COMPETITION OF WILD OATS (AVENA FATUA L.) WITH WHEAT AND FLAX

by

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A Thesis

Submitted to the Faculty of Graduate

Studies and Research in Partial

Fulfilment of the Requirements for

the degree of

Master of Science

THE UNIVERSITY OF MANITOBA

April, 1966

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ACKNOWLEDGEMENTS

The author wishes to express his appreciation to Monsanto Chemical Company, who made this study possible.

Grateful acknowledgement is extended to: Dr. G. Friesen, Department of Plant Science for his continual guidance and assistance; Dr. L. J. La Croix, Department of Plant Science and Dr. F. P. Ralston, Department of Botany, for reading and making helpful suggestions in the manuscript.

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INTRODUCTION

The presence of a number of plant species in a common area is commonly characterized by a condition detrimental to the welfare of one, several or all species concerned. This adverse condition occurs whenever these species must compete for the common requirements of moisture, mineral nutrients and light. These three basic requirements of plant growth are seldom available in proportions adequate for maximum crop production. If any one of these basic requirements is present in only limited supply due to weeds, then weed competition is active. Weed competition in agricultural crops is very difficult to control. A major difficulty in weed control practices, is that the weeds are generally more adaptable to environment than the crop plants. Weedy plants possess ecological adaptations which enable them to grow, survive and sometimes flourish in the same habitat as the crop, in spite of a sequence of agronomic practices designed to favour crop establishment and growth. The extent to which weeds succeed at the expense of the crop is reflected in the crop yield reductions which are the subject of this study.

Although weed competition probably dates back to the birth of agriculture itself, even in recent years little basic research has been devoted to a better understanding of weed-crop competition. Little is known of the biological interactions of the crop we wish to grow and the weeds we wish to destroy, this is a contributing factor to the weed problem. Accurate information about the biological capabilities, or more simply about the growth characteristics and habitat requirements of crops and weeds, is essential to ultimate success in growing the one and eliminating the other. Such research must be concerned with the habitat requirements and responses of the plants individually, and with the patterns of competition which developes in weed infested crops.

Wild oats was selected as the weed species for these studies, because little research has been reported on this weed and also because of the economic importance of wild oats to western Canadian agriculture. The purpose of this study was to: (a) determine the effect of various arithmetic proportioned densities of wild oats on the yield of flax and wheat, (b) study the effect of soil fertility on wild oat competition with wheat and flax, (c) determine information on the growth stages of wheat and flax when competition from wild oats begins to occur and (d) determine the effect of seeding date on the competitive efficiency of wild oats.

REVIEW OF LITERATURE

The literature dealing with competition of weeds and cereals might be grouped into two categories: (a) absolute competitive effects between weed species and cereal crops, (b) physical and biochemical factors responsible for plant competition.

Pavlychenko (38) defined plant competition as a natural force whereby each living organism tends to obtain maximum advantages at the expense of other living organisms occupying a common feeding area. Pavlychenko and Harrington (39, 41) were, perhaps the first workers to report on detailed competition studies between annual weeds and cereal crops. They found that a heavy infestation of wild mustard reduced the yield of Hannchen barley by 22.8 percent, that of Marquis wheat by 44.9 percent and that of Banner oats by 45.3 percent in comparison with a clean crop (39). Pavlychenko and Harrington (41) also carried out studies to determine the factors which cause the reductions in yields.

Clements et al (11), when studying plant competition and weed control, reported that a small advantage in root, culm or leaf improves the response and hence the chances for success of a parent plant. An advantage in root, culm or leaf also encourages the production of tillers, which are potential individuals and constitute what is virtually a reinforcement. Important features conditioning success in competition are duration of the plant, rate of top and root growth, rate and amount of germination and vigor and hardiness of the plant.

According to Blackman and Templeman (3), Pavlychenko and Harrington (41) and Welbank (51) species of plants differ in their ability to compete for the essential growth elements. Pavlychenko and Harrington (41) classified the competitive efficiencies of various weed species including wild oats, several varieties of wheat, oats and barley and one variety of rye and flax. They made comparisons of the amount of assimilation surface, number of stomata per square centimeter of leaf surface, and the extensiveness of the root system at periods of 5 and 21 days after emergence. With respect to top growth they classified barley as the best competitor of the cereals followed by rye, wheat, oats and flax. They reported that the cereals had greater assimilation surfaces, number of stomata and length of root system than the weeds (except wild mustard) at 5 days after emergence. At 21 days the situation was reversed, as the weeds then had the larger assimilation surface, more stomata and a longer root system. Pavlychenko and Harrington (41) concluded: (a) the advantage cereals have over weeds at 5 days after emergence is of extreme importance, (b) wild oats, wild mustard and stinkweed are very serious weeds and (c) the competitive efficiencies of the cereals was in the order of barley, spring rye, wheat, oats and flax.

Pavlychenko and Harrington (41) further reported that weed seeds require moist conditions for germination. In a dry spring therefore cereals would have a definite advantage over weeds. Friesen and Shebeski (16) also reported that wild oats require a soil temperature of 70 degrees fahrenheit for good germination, giving crops with lower temperature requirements an advantage during cool spring seasons.

A great deal of work has been done on competition of other weed species and general aspects of competition.

Clements et al (11) found that physical factors such as light, moisture, and nutrients are the controlling mechanisms of competition. They stated that, of the physical factors affecting competition, water is paramount, light next and nutrients third in importance. With field crops the problem is centered upon the relative merits of species and varieties in terms of competitive adaptation to seasonal and annual cycles. Korsmo (29) concluded in competition studies carried out in Norway, that competition between weeds and crops was mainly for water and soil nutrients. Blackman and Templeman (3) in data collected from 1932-1935 found variability in yields from year to year, possibly due to seasonal differences. They reported that the presence of weeds had a greater depressing effect on the yield of a cereal crop in a wet spring than in a dry spring, as weed seeds do not germinate well in a wet year. Their experiments indicated that competition between weeds and crops were for soil nutrients. They concluded that other factors such as competition for light and water were also involved, with competition for light depending on the weed species and on the density of the weed infestation.

Pavlychenko and Harrington (40) found in the prairie portion of western Canada, where light is generally plentiful and soil fertility is high or may be corrected, that water is usually the limiting factor. Following an investigation into the water requirements of crops in western Canada, Barnes and Hopkins (2) concluded that a crop is able to utilize as much water as it can secure.

Blackman and Templeman (3) in competition studies found that the presence of weeds depressed the nitrogen and potassium contents of the cereal, bud did not affect the phosphorous content. Additional nitrogen fertilizer raised the nitrogen and potassium contents. They also found that the application of nitrogen fertilizer increased tillering and yield of barley growing in competition with wild mustard. They concluded that the response of a weedy crop to nitrogen fertilizer is dependent upon the relative amounts taken up by the weeds and crop, also the critical period is confined to the early stages of development of the cereal. They also found that by increasing nitrogen supply one could bring the yield of a weedy crop up to the level of a clean unfertilized crop. Gregory

(24) and Brenchley (5) also found that nitrogen, potassium and phosphorous are taken up most actively during early stages of growth of the cereal.

Nakonshny and Friesen (36) in studies on the influence of fertilizer on weed competition with spring sown wheat found that losses due to weed competition in the fertilized plots were consistently lower than in adjacent unfertilized plots. Average loss was 4.8 bushels per acre, or 11.7 percent of total yield, in the fertilized plots as compared to an average loss of 6.6 bushels per acre or 20.5 percent of total yield in the unfertilized plots. They concluded that losses due to weed competition can be reduced considerably by the use of commercial fertilizers. McCurdy (34) reported on studies of the effect of crop competition on the number of wild oats in a barley crop. He found that a barley plot sown at 1½ bushels per acre and without fertilizer contained 48 wild oats per square yard while barley sown with fertilizer contained only 23 wild oats per square yard. Godel (21) and McNeil and Davis (35) similarly reported fertilizer reduced losses due to weed competition. Fertilizer will reduce losses due to weed competition, but the literature is not definite as to the relationship between various densities of a specific weed species and the response of crops to different soil fertility levels.

A number of cases have been reported of influences of higher plants upon one another, which cannot be attributed to competition for nutrients, water, light, etc. (43). In the case of such mutual effects, for which products of plant metabolism might be held responsible the term "allelopathy" has been used. The liberation of organic compounds from roots of higher plants has been shown, as for example the liberation of scopoletin from the roots of oat seedlings (31). Under certain conditions scopoletin is readily liberated from living root cells. These workers also found that Papaver rhoes was more inhibited by oats than rye. Also there was an inhibition effect of rye and oats on Sinapis arvensis. Potato and flax were strongly depressed when grown together with Polygonum persicaria. Research workers have studied the influence exerted by species of Camelina on flax by means of toxic substances (25), other studies have been made on toxin production from Agropyron repens (52).

Several workers have found that weeds reduce tillering of cereals (3, 7, 21, 22). Carter et al (10) found in the case of wheat, that tillering and yield were reduced in proportion to the density of weeds. Similarly Burrows and Olson (7), in work with wild mustard and wheat, found increased density of wild mustard resulted in a reduction of tillering and yield of wheat. Different weed species have varied competitive efficiency and similarly reduce tillering and yields in cereals by various amounts (41). It is therefore very evident that weeds have adverse effects on cereals by reducing the number of tillers per plant, reducing yield and bushel weight, often protein content of wheat. Weeds may effect the iodine number in flax.

Numerous studies have been carried out on wild mustard in competition with cereals. Work at the Regina Experimental Farm indicated the effect of wild mustard competition (42). Their observations based on an average of nine years showed that wheat yield was reduced 15 percent when wild mustard constituted up to 20 percent of the vegetation, and 53 percent reduction in yield when mustard constituted up to 60 percent of the vegetation present.

Burrows and Olson (7, 8) found in competition studies between wild mustard and flax and wheat, that 10 wild mustard plants per square yard were sufficient to significantly reduce the yield of flax, and 50 wild mustard plants per square yard would reduce significantly the yield of wheat. In flax 25, 50 and 100 wild mustard plants per square yard reduced yields by 2.1, 2.7 and 4.0 bushels per acre respectively. The identical wild mustard densities in wheat reduced yields by 2.6, 5.4 and 12.0 bushels an acre respectively. Burrows and Olson (7, 8) also investigated the effect of time of removal on the competitive effects of wild mustard on wheat yields. Removal with 2, 4-D of 200 wild mustard plants per square yard at 19 days after emergence resulted in a 5.8 bushel per acre loss in yield, while removal at 29 days produced a 8.4 bushel per acre reduction in yield. In treatments where the mustard plants were not treated until 35 days after emergence a yield reduction of 28.9 bushels per acre occurred.

Friesen, Shebeski and Robinson (18) found that reductions in yield resulting from weed competition are generally accompanied by reductions in protein content of the harvested grain. Burrows and Olson (7) showed a similar reduction in protein as weed competition increased. Friesen and Nakonshny (36) reported that increases in crop yield, as a result of fertilizer treatment were sometimes associated with decreases in the protein content of harvested grain. They also state that these reductions in protein content could be offset, to a certain extent, by weed control. Other research workers found that increases in yield from use of fertilizer does not increase the protein content of the cereal (26, 28, 35).

Considerable work has been done on competition between weeds and vegetable or special crops. Staniforth and Weber (50) found that where weeds were present for the entire season yield reductions averaged 3.7

bushels per acre or approximately 10 percent of yields of weed-free soybeans. Staniforth (46) also reported on weed competition in corn. When weeds were removed six weeks after corn planting, 15.3 bushels per acre or 13.7 percent was lost, if weeds were removed at the time of corn tasselling, 26.7 bushels per acre or 24 percent of the total corn yield was lost. He concluded that competition must be controlled early in the growing season in order to reduce losses due to weeds. Numerous experiments have been carried out on weed competition with crops such as corn, sugar beets, soybeans and beans, demonstrating losses due to weed competition (4, 6, 12, 30, 33, 47).

Only a very limited amount of research has been reported on the competitive effects of wild oats on cereal crops and flax.

Pavlychenko and Harrington (39, 41) found that wild oats in competition with cereals will reduce tillering, dry weight of straw and yield. Pavlychenko's results showed that an infestation of 20 to 40 wild oats per square yard reduced yields in barley, the best competitor, by 16 percent, wheat by 33 percent and flax, which provides little or no competition, by 84 percent. These experiments are inadequate as Pavlychenko did not define specific wild oat densities.

Friesen and Shebeski (17) made a study of weed competition in Manitoba grain fields during 1956-1958. In their survey wild oats were found to be present in amounts exceeding 10 plants per square yard in over 43 percent of all fields surveyed. Also they found 36 wild oats per square yard would reduce wheat yields by 12.6 percent, while 416 wild oats per square yard along with 62 other weeds per square yard of various other weed species, would reduce wheat yield by 49.6 percent of total yield. They concluded that yield reductions due to weed competition were as high as 17.2 bushels per acre in wheat (50.6%), 9.7 bushels per acre in barley (61.5%), 18.6 bushels per acre in oats (25.5%) and 5.1 bushels per acre in flax (45.8%). The average loss of 15.25 percent of total yield for all crops was in agreement with previous estimates by Anderson (1) and Wood (54). The yield reductions reported by Friesen and Shebeski (17), due to wild oat competition, were not entirely accurate in that other weed species were also present in the experimental plots.

