THE RESPONSE OF BARLEY AND FLAX VARIETIES TO DATE OF SEEDING, FERTILITY LEVEL AND PREVIOUS LAND CULTURE

by

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ABSTRACT

The Response of Barley and Flax Varieties to Date of Seeding, Fertility Level and Previous Land Culture.

The response of 4 barley and 4 flax varieties to date of seeding, fertility level and previous land culture were studied at 2 locations during the period 1961, 1962 and 1963.

Barley yields were found to be increased by factors such as early seeding, seeding on summerfallow culture and the application of commercial fertilizer at seeding time. Varieties of barley performed variably from year to year. It may be concluded therefore that variety recommendations within crop zones may be made only after prolonged testing. Since variety x culture interaction were not obtained in any of the tests it may be concluded that for the purpose of making variety recommendations, either stubble or summerfallow culture may be used in a variety testing program.

Flax does not respond to land culture, date of seeding and fertilizer as does barley. Flax yields were found to be higher in 3 of the 4 tests when seeded on stubble. In only 1 year of testing did early seeded flax outyield late seeded flax. The application of fertilizer to flax plots resulted in statistically but not economically significant differences in 2 of the 4 tests. In flax as with barley, no variety x culture interaction was detected in any of the tests and therefore variety testing programs may be conducted on either summerfallow or stubble culture.

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LIST OF FIGURES

TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDICES

Appendix Page

INTRODUCTION

Seed yields obtained from the crop kinds barley and flax are known to be influenced by factors such as the land culture used, the date on which the crop is seeded and the application of fertilizer to these crops. Research workers have also determined that varieties of these crop kinds differ in their yield response to the kind of land culture used, the date on which the variety is seeded and the kind and rate of fertilizer that is used.

The influence of date of seeding on the yield of barley and flax have been reported in several investigations (2, 4, 10, 35, 41). The differential yield response of barley varieties to date of seeding have been studied by other workers (33). Increased yield results obtained when commercial fertilizer has been applied to both barley and flax crops have been published by various research teams (1, 12, 25, 26, 27, 28, 34, 39). Several agencies and research workers (3, 4, 7, 8, 9, 39) have reported the increased yield obtained when barley and flax have been sown on summerfallow in comparison with yields obtained for these crops when sown on stubble land.

In the Province of Manitoba, variety recommendations for barley and flax have been based on experimental yield data obtained from tests conducted on summerfallow land. Agricultural organizations and Agrologists in general have been of the opinion that these results do not provide an accurate account of yields for these 2

crops because a large percentage of the acreage of these crops are grown on stubble or second crop land (7, 8, 9). In 1960 the Manitoba Agronomists Conference presented a resolution (30) requesting more extensive testing of flax seeded on stubble land, with the objective of obtaining more uniform data on provincial flax yields. The same information has been requested by organizations and individual Agricultural workers with respect barley yields in the Province.

This investigation was undertaken to determine the response of 4 barley varieties and 4 flax varieties to cultural treatment, fertility level and date of seeding. The object was to study the factors separately and in relation to each other.

LITERATURE REVIEW

The problems of the production of cereal and oil seed crops in Manitoba may be defined as follows: (a) choice of crop, (b) choice of varieties, (c) how to grow the varieties selected (32). Two crop choices available to Manitoba which in past years have proven valuable to the grain farm economy are barley and flax.

Barley and flax for the most part have been grown on stubble land in Manitoba. The Dominion Bureau of Statistics acreage report of January- March 1959 (7) states that in the year 1958, 78% of the flax crop was seeded on stubble land. The same report indicates that 65% of the barley acreage seeded occupied stubble land. Other Dominion Bureau of Statistics reports (8, 9) indicate similar acreage statistics for the years up to and including 1963. The 1959 report (7) stated that yields per acre on stubble and summerfallow land was respectively 8.0 and 10.9 bushels for flax and 24.5 and 33.8 bushels for barley.

Experiments carried out in Kansas over a 35 year period (17) indicated that barley on summerfallow yielded 26.8 bushels per acre whereas early ploughed stubble seeded to barley yielded 15.2 bushels per acre. Kansas workers generally agreed that barley seeded on stubble would produce about $\frac{1}{2}$ the yield of barley seeded on summerfallow.

There appears to be no best cropping system that can be recommended, especially on the grain farm (44). Systems must be

chosen that will suit the individual requirements of the farm. If one were to choose a land culture that would give one of the highest if not the highest yield per acre without the addition of fertilizer it would be summerfallow. The main advantage of summerfallow is that 20-30 percent of the seasonal rainfall is stored in well kept summerfallow. This is equivalent to the addition of 2 to 4 inches of rainfall to the land. Moisture is one of the major requirements of high yielding grain crops. Summerfallow land is also usually more free of weed seeds than cropped land and provides a good uniform seed bed (31).

The average Manitoba grain farm practices a 3 year crop rotation. Several of these rotations (4, 29, 44) are:

Rotation 1	Rotation 2	Rotation 3
Fallow	Fallow	Fallow
Wheat	Wheat	Grain
Coarse grain	Wheat	Special crops (eg. flax)

Rotation 1 normally follows a production pattern of fallow, wheat, oats or barley.

The Dominion Reclamation Station, Melita, Manitoba (4) reported that delayed seeding of barley rapidly decreased yield and bushel weight. Olson et al. (33) reported that early seeding of barley increased yields. Olson and his co-workers using the varieties O.A.C. 21, Mensury Ottawa 60 and Garton seeded the varieties at 4 locations using 3 dates of seeding. The experiment was conducted for 3 years. The dates of seeding were on the average

May 8, May 20 and June 3. The overall mean average for date of seeding favoured the earliest seeding date although the second date of seeding was highest at one location. The experiment indicated that varieties differ as regards the decrease in yield with later seeding dates.

Stoa (41) stated that early flax seeding gave better yields because of more even emergence, less disease and because weed competition would be decreased. Stoa also found that flax seedlings were generally tolerant to low spring temperatures.

Bothun (2) used 12 early and late maturing varieties of flax and reported average yields of 16.8, 10.9, 5.0 and 1.0 respectively for seeding dates May 21, June 5, June 19 and July 6. Bothun stated that Flor had previously observed that short season varieties required about the same number of days to mature regardless of the date of seeding whereas the long season varieties usually required more days to mature the later they were seeded.

Hopper and Johnson (15) reported that reduced precipitation and excess temperature materially decreased the yield per acre of flax. Both yield and oil content were negatively correlated with increasing temperature.

Gilson and Hedlin (12) report that since 1950, 300 field experiments have been carried out on barley in Manitoba and that the return on investment from fertilizer application has been very high. On the average, barley seeded on summerfallow and fertilized at recommended rates has given an average increase of 10 bushels per acre over a similar non-fertilized crop, while barley seeded on

stubble land and fertilized at recommended rates has given an average 12 bushel per acre increase. They report that fertilizer will usually give as good a profit in dry years as in years of normal precipitation unless a near or total crop failure occurs.

Hedlin (14) in a summary published in the Proceedings of the Manitoba Agronomists 1962 reported a 9 year average of barley yields on stubble land using 16-20 fertilizer at 100 pounds per acre. The average yield increase in bushels per acre over non-fertilized barley was 12 bushels per acre. In this report Hedlin stated that barley cannot be expected to respond to additional nitrogen if there are 100 pounds of nitrate nitrogen per acre to a depth of 4 feet and that it may not be profitable to fertilize if the figure is above 70-80 pounds per acre.

It has been determined by several research teams that barley varieties react differently to fertilizer treatments and seasonal growing condtions. Pendleton et al. (35) reported that several workers have noted a significant interaction between certain varieties and fertility treatment. They also presented the results of a 4 year test using 9 barley varieties with 4 fertilizer treatments, namely 8-8-8, 0-8-8, 8-0-8 and 8-8-0 analysis at 750 pounds per acre. They found that varieties differed significantly in their response to fertility treatment. The analysis indicated that additions of nitrogen and phosphate resulted in yield increases of 11.1 and 3.6 bushels per acre respectively.

Frey et al. (11) suggested that varieties adapted over a wide area generally do not show significantly different responses to

fertility. They applied 3 levels of fertilizer; namely 0-16-16, 4-16-8, 4-16-16 and 0-16-0 at the rate of 500 pounds per acre to 5 adapted Michigan varieties. The varieties were Bay, Wisconsin 38, O.A.C. 21, Montcalm and Moore. The experiment was conducted over a 4 year period. In 1948 variety differences were not significant but the use of fertilizer resulted in significantly higher yields in all varieties. Similar results were obtained in 1949 and 1950. In 1947 variety x fertilizer interactions involving Bay and Wisconsin 38 were observed. The authors concluded therefore that some varieties will respond to fertilizer more than others and a variety x fertilizer interaction may likely depend on adaptation.

Foote and Batchelder (10) published the results of a 3 year fertilizer experiment on barley under conditions of a wet spring and dry summer at Corvallis, Oregon. They stated that the beneficial results of a nitrogen broadcast in the spring may depend on time and rate of application of the fertilizer in combination with the available moisture present or a timely rainfall. The nitrogen treatments included different rates of application, different application times and 2 sources of nitrogen, namely ammonium sulphate applied in dry form and urea as a spray. Due to low precipitation in 1950, there was no response in yield to the addition of nitrogen. In 1951 and 1952 significant yield increases resulted from the use of 25 and 50 pounds of nitrogen when applied as ammonium nitrate. Applications of nitrogen (urea) as a foliar spray increased yields in 1952 and 1953. The highest yields were obtained with the use of ammonium nitrate.

Fertilizer experiments with barley in Nebraska have given varied results. Lowrey et al. (25, 26, 27, 28) during the years 1953-1956 found the following: nitrogen applied at the rate 60-0-0 or 40-30-0 gave the highest results over the non-treated checks, the range being an 18 bushel increase in 1953 using 60-0-0 and 3.5 bushels increase in 1954 using 40-30-0. In 1955 and 1956 there was no yield increase from the use of fertilizer. In 2 years out of the 4 year duration of the experiment protein was increased by the use of fertilizer, whereas in all years fertilizer had a depressing effect on weight per measured bushel.

Other Nebraska workers carrying on the work commenced by Lowrey obtained similar results. Lamke et al. (23, 24) in 1957 obtained significant yield increases from the use of nitrogen alone whereas phosphorus with nitrogen produced no apparent yield increases. Fertilizer application did not affect protein or weight per measured bushel. In 1958 and 1959 nitrate applied at 60 pounds per acre increased yields, decreased weight per measured bushel and produced a slight increase in protein.

In 1961 Lamke et al. (24) reported that a 6 year experiment at one location in Central Nebraska indicated that applications of nitrogen at 40 pounds per acre resulted in the highest barley yield per acre. The addition of 30 pounds of phosphate further increased yield by 2 bushels per acre. The 1961 data from this station indicated an increase in protein content from the use of nitrogen fertilizer but no influence of fertilizer was noted on weight per measured bushel.

In western Nebraska, Thompson et al. (42, 43) reported that, over a 6 year period (1957-62), 60-30-0 gave the highest yield per acre; 9 bushels per acre over the check which yielded 22 bushels per acre. However, the 1962 test at this station showed no significant difference between fertilized and non-fertilized plots. Weight per measured bushel was decreased with fertilizer application and protein content was increased with the same application.

Bauer and Zubriski (1) report profitable yields when fertilizer was applied to non-fallow barley fields. These authors state that increased yields often occur from fertilizer because many soils release available nitrogen from the soil organic matter too slowly for the maximum production of rapidly growing crops, therefore the addition of fertilizer provides the required plant nutrients at the correct time.

Bauer and Zubriski (1) studied the results of 5 barley trials at 2 sites following wheat and concluded that the addition of 50 pounds per acre of actual nitrogen plus 40 pounds per acre of P_2O_5 increased yield by 24.1 bushels per acre over the check plot. At one of the sites the weight per measured bushel was increased.

