Winter Rapeseed Research Program in Washington State

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Rapeseed (*Brassica napus*, L. and *B. campestris*, L.) is the third largest source of vegetable oil in the world. Rapeseed is grown either as a full-season biennial, a winter annual or as a spring annual and is considered a cool season crop. It is adapted to many areas of the continental U.S. and can produce a reasonable seed yield in the Pacific Northwest. Rapeseed oil can be classified as edible-type vegetable oil which contains less than 2% erucic acid (long chain fatty acid - C22) and industrial-type vegetable oil which has 40%+ erucic acid in its oil. Production of rapeseed will result in expanded crop rotation which will reduce problems associated with weeds, insects and diseases of other traditional crops.

Progress in developing an oilseed program in Washington is slow due to lack of processing capabilities, the high cash value of established crops and the lesser attention given to alternate crops. Recently, marketing has often been difficult and profit margins slim in traditional crops. Different species of interest for oilseed production especially winter rapeseed production for Washington were tested and developed. During the past 15 years, raising rapeseed for oil received no attention among all possible oil crops in Washington or in the U.S. because of FDA regulation. Recently, FDA permission to use canola (low erucic acid) rapeseed for edible oil along with the release of new high-yielding varieties are making Canola Rapeseed more attractive to Pacific Northwest growers.

Winter rapeseed has the highest specific yielding capacity and is the most efficient in terms of water consumption and reducing soil erosion compared to spring rapeseed and spring grain crops. Because it is a cool season crop with low heat tolerance, it produces a low yield if planted in the southern part of the United States.

Winter rapeseed must be sown in late August to early September to produce a good crop for the following year. It does not fit into existing crop rotation schemes of some northern Great Plains areas since no suitable grain crops mature before August.

Winter rapeseed is ready to harvest about 300 days after planting in central Washington (around the first week in July). It fits well into the rotation systems with small grain crops. One of the most important reasons for producers to grow rapeseed is the positive influence of this crop on other crops in the rotation. Rapeseed should be planted after winter (or spring) wheat, or winter (or spring) barley crops, enabling a grower to use his land, equipment and time more efficiently. The crop requires no additional specialized equipment, only slight adjustment to current machinery. Another advantage of winter rape is that it serves as an excellent "break crop" for cereals and canning peas (Allen, 1982 and Olsson, 1978). Both Allen in the United Kingdom and Olsson in Sweden report yield of grain crops are increased obviously after rapeseed.

Research program in Washington

Variety testing

National winter rapeseed variety trial. Prosser is one of the 11 cooperating locations across the United States. The main objectives of these trials are: 1) to determine areas where winter rapeseed could be adapted and produce economically competitive yields, 2) to determine the effect of the differential production environments on both fatty acid composition and total glucosinolate concentration, and 3) to identify specific varieties that are adapted to central Washington. Yield and performance of winter rapeseed are listed in Tables 1 and 2 along with temperature and precipitation in Figs. 1 and 2. Average yield was 4167 lb/a (4612 kg/ha) for 19 cultivars in 1986 and 3754 lb/a (4208 kg/ha) for 31 cultivars in 1987. Glucosinolate content in the meal of 19 cultivars tested in Prosser are lower than the canola meal quality requirements of 30 µmoles/g oil free meal except for Jupiter (Tables 1 and 3). Data for 1986-87 are presented in Tables 2 and 4.

Table 1. Seed yield, test weight, oil concentration, erucic acid and glucosinolate concentrations in winter rapeseed tested in Prosser, WA, 1985-1986.

Entries	Seed[1] yield lb/a	Test weight lb/bu	Oil conc.† %	Erucic acid‡ %	Glucosino-late µ mol/g
Dwarf Essex	5371	49.4	42.9	46.7	15.0
Belinda	4997	52.7	39.6	3.93	-
Darmor	4936	52.0	40.2	3.1	9.9
Korena	4882	50.5	41.0	low§	-
Lirama	4840	51.2	40.9	low	-
Jupiter	4763	48.9	40.6	2.0	41.6
Mikado	4546	50.2	43.3	low	-
BW-3	4208	51.2	40.0	low	-
Heruic	4109	50.4	-	-	-
Bridger	4101	50.2	42.0	50.4	11.6
Elena	4017	50.0	41.5	3.0	6.5
Santana	3919	50.5	41.6	0.4	1.2
Gorczanski	3902	50.2	41.2	41.1	-
Idaho Fuel	3818	50.9	42.2	39.8	9.0
Indore	3739	48.5	39.9	47.7	6.4
Jet Neuf	3459	50.8	39.7	low	-
Cascade	3420	50.9	40.1	2.1	5.6
Lirabon	3076	50.2	41.6	3.2	9.6
Argus	3076	51.3	41.6	49.3	-
Mean	4167	50.5	41.1	-	-
LSD .05	451		2.2	6.6	6.0

[1] Means of 4 replications.