Introduction of wild oat herbicides in recent years has permitted the measurement of wild oat competition to some extent. Dryden (13) while doing wild oat pre-emergence herbicide studies, found that 71 wild oats per square yard would reduce the yields in barley by 11.4 bushels per acre. In 1961 Friesen (20) reported a loss of 16.2 bushels per acre in wheat with a wild oat density of 229 per square yard, with a density of 403 wild oats per square yard 33.5 bushels per acre were lost. Molberg (32) revealed 10 wild oats per square yard on summerfallow reduced the yield of barley by 2.1 bushels per acre. Gorby (23) working with a post-emergent herbicide reported 298 wild oat tillers per square yard reduced wheat yields from 8.1 to 21.6 bushels per acre. A great number of similar studies have been carried out in western Canada over the past six years and results indicate that wild oat competition causes severe losses in cereal crops, but may be offset by using pre-emergent and post-emergent herbicides (9, 14, 15, 20, 44, 49). In the experimental work mentioned above no consistent or definite wild oat populations were evaluated and often no mention is made of specific wild oat densities.

As mentioned previously little experimental work has been conducted on wild oat competition with cereal crops. No investigation has been made to determine the specific number of wild oats required to reduce yields, or the interrelationships between populations of wild oats and fertilizer treatments in yield reductions. Also an important aspect requiring investigation is the period or stage of growth at which competition from wild oats commences.

MATERIALS AND METHODS

Seven experiments were included in this study, three involving wheat and four involving flax, in each of the two years, 1964 and 1965. The experiments were conducted at the Glenlea Research Station on a heavy clay soil (Osborne Clay). Wheat and flax were selected because of their differences in competitive efficiencies and because of their economic value to Manitoba agriculture.

All experiments were of a simple factorial design replicated four times. Each plot was 6 feet wide by 16 feet long. Wild oats were broadcast by hand at two and one-half times the density required. By using this seeding rate it was found that they emerged at almost the required density, although some hand picking at emergence was necessary to obtain the exact density required. The soil was double disked prior to broadcasting and this operation was repeated immediately following broadcasting. Disking was followed by harrowing and packing. In 1964, irrigation was required for wild oat germination. Pembina wheat was sown at 75 pounds per acre with a 6 foot pony press drill, and Raja flax was seeded at 35 pounds per acre. The wheat and flax were sown so as to emerge at approximately the same time as the wild oats. All weed species with the exception of wild oats were removed as soon as they emerged. As the crops reached maturity a 3-foot by 10-foot swath from the center of each plot was harvested for yield determinations.

In the first experiment, the effect of various populations of wild oats were compared on fertilized and unfertilized spring sown wheat. The wild oat populations used were as follows: 0, 10, 40, 70, 100, 130, 160, 190 wild oats per square yard. One-half of the experiment was left unfertilized, the remaining half received 50 pounds of 11-48-0 fertilizer drilled in with the seed. The first experiment was conducted on land previously summerfallowed, while the second experiment was on stubble land, using 100 pounds of 16-20-0 fertilizer on one-half of the experiment. Harvested grain was analyzed for yield and percent protein content (27). The number of tillers per plant were determined prior to harvest.

A similar experiment, testing the effect of various populations of wild oats on flax, was done with similar densities, but no fertilizer treatments were involved. The flax experiments were conducted on both summerfallow and stubble land. The harvested seed was analyzed for yield and oil content (37, 45).

The effect of stage of wild oat growth at time of removal on wheat was also studied. In this experiment, each replicate was divided into four randomized blocks with densities of 0, 100, 200 and 300 wild oats per square yard constituting the main blocks. Each main block was subdivided into six randomized treatments each representing a different date of wild oat removal. In the first treatment, wild oats were removed with a pre-emergent herbicide (triallate), applied at 1¼ pounds per acre (active ingredient) and soil incorporated with a hand rake immediately after application. In all subsequent treatments the wild oats were hand picked at the prescribed stages (2 to 3 leaf stage, 4 to 5 leaf stage, 5 to 6 leaf stage and shot-blade stage). The final treatment represented a weedy check.

In 1965 barban, a post-emergence herbicide, was also included in the experiment. This herbicide was applied at the rate of 4 ounces (active ingredient) per acre at the one and one-half leaf stage of the wheat. Hand weeding, in 1965, was done at the 1 to 2, 2 to 3, 4 to 5 and 7 to 8 leaf stage. In addition to yields, the protein content of wheat was determined in these two experiments (27).

Similarly studies were made on the effects of various stages of wild oat removal on flax. In the flax studies densities were reduced to 0, 50, 100 and 150 wild oats per square yard. Treatments were identical to those in the wheat experiments with the exception that diallate at one and one-half pounds per acre was substituted for triallate. Wild oat removal at the one and a half leaf stage was accomplished with barban at the rate of 4 ounces per acre (active ingredient) in 1965. Hand weeding dates were similar to those described for wheat.

Experiments were also carried out to test the effect of wild oat competition on yield of flax when seeded at different dates. This test was divided into 4 blocks, each representing a different seeding date. In 1964, the flax was seeded as to emerge three days prior to wild oat emergence, three days after wild oat emergence, seven days after wild oat emergence and eleven days after wild oat emergence. The wild oat densities were 0, 50, 100 and 150 plants per square yard. In 1965 the seeding dates were as follows: flax emergence three days prior to wild oats, five days after wild oat emergence, ten days after wild oat emergence and fifteen days after wild oat emergence. Both experiments were conducted on summerfallow land.

Yield data in all experiments were subjected to statistical analysis according to methods outlined in Steel and Torrie (48). An analysis of variance followed by Duncan's multiple range test, was calculated for each experiment.

RESULTS AND DISCUSSION

I. Effect of Various Populations of Wild Oats on Spring Sown Wheat

A. Experiment located on summerfallow land

Data on the effects of various densities of wild oats on the yield, protein content and tillering of wheat is presented in Tables I and II. Data on wheat yield are also presented graphically in Figure 1. In 1964 only 10 wild oats per square yard were required to reduce wheat yields significantly where no fertilizer was used, while on plots with fertilizer, 40 wild oats per square yard were needed to significantly reduce wheat yields. It was observed from data in 1964 that fertilizer would offset yield reductions due to wild oat competition. Differences between fertilized and unfertilized plots are very slight on weed-free treatments, but differences increased as wild oat densities increased. At 100 wild oats per square yard, the difference in yield was significantly different between the fertilized and the unfertilized treatments. Similar yields were obtained with 40 wild oats per square yard in an unfertilized plot and 100 wild oats per square yard in a fertilized plot.

In 1965, 40 wild oats per square yard were required to reduce yields significantly in both fertilized and unfertilized plots. This may have been due to higher precipitation received in 1965 (Appendix 17). Differences between fertilized and unfertilized plots were not significant in 1965 until the density reached 130 wild oats per square yard. From these figures it would appear that higher precipitation may reduce wild oat competition at lower densities, but at densities of 130 to 190 wild oats per square yard, available moisture again became a limiting factor.

Percent protein in harvested wheat samples was not significantly affected by wild oats in both 1964 and 1965.

Wild oats reduced tillering in wheat almost in proportion to the wild oat density. A greater degree of tillering was observed in 1965 than in 1964, which was possibly due to more available moisture in 1965. This is in agreement with research workers who have reported crops grown on weedy land produced less tillers than those grown on weed-free land and it was shown in one case that the number of wheat culms produced per unit area decreased proportionately with increase in weed density (10, 21, 22).

TABLE I

The effect of various densities of wild oats on the yield, protein content and number of tillers of wheat grown on summerfallow, 1964

Wild oat density plants per square yard	Yield		Protein content of wheat		Tillers per 100 wheat plants	
	Fert.*	Unfert.	Fert.*	Unfert.	Fert.*	Unfert.
	bu/ac	bu/ac	%	%	No.	No.
0	27.8	27.5	15.8	15.6	354	325
10	25.6	22.1	15.9	16.0	295	240
40	21.4	17.6	16.0	16.1	251	204
70	16.3	14.3	16.5	16.5	185	160
100	18.3	11.2	16.1	16.2	190	125
130	14.4	12.5	16.2	16.2	135	131
160	11.7	11.6	16.4	16.9	110	108
190	13.3	10.9	16.5	16.6	129	110

* 50 pounds of 11-48-0

Duncan's multiple range table testing for significant differences of wheat yields

Wild oat density plants per square yard	Yield* bu/ac	
Fertilized		
0	27.8	a
10	25.6	a b
40	21.4	b c d
70	16.3	e f g
100	18.3	c d e
130	14.4	e f g h
160	11.7	g h
190	13.3	f g h
Unfertilized		
0	27.5	a
10	22.1	b c
40	17.6	d e f
70	14.3	e f g h
100	11.2	h
130	12.5	g h
160	11.6	h
190	10.9	h

Note:* Any yield values with the same letter are not significantly different at the 5% level.

TABLE II

The effect of various densities of wild oats on the yield, protein content and number of tillers of wheat grown on summerfallow, 1965

Wild oat density plants per square yard	Yield		Protein content of wheat		Tillers per 100 wheat plants	
	Fert.	Unfert.	Fert.*	Unfert.	Fert.*	Unfert.
	bu/ac	bu/ac	%	%	No.	No.
0	31.7	31.6	14.4	14.5	385	344
10	30.6	29.2	14.3	14.8	360	296
40	27.2	24.1	14.2	14.4	305	257
70	25.1	23.1	14.4	14.3	253	248
100	25.0	22.2	14.5	14.6	250	198
130	23.8	17.6	14.2	14.6	205	145
160	18.9	18.3	14.5	14.3	145	132
190	19.8	15.3	14.3	14.5	151	108

* 50 pounds of 11-48-0

Duncan's multiple range table testing for significant differences of wheat yields

Wild oat density plants per square yard	Yield* bu/ac	
Fertilized		
0	31.7	a
10	30.6	a b
40	27.2	b c
70	25.1	c d
100	25.0	c d
130	23.8	c d
160	18.9	e f g h
190	19.8	e f g
Unfertilized		
0	31.6	a
10	29.2	a b
40	24.1	c d
70	23.1	c d e
100	22.2	d e f
130	17.6	g h
160	18.3	f g h
190	15.3	h

Note:* Any yield values with the same letter are not significantly different at the 5% level

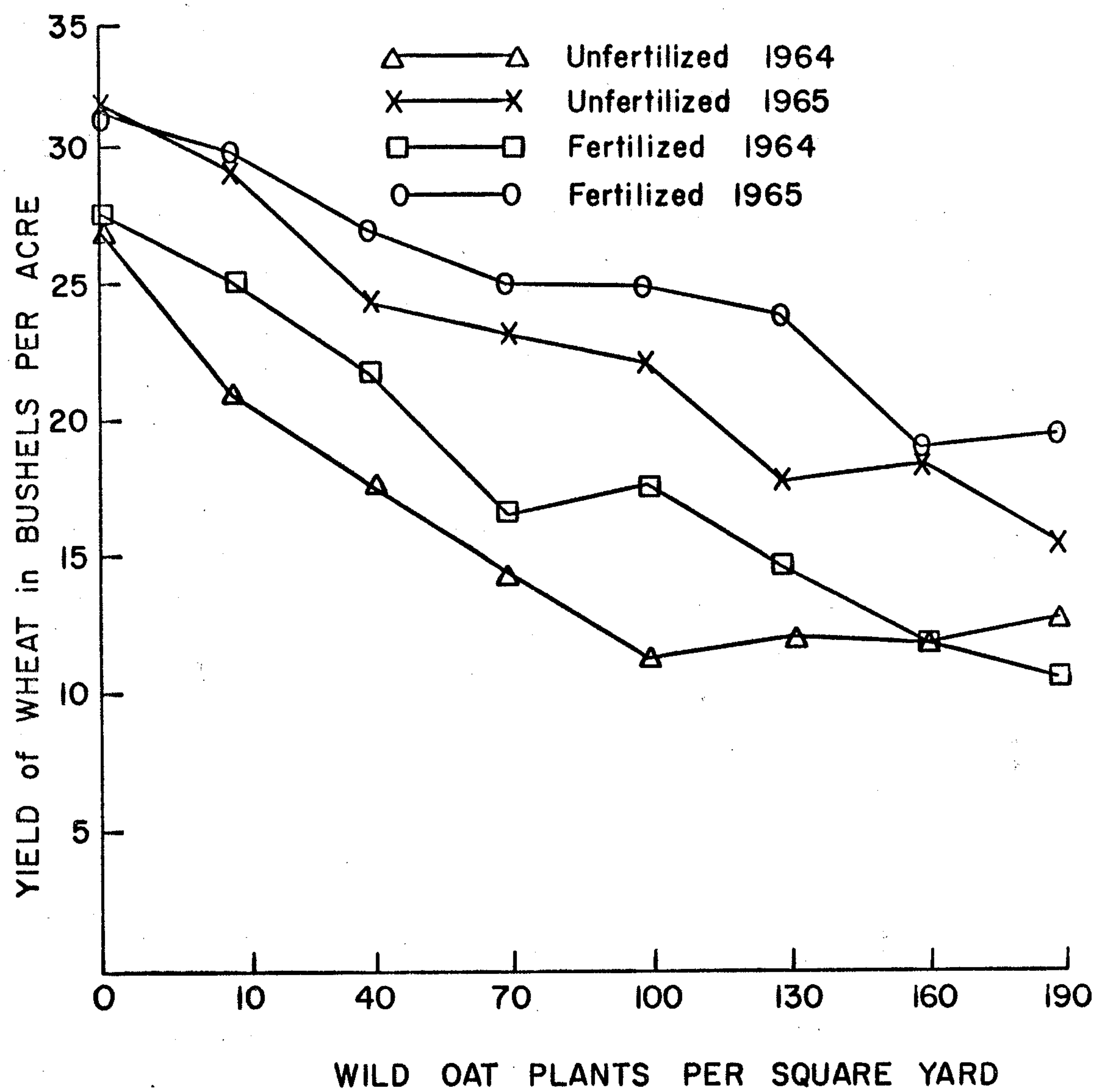

Figure I The Effect of Various Densities of Wild Oats on Spring Sown Wheat Grown on Summerfallow Land.