Pfeifer et al. (36) in tests conducted at the University of Wyoming reported that phosphorus did not measurably increase yield or protein content of barley whereas nitrogen increased yield by increasing the number of heads per acre and seeds per head. Seed size was generally unchanged by nitrogen application.

Cook et al. (5) stated that in barley closer row spacing, although tending to provide less plant food per foot of row, gave less

chance of seed injury from fertilizer application.

Flax does not respond to fertilizer as does barley. Several flax investigators have reported that flax has not responded to various rates or kinds of fertilizer while other workers have reported a satisfactory yield increase with the use of fertilizer.

J. O. Culbertson (6) indicated that flax gave best yield on fertile soil and that commercial fertilizer was seldom applied directly to the crop. Heavy nitrogen frequently stimulated weed growth, reported Culbertson, and consequently it was preferable to apply fertilizer to some other crop in the rotation. Flax performed well in rotation following wheat, barley, oats or corn provided that small grain stubble was ploughed immediately after harvest and then rough worked to obtain fall weed growth control. Spring work on this land provided further weed control and the uniform seed bed required by flax. Culbertson stated that weed control therefore began long before flax was sown and the fitting of flax into a rotation so that it followed a clean crop was essential.

Racz (38) found no significant increase in yield of flax at 3 locations in Manitoba in 1961 using actual nitrate and phosphate applications of 0-20-0, 40-0-0 and 40-20-0. He attributed the lack of response to the drought conditions prevalent that year.

Caldwell (3) summarizing a report from Dr. Hedlin, Head, Soils Department, University of Manitoba, Winnipeg, Manitoba quotes: "For the past four years we have been doing some experimental work with fertilization of flax. Each year we have had one or two experiments in which 16-20-0 was drilled in with the seed at about 50 to

100 pounds per acre and 11-48-0 was drilled in with the seed at rates ranging from 20 to 60 pounds per acre. Over this four year period we have had practically no significant increase and quite a number of small decreases."

Many research workers, however, have found that profitable increases can be obtained by the use of fertilizer on flax when sown on either summerfallow or stubble land.

Racz and Soper (39) found a 2.5 and 1.1 bushel increase per acre with the use of 60 pounds of nitrogen fertilizer broadcast per acre, when flax was sown on summerfallow and non-fallow respectively. Flax sown on summerfallow using 60 pounds per acre of nitrogen fertilizer yielded 18.2 bushels per acre while the non-fertilized check yielded 15.7 bushels per acre. On stubble land, using the same rate and kind of fertilizer the yield was 11.6 bushels per acre while the non-fertilized check yielded 10.5 bushels per acre. In the same experiment they reported a decrease in both summerfallow and stubble flax yields with the use of triple superphosphate at a rate of 20 pounds per acre (0-20-0) and concluded that the decrease was the likely result of seed injury due to the phosphate being drilled in with the seed.

Caldwell (3) reported increased flax yields from the use of nitrogen fertilizer in Iowa but little or no response from the use of phosphate or super phosphate. In a 3 station test in Iowa in 1947 Caldwell obtained average flax yields of 12.3, 14.4, 14.9, 16.3 and 15.9 from plots receiving 0, 10, 20, 40 and 80 pounds of nitrogen per acre. Caldwell stated that in earlier trials

conducted in 1941 in Northwestern Iowa, phosphorus and potassium were applied to flax. The comparisons included check plots, 150 and 300 pounds per acre of 0-20-0, and 300 pounds of 0-20-20. The yield of the flax was not significantly increased in any of the experiments.

In Minnesota, with 10 years of spasmodic testing of flax for fertility requirements Caldwell (3) found that nitrogen improved yield on some soils while in other regions phosphorus appeared more important. He cited a greenhouse experiment where plots receiving nitrogen applied at the rate of 80-0-0 pounds per acre yielded 31.4 bushels per acre as compared to the check plot yield of 7.5 bushels per acre. In the same experiment a fertilizer application of 80-40-40 pounds per acre of nitrogen, phosphorus and potassium gave a yield of 28.4 bushels per acre, an increase of 20.9 bushels over the check yield of 7.5 bushels per acre. A further treatment in this experiment consisted of an application of 80-80-80 pounds per acre of nitrogen, phosphorus and potassium, the yield being 26.0 bushels per acre or 18.5 bushels increase over the check. Caldwell (3) mentioned a further experiment conducted in Minnesota on Webster soil in which the fertilizer treatments of 80-0-0 yielded 20.7 bushels per acre, 80-40-0 yielded 22.1 bushels per acre and 80-80-80 yielded 24.1 bushels per acre while the non-treated fertilized check plot yielded 16.7 bushels per acre. The overall conclusion reached by Caldwell from the Minnesota experiments was that a nitrogen-phosphorus fertilizer would be the most universally applicable treatment for that state.

Caldwell (3) cited further flax experiments conducted in Alberta, Canada. At Collington, non-fertilized check plots yielded 13.0 bushels per acre whereas plots fertilized by the broadcast method with ammonium phosphate (16-20) at 80 pounds per acre and 9-27-9 at 100 pounds per acre yielded 18.5 and 18.3 bushels per acre respectively. This experiment was carried out using Redwing flax and was third crop after breaking.

Data obtained by Caldwell (3) from Indian Head, Saskatchewan, covering a flax experiment carried out in 1963 indicated no increase from the use of fertilizer and an actual detrimental yield effect in the majority of cases.

Since 1958, several workers have reported that fertilizer placement is extremely important when applied to flax. The methods commonly used in placing fertilizer in the soil are: (a) in the row placement, (b) side band placement, (c) broadcast and (d) side dressed or top dressed. The first 2 methods are the most commonly used at seeding time, although with small grains and flax the third method is also used to some extent.

Zubriski (46) reported the influence of fertilizer placement on the yield of flax sown on non-fallow land (average of 4 trials in 1958, 2 in 1959 and 2 in 1960). He placed 0-0, 0-20 or 40, 20-20, 40-20 or 40 and 60-20 or 60 pounds of N and P_2O_5 respectively in the row or to the side and lower than the seed at the spacing $1\frac{1}{2}$ inches x 0 inches and $1\frac{1}{2}$ inches x $1\frac{1}{2}$ inches. He found that in all experiments the average plot yields were higher when the band placement application was used as compared to in the row placement

application. The highest return in bushels per acre for the band placement application was with the use of 40 pounds of N and 20 or 40 pounds of P_2O_5. The plot yields were 19.0 bushels per acre for the 1½ inch x 0 inch placement, 19.1 bushels per acre for the 1½ inch x 1½ inch placement as compared with 15.4 and 15.2 bushels per acre respectively for the non-fertilized check plots. Zubriski concluded that although side band placement is more efficient than in the row placement or by the broadcast method, the present equipment that farmers have are not designed to do this.

Young (45) observed that 60-60-0 fertilizer seeded 1½ inches to the side of the flax row and 2 inches below the seed level gave a flax yield of 21.6 bushels per acre as compared with a yield of 11.6 bushels per acre when the same fertilizer rate was placed in the row. In the same experiment with the same fertilizer rate placements of 1½ inches to the row side and 1 inch below the seed and 1½ inches to the row side and level with the seed gave yields of 21.4 and 21.6 bushels per acre respectively.

Scherl et al. (40) obtained significant flax yield increases as the result of phosphorus and nitrogen fertilizer application if germination injury could be avoided by fertilizer placement. They used 2 fertilizer placements, one with the seed in the row and the second as a band placement 1 inch to the side of the seed at seed level. Using 40 pounds of nitrogen and 4.4 or 8.8 pounds per acre of phosphate placed with the seed a significant decrease in yield occurred due to seedling injury. The band method of placement using 20 pounds per acre of nitrogen and 4.4 or 8.8 pounds per acre

of fertilizer gave a significant increase over the non-fertilized check and the row placement method. Phosphate fertilizer in the absence of nitrogen gave no significant yield increases from the check plots.

Kingsley and Shubeck (18, 19, 20, 21, 22) conducted fertility and cultural practice experiments in South Dakota during the years 1958 through 1963 with the exception of 1961. Their approach was to apply 3 rates of fertilizer, namely, a check, 40-30-0 and 20-15-0 pounds per acre with 3 cultural practices, drilling with the seed, discing in and plowing under. It is assumed that the 2 latter methods were broadcast applications, incorporating the fertilizer into the soil by the methods described. Weed control chemicals were also applied in each year of the testing using TCA at 5 pounds per acre to control grassy weeds and $\frac{1}{4}$ pound of MCP to control broadleaf weeds in the years 1958, 59 and 60. In 1962 and 1963 TCA was replaced by Dalapon at the rates of 1 pound per acre and $\frac{3}{4}$ pound per acre respectively. In 1959, 60, 62 and 63, no significant yield increases were obtained by the use of fertilizer, cultural practice or weed control application. In 1958, 40-30-0 fertilizer gave yields of 19.1 and 21.8 when the fertilizer was drilled with the seed and disced in respectively. The 20-15-0 fertilizer rate when disced in gave a yield of 21.3 bushels per acre. The non-fertilized weed control check plot yielded 16.6 bushels per acre. The lower rate of application, when accompanied by weed control gave an excellent yield increase in this experiment.

MATERIALS AND METHODS

This 3-year study was undertaken to determine the yield response of 4 barley and 4 flax varieties to 2 land cultures, 2 dates of seeding and 2 fertilizer treatments.

The study was conducted on 2 different soil types located at Morris and Carman, Manitoba. The Morris site represents the Red River clay soil zone whereas the Carman site is situated on the Altona heavy sub-phase fine loam soil.

The field plan chosen for this experiment for both crop kinds is illustrated in Figure 1. It was a 4 replicate split-plot design with randomized main plots (summerfallow versus stubble) and sub plots (seeding dates and fertility treatments). Pathways were 10 feet wide between replicates and 4 feet wide between main plots within replicates. This plan could not be used until 1962. The method used to establish the field plan represented in Figure 1 was to have the farmer seed the complete experimental block which had previously been summerfallowed to wheat. The seedling wheat was removed a week after emergence from the area representing the pathways and the summerfallow range in each replicate and this area was maintained in a fallow condition by rotovation throughout that year. The wheat in the stubble range of each replicate was swathed and threshed at maturity and the straw was distributed evenly over the stubble portion of the range and then worked in by the co-operating farmer. At Carman where grain-corn rotations have

Fig. 1. Carman and Morris experiments in 1962 and 1963.

Field layout.

Early — Rep. 4. — Late.

Plot No.	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128
Variety	C	A	D	C	B	A	D	B	A	D	A	B	C	B	D	C
Fertilizer	2	2	1	1	1	1	2	2	1	1	2	2	1	1	2	2

Plot No.	79	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112
Variety	A	B	C	B	D	C	D	A	B	B	C	A	D	A	C	D
Fertilizer	1	2	1	1	1	2	2	2	1	2	2	1	1	2	1	2

Late — Rep. 3. — Early

Plot No.	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
Variety	D	C	B	D	A	B	A	C	A	C	A	D	B	D	B	C
Fertilizer	2	1	2	1	2	1	1	2	2	2	1	1	1	2	2	1

Plot No.	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Variety	C	B	C	B	D	A	D	A	B	A	D	C	A	C	D	B
Fertilizer	2	1	1	2	1	1	2	2	1	1	1	2	2	1	2	2

Early — Rep. 2. — Late.

Plot No.	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
Variety	B	A	D	C	B	D	A	C	D	C	B	D	C	A	B	A
Fertilizer	1	2	2	1	2	1	1	2	1	2	2	2	1	2	1	1

Plot No.	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Variety	D	C	A	B	A	C	D	B	C	A	C	B	D	B	A	D
Fertilizer	1	2	1	1	2	1	2	2	2	1	1	2	1	1	2	2

Late — Rep. 1. — Early.