(Table continued)

Table 1 (continued)

§Low: not analyzed for this year but they belong to the low erucic acid varieties.

All plots were at 50% flower by April 15, 1986, with the exception of Darmor which flowered approximately 3 weeks later.

†Oil content analyses done on open-pollinated seed.

‡Fatty acid analyses done on bagged seed. Commercial production should result in lower levels of erucic acid (less than 2.0%) due to lack of cross-pollination with high erucic acid varieties.

CULTURAL PRACTICES

Planted - August 16, 1985

Seeding rate - 6 lb/A

Row spacing - 9" rows

Irrigation - Pre-irrigated to black on August 4, 1985
Rill-irrigated 3 times in the fall, scheduled on a 14-day cycle then rill-irrigated every 10 days from April 15 to June 1 for 24 hr/set at approx. a 4 gal/min rate.

Harvested - July 9, 1986

Fertilizer - Preplant: 100 lb N/A and 50 lb P_2O_5 into top 4 inches.

Weed Control - Treflan applied preplant at rate of 1 lb a.i./a.

Table 2. Seed yield, test weight, oil concentration, erucic acid and glucosinolate concentrations in winter rapeseed tested in Prosser, WA 1986-1987.

Entries	Winter survival %	Seed yield lb/a	Test weight lb/bu	Oil conc. %	Erucic acid %	Glucosinolate conc. µmol/g oil free meal
WW 988	84	4935	50.0	45.1	Low*	Low*
SV 0214	100	4282	49.7	44.9	Low*	Low*
WW 1011	98	4198	50.6	45.1	Low*	Low*
Ariana	100	4595	50.6	44.8	Low*	Low*
WW 1031	86	3996	50.2	43.8	Low*	Low*
Glacier	100	4045	48.8	46.4	Low*	Low*
Bridger	97	4107	48.8	46.4	46.8	27
NPZ 51	100	3804	49.3	45.5	1.5	Low*
RBR-US1	100	4012	48.6	45.6	Low*	Low*
Cascade	100	3986	48.5	45.3	1.7	12
Bienvenu	91	3938	48.9	44.9	1.8	82
SV 0223	99	3925	50.4	45.6	Low*	Low*
Jet Neuf	99	3496	49.1	44.4	0.8	100
Tandem	100	3889	50.4	45.0	0.8	Low*
Lindora	100	4617	49.6	45.0	Low*	Low*
Semu1068/83	99	3463	50.2	44.5	Low*	Low*

Table 2 (continued)

Entries	Winter survival %	Seed yield lb/a	Test weight lb/bu	Oil conc. %	Erucic acid %	Gluco-sinolate conc. µmol/g oil free meal
RBR-US2	98	3785	49.6	46.3	Low*	Low*
Darmor	96	3255	49.3	45.6	1.4	Low*
RBR-US3	100	3405	49.6	45.0	Low*	Low*
Dwarf Essex	99	3577	49.8	47.1	44.6	94
Mitre	100	3488	50.7	43.9	Low*	High!
SV 0253	97	3486	49.4	45.8	Low*	Low*
SV 0263	100	3443	50.2	44.6	Low*	Low*
Cobra	100	3421	51.0	45.9	1.1	Low*
SV 0238	100	3382	49.1	44.8	Low*	Low*
Rubin	100	3340	49.2	44.8	Low*	Low*
Ceres	100	2911	50.0	45.2	1.4	Low*
Santana	100	4822	49.7	45.3	Low*	Low*
WW 1033	100	3180	49.7	45.2	Low*	Low*
Arabella	92	2946	49.9	43.6	Low*	Low*
WW 1039	100	2640	49.8	44.1	Low*	Low*
Mean	100	3754	49.8	45.0	-	-
LSD .05	N.S.	1062	1.44	1.60	-	-

Table 2 (continued)

Plant Date: August 29, 1987.

All plots were at 50% flower on April 20, 1987, 231 days after planting. Winter survival was based on plant counts taken October 8, 1986 and March 17, 1987.

Yield is based on 8% moisture of 4 replications.

Test weight is an average of 4 readings.

Oil content analysis done on bagged seed. Commercial production should result in lower levels of erucic acid (less than 2%) due to lack of cross-pollination with high erucic acid varieties.