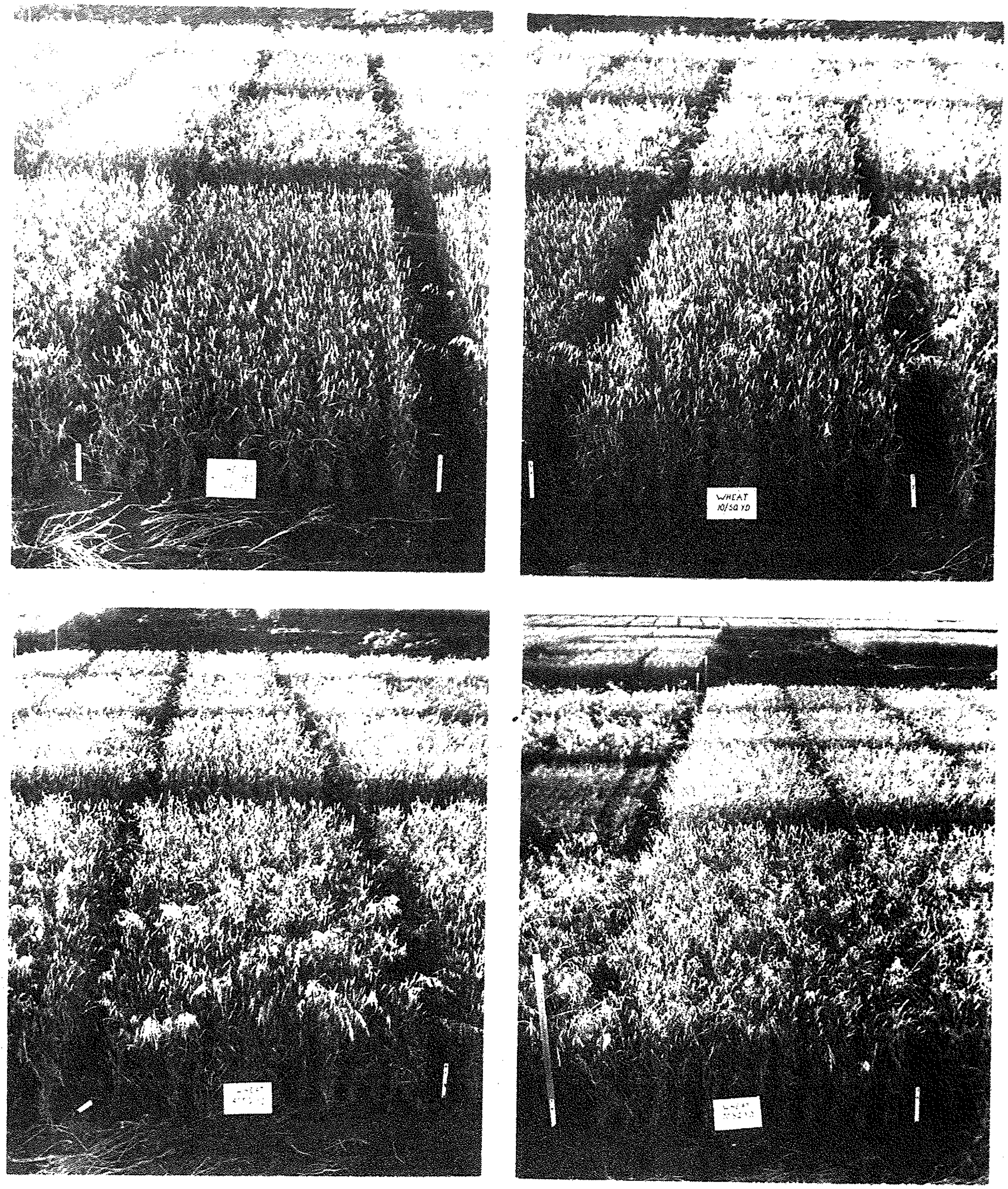

Figure 2

Upper left: Weed-free check in wheat

Upper right: 10 wild oats per square yard in wheat

Lower left: 40 wild oats per square yard in wheat

Lower right: 70 wild oats per square yard in wheat

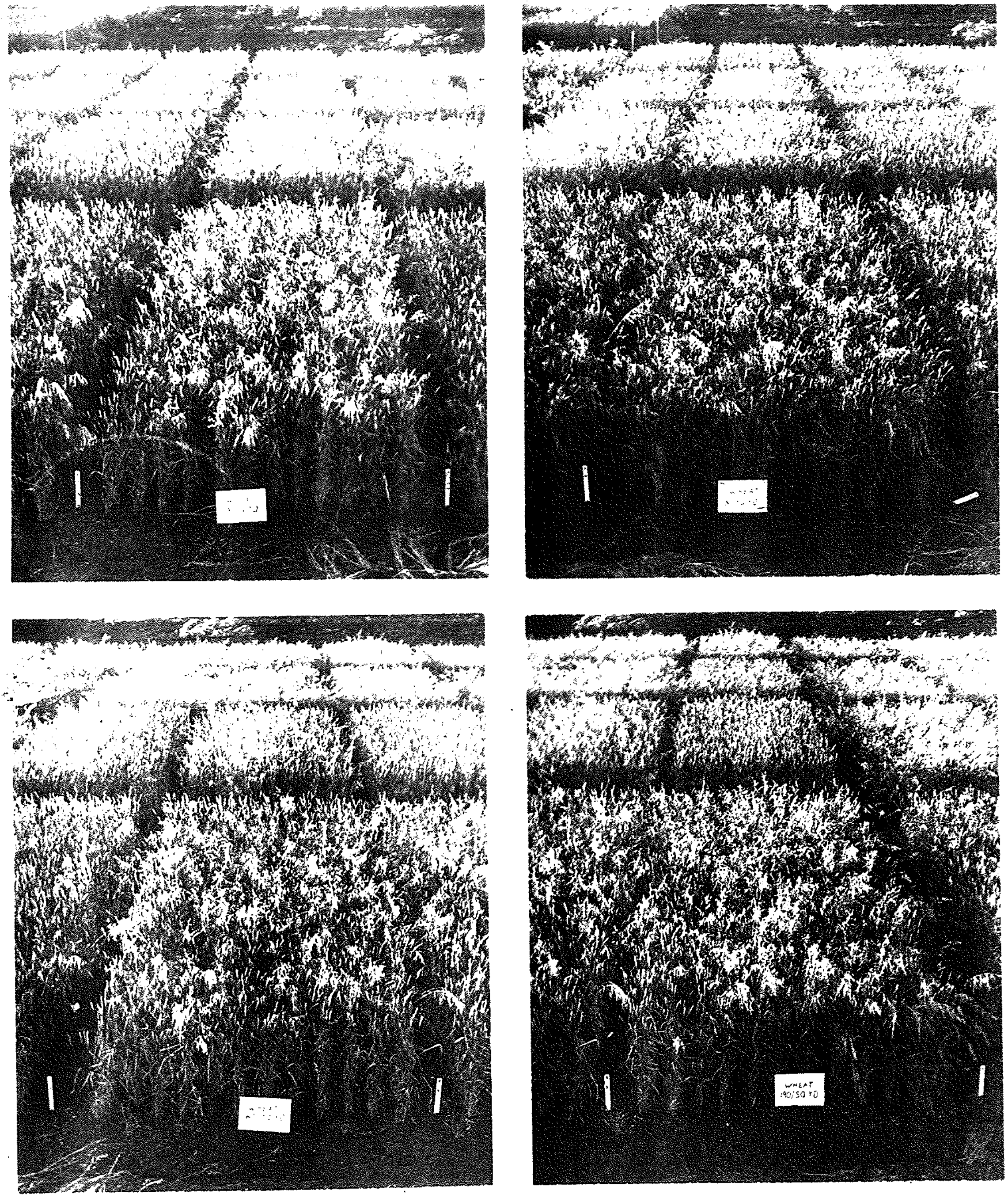

Figure 3

Upper left: 100 wild oats per square yard in wheat

Upper right: 130 wild oats per square yard in wheat

Lower left: 160 wild oats per square yard in wheat

Lower right: 190 wild oats per square yard in wheat

B. Experiment located on stubble land

The results in these experiments, Tables III & IV, Figure 4, followed patterns very similar to those carried out on summerfallow. Yields declined progressively as wild oat populations increased. In 1964, 40 wild oat plants per square yard were sufficient to cause significant yield reductions when the soil was fertilized. In 1965, only 10 wild oat plants per square yard caused similar yield reductions when the soil was fertilized. In unfertilized plots, 100 and 70 wild oat plants per square yard were required before yields were significantly depressed in 1964 and 1965, respectively. On weed-free plots the response to fertilizer was similar in both years. With densities ranging from 10 to 190 wild oats per square yard, all fertilized plots had yields of 2 to 4 bushels per acre higher than the unfertilized plots.

Yields in 1965 were considerably higher than those recorded in 1964, perhaps due to more favourable growing conditions. It is interesting to note that once the wild oat density increased to 100 plants per square yard no significant differences in yield occurred between fertilized and unfertilized plots. The weed populations appeared to cancel out any advantage the fertilizer might have provided.

Again, in both years the presence of wild oats in the crop did not significantly affect the percent protein content of the harvested wheat.

Wild oats, however, seriously affected crop tillering; as the density of the wild oat stand increased the amount of tillering of the wheat plants decreased. At densities of 160 and 190 wild oats per square yard tillering was negligible in 1964.

TABLE III

The effect of various densities of wild oats on the yield, protein content and number of tillers of wheat grown on stubble land, 1964

Wild oat density plants per square yard	Yield		Protein content of wheat		Tillers per 100 wheat plants	
	Fert.*	Unfert.	Fert.*	Unfert.	Fert.*	Unfert.
	bu/ac	bu/ac	%	%	No.	No.
0	21.7	14.4	14.4	14.5	251	152
10	18.1	13.5	14.3	14.8	205	129
40	14.3	12.0	14.2	14.4	150	131
70	15.4	11.5	14.4	14.3	156	125
100	10.8	9.0	14.5	14.6	130	110
130	11.8	8.6	14.2	14.6	131	106
160	8.6	5.5	14.5	14.3	103	101
190	8.6	6.3	14.3	14.5	105	103

* 100 pounds of 16-20-0

Duncan's multiple range table testing for significant differences of wheat yields

Wild oat density plants per square yard	Yield*	
	bu/ac	
Fertilized		
0	21.7	a
10	18.1	a b
40	14.3	b c d
70	15.4	b c
100	10.8	d e
130	11.8	c d e
160	8.6	e f
190	8.6	e f
Unfertilized		
0	14.4	b c d
10	13.5	c d
40	12.0	c d e
70	11.5	c d e
100	9.0	e f
130	8.6	e f
160	5.5	f
190	6.3	f

Note:* Any yield values with the same letter are not significantly different at the 5% level

TABLE IV

The effect of various densities of wild oats on the yield, protein content and number of tillers of wheat grown on stubble land, 1965

Wild oat density plants per square yard	Yield		Protein content of wheat		Tiller per 100 wheat plants	
	Fert.*	Unfert.	Fert.*	Unfert.	Fert.*	Unfert.
	bu/ac	bu/ac	%	%	No.	No.
0	36.7	26.5	13.7	15.3	351	285
10	32.7	26.0	13.5	15.2	330	288
40	25.9	25.3	14.0	15.4	276	255
70	21.2	18.5	13.5	16.0	260	165
100	20.1	16.9	13.3	15.7	258	159
130	14.6	14.2	14.0	15.4	165	153
160	14.9	14.7	14.2	15.9	164	158
190	12.7	13.0	14.3	15.5	130	133

* 100 pounds of 16-20-0

Duncan's multiple range table testing for significant differences of wheat yields

Wild oat density plants per square yard	Yield* bu/ac	
Fertilized		
0	36.7	a
10	32.7	b
40	25.9	c
70	21.2	d
100	20.1	d
130	14.6	e f
160	14.9	e f
190	12.7	f
Unfertilized		
0	26.5	c
10	26.0	c
40	25.3	c
70	18.5	d
100	16.9	d e
130	14.2	e f
160	14.7	e f
190	13.0	f

Note:* Any yield values with the same letter are not significantly different at the 5% level