Plot No.	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Variety	B	A	C	A	D	C	B	D	A	D	A	C	B	D	C	B
Fertilizer	2	1	1	2	1	2	1	2	1	1	2	2	1	2	1	2

Plot No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Variety	A	D	B	C	A	B	C	D	C	B	D	D	A	C	B	A
Fertilizer	1	2	1	1	2	2	2	1	1	2	1	2	1	2	1	2

Key:

Variety.
A. Redwood
B. Raja
C. Arny
D. Marine
◤ Stubble
● Fallow

Variety.
A. Husky
B. Herta
C. Traill
D. Parkland

Fertilizer.
1. No fertilizer
2. a. 40 lbs. 33.5-0-0
   b. 30 lbs. 0-45-0

removed the necessity of ploughing, the stubble land was deep tilled in the fall by cultivation. At Morris, the stubble land was prepared by fall ploughing which is the normal practice in the alfalfa-grain rotations of that area.

Figure 2 illustrates $\frac{1}{2}$ of the design used in 1961. In this test the summerfallow plots were removed from the stubble plots by approximately 200 yards. This was necessary to obtain the required land culture. The 1961 design required a factorial analysis for each culture compared with the split plot analysis of the entire test used in 1962 and 1963.

The varieties which were included in this series of experiments were chosen from the 1961 Manitoba Recommended Variety list and seed stocks of all the varieties were obtained from the Canada Research Branch, Brandon, Manitoba. The barley varieties chosen were Husky, Herta, Traill and Parkland. Husky and Traill are 6-row varieties while Herta is a 2-row variety. At the inception of the experiment these 3 feed varieties were the most widely grown feed varieties in Manitoba. Parkland was the predominant 6-row malting variety in Manitoba occupying 55.5 percent of the total barley acreage of the province in 1960.

The flax varieties chosen were Redwood, Raja, Arny and Marine. Of these recommended flax varieties Redwood is classified as late, Arny is intermediate and Raja and Marine are early maturing. Redwood, Raja and Marine flax were the varieties occupying the largest flax acreage at the time the experiment commenced.

In order to obtain results as comparable as possible to farm

Carman and Morris experiments in 1961. . . .

Fig. 2.

Field layout.

Rep. I.

Variety	A	B	C	A	D	A	D	B	C	D	B	D	C	A	C	B
Date	E	E	L	L	E	E	E	E	L	L	L	L	E	L	E	L
Fertilizer	1	2	1	1	2	2	1	1	2	2	2	1	1	2	2	1
Plot No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

Rep. II.

Variety	C	A	D	B	C	B	C	D	A	B	C	A	D	B	D	A
Date	E	E	L	L	L	E	L	E	E	L	E	L	L	E	E	L
Fertilizer	1	1	2	2	1	2	2	1	2	1	2	2	1	1	2	1
Plot No.	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32

Rep. III.

Variety	B	D	C	A	D	A	D	B	C	A	B	D	C	A	B	C
Date	E	L	L	E	L	L	E	E	L	E	L	E	E	L	L	E
Fertilizer	2	1	1	1	2	1	2	1	2	2	2	1	1	2	1	2
Plot No.	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48

Rep. IV.

Variety	C	A	D	B	B	C	B	A	D	C	A	B	D	C	A	D
Date	L	E	E	L	E	L	L	E	L	E	L	E	L	E	L	E
Fertilizer	2	1	2	1	2	1	2	2	1	1	2	1	2	2	1	1
Plot No.	49	50	51	52	53	54	56	56	57	58	59	60	61	62	63	64

Key:

Variety	Variety	Fertilizer.
A. Redwood	A. Husky	1. No fertilizer
B. Raja	B. Herta	2. a. 40 lbs. 33.5-0-0
C. Arny	C. Traill	b. 30 lbs. 0-45-0
D. Marine	D. Parkland	

conditions, plot size was of rod row length with 16 rows per plot at 6 inch spacing between rows. This plan was adopted to eliminate varietal interaction. Standard seeding rates for flax and barley were used. The Plant Science Department rod row seeder set at a 6-inch row spacing was used to seed the plots.

The available nitrate and phosphate in the soil was determined at each of the 2 locations by soil analyses in 1962 and 1963. Soil samples were taken at seeding time and analyzed by the Department of Soil Science, University of Manitoba. This procedure was not carried out in 1961 although available phosphate was determined at the Carman site.

Two fertilizer treatments, a check of 0-0-0 and a treatment of 30 pounds of 0-45-0 plus 40 pounds of 33.5-0-0 were used throughout the entire experiment. The phosphorus was drilled with the seed whereas the nitrogen was broadcast immediately after seeding. These rates were determined prior to soil analyses on the basis of recommendations by the Soil and Plant Science Departments.

Weather conditions played an unfavorable role in the experiments at both locations in 1961 and 1962. In 1961 drought conditions (Table 1) forced the abandonment of the Morris plots and therefore only yield data from Carman were available. In 1962 excess moisture conditions (Table 2) prevented seeding of the Carman location. Further, only 1 seeding date at the Morris location could be carried out in that year.

TABLE 1

Precipitation in inches during the period April 1-October 1 at stations surrounding the test locations.

Station	1960	1961	Normal
Portage La Prairie	8.57	10.66	13.63
Morden	8.28	10.58	13.79
Emerson	9.89*	10.90	13.60
Winnipeg	7.97	10.17	13.50
Average	8.68	10.57	13.63

* Incomplete.

TABLE 2

Precipitation in inches during the period April 1-September 22 at stations surrounding the test locations.

Station	1962	Normal
Portage La Prairie	19.94	13.14
Morden	17.93	13.21
Emerson	15.90	13.03
Winnipeg	21.55	12.87
Average	18.83	13.08

Seeding dates were used which correspond to those generally considered to be in the mid-season range. The dates were spaced approximately 2 weeks apart or as close to this spacing as permitted by weather conditions. Seeding dates for the 3 years were as follows:

TABLE 3

Seeding dates at Morris and Carman in 1961, 1962 and 1963.

	Location					
	Morris			Carman		
Seeding date	1961	1962	1963	1961	1962	1963
Early	May 19		May 15	May 18		May 23
Late	June 5	June 14	May 30	June 2		June 7

Assistance in spring planting was given by the farmer at each of the 2 locations. The summerfallow and stubble land strips were cultivated lengthwise to prevent soil mixing. The plots were also harrowed lengthwise to give even spread to the above-ground straw on the stubble plots and to obtain a uniform seed bed on the 2 land cultures.

The plots at each location in each year were harvested by hand as they reached maturity. Only the 2 centre rows of each 16-row plot were harvested after the removal of 1 foot of each row end to eliminate border effect. All harvested material was returned to the Department of Plant Science, University of Manitoba, Winnipeg,

threshed and the gram weight yield for each plot was recorded. The gram weights were then converted to bushels per acre.

The 1961 Carman yield results for barley and flax were analysed using a factorial statistical analysis. The 1962 and 1963 yield results for the barley and flax experiments conducted at Carman and Morris were analyzed by the use of a split plot statistical analysis. The analysis of variance of the 3 years of experiments determined each individual factor effect as well as the relationship of all the factors in combination with each other. Significant differences between individual factors or factors in combination with each other were calculated by the method of Least Significant Differences.

Barley samples from all plots in the experiments conducted at Carman and Morris in the years 1962 and 1963 were submitted to the Chemistry Section, Department of Plant Science, University of Manitoba for protein analysis. Protein analysis were made by the improved Kjeldahl method for nitrate free samples (16). To determine if any one factor or factors in the experiments had an influence on protein content the percent protein for each plot in each experiment was transformed to $\text{Sin}^2\ \theta$ (13) and the transformed data were then statistically analyzed using a split plot analysis.

Weight per measured bushel and 1000 kernel weight for the 1962 and 1963 barley experiments conducted at Carman and Morris were calculated by bulking replicate plots taking into consideration their land culture, date of seeding and fertilizer treatment. This procedure was necessary because several of the plots produced

insufficient seed to record accurate bushel weight. It was determined that as each treatment was replicated 4 times, the bulking of the replicate samples would be a reasonably accurate method of determining bushel weight and 1000 kernel weight. These data were not statistically analyzed.

RESULTS AND DISCUSSION

A. The response of 4 barley varieties to date of seeding, fertility level and previous land culture.

1. Yield data:

The 1961 tests at Carman were set up as variety-seeding date-fertilizer experiments on separate land cultures because appropriate test areas were not available. The yield data for these tests may be found in Appendices 1 and 2. The analysis of the yields obtained for the various treatments on stubble land is presented in Table 4. From this analysis it may be concluded that under this land culture system significant differences ($P \leq .05$) could be detected among varieties. Considering the mean yields (Table 5) it becomes apparent that the 3 highest yielding varieties, Husky, Herta and Traill are similar and significantly higher yielding than Parkland.

TABLE 4

Analysis of barley yield data from 1961 stubble land test at Carman.

Source of Variation	D.F.	Mean Square	F.	5%	1%
Replicates	3	13044.79			
Varieties	3	17980.21	2.99*	2.82	4.25
Dates	1	26001.50	4.32*	4.06	7.24
Fertilizer	1	351.50	0.0584	4.06	7.24
Var. x Date	3	5313.04	0.88	2.82	4.25
Fert. x Date	1	2025.12	0.347	4.06	7.24
Fert. x Var.	3	3117.21	0.518	2.82	4.25
Fert. x Date x Var.	3	2525.83	0.420	2.82	4.25
Error	45	6013.38			
Total	63				

* Significant at 5% level of probability.

TABLE 5

Mean yield in bushels per acre of barley varieties grown on stubble land at Carman in 1961.

Varieties	Yield
Husky	35.8
Herta	33.1
Traill	33.5
Parkland	26.4

Least significant difference: 6.68

TABLE 6

Mean yields in bushels per acre at 2 seeding dates of barley grown on stubble land at Carman in 1961.

Dates	Yield
Early	34.6
Late	29.7

Least significant difference: 4.76

The influence of seeding date on yields of barley grown on stubble may be observed in Table 6. The average yield of the 4 varieties sown at the early date was significantly higher than the average of the same varieties sown at the later date ($P < .05$).

The analysis of the yields obtained for the various treatments on summerfallow land at Carman is presented in Table 7. The analysis indicates that of the factors being tested only the interaction of Variety x Date was significant ($P < .05$). An explanation of this interaction may be found in Table 8. It is apparent that in this test Herta, Traill and Parkland were higher yielding when sown at the later date while Husky performs best at the earlier seeding date. It is particularly worthy of note that Husky is the highest yielding variety at the early seeding date and the lowest yielding variety at the later seeding date whereas the other varieties show the same relative performance at both dates of seeding.

TABLE 7

Analysis of barley yield data from 1961 summerfallow test at Carman.

Source of Variation	D.F.	Mean Square	F.	5%	1%
Replicates	3	4994.27			
Varieties	3	583.18	0.213	2.82	4.25
Dates	1	2025.00	0.743	4.06	7.24
Fertilizer	1	2889.10	1.06	4.06	7.24
Var. x Date	3	8618.41	3.16*	2.82	4.25
Var. x Fert.	3	5636.62	2.07	2.82	4.25
Date x Fert.	1	6400.00	2.35	4.06	7.24
Fert. x Date x Var.	3	2596.85	0.95	2.82	4.25
Error	45	2726.87			
Total	63				

* Significant at the 5% level of probability.

TABLE 8

Response of barley varieties to date of seeding at Carman in 1961.