Oil concentration analysis done on open pollinated seed.

Low*: erucic acid below 2% and glucosinolate under 30 μmol/g oil free meal (canola).

High!: Glucosinolate concentration greater than 30 μmol/g oil free meal.

Table 3. Average yield, oil, erucic acid and glucosinolate concentration of 12 winter rapeseed varieties at 8 locations during 1985-1986.

Cultivar	Seed yield lb/a	Seed yield kg/ha	Oil conc. %	Erucic acid conc. %	Glucosinolate conc. µmol/g oil free meal
High erucic acid and high glucosinolate varieties					
Bridger	2178	2442 (8)	39.4	50.4	14.8
Dwarf Essex	2351	2636 (7)	37.3	45.2	77.6
Idaho Fuel	2030	2276 (8)	38.9	43.8	17.1
Indore	1796	2014 (8)	38.1	47.0	8.6
Mean	2088	2342	38.4	46.6	29.5
High erucic acid and high glucosinolate					
Darmor	1925	2158 (7)	35.1	4.1	34.8
Jupiter	2465	2764 (7)	37.3	4.1	70.0
Lirabon	1983	2223 (7)	37.3	4.1	20.6
85-WRB-0042	2341	2624 (5)	37.8	13.8	55.6
85-WRB-0048	3141	3522 (4)	40.1	3.4	57.2
Mean	2371	2658	37.5	5.9	47.6
Double zero (low erucic acid and low glucosinolate)					
Cascade	1822	2043 (8)	37.3	2.3	16.1
Elena	2018	2263 (7)	38.8	4.9	16.1
Santana	2217	2486 (7)	38.2	1.8	25.7
Mean	2019	2263	38.1	3.0	19.3

From the National winter rapeseed variety trial, 1985-1986, Univ. of Idaho Misc. Series No. 98.

( ) number of test locations.

Table 4. Average yield, oil, erucic acid and glucosinolate concentration of 30 winter rapeseed varieties at 11 locations in the U.S. during 1986-1987.

Cultivar	Seed yield		Oil conc.	Erucic acid	Glucosinolate conc.
	lb/a	kg/ha	%	%	µmol/g oil free meal
High erucic acid and high glucosinolate varieties (industrial oil)					
Bridger	1695	1900 (11)	36.3	45.5	49
Dwarf Essex	1614	1809 (11)	38.3	43.5	137
LEI-1	1306	1464 (4)	40.0	34.7	70
LEI-11	1435	1609 (4)	41.0	H	64
Mean	1513	1696	38.9	41.2	80
Edible low erucid acid varieties					
Arabella	1666	1868 (11)	37.8	L	L
Ariana	1840	2063 (10)	37.2	L	L
Bienvenu	1750	1962 (11)	38.5	1.9	128
Cascade	1617	1813 (11)	38.7	1.4	23
Ceres	2692	3018 (4)	40.6	L	L
Cobra	3039	3407 (4)	39.6	L	L
Darmor	2796	3135 (4)	40.4	L	L
Glacier	1811	2030 (11)	37.9	L	L
Jet Neuf	1699	1905 (11)	35.8	1.7	141
Mitre	1874	2101 (11)	36.3	L	H
NPZ 51	2577	2889 (4)	40.0	L	L

Table 4 (continued)

Cultivar	Seed yield		Oil conc.	Erucic acid	Glucosinolate conc.
	lb/a	kg/ha	%	%	µmol/g oil free meal
RBR-US1	3427	3842 (3)	40.9	L	L
RBR-US2	3525	3952 (3)	41.3	L	L
RBR-US3	2987	3349 (3)	40.3	L	L
Rubin	2592	2906 (4)	39.2	L	L
Santana	1795	2012 (11)	38.7	L	L
Semu 1068/83	2018	2263 (8)	38.7	L	L
SV 0214	2301	2580 (5)	38.8	L	L
SV 0223	3925	4400 (1)	45.6	L	L
SV 0238	1954	2191 (6)	38.6	L	L
SV 0253	2068	2318 (6)	38.7	L	L
SV 0263	2191	2456 (5)	38.4	L	L
Tandem	2899	3250 (4)	40.6	L	L
WW 988	2176	2439 (5)	38.7	L	L
WW 1011	2019	2263 (5)	38.7	L	L
WW 1031	1664	1866 (5)	37.4	L	L
WW 1033	1810	2029 (5)	38.4	L	L
WW 1039	1862	2087 (5)	38.4	L	L
Mean	2307	2586	39.1	-	-

L Erucic acid and glucosinolate concentration less than 2% and 30 µmol/g oil free meal, respectively.