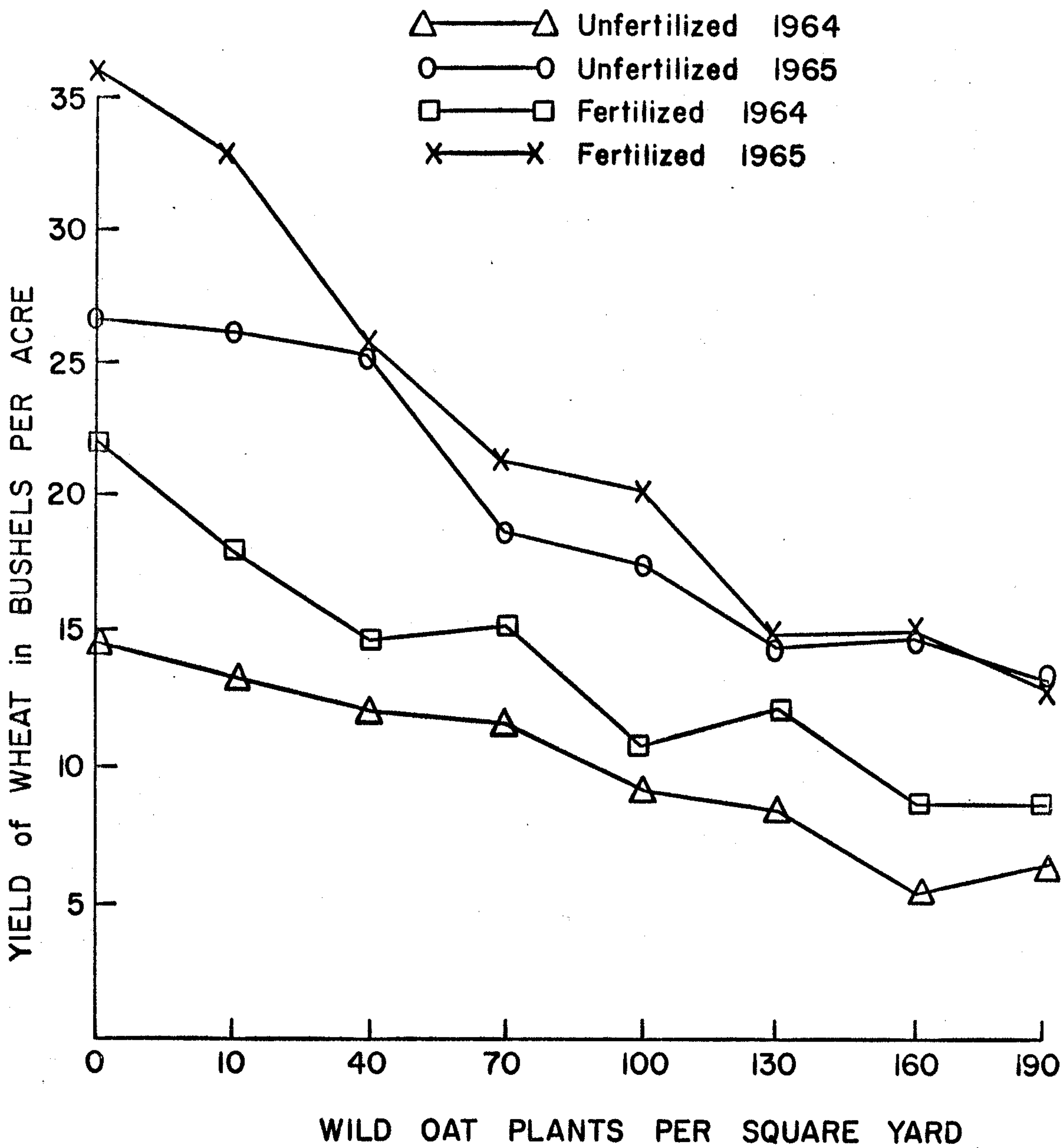

Figure 4 The Effect of Various Densities of Wild Oats on Spring Sown Wheat Grown on Stubble Land.

II. The Effect of Stage of Wild Oat Growth at Time of Removal on Yield and Protein Content in Wheat

The purpose of this experiment was to determine, if possible, the particular stage of growth when competition between wild oats and wheat begins. Yield comparisons were made with weed-free check plots and pre-emergence herbicidal treatments. Data are presented in Table V and Figure 5. In 1964 it was found that considerable competition in the form of wheat yield reductions had occurred at the 2 to 3 leaf stage of wild oat removal. This was apparent at all density levels. The full impact of competitive effects, or maximum competition, had occurred by the time the shot-blade stage was reached. In the case of 100 wild oat plants per square yard, this had already occurred by the 4 to 5 leaf stage.

Data for experiments carried out in 1965 are presented in Table VI and yields illustrated graphically in Figure 6. These studies were similar to those carried out in 1964, with the exception that post-emergent herbicide was included. In 1965 the application of a pre-emergent herbicide (diallate) did not result in complete control of wild oats. This was perhaps due to very wet conditions at the time of application, resulting in poor incorporation into the heavy clay soil. The post-emergent herbicide (barban) similarly did not provide adequate control of wild oats, especially in the heavy wild oat populations. In 1965, competition was found to have commenced prior to the 1 to 2 leaf stage of the wild oats. A loss of 4 bushels per acre was evident in plots containing 100 wild oats per square yard, while in the higher densities 8.0 and 6.6 bushels per acre, respectively, had been lost prior to the 1 to 2 leaf stage of wild oat removal. Again the full impact or maximum competition had occurred at approximately the 7 to 8 leaf stage.

Wheat yield reductions were not as severe in 1965 compared to those in 1964. It is seen (Figure 6) that yields did not decrease as rapidly with delayed removal as they did in 1964. These differences could be due to variations in precipitation in the two years.

In 1964 the percent protein was at its lowest level in the pre-emergent treatment, while there was an increase in percent protein at the 2 to 3 leaf stage of wild oat removal. This upward trend continued in the 4 to 5 leaf, 5 to 6 leaf and the shot-blade removal stages, but in the weedy check the percent protein content dropped sharply. This trend was found to be evident in the 100, 200 and 300 wild oats per square yard densities. As the yield of wheat decreased, due to a later date of wild oat removal, the percent protein content increased. This is in agreement with Wilson et al (53), who found experimentally that when moisture supplies are high plants produce more vegetative growth. A great deal of the available nitrogen is utilized for vegetative parts, resulting in higher yields and lower protein content in harvested grain. The protein content of the wheat seed in the various dates of removal in 1965, displayed similar trends to those reported for 1964. Although of somewhat lower magnitude, the percent protein content in the seed was closely related to the yield of wheat seed in that particular treatment.

TABLE V

The effect of stage of wild oat growth at time of removal on yield and protein content of wheat, 1964

Wild oat density plants per square yard	Stage of wild oat removal	Protein content in wheat seed	Yield*	
		%	bu/ac	
0		16.9	21.5	a
0		15.9	21.3	a
0	Weed-free check	15.7	22.3	a
0		16.0	22.4	a
0		15.9	21.0	a
0		15.8	23.9	a
100	pre-emergence**	16.1	19.3	a b
100	2-3 leaf stage	16.4	15.7	b c
100	4-5 leaf stage	16.7	11.9	c d e
100	5-6 leaf stage	16.9	10.5	c d e f g h
100	shot-blade stage	17.2	10.4	d e f g h
100	weedy check	16.5	10.8	c d e f g h
200	pre-emergence**	16.0	19.7	a b
200	2-3 leaf stage	16.5	12.5	c d e
200	4-5 leaf stage	16.3	11.1	c d e f
200	5-6 leaf stage	17.5	7.8	e f g h i
200	shot-blade stage	17.6	5.7	g h i
200	weedy check	16.4	6.5	f g h i
300	pre-emergence**	14.4	15.0	b c d
300	2-3 leaf stage	16.7	8.8	e f g h i
300	4-5 leaf stage	16.9	5.5	g h i
300	5-6 leaf stage	17.5	5.2	h i
300	shot-blade stage	18.4	3.6	i
300	weedy check	16.4	5.8	g h i

Note:* Any yield values with the same letter are not significantly different at the 5% level

** Removal with pre-emergent herbicide

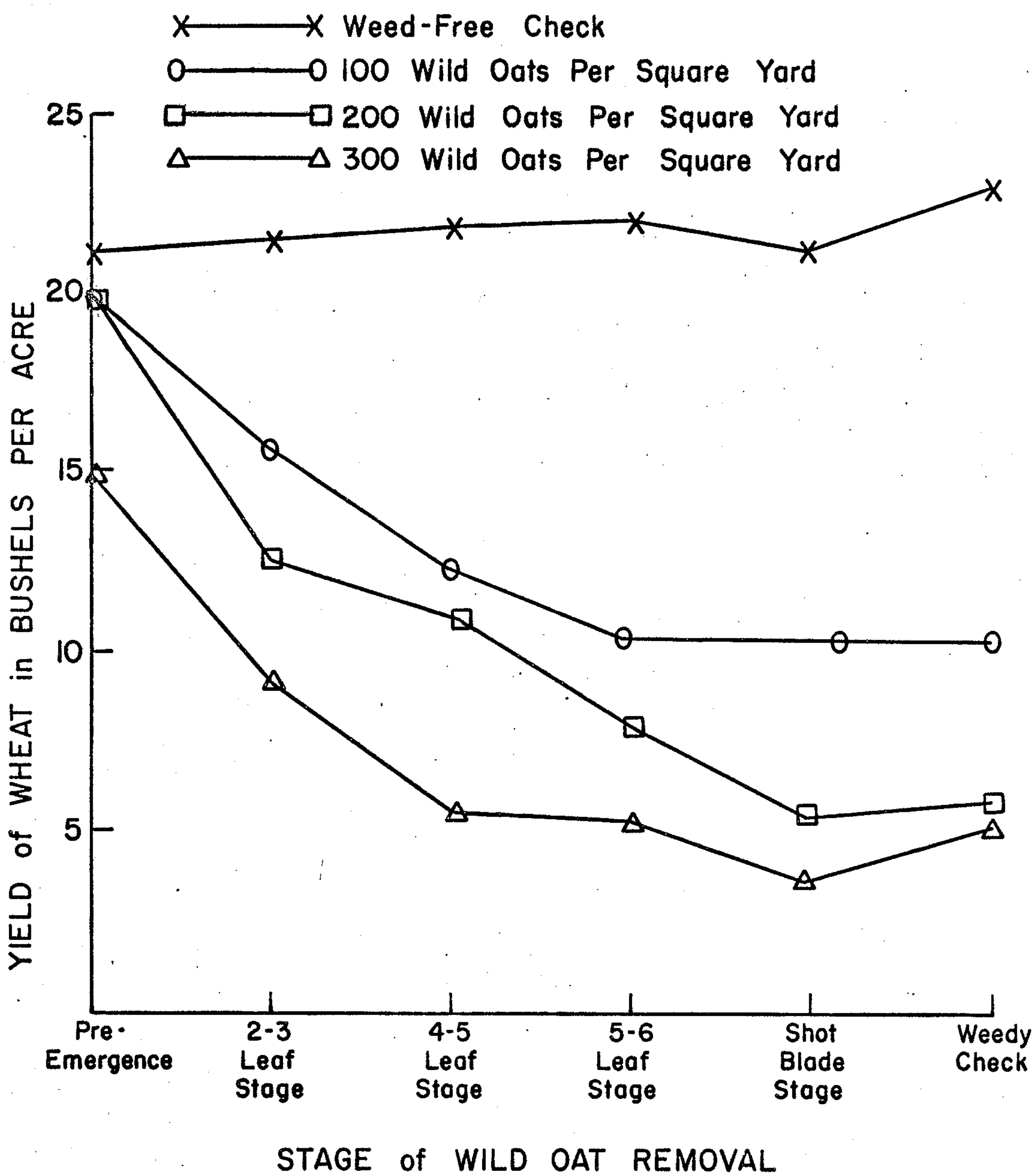

Figure 5 The Effect of Stage of Wild Oat Growth at Time of Removal on Yield of Wheat, 1964.