	Early Date		Late Date	
Variety	Yield	Rank	Yield	Rank
Husky	47.0	1	43.2	4
Traill	45.7	2	51.1	1
Herta	43.9	3	45.2	2
Parkland	42.0	4	44.5	3

Least significant difference for variety x date: 6.68

The evaluation of the effect of cultural practices on barley yields at Morris began in 1962. The experimental design was a split-plot with date of seeding as one of the sub-plots. However because spring precipitation was heavy only 1 date of seeding was realized. The yield data from the test are presented in Appendix 3. The analysis of this data may be found in Table 9. Significant differences were noted between cultures, between varieties and between fertilizers.

In this test barley varieties grown on summerfallow significantly ($P < .05$) outyielded the same varieties grown on stubble (Table 10). Traill, the highest yielding variety, was significantly ($P < .05$) different from Herta, the lowest yielding variety. Fertilized plots outyielded non-fertilized or check plots and this difference was significant ($P < .05$)

TABLE 9

Analysis of barley yield data from 1962 test at Morris.

Source of Variation	D.F.	Mean Square	F.	5%	1%
Replicates	3	53756.37			
Culture	1	448062.90	31.89*	10.13	34.12
Error a.	3	14048.00			
Variety	3	22960.07	4.55*	3.16	5.09
Variety x Cult.	3	3135.80	0.622	3.16	5.09
Error b.	18	5043.78			
Fertilizer	1	42384.60	5.13*	4.26	7.82
Fert. x Var.	3	5779.40	0.699	3.01	4.72
Fert. x Cult.	1	7854.30	0.951	4.26	7.82
Fert. x Var. x Cult.	3	12060.45	1.46	3.01	4.72
Error c.	24	8256.42			
Total	63				

* Significant at the 5% level of probability.

TABLE 10

Effect of various treatments on yield of barley at Morris in 1962.

Treatment	Yield
Culture	
Stubble	43.3
Summerfallow	63.5
Least significant difference (.05): 11.41	
Variety	
Husky	51.8
Herta	48.5
Traill	55.4
Parkland	53.8
Least significant difference (.05): 6.4	
Fertilizer	
Fertilized	56.5
Check	50.3
Least significant difference (.05): 5.7	

In 1963 complete tests were established at Carman and Morris. The yield data obtained from these tests may be found in Appendices 4 and 5.

The analysis of variance of the Carman yield data are presented in Table 11. Differences associated with land culture were not significant but significant differences were noted for several main effects and interactions.

Each variety produced higher yields at the earlier seeding date and, on the average, early seeded barley significantly ($P < .01$) outyielded late seeded barley (Table 12). Within each seeding date the ranking of the varieties from highest to lowest was Herta, Traill, Parkland and Husky. On the average Herta significantly ($P < .01$) outyielded Traill which in turn outyielded Parkland and Husky. Although the direction of the differences was the same within and between dates of seeding the magnitude of the differences was not. In particular, for the variety Herta the difference between early and late seeding was significantly ($P < .01$) greater than for the other 3 varieties. The significant ($P < .05$) Variety x Date x Culture interaction involving the variety Herta with Husky and Parkland suggests that Herta is more sensitive to land culture particularly at the early date of seeding.

Plots receiving fertilizer significantly ($P < .01$) outyielded check plots (Table 13). This trend was observed at both dates of seeding but the magnitude of the response was greater at the early seeding date.

TABLE 11

Analysis of barley yield data from 1963 test at Carman.

Source of Variation	D.F.	Mean Square	F.	5%	1%
Replicates	3	2644.06			
Culture	1	450.00	0.17	10.13	34.12
Error a.	3	2585.56			
Dates	1	832372.50	136.04**	5.19	13.74
Dates x Cult.	1	512.00	.084	5.19	13.74
Error b.	6	6118.73			
Variety	3	36088.04	60.18**	2.86	4.38
Var. x Date	3	7925.79	13.22**	2.86	4.38
Var. x Cult.	3	725.25	1.21	2.86	4.38
Var. x Cult. x Date	3	2065.58	3.44*	2.86	4.38
Error c.	36	599.62			
Fertilizer	1	29403.10	28.49**	4.04	7.19
Fert. x Date	1	16020.50	15.52**	4.04	7.19
Fert. x Var.	3	945.05	0.92	2.80	4.22
Fert. x Cult.	1	2.58	0.0025	4.04	7.19
Fert. x Date x Cult.	1	94.57	0.092	4.04	7.19
Fert. x Date x Var.	3	960.42	0.93	2.80	4.22

Table 11, cont.

Source of Variation	D.F.	Mean Square	F.	5%	1%
Fert. x Var. x Cult.	3	293.85	0.28	2.80	4.22
Fert. x Cult. x Date x Var.	3	869.27	0.84	2.80	4.22
Error d.	48	1031.86			
Total	127				

* Significant at the 5% level of probability.

** Significant at the 1% level of probability.

TABLE 12

Yield in bushels per acre of barley varieties as influenced by land cultures and dates of seeding at Carman in 1963.

Variety	Early			Late			Station Mean
	Stubble	Summer-fallow	Mean	Stubble	Summer-fallow	Mean	
Husky	21.3	20.8	21.0	4.2	3.9	4.1	12.5
Herta	31.7	37.0	34.3	10.1	10.1	9.5	21.9
Traill	26.7	25.9	26.3	6.3	6.3	6.4	16.3
Parkland	22.7	22.5	22.6	5.5	5.5	6.1	14.4
Mean			26.1			6.5	

Least significant difference for date of seeding (.01): 6.2

Least significant difference for varieties (.01): 1.94

Least significant difference for Variety x Date interaction (.01): 4.03

Least significant difference for Variety x Date x Culture interaction (.05): 6.02

TABLE 13

Yield of barley in bushels per acre of fertilized and check plots at 2 dates of seeding at Carman in 1963.

	Yield		
Treatment	Early	Late	Average
Fertilizer	29.3	7.0	18.1
Check	22.9	6.0	14.5

Least significant difference for fertilizer treatments (.01): 1.85

Least significant difference for fertilizer x date (.01): 3.70

The analysis of the 1963 experiments at Morris is given in Table 14. Significant differences were noted for all of the main factors studied as well as for the interaction Culture x Date.

Yields from barley grown on summerfallow plots were significantly ($P < .05$) higher than yields from the same varieties grown on fallow (Table 15). Early seeded barley significantly ($P < .01$) outyielded late seeded barley. The varieties Herta and Parkland significantly ($P < .01$) outyielded the varieties Traill and Husky. Plots receiving fertilizer significantly ($P < .01$) outyielded the check plots. The significant ($P < .05$) Culture x Date interaction indicates that although barley performed in the same manner at the early and the late seeding date for both cultures, the magnitude of the difference between early and late seeding on summerfallow was much larger than that on stubble.

TABLE 14

Analysis of barley yield data from 1963 test at Morris.

Source of Variation	D.F.	Mean Square	F.	5%	1%
Replicates	3	7500.67			
Culture	1	112694.00	17.12*	10.13	34.12
Error a.	3	6583.30			
Dates	1	266086.00	47.46**	5.99	13.74
Date x Cult.	1	34649.30	6.18*	5.99	13.74
Error b.	6	5605.98			
Variety	3	42655.067	12.23**	2.86	4.38
Var. x Cult.	3	7709.30	2.21	2.86	4.38
Var. x Date	3	2313.93	0.66	2.86	4.38
Var. x Date x Cult.	3	4000.43	1.15	2.86	4.38
Error c.	36	3488.36			
Fertilizer	1	21218.00	7.64**	4.04	7.19
Fert. x Date	1	10152.30	3.66	4.04	7.19
Fert. x Var.	3	1149.00	0.414	2.80	4.22
Fert. x Cult.	1	5644.40	2.03	4.04	7.19
Fert. x Date x Cult.	1	6301.00	2.27	4.04	7.19
Fert. x Date x Var.	3	889.63	0.320	2.80	4.22

Table 14, cont.

Source of Variation	D.F.	Mean Square	F.	5%	1%
Fert. x Var. x Cult.	3	1698.90	0.612	2.80	4.22
Fert. x Cult. x Date x Var.	3	2166.90	0.781	2.80	4.22
Error d.	48	2775.80			
Total	127				

* Significant at the 5% level of probability.

** Significant at the 1% level of probability.

TABLE 15

Effect of various treatments on yield of barley at Morris in 1963.

Treatment		Stubble	Summerfallow	Mean Yield
Date				
	Early	45.3	56.4	50.8
	Late	38.2	41.4	39.8
	Mean	41.7	48.9	
Least significant difference for culture (.05):				5.5
Least significant difference for date (.01):				5.9
Least significant difference for culture x date (.05):				7.8
Varieties				
	Husky			39.5
	Herta			49.9
	Traill			44.6
	Parkland			47.3
Least significant difference for varieties (.01):				4.9
Fertilizer				
	Fertilized			46.9
	Check			43.8
Least significant difference for fertilizer (.01):				3.0

An examination of the Carman and Morris barley yields for the years 1961, 1962 and 1963 indicate a low response to fertilizer application. A review of the Manitoba fertilizer requirement tables (37) appears to satisfactorily answer this problem. These tables state that if the available nitrate (pounds of nitrogen in the soil) is above the 42 pound level then the nitrogen rating is classified as high and there is no need to apply nitrogen fertilizer to barley. Similarily the tables state that if available phosphate (pounds of phosphate in the soil) is greater than the 36 pound level, the phosphate rating is classified as very high and barley requires additional phosphorous in minimum quantities of 10 pounds per acre. An examination of Appendices 6 and 7, available nitrate in pounds per acre and available phosphate in pounds per acre for the Carman and Morris experimental locations, will show levels of nitrate well in excess of the minimum requirement and phosphate levels approximately equal to the very high rating. It may be concluded therefore that the small increase in yield of barley from fertilizer at the 2 locations is a response to phosphate fertilizer rather than to nitrogen fertilizer.

2. Protein data:

The protein data from the barley experiments conducted at Morris in 1962 and 1963 and at Carman in 1963 may be found in Appendices 8, 9 and 10. The analysis of the protein yields of barley grown at Morris in 1962 and 1963 and at Carman in 1963 are shown in Tables 16, 17 and 18.

Significant ($P < .05$) increases in protein were obtained from the application of fertilizer at Morris in 1962 (Table 19) but this trend was not observed in other years or at the Carman location. These results are similar to the findings of Lowrey *et al.* (25,26 27, 28) who noted that in Nebraska the use of fertilizer did not consistently increase the yield of protein in the material they were studying.

Variety performance was similar at both locations (Tables 20 and 21). On the average Husky had the highest protein yield and Parkland the lowest. Husky significantly ($P < .01$) outyielded Traill and Parkland at Morris in 1963 and Herta, Traill and Parkland at Carman in 1963. At Carman significant interactions between Varieties and Culture were noted (Table 21) while in all cases varieties grown on summerfallow had higher protein content than varieties grown on stubble. The ranking of these varieties was not the same. In particular, there has been a disproportionate increase in the protein yield of Parkland grown on fallow such that this variety now outyields Traill in protein content. At Carman protein content of barley seeded at the late date of seeding was significantly higher ($P < .01$) than the protein content of barley seeded at the early seeding date (Table 22). While, in general, this would appear to substantiate the negative correlation between protein content and yield it should be noted that other factors must also influence protein content. For example, protein content from barley grown on fallow fields was higher than protein content of barley grown on stubble (Table 21), however, in this particular

instance summerfallow yields also exceeded stubble yields (Table 12).

TABLE 16

Analysis of protein yields ($\sin^2\theta$) of barley grown at Morris in 1962.

Source of Variation	D.F.	Mean Square	F.	5%	1%
Replicates	3	0.49			
Culture	1	0.04	0.08	10.13	34.12
Error a.	3	0.50			
Variety	3	0.72	2.32	3.16	5.09
Var. x Cult.	3	0.34	1.17	3.16	5.09
Error b.	18	0.31			
Fertilizer	1	1.35	4.35*	4.26	7.82
Fert. x Var.	3	0.52	1.68	3.01	4.72
Fert. x Cult.	1	0.55	1.77	4.26	7.82
Fert. x Var. x Cult.	3	0.20	0.64	3.01	4.72
Error c.	24	0.31			
Total	63				

* Significant at the 5% level of probability.