H Erucic acid and glucosinolate concentration greater than 2% and 30 µmol/g oil free meal, respectively.

( ) number of test locations.

From the National winter rapeseed variety trial 1986-1987. Univ. of Idaho Misc. Series No. 113.

Table 5. Effect of harvest date on seed yield, seed-pod ratio, and oil concentration of selected winter rapeseed cultivars, 1986.

Cultivar	Harvest date	Seed yield lb/a	Seed yield (kg/ha)	Seed-pod ratio	Oil conc. %
Santana (0,0)	05 June 1986	1421	(1593)	0.31	-†
	12 June 1986	2583	(2896)	0.38	40.6c
	19 June 1986	3287	(3685)	0.42	42.6b
	26 June 1986	5555	(6228)	0.48	43.1b
	03 July 1986	7132	(7995)	0.52	44.5a
Gorczanski	05 June 1986	1579	(1771)	0.25	-†
	12 June 1986	3242	(3634)	0.40	42.8c
	19 June 1986	4139	(4640)	0.45	45.4b
	26 June 1986	5528	(6197)	0.50	46.7a
	03 July 1986	7530	(8442)	0.58	45.5b

†Oil conc. followed by same letter are not significantly different at 5% level.

Table 6. Effect of harvest date on seed yield, seed-pod ratio, and oil concentration of selected winter rapeseed cultivars, 1987.

Cultivar	Harvest date	Seed yield lb/a	(kg/ha)	Seed-pod ratio	Oil conc. %
Santana (0,0)	28 May 1987	3184	(3570)	0.42	40.5d[†]
	04 June 1987	4341	(4867)	0.54	44.8a
	11 June 1987	5164	(5789)	0.58	44.3ab
	18 June 1987	5663	(6349)	0.59	43.5bc
	25 June 1987	7284	(8166)	0.59	42.6c
Lindora (0,0)	28 May 1987	2923	(3277)	0.42	41.0b[†]
	04 June 1987	4531	(5080)	0.50	43.7a
	11 June 1987	4001	(4486)	0.57	44.1a
	18 June 1987	4826	(5410)	0.58	44.2a
	25 June 1987	7305	(8189)	0.58	43.6a

[†] Oil conc. followed by same letter are not significantly different at 5% level.

Harvest methods

Up to 40% of seed can be lost during harvest operations if growers are not careful in adjusting their machinery and harvesting their crop at the proper time. Canadians have typically swathed their rapeseed crop when seed is at 30% moisture and allowed the crop to dry before combining. We have found that about 10% of the seed is lost by the Canadian swathing method as applied at Prosser, WA.

Direct combining also has its problems. Growers with large acreages of rapeseed tend to allow some rapeseed to get too ripe before they can harvest it. The harvest period for rapeseed is short (7-10 days) and a grower should plan accordingly (Tables 5,6). Uneven ripening caused by uneven stand is also very prominent with the new double zero varieties causing even more problems with direct combining. In 1986, Spodnam[1] was used to control pod shatter at two locations. The first location on the Roza Research Farm, Washington State University, was hand-sprayed and the second location was air sprayed on 12½ and 2½ acres of the commercial fields in Toppenish, WA.

Spodnam was not beneficial for controlling shatter at either location (Tables 7,8). The reasons for that are:

-the chemical is new for use, we have to learn how to use it properly;

-timing: we need to apply when the pods are mature.

More study is needed to gain experience in proper timing for the dry area.

Another experiment was established last year to study the long-term effect of Spodnam on shatter control. Spodnam was sprayed by air on June 6, 1987. The plots were harvested 4 times at weekly intervals starting June 30. Seed yields were highest from plots harvested on July 7 and gradually decreased for later harvests (Table 9).

Gramoxone used as a desiccant could possibly help control uneven ripening along with Spodnam and swathing. Mandops literature claims that "Pods do not fill and ripen evenly especially in poor growing seasons. The unique coating action from Spodnam enables more pods to achieve a better fill so a seed yield increase may be achieved even when shatter control is not required." The question is could the use of desiccants increase seed yield by prolonging the seed filling duration for green seed.

In 1987, a split plot was designed to study the effect of four harvest methods on seed yield of two winter rapeseed cultivars, 'Santana' and 'Lindora'. The four methods were direct combine (control), Spodnam treated (June 6, 1987), desiccant treated (gramoxone sprayed one week before harvest) and swathing at one week prior to combining.