TABLE VI

The effect of stage of wild oat growth at time of removal on yield and protein content of wheat, 1965

Wild oat density plants per square yard	Stage of wild oat removal	Protein content in wheat seed	Yield*	
		%	bu/ac	
0	Weed-free check	13.3	26.1	a
0		13.2	20.5	c d e f g
0		13.3	23.5	a b c
0		13.2	23.2	a b c
0		13.2	23.0	a b c
0		13.3	22.7	a b c d
0		13.2	25.7	a b
100	pre-emergence**	12.9	20.6	c d e f
100	post-emergence***	13.0	20.1	c d e f g
100	1-2 leaf stage	13.0	23.1	a b c
100	2-3 leaf stage	13.1	20.9	b c d e
100	4-5 leaf stage	13.7	17.2	e f g h i
100	7-8 leaf stage	14.1	16.2	e f g h i j
100	weedy check	12.8	16.1	e f g h i j
200	pre-emergence**	12.5	17.9	d e f g h
200	post-emergence***	13.3	15.6	f g h i j
200	1-2 leaf stage	13.3	15.5	g h i j
200	2-3 leaf stage	13.4	14.9	h i j k
200	4-5 leaf stage	13.8	14.0	h i j k l
200	7-8 leaf stage	14.6	12.8	h i j k l
200	weedy check	12.5	10.2	k l
300	pre-emergence**	12.6	14.5	h i j k
300	post-emergence***	13.1	13.5	h i j k l
300	1-2 leaf stage	13.0	16.9	e f g h i
300	2-3 leaf stage	13.1	15.9	e f g h i j
300	4-5 leaf stage	14.2	12.1	i j k l
300	7-8 leaf stage	15.4	9.5	l
300	weedy check	12.3	11.7	j k l

Note: * Any yield values with the same letter are not significantly different at the 5% level

** Removal with pre-emergent herbicide

*** Removal with post-emergent herbicide

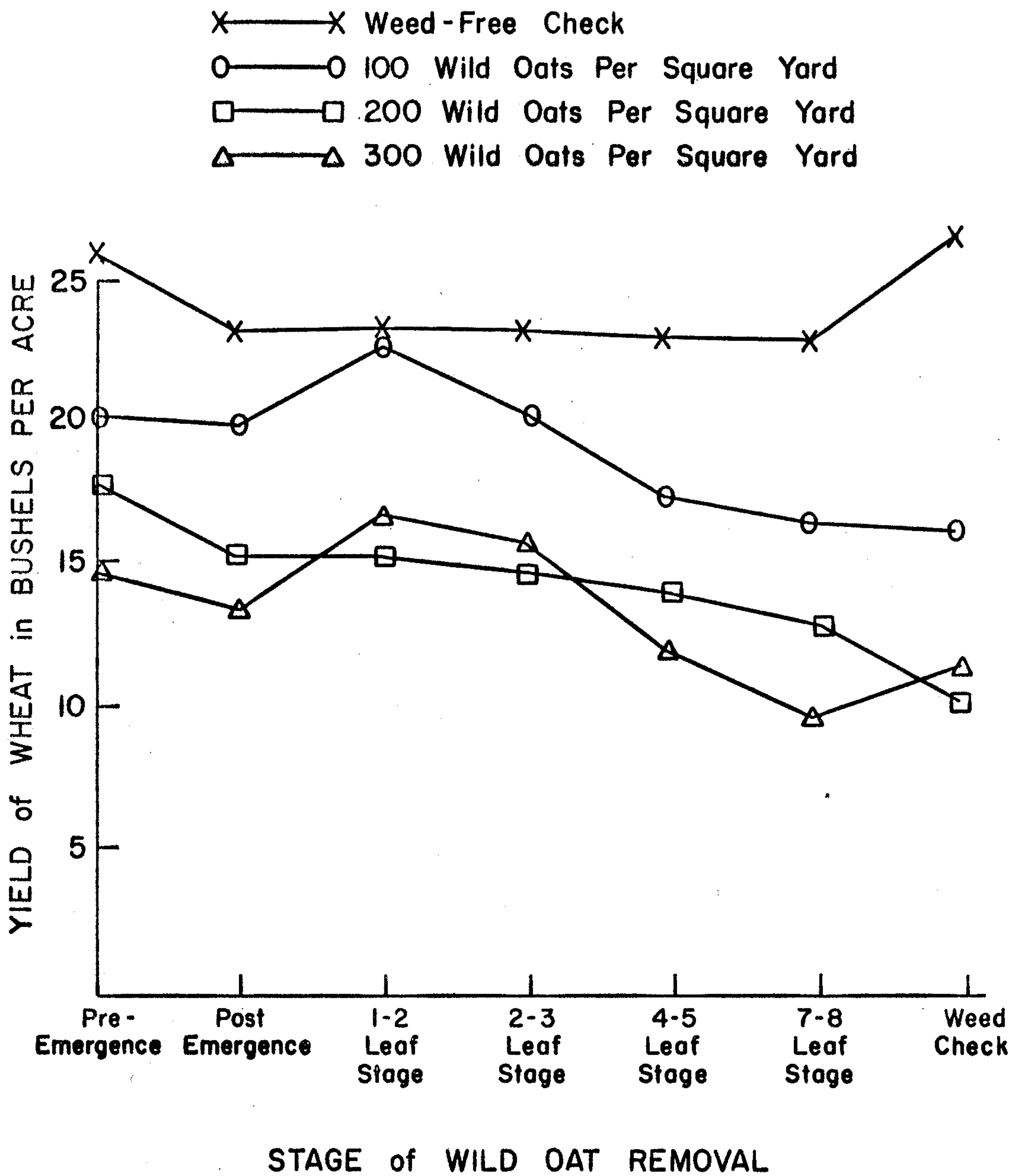

Figure 6 The Effect of Stage of Wild Oat Growth at Time of Removal on Yield of Wheat, 1965

III. Effect of Various Populations of Wild Oats on Flax

A. Experiment located on summerfallow land

Flax is generally considered a poor competitor with respect to weed infestations. This soon became very evident in experiments involving various densities of wild oats (Table VII & Figure 7). In 1964 as few as 10 wild oats per square yard significantly reduced flax yields as compared to a weed-free check. Further increases in weed densities resulted in corresponding decreases in flax yields. However, when wild oat populations reached 130 per square yard, then any further increase in density did not significantly reduce yields further. Yield reduction totalled 16.3 bushels per acre at a density of 130 wild oats per square yard. This appeared to be the point where further increases in weed populations had little further effect on yield.

Similarly in 1965, 10 wild oats per square yard were sufficient to reduce the yield significantly. A wild oat population of 40 per square yard reduced the flax yield by almost 12 bushels per acre, while increasing the wild oat density to 190 per square yard, further reduced the yield by only an additional 7 bushels per acre.

Flax seed harvested in 1964 was analyzed for percent oil content and iodine number. As no significant differences were found, oil seed analysis were not carried out on other experiments.

TABLE VII

The effect of various densities of wild oats on yield of flax grown on summerfallow

Wild oat density plants per square yard	Oil content	Iodine No.	Yield*		Yield*	
	1964				1965	
	%		bu/ac		bu/ac	
0	42.3	192.9	22.8	a	25.6	a
10	43.2	192.9	18.2	b	20.3	b
40	42.5	191.0	12.7	c	13.6	c
70	42.1	190.2	9.2	d	12.1	c d
100	41.5	191.1	8.6	d	9.9	d e
130	42.3	190.2	6.5	d e	8.0	e
160	42.5	191.1	5.3	e	6.7	e
190	41.2	190.2	5.4	e	6.2	e

Note:* Any yield values with the same letter are not significantly different at the 5% level

TABLE VIII

The effect of various densities of wild oats on yield of flax grown on stubble land

Wild oat density plants per square yard	Yield*		Yield*	
	1964		1965	
	bu/ac		bu/ac	
0	6.6	a	15.9	a
10	2.8	b	12.6	b
40	1.7	b	7.2	c
70	2.4	b	6.1	c d
100	1.2	b	6.2	c d
130	1.0	b	4.9	d e
160	.8	b	5.0	d e
190	1.0	b	4.1	e

Note:* Any yield values with the same letter are not significantly different at the 5% level

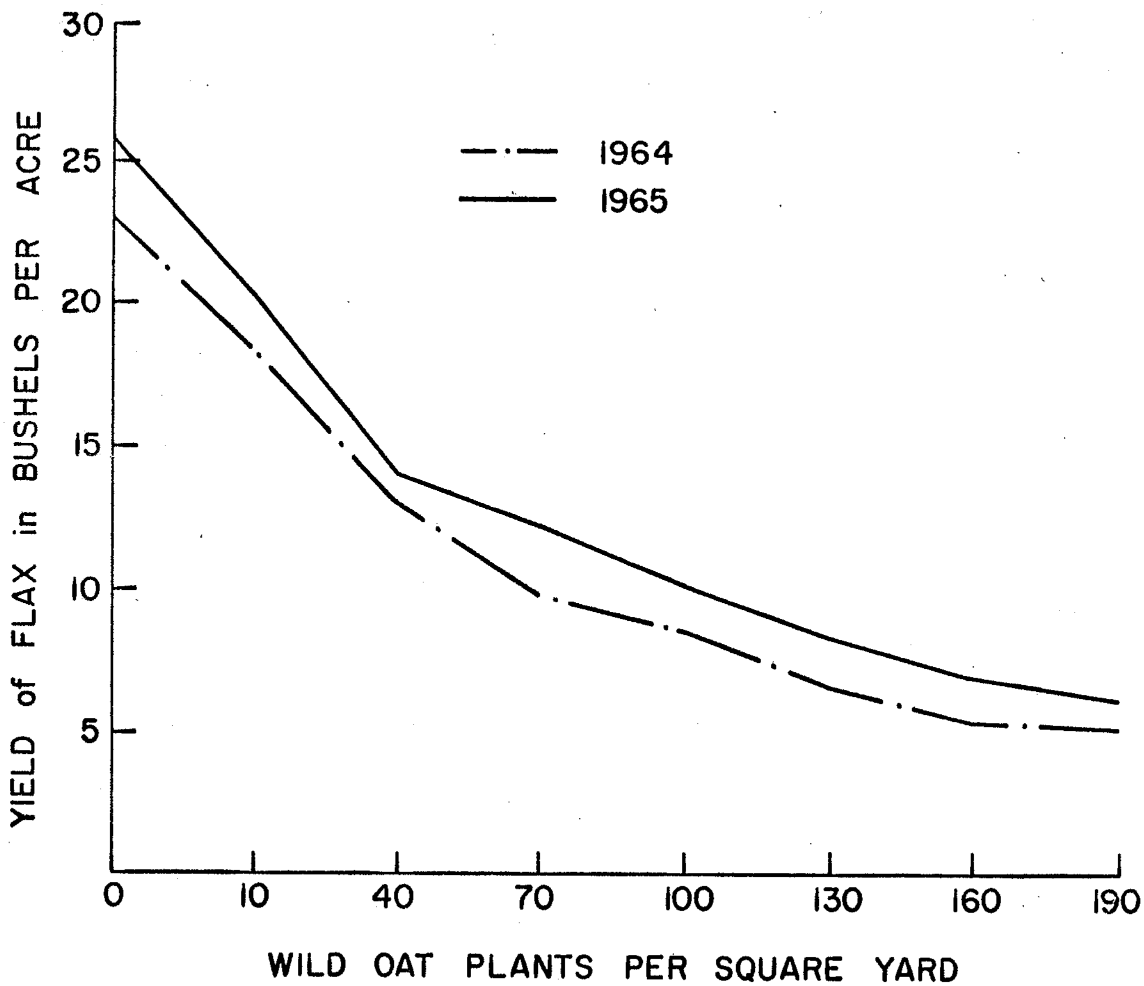

Figure 7 The Effect of Various Densities of Wild Oats on Yield of Flax Grown on Summerfallow Land.