TABLE 17

Analysis of protein yields ($\sin^2\theta$) of barley grown at Morris in 1963.

Source of Variation	D.F.	Mean Square	F.	5%	1%
Replicates	3	0.51			
Culture	1	1.60	7.17	10.13	34.12
Error a.	3	0.22			
Date	1	0.00	0.00	0.00	0.00
Date x Cult.	1	0.39	1.77	5.99	13.74
Error b.	6	0.22			
Variety	3	3.82	12.73**	2.86	4.38
Var. x Date	3	0.08	0.26	2.86	4.38
Var. x Cult.	3	0.23	0.77	2.86	4.38
Var. x Date x Cult.	3	0.17	0.57	2.86	4.38
Error c.	36	0.30			
Total	63				

** Significant at the 1% level of probability.

TABLE 18

Analysis of protein yields ($\sin^2\theta$) of barley grown at Carman in 1963.

Source of Variation	D.F.	Mean Square	F.	5%	1%
Replicates	3	4.57			
Culture	1	31.70	19.57*	10.13	34.12
Error a.	3	1.62			
Date	1	41.06	120.76**	5.99	13.74
Date x Cult.	1	0.47	1.38	5.99	13.74
Error b.	6	0.34			
Variety	3	7.01	22.61**	2.86	4.38
Var. x Date	3	0.72	2.25	2.86	4.38
Var. x Cult.	3	1.90	5.94**	2.86	4.38
Var. x Date x Cult.	3	0.21	0.66	2.86	4.38
Error c.	36	0.32			
Fertilizer	1	0.37	1.37	4.04	7.19
Fert. x Date	1	0.13	0.48	4.04	7.19
Fert. x Var.	3	0.53	1.96	2.80	4.22
Fert. x Cult.	1	0.01	0.06	4.04	7.19
Fert. x Date x Cult.	1	0.01	0.06	4.04	7.19
Fert. x Date x Var.	3	0.13	0.48	2.80	4.22

Table 18, cont.

Source of Variation	D.F.	Mean Square	F.	5%	1%
Fert. x Var. x Cult.	3	0.18	0.66	2.80	4.22
Fert. x Var. x Date x Cult.	3	0.03	0.11	2.80	4.22
Error d.	48	0.27			
Total	127				

* Significant at the 5% level of probability.

** Significant at the 1% level of probability.

TABLE 19

Protein content ($\sin^2\theta$) of barley

at 2 fertilizer levels at Morris in 1962.

Fertilizer Treatment	Mean
Fertilized	21.61
Check	21.32

Least significant difference (.05): .2867

TABLE 20

Protein content ($\sin^2\theta$) of barley varieties grown at Morris in 1963.

Varieties	Mean
Husky	23.47
Herta	23.20
Traill	22.91
Parkland	22.68

Least significant difference (.01): .3724

TABLE 21

Yield of protein ($\sin^2\theta$) in barley grown on stubble and summerfallow at Carman in 1963.

Variety	Stubble Mean	Summerfallow Mean	Variety Mean
Husky	24.63	25.99	25.30
Herta	24.29	25.25	24.77
Traill	24.14	24.46	24.30
Parkland	23.67	25.02	24.30
Culture Mean	24.18	25.20	

Least significant difference for varieties (.01): .385

Least significant difference for culture (.05): .729

Least significant difference for variety x culture (.01): .769

TABLE 22

Protein content ($\sin^2\theta$) of barley varieties at different dates of seeding at Carman in 1963.

Dates	Mean
Early	24.11
Late	25.24

Least significant difference (.01): .382

The influence of land culture, date of seeding and fertility level on 1000 kernel weight (in grams) and bushel weight (in pounds) was not statistically analysed but reference to Appendix 11 and 12 will indicate results similar to those obtained by workers in Nebraska (23, 24, 25, 26, 27, 28). These workers reported that in 9 years of fertilizer tests with barley, bushel weight was increased in 1 year only from the application of fertilizer. Similarly in 4 years fertilizer had no affect on bushel weight and in the other 5 years had a generally depressing effect on bushel weight. An examination of the average weight per measured bushel of barley at Morris in 1962 and 1963 indicated a slight increase from the use of fertilizer. Weight per measured bushel at Carman in 1963 was decreased slightly rather than increased by the use of fertilizer.

B. The response of 4 flax varieties to date of seeding, fertility level and previous land culture.

The 1961 flax tests at Carman were set up as variety-seeding date-fertilizer experiments on separate land cultures because appropriate test areas were not available. The yield data for these tests may be found in Appendices 13 and 14. The analysis of the various treatment on stubble land is presented in Table 23. Significant differences were noted for varieties ($P < .05$) and dates of seeding ($P < .01$). From the data in Table 24 it may be noted that the varieties Arny, Raja and Marine significantly ($P < .05$) outyielded the variety Redwood. Early seeded flax significantly ($P < .01$) outyielded late seeded flax.

TABLE 23

Analysis of flax yield data from 1961 stubble land test at Carman.

Source of Variation	D.F.	Mean Square	F.	5%	1%
Replicates	3	917.70			
Variety	3	1235.42	3.77*	2.82	4.25
Date	1	45156.25	137.67**	4.06	7.24
Fertilizer	1	1225.00	3.73	4.06	7.24
Var. x Date	3	387.50	1.18	2.82	4.25
Var. x Fert.	3	72.92	0.222	2.82	4.25
Fert. x Date	1	156.25	0.476	4.06	7.24

Table 23, cont.

Source of Variation	D.F.	Mean Square	F.	5%	1%
Var. x Date x Fert.	3	441.66	1.34	2.82	4.25
Error	45	327.99			
Total	63				

* Significant at the 5% level of probability.

** Significant at the 1% level of probability.

TABLE 24

Effect of various treatments

on yield of flax on stubble land at Carman in 1961.

Treatment	Yield
Varieties	
Redwood	3.9
Raja	5.7
Arny	5.9
Marine	5.4

Least significant difference (.05): 1.3

Table 24, cont.

Treatment	Yield
Dates	
Early	7.9
Late	2.4

Least significant difference (.01): 1.8

The analysis of the yields obtained for the various treatments grown on summerfallow at Carman will be found in Table 25. Two interactions, namely Variety x Date ($P < .01$) and Variety x Date x Fertilizer ($P < .05$) were significant (Table 26). On the average Redwood is the highest yielding variety and Raja the lowest yielding variety at the early date of seeding. At the late date of seeding the situation is reversed and Raja is the highest and Redwood the lowest yielding variety. Although the trend is the same on fertilized and check plots larger differences were obtained from the fertilized plots particularly at the early date of seeding. Similarly Raja yielded significantly ($P < .05$) less than Arny when seeded with fertilizer at the early date but outyielded this variety when sown with fertilizer at the late seeding date.

TABLE 25

Analysis of flax yield data

from 1961 summerfallow land test at Carman.

Source of Variation	D.F.	Mean Square	F.	5%	1%
Replicates	3	459.76			
Variety	3	52.14	0.118	2.82	4.25
Date	1	206.02	0.467	4.06	7.24
Fertilizer	1	284.77	0.646	4.06	7.24
Var. x Date	3	3893.64	8.84**	2.82	4.25
Var. x Fert.	3	144.48	0.328	2.82	4.25
Date x Fert.	1	376.05	0.853	4.06	7.24
Var. x Date x Fert.	3	1302.96	2.96*	2.82	4.25
Error	45	440.60			
Total	63				

* Significant at the 5% level of probability.

** Significant at the 1% level of probability.

TABLE 26

Yield in bushels per acre of flax varieties as influenced by dates of seeding and fertilizer at Carman in 1961.

	Early			Late		
Variety	Fert.	Check	Mean	Fert.	Check	Mean
Redwood	12.5	11.6	12.0	6.7	6.1	6.4
Raja	6.8	10.9	8.8	11.2	9.7	10.4
Army	9.5	9.3	9.4	9.7	10.3	10.0
Marine	9.0	9.5	9.2	9.6	8.3	8.9

Least significant difference for variety x date (.01): 4.10

Least significant difference for var. x date x fert. (.05): 6.2

The evaluation of effect of cultural practices and fertilizer application on flax yields began at Morris in 1962. The experimental design was a split-plot with date of seeding as one of the sub-plots. However due to spring precipitation (Table 2) only 1 date of seeding was carried out. The yield data from the test are presented in Appendix 15. The analysis of this data may be found in Table 27. Significant differences were observed between cultures and between fertilizers (Table 28). Flax seeded on stubble significantly ($P < .01$) outyielded flax seeded on summerfallow. Fertilized flax plots significantly ($P < .01$) outyielded non-fertilized or check plots.

TABLE 27

Analysis of flax yield data from 1962 test at Morris.

Source of Variation	D.F.	Mean Square	F.	5%	1%
Replicates	3	4458.81			
Culture	1	42487.53	72.93**	10.13	34.12
Error a.	3	582.55			
Variety	3	1499.30	1.83	3.16	5.09
Var. x Cult.	3	1169.31	1.43	3.16	5.09
Error b.	18	816.36			
Fertilizer	1	7417.53	14.57**	4.26	7.82
Fert. x Var.	3	402.25	0.79	3.01	4.72
Fert. x Cult.	1	235.08	0.46	4.26	7.82
Fert. x Cult. x Var.	3	646.94	1.27	3.01	4.72
Error c.	24	509.05			
Total	63				

** Significant at the 1% level of probability.

TABLE 28

Effect of various treatments on yield of flax at Morris in 1962.

Treatment	Yield
Culture	
Stubble	22.2
Summerfallow	16.8
Least significant difference (.01): 3.66	
Fertilizer	
Fertilized	20.6
Check	18.4
Least significant difference (.01): 1.64	

In 1963 complete tests were conducted at Carman and Morris. The yield data from these tests may be found in Appendices 16 and 17.

The analysis of variance of the Carman data are presented in Table 29. Differences associated with the main effects, land culture, varieties and fertilizer and the interaction Variety x Date were significant (Table 30). Flax seeded on stubble significantly ($P < .05$) outyielded flax seeded on summerfallow. The variety Redwood significantly ($P < .05$) outyielded the varieties Raja and

Marine. There was no significant yield difference between Redwood and Arny or between Arny, Raja and Marine. Flax grown on non-fertilized or check plots significantly ($P < .05$) outyielded the fertilized flax plots. The Variety x Date interaction indicates that the varieties have not performed in the same manner at both dates. The varieties Redwood and Raja were highest yielding at the late seeding date whereas Arny and Marine were the highest yielding varieties at the early seeding date. Redwood significantly ($P < .01$) outyielded Arny and Marine when seeded late. Raja significantly ($P < .05$) outyielded Arny and significantly ($P < .01$) outyielded Marine at the late seeding date. There was no significant difference between the varieties Redwood and Raja.

TABLE 29

Analysis of flax yield data from 1963 test at Carman.

Source of Variation	D.F.	Mean Square	F.	5%	1%
Replicate	3	1611.48			
Culture	1	5578.22	11.28*	10.13	34.12
Error a.	3	494.39			
Date	1	431.42	0.26	5.99	13.75
Date x Cult.	1	765.49	0.46	5.99	13.75
Error b.	6	1669.11			
Variety	3	1883.45	3.27*	2.86	4.38

Table 29, cont.