All three harvest methods increased seed yields when compared to direct combining. The highest yields were achieved using a swathing before combining. Spodnam treated plots produced slightly higher seed yields when compared to direct combine. It should be noted that the swathing method took more time. The crop was swathed and tied down or packed to prevent wind

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[1]Spodnam, a product manufactured by Mandops, has been used as a plant hormone by some growers to control pod shatter and prolong harvest on rapeseed, alfalfa, and dry beans, particularly in England.

damage. Tests weights and oil concentrations showed no significant differences among treatments (Table 10).

Table 7. 1986 Spodnam trial - Prosser, WA

	Seed yield lb/a*		Test weight lb/bu*		Oil conc. %	
Treatment	Gorczanski	Santana	Gorczanski	Santana	Gorczanski	Santana
Spodnam DC	4780	5606	50.70	51.60	41.4	36.0
Untreated	4467	6271	49.20	49.20	40.1	36.4
Mean	4624	5912	49.95	50.50	40.8	36.2
LSD .05	65.59	123.00	0.30	0.48	0.26	0.08

*All seed weights are corrected to 8% moisture.

Table 8. 1986 Spodnam effects on Santana seed yields - Toppenish, WA.

	Seed yield lb/a*		Test weight lb/bu*		Oil conc. %	
Treatment	Field 1	Field 2	Field 1	Field 2	Field 1	Field 2
Spodnam DC	5159	3951	50.50	49.50	41.1	41.6
Untreated	5056	3865	50.80	49.60	40.0	41.7
Mean	5108	3908	50.65	49.55	40.5	41.65
LSD .05	20.60	17.00	0.17	0.02	0.23	0.01

*All seed weights are corrected to 8% moisture.

Table 9. Effect of Spodnam treatment on seed yield of Santana and Lindora rapeseed at various harvest dates.

	Spodnam treated seed yield		Oil conc.	Control seed yield		Oil conc.
Harvest date	lb/a	(kg/ha)	%	lb/a	(kg/ha)	%
			cv. Santana			
30 June 1987	4044	(4534)	43.7	3456	(3875)	41.1
07 July 1987	4349	(4876)	43.6	3197	(3584)	43.3
14 July 1987	4170	(4675)	44.0	3421	(3835)	41.6
21 July 1987	3181	(3566)	43.3	2152	(2412)	40.8
			cv. Lindora			
30 June 1987	3652	(4094)	43.0	3287	(3685)	42.9
07 July 1987	4094	(4590)	42.7	3896	(4368)	42.6
14 July 1987	3528	(3955)	42.6	3412	(3825)	42.7
21 July 1987	2793	(3131)	42.2	2689	(3015)	42.5

Lsd (.05) Seed yield: 243 (272)

Oil concen. .98

Table 10. Effect of harvest procedure on seed yield, test weight and oil concentration of Santana and Lindora winter rapeseed, 1987.

	Seed yield		Test wt.	Oil conc.
	lb/a	(kg/ha)	lb/bu	%
Santana				
Spodnam	4044	(4534)	48.8	43.66
Swath	4108	(4606)	48.7	43.34
Gramoxone	3131	(3510)	48.9	43.96
Control	2981	(3342)	49.3	41.05
Lindora				
Spodnam	3652	(4094)	48.7	43.04
Swath	3692	(4139)	49.3	42.52
Gramoxone	3229	(3620)	49.6	42.44
Control	2896	(3247)	48.7	42.92
Lsd (.05)	191	(214)	1.1 (NS)	1.8 (NS)

Low yield due to bird damage and/or shattering.

Irrigation study

All plots were planted on Aug 31, 1986 on a pre-irrigated field. Soil moisture was kept optimum for seed germination and growth before winter. Treatments of 2,3 and 5 irrigation scheduling were applied to each subplot as follows:

Treatment 1: No irrigation in spring;
Treatment 2: Water was applied twice: 4/16/87 and 5/5/87;
Treatment 3: Water was applied 3 times: 4/16, 5/5 and 5/13/87;
Treatment 4: Water was applied 5 times: 4/16, 5/5, 5/13, 6/10, and 6/19/87.

Yield and oil concentration were reported in Table 11. With three irrigations, no seed yield increases were noted when compared to seed yields of the plots which received only two irrigations. This would suggest that irrigation on May 13 may have been unnecessary.

Five spring irrigations resulting in a net soil moisture increase of 5.22" (13.27 cm) increased seed yields of both cvs. Santana and Lindora. Significant increases in seed yields of both cultivars were observed at five irrigations. This would suggest that a late irrigation at seed filling is beneficial to the seed yields. More work is needed in the area of irrigation scheduling in terms of when the greatest demand for water occurs to achieve optimum yields. According to these data irrigation at full bloom (late April to early May) and at pod and seed filling stage (early June) were the most beneficial periods to irrigate. Water use efficiency was maximum if no water was applied during spring even though the yield was low. It gradually decreased as the amount of water applied increased (Table 11).