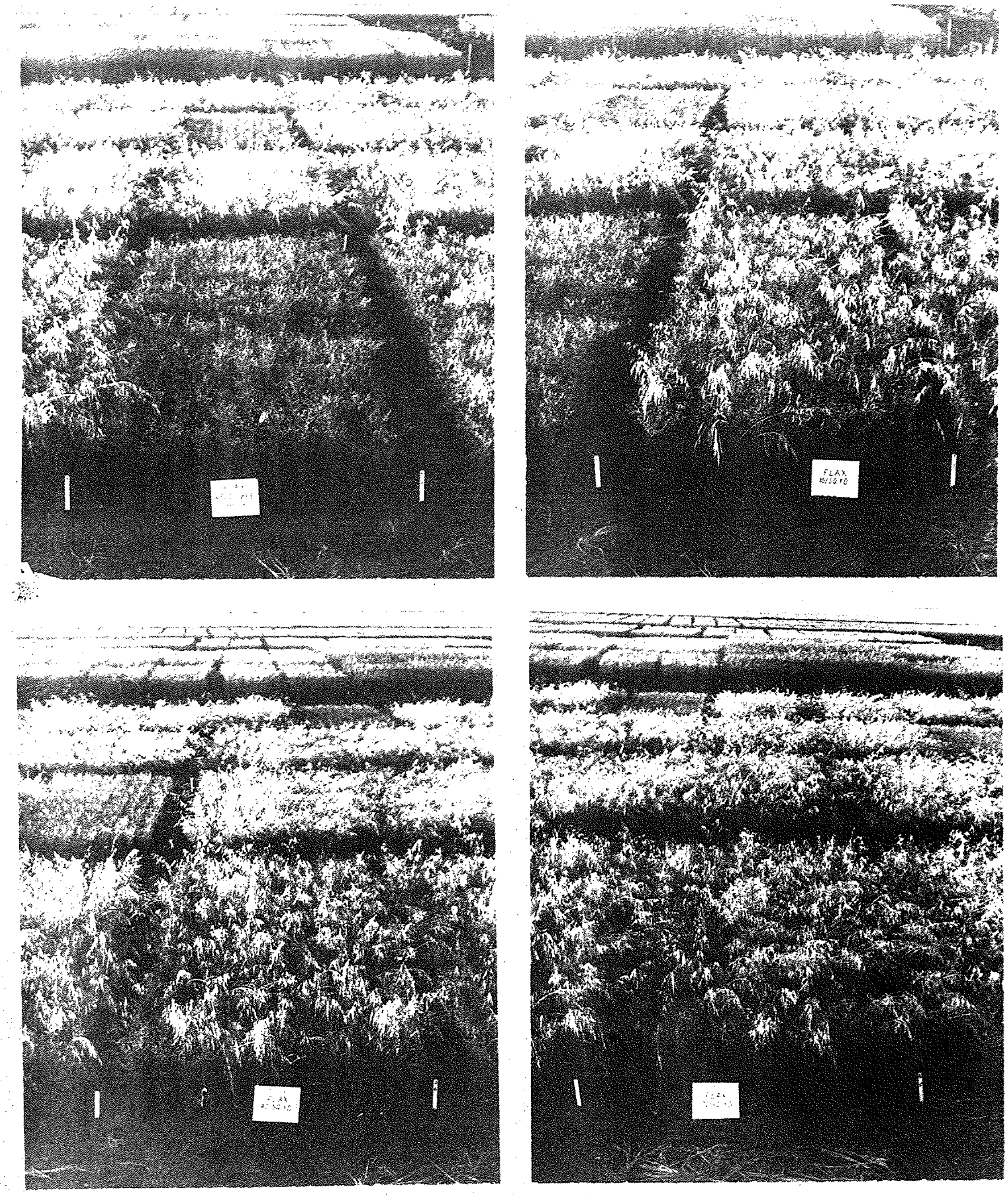

Figure 8

Upper left: Weed-free check in flax

Upper right: 10 wild oats per square yard in flax

Lower left: 40 wild oats per square yard in flax

Lower right: 70 wild oats per square yard in flax

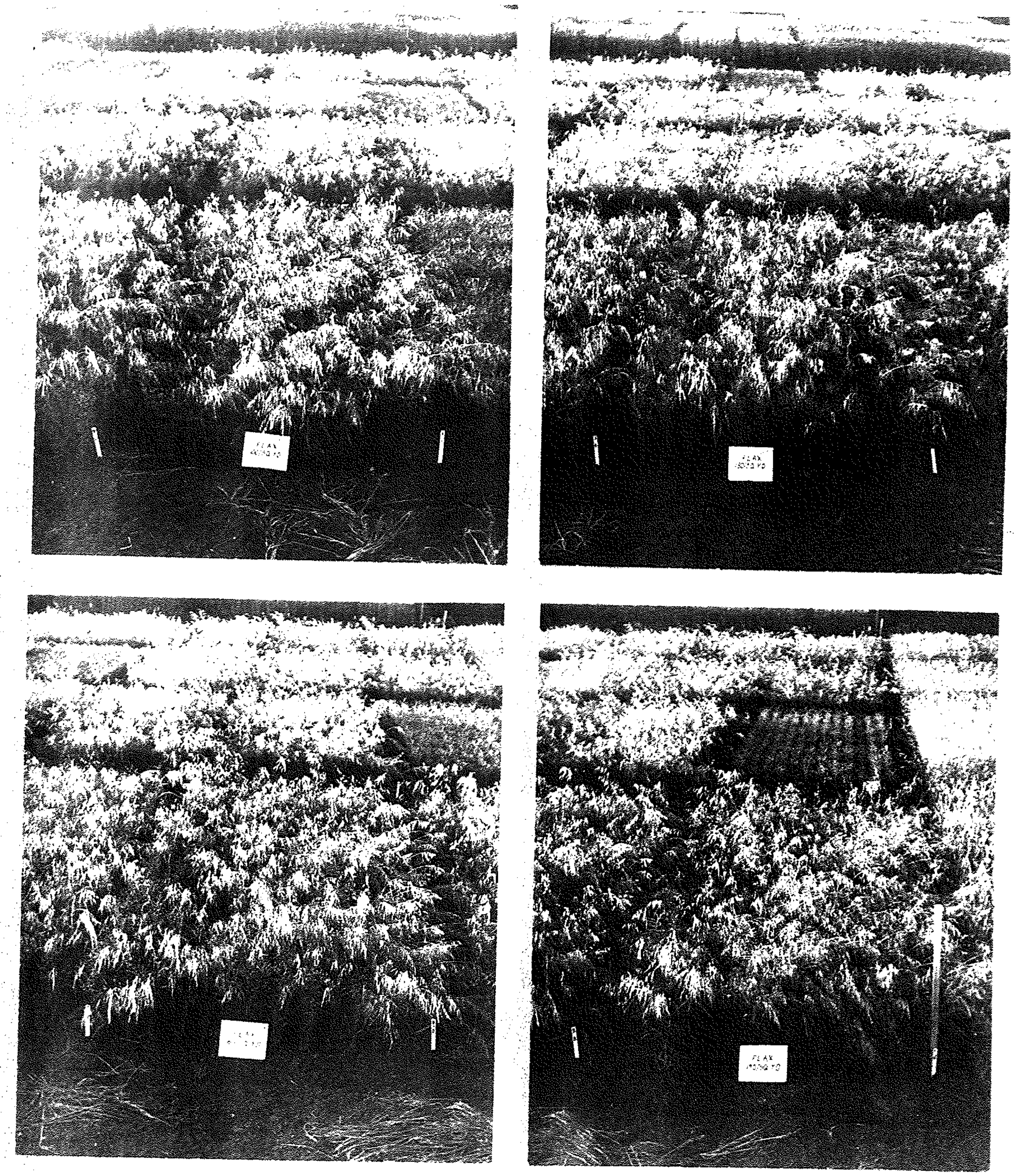

Figure 9

Upper left: 100 wild oats per square yard in flax

Upper right: 130 wild oats per square yard in flax

Lower left: 160 wild oats per square yard in flax

Lower right: 190 wild oats per square yard in flax

B. Experiment located on stubble land

Flax germination was very low in 1964 due to very dry soil conditions. The experiment was reseeded at a later date but the yields, nevertheless, remained very low. A density of 10 wild oats per square yard was again sufficient to reduce yields significantly (Table VIII). Increasing the density of wild oats had little additional effect on yield.

In a similar test in 1965 (Table VIII) it is interesting to note that the greatest reductions in yield occurred between the weed-free check and the plots containing 10 and 40 wild oats per square yard. This would suggest that very small numbers of wild oats will seriously reduce flax yields. After reaching a density of 40 wild oats per square yard, then any additional increase in density had very little additional effect on flax yields.

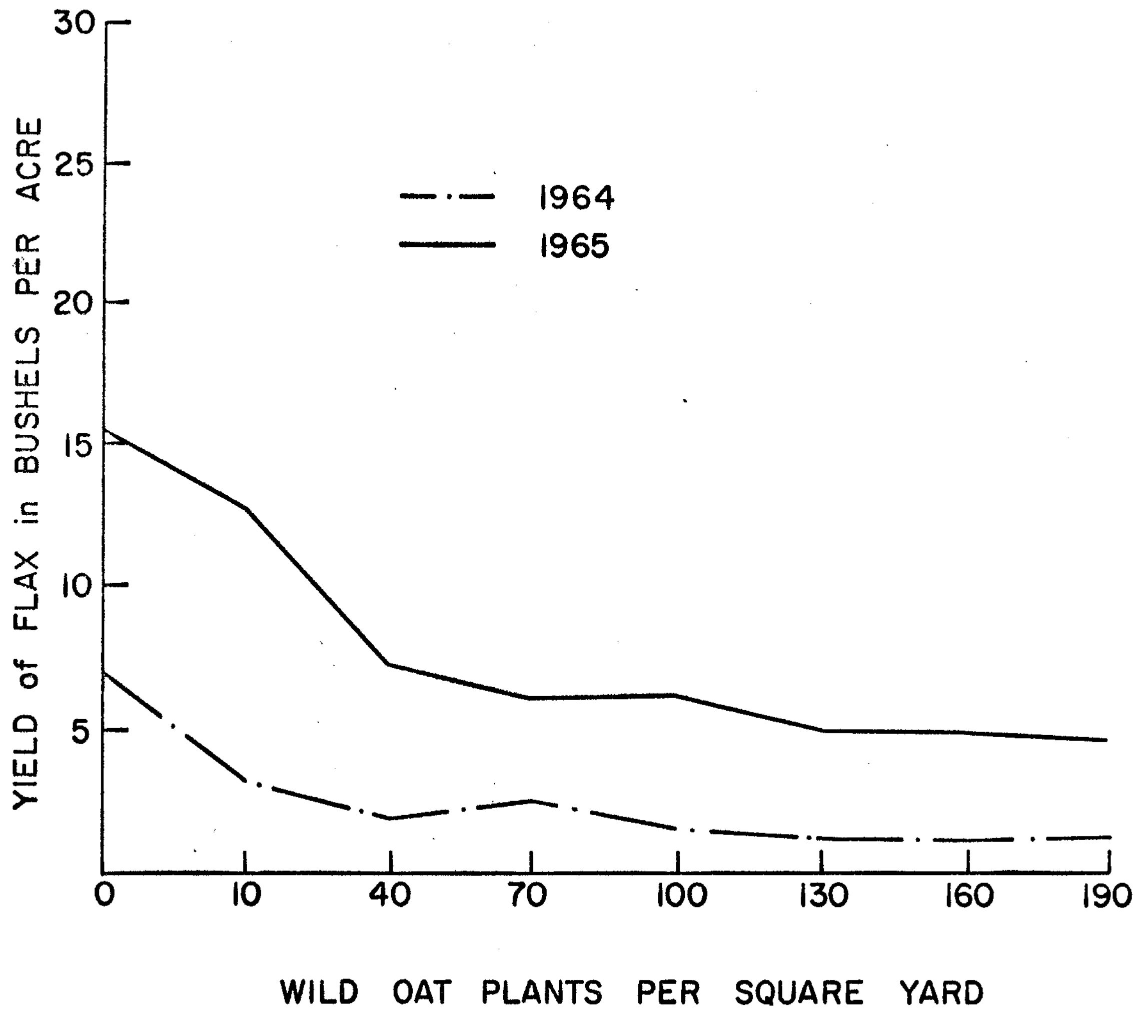

Figure 10 The Effect of Various Densities of Wild Oats on Yield of Flax Grown on Stubble Land.

IV. The Effect of Stage of Wild Oat Growth at Time of Removal on Yield of Flax

Data for 1964 are presented in Table IX and illustrated graphically in Figure 11. Virtually complete control of wild oats was obtained in 1964 with the pre-emergent herbicide, diallate, resulting in yields of 15.4, 14.8 and 16.1 bushels per acre in the three densities of 50, 100 and 150 wild oats per square yard. These yields compare favourably to the average yield of 14.6 bushels per acre recorded for the weed-free check plots. The results indicate that competition had commenced prior to the 2 to 3 leaf stage of wild oat removal. Yields recorded for plots in which wild oats were removed in the 2 to 3 leaf stage were significantly lower than in the weed-free check plots. A slight increase in yield was noted when wild oats were removed at the 4 to 5 leaf stage. This is difficult to explain, although it is possible that removal at this stage disturbed a heavy crust layer which had developed on the soil surface following heavy rains. Since the wild oats were pulled by hand, such disturbance was unavoidable. This could have resulted in improved soil aeration and consequently slightly higher flax yields. The full competitive effects appear to have occurred by the time the 5 to 6 leaf stage was reached.

In 1965, the results were not as clearly defined (Table X and Figure 12). This was further complicated by the incomplete wild oat control obtained with the pre-emergent and post-emergent herbicides. It would appear, however, that some wild oat competition had again occurred before the 1 to 2 leaf stage of growth, at least in the plots with densities of 100 and 150 wild oats per square yard. Also there was evidence that the full impact of competition had occurred at the 7 to 8 leaf stage, the last date of removal. Further declines were noted for the weedy check treatments.

Comparing the two experiments, in 1964 data indicate that yield reductions due to wild oat competition had commenced at the 5 to 6 leaf stage of wild oat removal, while on the contrary in 1965 yield reductions due to wild oat competition continued until the final date of removal. Perhaps this discrepancy between 1964 and 1965 results could be explained by examining differences in precipitation during the two seasons. In 1964, there was not sufficient soil moisture to permit flax to recover when wild oats were left in the crop until the 5 to 6 leaf stage. Reserve moisture was maintained at a higher level in 1965, possibly contributing to the partial recovery of flax plants after competition was removed at the 7 to 8 leaf stage.