Source of Variation	D.F.	Mean Square	F.	5%	1%
Var. x Date	3	2787.15	4.84**	2.86	4.38
Var. x Cult.	3	649.88	1.13	2.86	4.38
Var. x Date x Cult.	3	1560.82	2.71	2.86	4.38
Error c.	36	575.67			
Fertilizer	1	2619.02	4.18*	4.04	7.19
Fert. x Date	1	7.57	0.012	4.04	7.19
Fert. x Var.	3	30.37	0.048	2.80	4.22
Fert. x Cult.	1	1424.58	2.27	4.04	7.19
Fert. x Cult. x Date	1	736.18	1.18	4.04	7.19
Fert. x Date x Var.	3	1112.37	1.77	2.80	4.22
Fert. x Var. x Cult.	3	313.54	0.50	2.80	4.22
Fert. x Var. x Cult. x Date	3	996.65	1.59	2.80	4.22
Error d.	48	626.85			
Total	127				

* Significant at the 5% level of probability.

** Significant at the 1% level of probability.

TABLE 30

Effect of various treatments on yield of flax at Carman in 1963.

Treatment	Date		Mean
	Early	Late	
Culture			
Stubble			12.6
Summerfallow			11.2
Least significant difference (.05): 1.29			
Variety			
Redwood	11.8	14.2	13.0
Raja	10.3	12.0	11.1
Arny	12.4	11.5	11.9
Marine	12.4	10.7	11.5
Least significant difference for variety (.05):			1.3
Least significant difference for variety x date (.05):			2.5
Least significant difference for variety x date (.01):			3.4
Fertilizer			
Fertilized			11.4
Check			12.4

Table 30, cont.

Least significant difference (.05): .92

The analysis of variance of the 1963 Morris yield data are presented in Table 31. Differences associated with culture, fertilizer and the interaction of Culture x Fertilizer were observed (Table 32). Flax seeded on stubble significantly ($P < .05$) outyielded flax seeded on summerfallow. Plots receiving fertilizer significantly ($P < .05$) outyielded non-fertilized or check plots. A significant ($P < .05$) Fertilizer x Culture interaction was observed with non-fertilized flax sown on stubble outyielding fertilized flax sown on stubble whereas on summerfallow a reverse relationship occurred.

Table 31

Analysis of flax yield data from 1963 test at Morris

Source of Variation	D.F.	Mean Square	F.	5%	1%
Replicate	3	3663.93			
Culture	1	15225.07	123.70**	10.13	34.12
Error a.	3	123.08			
Date	1	10224.47	3.66	5.99	13.75
Date x Cult.	1	12561.20	4.50	5.99	13.75
Error b.	6	2790.43			
Variety	3	90.14	0.146	2.86	4.38

Table 31, cont.

Source of Variation	D.F.	Mean Square	F.	5%	1%
Var. x Date	3	721.32	1.17	2.86	4.38
Var. x Cult.	3	1026.71	1.66	2.86	4.38
Var. x Date x Cult.	3	776.04	1.26	2.86	4.38
Error c.	36	618.00			
Fertilizer	1	3741.07	4.50*	4.04	7.19
Fert. x Date	1	18.08	0.022	4.04	7.19
Fert. x Var.	3	112.46	0.135	2.80	4.22
Fert. x Cult.	1	5151.23	6.20*	4.04	7.19
Fert. x Date x Cult.	1	2211.00	2.66	4.04	7.19
Fert. x Date x Var.	3	588.70	0.71	2.80	4.22
Fert. x Cult. x Var.	3	426.57	0.513	2.80	4.22
Fert. x Var. x Cult. x Date	3	73.02	0.088	2.80	4.22
Error d.	48	830.55			
Total	127				

* Significant at the 5% level of probability.

** Significant at the 1% level of probability.

TABLE 32

Effect of various treatments on yield of flax at Morris in 1963.

Treatment	Fertilized	Check	Mean
Stubble	12.3	12.5	12.4
Summerfallow	11.4	9.0	10.2
Mean	11.8	10.7	

Least significant difference for culture (.01): 1.18

Least significant difference for fertilizer (.05): 1.06

Least significant difference for culture x date interaction (.05): .67

SUMMARY

Carman:

Barley- 2 year summary.

From the summary presented in Table 33 it may be noted that the tests were not consistent from year to year. Yields were significantly influenced by Date of seeding, Varieties and the interaction Varieties x Date in 2 of the tests. Significant differences attributable to fertilizer application and the interactions Fertilizer x Date and Variety x Date x Culture were detected in 1 year only. These results suggest that at this location barley should be seeded early and that some varieties are more sensitive to date of seeding than others.

Flax- 2 year summary.

It may be seen from the summary presented in Table 33 that the analyses of the tests are not similar. Significant differences between varieties were noted in both tests but variety performance was not similar. Differences attributable to date of seeding were detected in only 1 test suggesting that at this location date of seeding has less influence on flax than on barley. Variety x Date interactions were significant in 2 tests emphasizing that the magnitude and direction of differences between varieties varied with date of seeding. Variations due to Land Culture, Fertilizer and Varieties x Date x Fertilizer were significant in 1 test only

and therefore no definite conclusions may be drawn from them.

Morris:

Barley- 2 year summary.

Significant differences associated with Land Culture, Fertilizer and Varieties (Table 33) were obtained in both years of testing at Morris. Yields of barley were also significantly affected by date of seeding in the 1963 test, the only year in which response to this factor was measured. These results point out that higher yields are obtained from the early seeding date, summerfallow plots and plots receiving fertilizer.

Flax- 2 year summary.

Stubble plots consistently and significantly outyielded summerfallow plots at Morris. Similarly fertilized plots significantly outyielded check plots. This would seem to suggest that under good management high yields of flax may be obtained on stubble. The addition of fertilizer would appear to be beneficial in supplying nutrients at an early and critical stage of plant development regardless of whether the crop is grown on stubble or fallow.

Carman and Morris:

Barley- 2 year summary.

It is apparent (Table 33) that the results from these tests are not consistent from year to year or from location to location.

Early seeded barley significantly outyielded late seeded

barley in 3 of 5 tests. In 3 out of 4 tests an application of fertilizer also increased yield. Significant variety differences were detected in 4 out of 5 tests but the ranking of the varieties was not the same in all tests. These data suggest that barley responds in a positive way to early seeding and to application of fertilizer and that some varieties are more sensitive to change than others.

The absence of consistent Land Culture interactions, in particular Land Culture x Variety, is especially worthy of note. This means that although yield of barley is influenced in varying degrees and directions by date of seeding, use of fertilizer, varieties and land culture, for predictive purposes, assuming materials and conditions similar to those used in this test, it makes no difference whether the varieties are grown on stubble or fallow.

Flax- 2 year summary.

Significant differences associated with each of Land Culture and Fertilizer were obtained in 3 of 5 tests (Table 33). Significant Variety and Variety x Date differences were noted in 2 of 5 tests. The behavior of varieties and the response to fertilizers varied with location and year. In all tests where differences due to land culture were significant flax on stubble outyielded flax on summerfallow. The absence of significant Variety x Land Culture differences would seem to indicate that for predictive purposes variety tests may be conducted on either stubble or fallow.

TABLE 33

Summary of the significant yield treatments in the analysis of variance tests at Carman and Morris in 1961, 1962 and 1963.

Location		Morris		Carman		
Crop	Source of Variation	1962	1963 Combined[1]	1961 St.[2]	1963 Fa.[3]	1963 Combined
Barley	Date		S	S		S
	Culture	S	S			
	Fertilizer	S	S			S
	Variety	S	S	S		S
	Cult. x Date		S			
	Var. x Date				S	S
	Fert. x Date					S
	Var. x Cult. x Date					S
Flax	Date			S		
	Culture	S	S			S
	Fertilizer	S	S			S
	Variety			S		S
	Cult. x Fert.		S			
	Var. x Date				S	S
	Var. x Date x Fert.				S	

S. Significantly different in yield (.05 level).

1. Complete tests on stubble and summerfallow.

2. Stubble.

3. Summerfallow.

CONCLUSIONS

The following conclusions have been determined from the barley and flax experiments conducted at Morris in 1962 and 1963 and at Carman in 1961 and 1963.

A. Barley:

Yield Data-

1. The date of seeding contributes significantly to higher barley yield. Early seeding of barley is essential to obtain maximum returns.

2. Land culture influences barley yield. Summerfallow yields of barley are significantly higher than yields obtained on stubble culture.

3. The application of fertilizer has a beneficial effect on barley yield. The increase in yield will depend on the available nitrate and phosphate in the soil and therefore a soil analysis for these nutrients is necessary prior to determining the rate and kind of fertilizer that should be applied at seeding time. The response of barley to fertilizer in these tests was relatively low because of a high available nitrate and phosphate content at both locations.

4. Barley varieties react differently in yield from year to year at locations within a crop testing zone. Consequently, it is necessary to carry out a variety testing program for more than 1 year and preferably at more than 1 location within a zone before

satisfactory data may be obtained on the performance of a variety.

5. Barley yield tests may be carried out on either summerfallow or stubble culture since an interaction of Variety x Culture was not obtained at either location in any test year.

Protein data-

1. The fertilizer rates used in the experiments did not appreciably increase protein content in barley.

2. Protein content was not consistently influenced by date of seeding, land culture or variety sown.

B. Flax:

1. In this experiment, the dates of seeding used did not appreciably influence flax yields at either location.

2. The yield of flax is influenced by seed bed preparation, weed control and the choice of variety. Where management practices are satisfactory equivalent or higher yields may be obtained on stubble as compared to summerfallow culture.

3. The application of fertilizer significantly increased flax yields at Morris in 1962 and 1963. However, the magnitude of the increase was not sufficiently large to warrant fertilizer application.

4. Since Variety x Culture interactions were not obtained in these experiments, it may be concluded that for purposes of variety recommendations, testing may be carried out on either stubble or summerfallow.

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APPENDICES

APPENDIX 1

Plot yields in grams and mean yields in bushels per acre of barley grown on stubble at Carman in 1961.

Variety	Date	Fert. T'ment	Plot yields in grams Replicate 1	2	3	4	Mean Yield Bus./A.
Husky	Early	Fert.	350	350	430	230	41.2
		Check	345	80	360	320	33.5
	Late	Fert.	310	220	360	280	35.5
		Check	285	290	260	255	38.0
Herta	Early	Fert.	385	140	170	485	35.7
		Check	260	405	320	395	41.8
	Late	Fert.	240	190	255	220	27.4
		Check	170	215	310	215	27.6
Traill	Early	Fert.	180	335	365	280	35.1
		Check	305	95	310	380	33.0
	Late	Fert.	310	215	315	225	32.3
		Check	300	245	290	270	33.5
Parkland	Early	Fert.	190	255	255	295	30.3
		Check	185	265	210	210	26.4
	Late	Fert.	285	65	195	190	22.3
		Check	285	210	175	205	26.5

APPENDIX 2

Plot yields in grams and mean yields in bushels per acre of barley grown on summerfallow at Carman in 1961.

Variety	Date	T'ment	Plot yields in grams Replicate 1	2	3	4	Mean Yield Bus./A.
Husky	Early	Fert.	410	375	325	350	44.2
		Check	295	470	510	370	49.8
	Late	Fert.	315	425	350	430	46.1
		Check	235	410	375	315	40.5
Herta	Early	Fert.	330	390	415	245	41.8
		Check	430	335	415	340	46.1
	Late	Fert.	430	315	370	385	45.5
		Check	390	360	370	365	45.0
Traill	Early	Fert.	385	410	380	270	43.8
		Check	400	370	400	400	47.6
	Late	Fert.	520	470	410	340	52.7
		Check	440	375	465	355	49.5
Parkland	Early	Fert.	425	325	350	245	40.8
		Check	315	410	340	365	43.3
	Late	Fert.	395	335	335	305	41.5
		Check	455	390	365	360	47.6

APPENDIX 3

Plot yields in grams and mean yields in bushels per acre of barley grown at Morris in 1962.