Crop rotation

Rapeseed acreage in the Pacific Northwest has increased from almost 20,000 acres in 1983 to over 30,000 acres in 1987. Rapid expansion of a new crop when rotated in with traditional crops will alter existing cultural practices. Some claims have been made that rapeseed planted every four years in rotation with small grains breaks up disease, insect and weed cycles and increases seed yield. There are benefits and problems in introducing a new crop into a rotation system. Weed control, disease and insect control are among them. In 1987, a study was established to identify advantages and problems associated with rotating rapeseed into corn, potato, bean, wheat and barley rotation systems (Table 12).

Starting in August 1986, two acres of fresh wheat stubble at Roza Research Farm, IAREC, was plowed under and four 18 ft. strips of rapeseed (cv. Lindora) were planted. A 24-ft. wide open space was left between each strip for planting winter wheat, potato, corn, dry bean and barley. Sixteen different 4-year crop rotation schemes of 7 different crops will be used to identify crop interaction, yields, and problems associated with each rotation system.

This is a joint project involving the cooperation of a weed scientist, and two plant pathologists. Dr. Boydston will study potential herbicide interactions within each rotation scheme. Dr. Silbernagel will help identify the diseases in legume rotation regimes. Dr. Easton will help identify any soil borne pathogens associated with potatoes which will cause detrimental effects on the following crops. The first year's data is presented in Table 13.

Table 11. Effect of irrigation on seed yield, test weight and oil concentration of winter rapeseed cvs., 1987.

	Amount of water applied		Seed yield		Test wt.	Oil conc.	Soil moisture % by	Water use efficiency
Treatment	inch	(cm)	lb/a	(kg/ha)	lb/bu	%	volume	lb/in
			cv. Santana					
Control	0	(0)	1150	(1290)	49.8	43.2	10.5	1142
2 irrig.	2.45	(6.23)	3774	(4231)	49.6	44.9	17.4	1111
3 irrig.	4.18	(10.63)	3480	(3897)	49.7	44.7	21.7	928
5 irrig.	5.22	(13.27)	4370	(4903)	49.6	43.9	25.0	750
			cv. Lindora					
Control	0	(0)	1370	(1535)	49.6	44.2	10.5	1138
2 irrig.	2.45	(6.23)	3250	(3642)	49.4	45.0	17.4	1039
3 irrig.	4.18	(10.63)	3340	(3747)	49.4	44.8	21.7	822
5 irrig.	5.22	(13.27)	4110	(4606)	49.7	43.6	25.0	705
Lsd (.05)			818	(918)	NS	NS		

Table 12. Four-year crop rotation schemes.

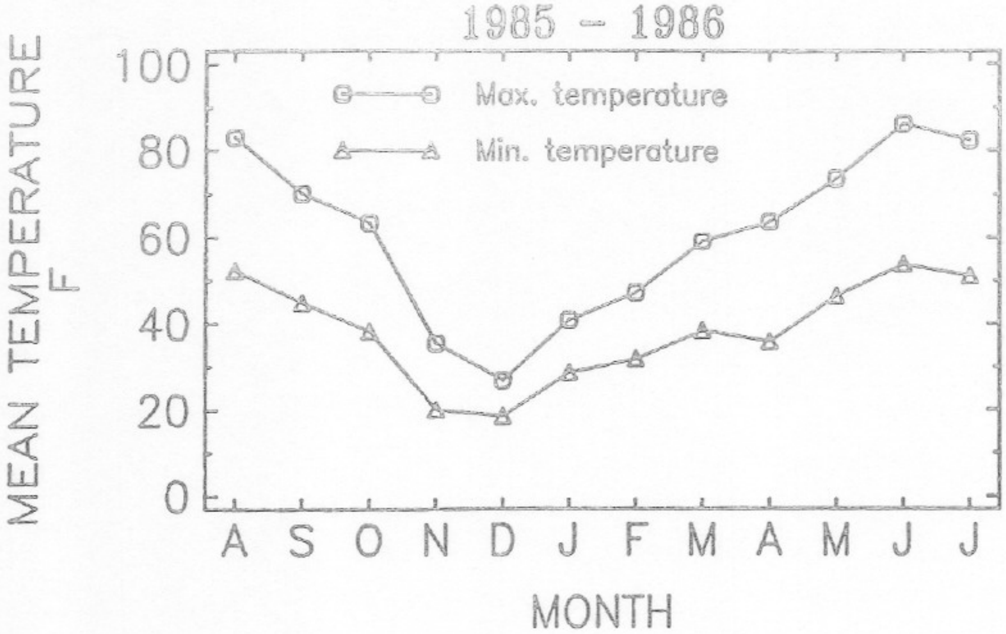
1. W. canola - S. wheat - W. canola (green manure) - beans - wheat
2. W. canola (green manure) - potato - S. wheat - W. canola - wheat
3. Corn - S. canola - S. barley - W. canola - corn
4. Potato - S. canola - beans - W. canola - potato
5. W. canola - wheat - W. canola (green manure) - potato - wheat
6. W. canola (green manure) - beans - wheat - W. canola - wheat
7. Wheat - W. canola - corn - S. canola - wheat
8. Wheat - W. canola (green manure) - beans - potato - S. canola
9. W. canola - beans - wheat - W. canola
10. W. canola - S. barley - wheat - W. canola
11. Beans - W. canola - wheat - W. canola
12. Barley - W. canola (green manure) - potato - wheat - W. canola
13. W. canola - potato - S. barley - W. canola
14. W. canola - corn - S. barley - W. canola
15. Wheat - wheat - wheat - wheat
16. W. canola - W. canola - W. canola - W. canola