TABLE IX

The effect of stage of wild oat growth at time of removal on yield of flax, 1964

Wild oat density plants per square yard	Stage of wild oat removal	Yield*	
		bu/ac	
0		14.5	a b
0		14.9	a b
0	Weed-free	15.2	a
0	check	13.0	a b c
0		14.3	a b
0		15.6	a
50	pre-emergence**	15.4	a
50	2-3 leaf stage	10.5	c d
50	4-5 leaf stage	11.4	b c d
50	5-6 leaf stage	9.5	c d e f
50	shot-blade	8.9	d e f g
50	weedy check	6.6	e f g h i
100	pre-emergence**	14.8	a b
100	2-3 leaf stage	8.6	d e f g h
100	4-5 leaf stage	10.4	c d
100	5-6 leaf stage	6.5	f g h i
100	shot-blade	5.8	g h i
100	weedy check	4.5	i
150	pre-emergence**	16.1	a
150	2-3 leaf stage	8.0	d e f g h i
150	4-5 leaf stage	10.1	c d e
150	5-6 leaf stage	6.2	f g h i
150	shot-blade	5.3	g h i
150	weedy check	5.1	h i

Note:* Any yield values with the same letter are not significantly different at the 5% level

** Removal with pre-emergent herbicide

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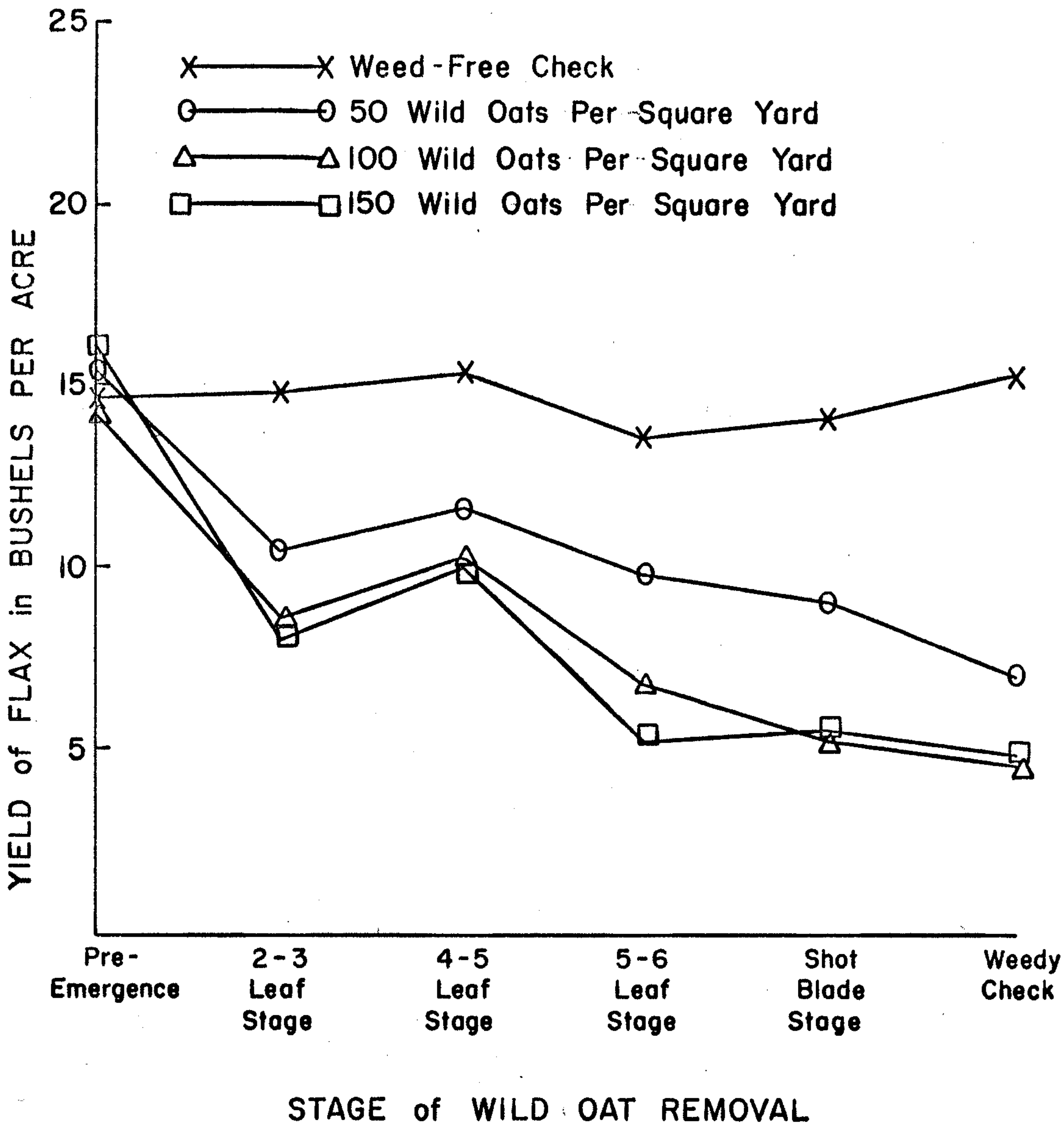

Figure 11 The Effect of Stage of Wild Oat Growth at Time of Removal on Yield of Flax, 1964

TABLE X

The effect of stage of wild oat growth at time of removal on yield of flax, 1965

Wild oat density plants per square yard	Stage of wild oat removal	Yield* bu/ac	
0	Weed-free check	21.8	a b c d e
0		22.9	a b c
0		23.4	a
0		22.6	a b c d
0		23.6	a
0		23.2	a b
0		22.7	a b c d
50	pre-emergence**	16.6	g h
50	post-emergence***	20.1	b c d e f
50	1-2 leaf stage	22.5	a b c d e
50	2-3 leaf stage	21.6	a b c d e
50	4-5 leaf stage	20.5	a b c d e f
50	7-8 leaf stage	16.4	h
50	weedy check	12.2	j k l
100	pre-emergence**	12.9	i j k
100	post-emergence***	15.2	h i
100	1-2 leaf stage	20.8	a b c d e f
100	2-3 leaf stage	19.4	e f g
100	4-5 leaf stage	18.1	f g h
100	7-8 leaf stage	12.6	i j k l
100	weedy check	7.8	m n
150	pre-emergence**	11.8	k l
150	post-emergence***	15.5	h i
150	1-2 leaf stage	19.6	d e f
150	2-3 leaf stage	20.0	c d e f
150	4-5 leaf stage	15.1	h i j
150	7-8 leaf stage	9.8	l m
150	weedy check	5.6	n

Note:* Any yield values with the same letter are not significantly different at the 5% level

** Removal with pre-emergent herbicide
*** Removal with post-emergent herbicide

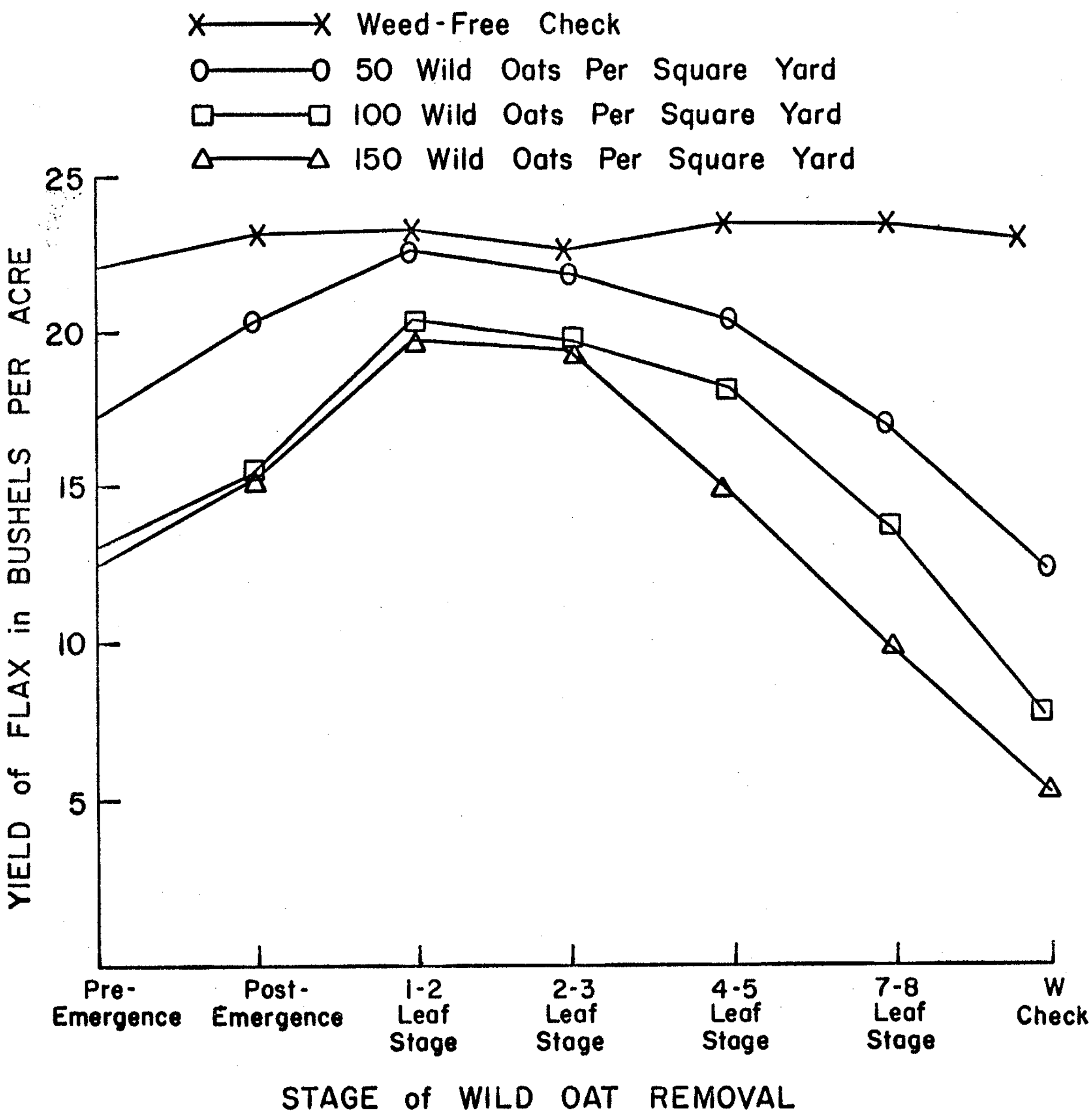

Figure 12 The Effect of Stage of Wild Oat Growth at Time of Removal on Yields of Flax, 1965.

V. The Effect of Wild Oat Competition on Flax Following Various Seeding Dates

The purpose of these experiments was to determine the most optimum seeding date for flax in order to reduce losses from wild oat competition. Data are presented in Table XI and XII and corresponding histograms in Figure 13 and 14. In 1964, the highest flax yields of 18.4 bushels per acre were recorded when seeded on May 22. Yields steadily decreased as seeding was delayed and the final seeding date, June 15, yielded only 10.3 bushels per acre. Yields declined very rapidly as seeding was delayed and where wild oat populations increased.

The optimum seeding date in 1965, under weed-free conditions, appeared to be on June 7. Flax yields decreased with delayed seeding, but not to the same degree as occurred in 1964. Results from this experiment further substantiate that flax is a very poor competitor with wild oats. For example, a treatment containing only 50 wild oats per square yard and in which the flax plants emerged three days prior to wild oat emergence, still suffered a yield reduction of almost 8 bushels per acre. Yields of flax, when wild oats were allowed to emerge prior to the flax, decreased to virtually nothing. The results further suggest that early seeding, and wild oat control at an early stage are essential to the successful production of a flax crop.

TABLE XI

The effect of wild oat competition on the yield of flax following various seeding dates, 1964

Wild oat density plants per square yard	Date of seeding	Flax emergence relative to wild oat emergence	Yield*	
			bu/ac	
0	May 22	+5	18.4	a
0	June 5	-5	16.7	a
0	June 10	-10	11.6	b
0	June 15	-15	10.3	b c
50	May 22	+5	10.4	b c
50	June 5	-5	8.8	b c d
50	June 10	-10	3.6	f g
50	June 15	-15	1.6	g
100	May 22	+5	7.4	c d e
100	June 5	-5	6.9	d e
100	June 10	-10	2.5	g
100	June 15	-15	.8	g
150	May 22	+5	7.5	c d e
150	June 5	-5	5.6	e f
150	June 10	-10	.9	g
150	June 15	-15	.6	g

Note:* Any yield values with the same letter are not significantly different at the 5% level

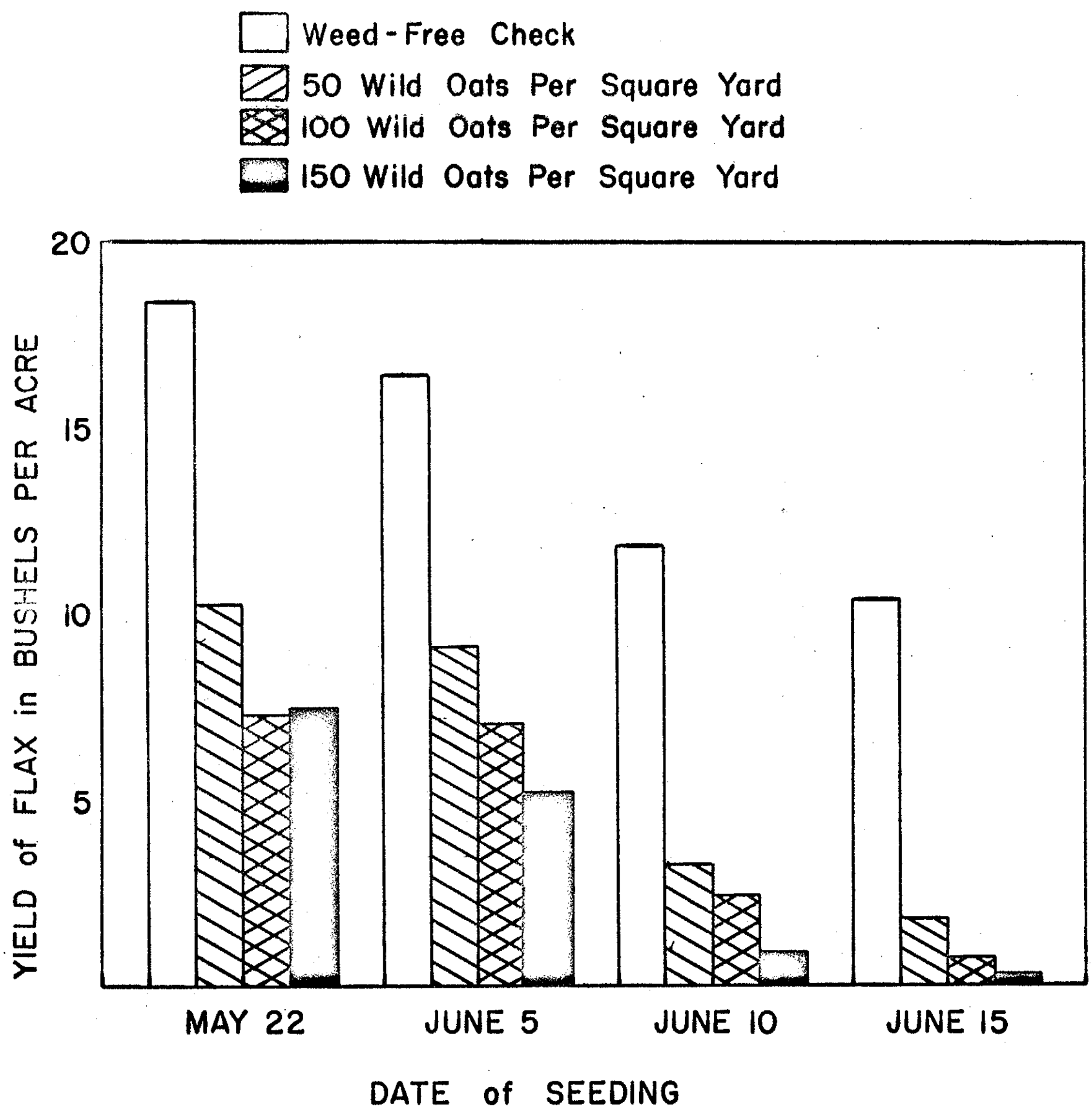

Figure 13. The Effect of Wild Oat Competition on the Yield of Flax Following Various Seeding Dates, 1964.