Variety	Culture	Fert. T'ment	Plot yields in grams Replicate 1	2	3	4	Mean Yield Bus./A.
Husky	Stubble	Fert.	516	462	418	382	53.9
		Check	340	337	237	226	34.5
	Summer-fallow	Fert.	650	494	444	369	59.3
		Check	498	578	443	446	59.5
Herta	Stubble	Fert.	470	358	357	282	44.4
		Check	274	290	240	206	30.6
	Summer-fallow	Fert.	584	614	310	575	68.1
		Check	678	329	341	498	55.9
Traill	Stubble	Fert.	455	390	315	523	51.0
		Check	334	471	406	318	46.3
	Summer-fallow	Fert.	672	423	599	573	68.7
		Check	644	653	562	512	71.8
Parkland	Stubble	Fert.	413	250	321	389	41.6
		Check	350	461	351	282	43.7
	Summer-fallow	Fert.	657	661	435	564	70.2
		Check	770	392	414	397	59.8

APPENDIX 4

Plot yields in grams and mean yields in bushels per acre of barley grown at Carman in 1963.

Variety	Cult.	Date	Fert. T'ment	Plot yields in grams Replicate 1	2	3	4	Mean Yield Bus./A.
Husky	St.[1]	Early	Fert.	222	195	143	242	24.3
			Check	124	137	166	176	18.3
		Late	Fert.	51	27	36	30	4.4
			Check	60	21	35	20	4.1
	Fa.[2]	Early	Fert.	168	220	199	161	22.7
			Check	153	215	106	149	18.9
		Late	Fert.	47	22	22	38	3.9
			Check	65	9	28	29	4.0
Herta	St.	Early	Fert.	329	262	246	283	33.9
			Check	240	201	224	306	29.4
		Late	Fert.	97	93	108	54	10.7
			Check	146	60	76	36	9.6
	Fa.	Early	Fert.	350	362	335	342	42.1
			Check	109	308	322	316	32.0
		Late	Fert.	133	56	67	30	8.7
			Check	89	60	85	71	9.2
Traill	St.	Early	Fert.	270	259	196	205	28.2
			Check	167	224	191	252	25.3
		Late	Fert.	112	36	59	43	7.6
			Check	68	35	40	22	5.0
	Fa.	Early	Fert.	210	273	204	248	28.3
			Check	190	211	202	170	23.4
		Late	Fert.	69	58	48	61	7.1
			Check	56	54	45	36	5.8
Parkland	St.	Early	Fert.	247	249	178	260	28.3
			Check	143	145	96	183	17.2
		Late	Fert.	90	47	33	23	5.8
			Check	95	25	23	27	5.1
	Fa.	Early	Fert.	222	281	145	222	26.4
			Check	115	150	171	180	18.7
		Late	Fert.	112	42	45	62	7.9
			Check	54	39	32	56	5.5

1. Stubble
2. Summerfallow

APPENDIX 5

Plot yields in grams and mean yields in bushels per acre of barley grown at Morris in 1963.

Variety	Cult.	Date	Fert. T'ment	Plot yields in grams Replicate 1	2	3	4	Mean Yield Bus./A.
Husky	St.[1]	Early	Fert.	372	318	339	262	39.1
			Check	333	338	408	332	42.7
		Late	Fert.	295	287	300	233	33.8
			Check	245	230	250	241	29.3
	Fa.[2]	Early	Fert.	533	447	525	383	57.2
			Check	463	350	440	292	46.8
		Late	Fert.	250	350	269	251	33.9
			Check	305	269	283	247	33.4
Herta	St.	Early	Fert.	370	416	370	461	49.0
			Check	365	350	340	340	42.3
		Late	Fert.	230	477	410	333	43.9
			Check	323	472	289	312	42.3
	Fa.	Early	Fert.	573	576	562	480	66.4
			Check	453	535	650	411	62.1
		Late	Fert.	427	347	371	389	46.5
			Check	373	438	353	372	46.5
Traill	St.	Early	Fert.	381	345	411	346	44.9
			Check	308	393	290	493	45.0
		Late	Fert.	304	331	284	205	34.1
			Check	266	356	332	251	36.5
	Fa.	Early	Fert.	461	492	480	518	59.1
			Check	501	310	507	386	51.6
		Late	Fert.	400	280	369	372	43.1
			Check	386	359	260	393	43.4
Parkland	St.	Early	Fert.	420	471	438	386	52.0
			Check	490	310	385	371	47.1
		Late	Fert.	298	360	429	337	43.1
			Check	345	382	355	325	42.6
	Fa.	Early	Fert.	553	450	404	582	60.3
			Check	471	414	366	336	48.1
		Late	Fert.	424	390	365	270	43.9
			Check	355	329	360	327	41.5

1. Stubble
2. Summerfallow

APPENDIX 6

Nitrate nitrogen in pounds per acre* at Morris and Carman.

Year	Location	Crop	Culture	Replication 1	2	3	4	Average Available Nitrate per Acre
1962	Morris	Barley and Flax	Summerfallow	133.8	71.3	107.6	101.5	103.55
			Stubble	97.6	53.0	89.8	82.8	80.80
1963	Morris	Barley	Summerfallow	540.2	178.2	202.2	360.6	320.3
			Stubble	174.4	109.1	150.1	82.0	128.9
		Flax	Summerfallow	333.2	328.8	252.8	157.3	268.0
			Stubble	288.5	159.3	152.5	59.5	164.9
1963	Carman	Barley	Summerfallow	113.7	150.4	209.9	209.5	170.9
			Stubble	90.0	73.6	41.6	266.1	117.8
		Flax	Summerfallow	92.9	127.7	166.0	209.5	149.0
			Stubble	81.7	49.3	125.4	195.6	113.0

* Average of sample depths:
0 - 6 inches
6 - 12 inches
12 - 24 inches
24 - 36 inches
36 - 48 inches

APPENDIX 7

Available phosphate in pounds per acre at Carman and Morris.

Year	Location	Crop	Culture	Sample Depth	Replication 1	2	3	4	Average Posphate per Acre
1961	Carman	Flax	Summerfallow	0- 6"	32.18	29.98	52.64	29.98	36.2
				6-12"	11.70	6.10	27.62	6.10	12.9
		Barley	Stubble	0- 6"	79.18*	23.64	33.66	33.04	42.4
				6-12"	55.74*	4.30	15.16	7.56	20.7
1962	Morris	Flax and Barley	Summerfallow	0-12"	38.2	36.7	50.4	20.9	36.5
			Stubble	0-12"	48.4	24.6	29.1	48.4	37.6
1963	Morris	Barley	Summerfallow	0- 6"	35.6	35.6	34.6	37.8	35.9
			Stubble	6-12"	51.2	34.1	34.6	49.8	42.4
		Flax	Summerfallow	0- 6"	30.4	44.0	24.2	30.8	32.3
			Stubble	6-12"	41.6	31.8	21.0	21.4	28.9
1963	Carman	Barley	Summerfallow	0- 6"	18.8	16.2	27.6	37.8	28.9
			Stubble	6-12"	27.2	24.6	22.2	36.2	27.5
		Flax	Summerfallow	0- 6"	5.8	4.0	31.2	33.6	18.6
			Stubble	6-12"	17.6	17.0	10.6	16.2	15.3

* Soil analysis is extremely high.

APPENDIX 8

Percent protein in barley
grown under varying management treatments at Morris in 1962.

Variety	Culture	Fert. T'ment	Yield of Protein in Percent Replicate 1	2	3	4	Mean
Husky	Stubble	Fert.	13.0	13.6	13.8	12.0	13.1
		Check	12.8	13.9	14.2	13.7	13.6
	Summer-fallow	Fert.	14.1	13.7	12.6	14.3	13.7
		Check	12.1	13.8	13.3	13.4	13.1
Herta	Stubble	Fert.	14.6	14.6	13.6	14.1	14.2
		Check	13.0	13.5	14.5	13.2	13.5
	Summer-fallow	Fert.	13.6	14.0	14.7	13.6	14.0
		Check	12.7	12.1	12.9	13.2	12.7
Traill	Stubble	Fert.	13.1	13.0	14.1	12.9	13.3
		Check	12.2	12.7	13.6	12.7	12.8
	Summer-fallow	Fert.	13.0	14.0	12.9	12.8	13.2
		Check	12.8	11.6	13.6	13.9	13.0
Parkland	Stubble	Fert.	13.3	12.5	14.2	13.7	13.4
		Check	13.1	13.3	14.0	13.6	13.5
	Summer-fallow	Fert.	13.7	14.1	13.4	14.0	13.8
		Check	13.7	13.3	13.6	13.4	13.5

APPENDIX 9

Percent protein in barley
grown under varying management treatments at Carman in 1963.

Variety	Cult.	Date	Fert. T'ment	Yield of Protein in Percent Replicate 1	2	3	4	Mean
Husky	St.[1]	Early	Fert.	17.0	15.8	15.7	17.5	16.5
			Check	17.0	15.9	15.5	18.4	16.7
		Late	Fert.	18.0	16.6	17.1	19.4	17.8
			Check	18.9	17.6	18.1	19.2	18.4
	Fa.[2]	Early	Fert.	18.3	18.4	17.5	19.4	18.4
			Check	17.8	18.0	18.4	18.5	18.2
		Late	Fert.	20.5	19.5	20.0	19.7	19.9
			Check	20.0	21.6	20.2	19.7	20.4
Herta	St.	Early	Fert.	17.1	15.8	16.7	17.6	16.8
			Check	15.4	15.2	16.7	18.3	16.4
		Late	Fert.	17.0	16.1	17.2	19.9	17.5
			Check	17.0	16.8	16.6	17.6	17.0
	Fa.	Early	Fert.	18.0	17.0	17.3	18.5	17.7
			Check	19.0	17.1	16.8	17.4	17.6
		Late	Fert.	18.7	19.3	18.7	19.8	19.1
			Check	17.6	18.9	18.4	18.7	18.4
Traill	St.	Early	Fert.	16.2	16.6	16.4	16.4	16.4
			Check	15.4	16.6	14.5	16.7	15.8
		Late	Fert.	17.2	18.2	17.1	17.7	17.5
			Check	16.8	16.6	17.7	17.9	17.2
	Fa.	Early	Fert.	16.7	15.2	16.6	16.2	16.2
			Check	16.9	13.4	17.5	16.6	16.1
		Late	Fert.	18.3	16.6	19.2	18.5	18.1
			Check	18.4	17.9	18.9	18.1	18.3
Parkland	St.	Early	Fert.	15.3	15.5	14.3	16.7	15.4
			Check	14.9	14.5	14.6	16.2	15.0
		Late	Fert.	16.7	14.7	17.8	19.1	17.0
			Check	16.4	17.4	16.1	18.1	16.2
	Fa.	Early	Fert.	17.7	17.0	16.8	17.3	17.2
			Check	17.3	16.8	16.6	17.0	16.9
		Late	Fert.	18.9	17.7	19.5	19.2	18.6
			Check	18.4	18.4	18.1	19.3	18.5

1. Stubble
2. Summerfallow

APPENDIX 10

Percent protein in barley
grown under varying management treatments at Morris in 1963.