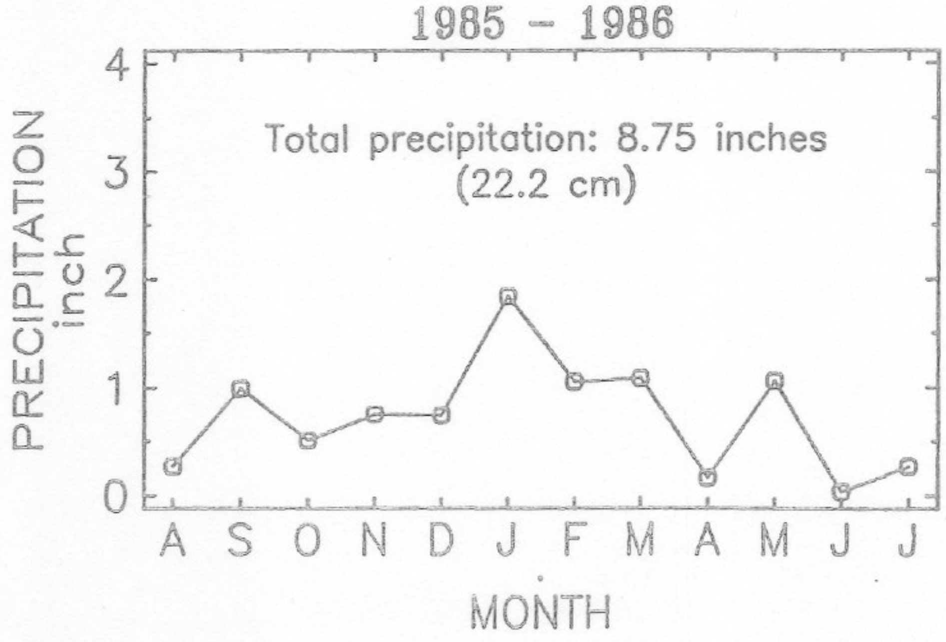
Table 13. Yield and harvest date of 7 crops in the first year crop rotation, 1987.

