29.9	3170.7
Herbicide	576,707	86.98	182.2	62.6	23.4	2560.2
Harrow x 1	546,016	82.35	584.3	1132.1	17.6	2193.5
Harrow x 2	580,989	87.62	467.0	1193.8	24.5	2877.7
Rotary Hoe + Herbicide	540,306	81.49	248.0	81.6	30.1	3294.6
Rotary hoe x 1	527,458	79.55	359.6	1126.5	22.2	2732.1
Rotary hoe x 2	513,897	77.50	324.9	1186.5	27.3	3332.6
Mean	563,503		382.8	955.3	24.0	2687.3
CV(%)	10.4		72.1	115.9	22.2	24.5
$LSD_{0.05}$	86,204		NS	NS	7.8	969.2