Variety	Cult.	Date	Fert. T'ment	Yield of Protein in Percent Replicate 1	2	3	4	Mean
Husky	St.[1]	Early	Fert.	16.4	15.6	16.4	16.9	16.3
			Check	14.1	15.4	15.5	16.2	15.3
		Late	Fert.	16.4	16.5	16.1	15.9	16.2
			Check	15.8	16.2	15.7	16.1	15.9
	Fa.[2]	Early	Fert.	15.9	16.5	15.7	16.3	16.1
			Check	15.6	16.0	15.0	15.2	15.4
		Late	Fert.	16.5	15.1	15.8	16.3	15.9
			Check	16.6	14.5	16.1	15.4	15.6
Herta	St.	Early	Fert.	16.5	16.0	16.9	14.3	15.9
			Check	16.1	16.6	15.6	15.4	15.9
		Late	Fert.	18.1	14.6	15.8	15.0	15.9
			Check	15.9	15.3	15.9	15.2	15.6
	Fa.	Early	Fert.	16.0	15.4	15.7	15.2	15.6
			Check	14.6	14.7	14.2	15.0	14.6
		Late	Fert.	15.4	15.2	15.5	15.0	15.3
			Check	15.9	15.6	15.3	15.2	15.5
Traill	St.	Early	Fert.	15.7	15.5	14.5	16.1	15.4
			Check	16.0	14.9	15.0	15.7	15.4
		Late	Fert.	16.4	15.4	14.7	15.8	15.6
			Check	14.8	15.3	15.7	13.3	14.8
	Fa.	Early	Fert.	14.8	14.9	15.2	15.4	15.1
			Check	15.0	14.9	14.2	15.0	14.8
		Late	Fert.	15.1	15.6	14.7	15.3	15.2
			Check	14.6	15.8	15.0	15.2	15.1
Parkland	St.	Early	Fert.	16.0	14.6	15.4	15.2	15.3
			Check	15.1	14.7	14.0	15.6	14.8
		Late	Fert.	15.0	14.8	14.7	15.0	14.9
			Check	14.4	14.0	14.9	14.4	14.4
	Fa.	Early	Fert.	15.3	14.7	14.7	15.1	14.9
			Check	14.9	14.7	14.6	14.7	14.7
		Late	Fert.	14.8	14.7	15.7	15.0	15.0
			Check	15.0	14.5	14.5	15.3	14.8

1. Stubble
2. Summerfallow

APPENDIX 11

Influence of land culture and fertilizer application on 1000 kernel weight (in grams) and weight per measured bushel (in pounds) of 4 barley varieties at Morris in 1962 and 1963.

Variety			Husky		Herta		Traill		Parkland		Mean	Mean
Cult.	Date	Fert. T'ment	K/wt.	Bus. wt.	K/wt.	Bus. wt.	K/wt.	Bus. wt.	K/wt.	Bus. wt.	K/wt.	Bus. wt.
Morris 1962												
St.[1]		Fert.	26.8	44.0	31.6	48.2	32.0	48.5	28.8	44.2	29.8	46.2
		Check	27.8	42.2	31.1	46.0	31.0	48.2	28.0	44.7	29.4	45.2
Fa.[2]		Fert.	27.3	46.0	32.7	50.5	30.6	51.0	28.3	48.5	29.7	49.0
		Check	28.1	45.5	34.0	51.0	31.6	50.2	27.9	46.5	30.4	48.3
Morris 1963												
St.	Early	Fert.	26.0	41.5	32.5	50.0	29.0	48.0	29.5	45.0	29.2	46.1
		Check	25.0	41.5	33.0	49.0	29.0	45.0	27.5	43.5	28.6	44.7
	Late	Fert.	21.5	37.5	29.5	49.5	25.0	43.5	23.5	42.0	24.9	43.0
		Check	21.0	36.5	29.0	49.5	27.0	44.0	27.8	42.0	26.2	43.0
Fa.	Early	Fert.	26.5	42.0	29.0	50.0	28.5	46.0	30.0	45.0	28.5	46.0
		Check	24.0	42.0	31.0	50.5	27.5	46.0	28.5	43.0	27.7	45.4
	Late	Fert.	19.5	36.0	25.5	47.5	24.0	42.0	26.0	42.0	23.7	41.9
		Check	19.5	36.0	27.0	48.0	24.0	43.5	22.5	41.0	23.2	42.1

1. Stubble
2. Summerfallow

APPENDIX 12

Influence of land culture, date of seeding and fertilizer application on 1000 kernel weight (in grams) and weight per measured bushel (in pounds) of 4 barley varieties at Carman in 1963.

Variety			Husky		Herta		Traill		Parkland		Mean	Mean
Cult.	Date	Fert. T'ment	K/wt.	Bus. wt.	K/wt.	Bus. wt.	K/wt.	Bus. wt.	K/wt.	Bus. wt.	K/wt.	Bus. wt.
St.[1]	Early	Fert.	24.5	38.0	34.0	49.5	27.5	43.5	23.5	37.0	27.4	42.0
		Check	24.0	38.0	32.5	49.0	26.5	45.0	23.5	37.0	26.6	42.2
	Late	Fert.	24.5	37.0	32.5	49.0	24.5	43.2	23.0	39.0	26.1	42.0
		Check	22.5	39.0	32.5	49.0	24.5	42.0	22.0	38.0	25.4	42.0
Fa.[2]	Early	Fert.	24.5	39.0	33.0	49.0	27.0	43.5	24.0	37.0	27.1	42.1
		Check	24.5	38.0	33.5	50.0	26.0	44.0	24.5	41.0	27.1	43.2
	Late	Fert.	22.0	38.0	31.5	49.0	26.5	43.0	22.5	39.5	25.6	42.3
		Check	23.0	38.0	31.5	50.0	24.5	42.0	22.5	37.0	25.4	41.7

1. Stubble
2. Summerfallow

APPENDIX 13

Plot yields in grams and mean yields in bushels per acre of flax grown on stubble at Carman in 1961.

Variety	Date	Fert. T'ment	Plot yields in grams Replicate 1	2	3	4	Mean Yield Bus./A.
Redwood	Early	Fert.	45	50	60	45	5.2
		Check	65	90	70	85	8.1
	Late	Fert.	10	10	10	15	1.2
		Check	10	10	15	5	1.0
Raja	Early	Fert.	60	75	80	70	7.4
		Check	90	50	105	100	9.0
	Late	Fert.	40	40	25	15	3.1
		Check	20	20	65	20	3.2
Arny	Early	Fert.	60	45	150	80	8.7
		Check	80	105	85	115	10.0
	Late	Fert.	15	20	20	20	1.9
		Check	20	50	25	15	2.9
Marine	Early	Fert.	105	70	90	45	8.1
		Check	55	105	80	40	7.3
	Late	Fert.	30	30	25	5	2.3
		Check	40	25	65	15	3.8

APPENDIX 14

Plot yields in grams and mean yields in bushels per acre of flax grown on summerfallow at Carman in 1961.

Variety	Date	Fert. T'ment	Plot yields in grams Replicate 1	2	3	4	Mean Yield Bus./A.
Redwood	Early	Fert.	90	110	165	115	12.5
		Check	130	80	150	85	11.6
	Late	Fert.	80	70	55	55	6.8
		Check	75	75	65	55	7.0
Raja	Early	Fert.	70	70	60	60	6.8
		Check	100	80	105	135	10.9
	Late	Fert.	95	145	120	110	12.2
		Check	100	90	100	85	9.7
Arny	Early	Fert.	90	80	100	95	9.5
		Check	75	85	85	115	9.4
	Late	Fert	70	100	95	110	9.7
		Check	95	110	80	110	10.3
Marine	Early	Fert.	115	45	105	80	9.0
		Check	100	55	135	80	9.6
	Late	Fert.	115	105	85	60	9.5
		Check	100	110	105	105	10.9

APPENDIX 15

Plot yields in grams and mean yields in bushels per acre of flax grown at Morris in 1962.

Variety	Culture	Fert. T'ment	Plot yields in grams Replicate 1	2	3	4	Mean Yield Bus./A.
Redwood	Stubble	Fert.	170	221	172	162	18.8
		Check	156	160	170	135	16.1
	Summer-fallow	Fert.	214	212	253	237	23.8
		Check	157	226	156	190	18.9
Raja	Stubble	Fert.	208	219	178	132	19.1
		Check	135	174	180	126	16.0
	Summer-fallow	Fert.	244	256	207	226	24.2
		Check	194	278	237	232	24.4
Arny	Stubble	Fert.	175	217	173	152	18.6
		Check	118	209	144	107	15.0
	Summer-fallow	Fert.	191	239	200	179	21.0
		Check	176	264	148	187	20.1
Marine	Stubble	Fert.	153	160	149	161	16.2
		Check	115	147	159	147	14.7
	Summer-fallow	Fert.	215	201	272	205	23.2
		Check	200	194	220	223	21.7

APPENDIX 16

Plot yields in grams and mean yields in bushels per acre of flax grown at Carman in 1963.

Variety	Cult.	Date	Fert. T'ment	Plot yields in grams Replicate 1	2	3	4	Mean Yield Bus./A.
Redwood	St.[1]	Early	Fert.	122	133	137	81	12.3
			Check	108	113	123	152	12.9
		Late	Fert.	126	171	136	168	15.6
			Check	139	135	136	184	15.4
	Fa.[2]	Early	Fert.	112	106	104	121	11.5
			Check	88	93	135	95	10.7
		Late	Fert.	107	138	116	87	11.6
			Check	127	148	131	136	14.1
Raja	St.	Early	Fert.	119	101	87	81	10.1
			Check	110	86	112	88	10.3
		Late	Fert.	152	145	105	166	14.7
			Check	137	126	130	143	13.9
	Fa.	Early	Fert.	98	142	113	60	10.7
			Check	82	100	115	96	10.2
		Late	Fert.	45	63	118	31	6.7
			Check	101	152	128	114	12.9
Arny	St.	Early	Fert.	162	160	135	49	13.1
			Check	143	128	148	111	13.8
		Late	Fert.	85	95	107	151	11.4
			Check	127	114	108	107	11.9
	Fa.	Early	Fert.	67	133	122	60	9.9
			Check	121	111	129	127	12.7
		Late	Fert.	123	114	119	70	11.1
			Check	119	116	106	108	11.7
Marine	St.	Early	Fert.	133	135	137	48	11.8
			Check	136	103	148	118	13.1
		Late	Fert.	78	110	122	109	10.9
			Check	104	98	120	87	10.6
	Fa.	Early	Fert.	157	91	118	53	10.9
			Check	120	131	168	113	13.8
		Late	Fert.	80	75	109	158	11.0
			Check	112	74	106	111	10.5

1. Stubble
2. Summerfallow

APPENDIX 17

Plot yields in grams and mean yields in bushels per acre of flax grown at Morris in 1963.

Variety	Cult.	Date	Fert. T'ment	Plot yields in grams Replicate 1	2	3	4	Mean Yield Bus./A
Redwood	St.[1]	Early	Fert.	161	188	58	145	14.3
			Check	61	178	145	166	14.3
		Late	Fert.	104	115	114	126	11.9
			Check	121	82	120	131	11.8
	Fa.[2]	Early	Fert.	157	126	110	78	12.2
			Check	70	129	67	81	9.0
		Late	Fert.	155	41	105	90	10.2
			Check	83	135	90	88	10.3
Raja	St.	Early	Fert.	106	154	140	111	13.3
			Check	158	166	102	122	14.2
		Late	Fert.	108	107	121	79	11.4
			Check	99	102	115	136	11.7
	Fa.	Early	Fert.	103	171	90	143	13.2
			Check	50	114	50	105	8.3
		Late	Fert.	136	123	120	92	12.2
			Check	118	92	99	60	9.6
Arny	St.	Early	Fert.	167	178	58	138	14.0
			Check	154	150	149	172	16.2
		Late	Fert.	90	70	101	126	10.0
			Check	92	107	83	23	7.9
	Fa.	Early	Fert.	65	165	129	114	12.3
			Check	112	131	83	71	10.3
		Late	Fert.	165	121	93	59	11.4
			Check	94	113	119	69	10.3
Marine	St.	Early	Fert.	145	168	125	154	15.4
			Check	182	150	174	142	16.8
		Late	Fert.	114	120	147	96	12.4
			Check	132	54	143	83	10.7
	Fa.	Early	Fert.	104	126	126	59	10.8
			Check	98	102	69	37	7.9
		Late	Fert.	116	142	113	105	12.4
			Check	113	110	99	39	9.4

1. Stubble
2. Summerfallow