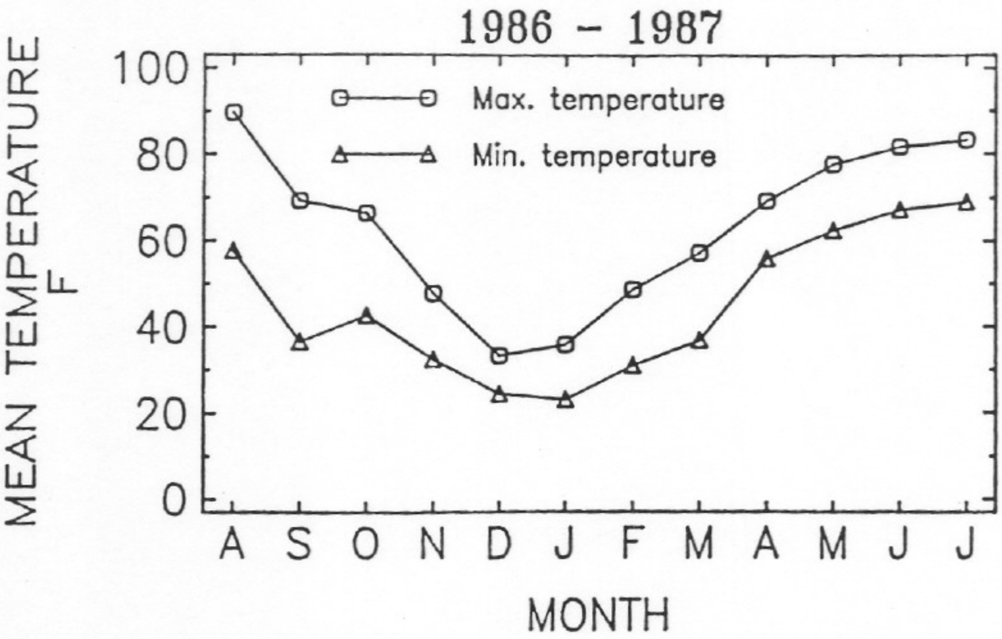
Crop	Planting date	Harvest date	Yield[@] lb/a	(kg/ha)	Test wt. lb/bu
Winter rapeseed var. Lindora	8/31/86	6/23/87	3988	(4471)	48.8
Corn - NK 9470	5/05/87	10/26/87	12092	(13556)	56.6
Drybean var. Othello	5/08/87	8/17/87	3786	(4244)	59.9
W. rapeseed as green manure and drybean var. Othello	5/01/87	8/17/87	3913	(4387)	61.7
Winter wheat	10/17/86	7/13/87	5575	(6250)	56.0
Spring barley var. Columbia	4/07/87	8/11/87	6110	(6850)	45.4
Potato var. Russet Burbank	4/16/87	9/18/87	49696[1]	(55713)	N/A
Winter rapeseed green manure Potato var. Russet Burbank	4/21/87	9/18/87	39349[1]	(44113)	N/A

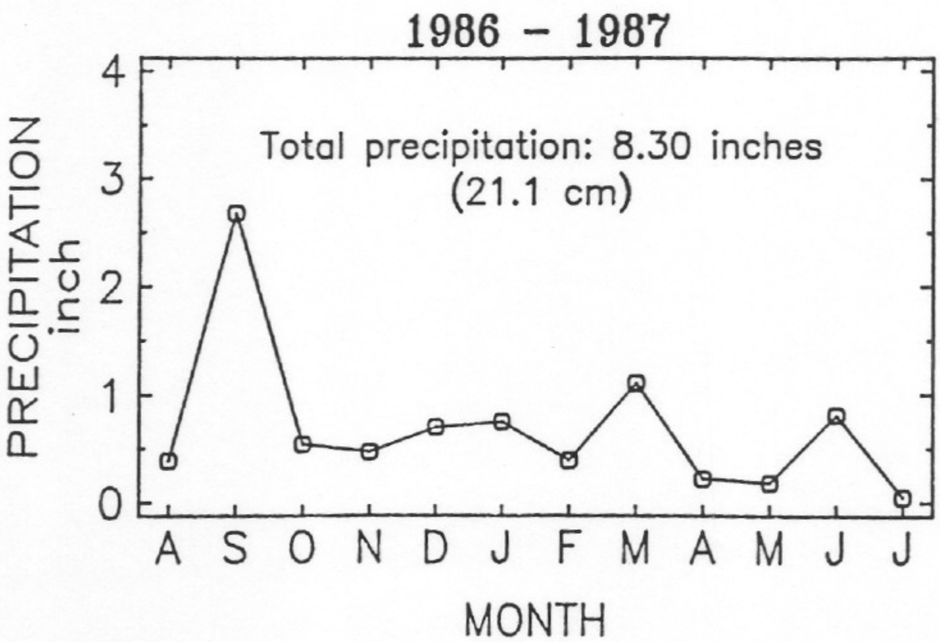
[@]Yield with corrected moisture.

[1]Fresh weight.


1985 – 1986
MEAN TEMPERATURE F
100
80
60
40
20
0
Max. temperature
Min. temperature
A S O N D J F M A M J J
MONTH


1985 – 1986
PRECIPITATION inch
4
3
2
1
0
Total precipitation: 8.75 inches
(22.2 cm)
A S O N D J F M A M J J
MONTH


1986 - 1987
MEAN TEMPERATURE
F
100
80
60
40
20
0
Max. temperature
Min. temperature
A S O N D J F M A M J J
MONTH


1986 - 1987
PRECIPITATION
inch
4
3
2
1
0
Total precipitation: 8.30 inches
(21.1 cm)
A S O N D J F M A M J J
MONTH