TABLE XII

The effect of wild oat competition on the yield of flax following various seeding dates, 1965

Wild oat density plants per square yard	Date of seeding	Flax emergence relative to wild oat emergence	Yield* bu/ac	
0	June 1	+3	16.3	b
0	June 7	-3	20.7	a
0	June 11	-7	16.1	b c
0	June 15	-11	15.4	c
50	June 1	+3	8.5	d
50	June 7	-3	3.6	f
50	June 11	-7	1.2	h
50	June 15	-11	1.2	h
100	June 1	+3	6.6	e
100	June 7	-3	2.7	g
100	June 11	-7	1.1	h
100	June 15	-11	.8	h
150	June 1	+3	5.8	e
150	June 7	-3	1.2	h
150	June 11	-7	.7	h
150	June 15	-11	.6	h

Note:* Any yield values with the same letter are not significantly different at the 5% level

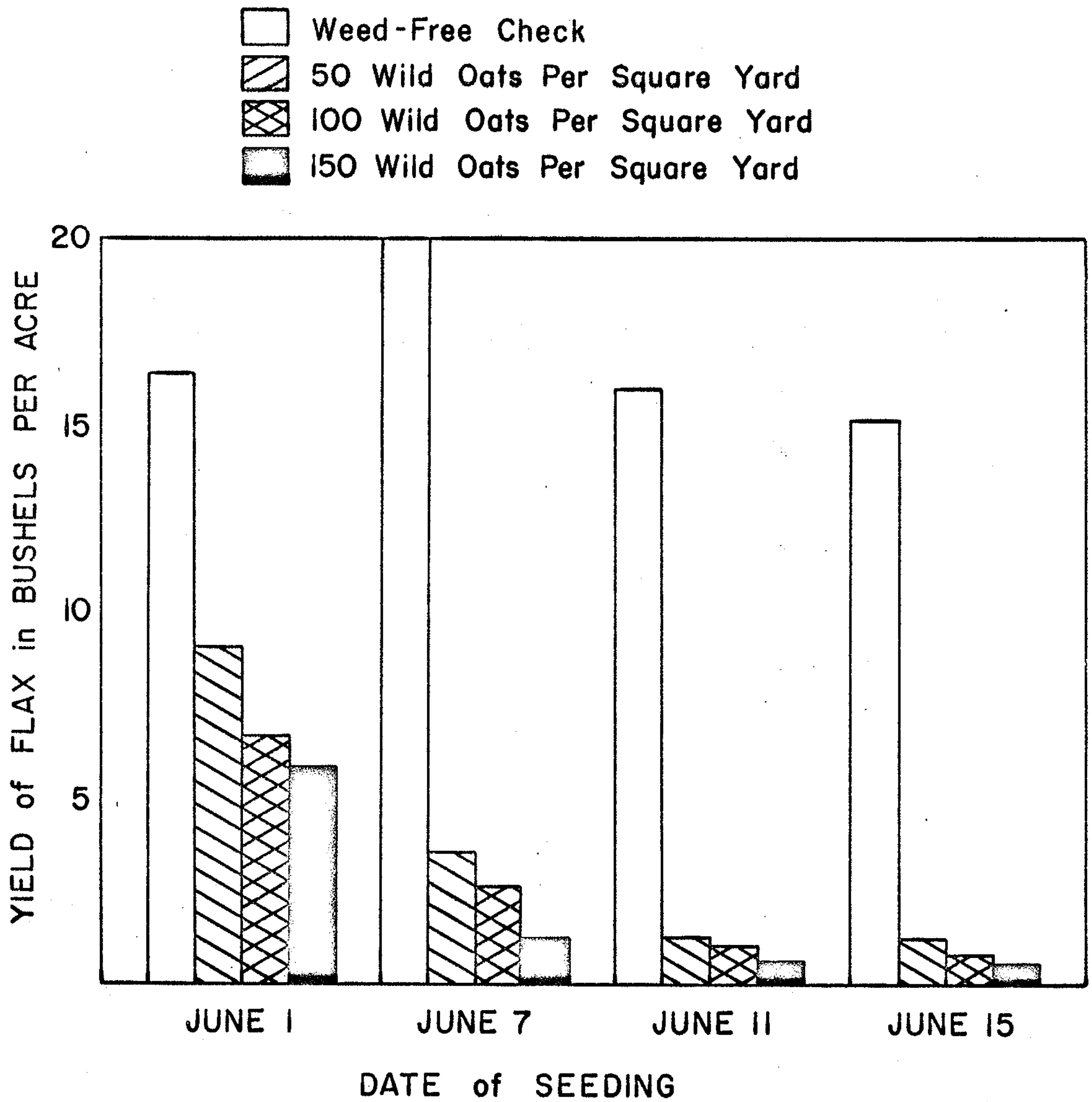

Figure 14 The Effect of Wild Oat Competition on the Yield of Flax Following Various Seeding Dates, 1965.

SUMMARY AND CONCLUSIONS

This project was designed to study various aspects of wild oat competition in wheat and flax. The main purpose was (a) to determine the effect of various densities of wild oats on wheat and flax grown on summerfallow and stubble land, (b) to determine the effect of soil fertility on wild oat competition with wheat grown on summerfallow and stubble land, (c) to determine the stage of growth of wheat and flax when wild oat competition commences and (d) to determine the effect of seeding date on the competition efficiency of flax.

Densities of 0, 10, 40, 70, 100, 130, 160 and 190 wild oats per square yard were established in wheat and flax to determine the effect of this weed on crop yields and other agronomic factors. The experiments were duplicated on summerfallow and stubble land. In 1964 only 10 wild oat plants per square yard were needed to significantly reduce the yield of wheat when no fertilizer was added to the crop and when the experiment was conducted on summerfallow. However when the crop received the benefit of a commercial fertilizer treatment it took 40 wild oat plants per square yard to significantly reduce wheat yields. In 1965, 40 wild oats per square yard were needed to reduce wheat yields regardless of fertilizer treatment. When similar experiments were conducted on stubble land, the influence of a commercial fertilizer treatment was more pronounced. With 16-20-0 fertilizer at 100 pounds per acre, 10 to 40 wild oats reduced yields significantly, whereas without the benefit of fertilizer densities of 70 and 100 wild oats per square yard were needed to suppress wheat yields significantly. This indicates that on stubble land soil fertility was a more important factor than moderate densities of wild oats in determining eventual crop yields. In all experiments, wild oats reduced the number of tillers produced per plant, but did not significantly effect the protein content of the harvested grain.

Similar experiments were conducted with flax on summerfallow and stubble land. In 1964 and 1965, 10 wild oat plants per square yard were sufficient to reduce flax yields significantly on both the summerfallow and stubble land experiments. This confirms the general observations that flax is a poor competitor with weeds.

In attempting to determine the time when competition begins the experimental results suggest that wild oat competition commenced prior to the 2 to 3 leaf stage in 1964 and perhaps prior to the 1 to 2 leaf stage in 1965, particularly with the higher densities of wild oats. The full impact of wild oat competition had occurred by the time the 5 to 6 leaf stage had been reached in 1964 and by the time the 7 to 8 leaf stage had been reached in 1965.

In similar experiments conducted with flax, severe competition had commenced prior to the 2 to 3 leaf stage in 1964, and prior to the 1 to 2 leaf stage of wild oat growth in 1965. In both years, the maximum competitive effects had not yet been reached by the time the wild oat plants were in the shot-blade stage.

In the final series of experiments (d) the results suggested optimum seeding date is, perhaps, the latter part of May or the first weed of June, as flax yield reductions due to wild oat competition were very severe in the later seeding dates.

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APPENDIX

Appendix 1

Analysis of Variance. The effect of various densities of wild oats on the yield of wheat grown on summerfallow, 1964

Source of Variance	D.F.	M.S.	F
Replicates	3	16.98	.39
Fertilizer	1	33.18	.77
Error A	3	43.38	
Main Plots	7		
Densities	7	262.79	33.05**
Densities x fertilizer	7	20.94	2.63*
Error B	42	7.95	
Total	63		

** Significant at 1% level of probability
* Significant at 5% level of probability

Appendix 2

Analysis of Variance. The effect of various densities of wild oats on the yield of wheat grown on summerfallow, 1965

Source of Variance	D.F.	M.S.	F
Replicates	3	79.03	37.35**
Fertilizer	1	99.76	34.55**
Error A	3	2.89	
Main Plots	7		
Densities	7	205.07	31.02**
Densities x fertilizer	7	56.34	.82
Error B	42	277.64	
Total	63		

** Significant at 1% level of probability
* Significant at 5% level of probability

Appendix 3

Analysis of Variance. The effect of various densities of wild oats on the yield of wheat grown on stubble land, 1964

Source of Variance	D.F.	M.S.	F
Replicates	3	33.58	1.39
Fertilizer	1	203.06	7.31**
Error A	3	27.77	
Main Plots	7		
Densities	7	122.09	16.13**
Densities x fertilizer	7	6.14	.81
Error B	42	7.57	
Total	63		

** Significant at 1% level of probability
* Significant at 5% level of probability

Appendix 4

Analysis of Variance. The effect of various densities of wild oats on the yield of wheat grown on stubble land, 1965

Source of Variance	D.F.	M.S.	F
Replicates	3	17.86	.42
Fertilizer	1	41.60	.97
Error A	3	42.80	
Main Plots	7		
Densities	7	410.14	84.56**
Densities x fertilizer	7	41.89	8.64**
Error B	42	4.85	
Total	63		

** Significant at 1% level of probability
* Significant at 5% level of probability

Appendix 5

Analysis of Variance. The effect of stage of wild oat growth at the time of removal on wheat yield, 1964

Source of Variance	D.F.	M.S.	F
Replicates	3	45.78	3.31
Density	3	951.42	68.84**
Error A	9	13.82	
Main Plots	15		
Stages	5	151.27	14.59**
Stages x density	15	27.49	2.65
Error B	60	10.37	
Total	95		

** Significant at 1% level of probability.
* Significant at 5% level of probability

Appendix 6

Analysis of Variance. The effect of stage of wild oat growth at the time of removal on wheat yield, 1965

Source of Variance	D.F.	M.S.	F
Replicates	3	219.42	29.41**
Density	3	604.18	80.99**
Error A	9	7.46	
Main Plots	15		
Stages	6	50.81	5.48*
Stages x density	18	14.00	1.51
Error B	72	9.27	
Total	111		

** Significant at 1% level of probability
* Significant at 5% level of probability

Appendix 7

Analysis of Variance. The effect of stage of wild oat growth at time of removal on protein content of wheat seed, 1964

Source of Variance	D.F.	M.S.	F
Replicates	3	.05	2.78
Density	3	5.58	310.00**
Error A	9	.02	
Main Plots	15		
Stages	5	3.49	109.06**
Stages x density	5	.60	18.75**
Error B	60	.03	
Total	95		

** Significant at 1% level of probability
* Significant at 5% level of probability

Appendix 8

Analysis of Variance. The effect of stage of wild oat growth at time of removal on protein content of wheat seed, 1965

Source of Variance	D.F.	M.S.	F
Replicates	3	.02	1.00
Density	3	.14	7.00**
Error A	9	.02	
Main Plots	15		
Stages	6	5.15	147.14**
Stages x density	18	.82	23.43**
Error B	72	.04	
Total	111		

** Significant at 1% level of probability
* Significant at 5% level of probability

Appendix 9

Analysis of Variance. The effect of various densities of wild oats on the yield of flax grown on summerfallow, 1964

Source of Variance	D.F.	M.S.	F
Replicates	3	26.77	6.89**
Densities	7	163.33	42.04**
Error	21	3.89	
Total	31		

** Significant at 1% level of probability
* Significant at 5% level of probability

Appendix 10

Analysis of Variance. The effect of various densities of wild oats on the yield of flax grown on summerfallow, 1965

Source of Variance	D.F.	M.S.	F
Replicates	3	3.51	.65
Densities	7	190.59	35.10**
Error	21	5.43	
Total	31		

** Significant at 1% level of probability
* Significant at 5% level of probability

Appendix 11

Analysis of Variance. The effect of various densities of wild oats on the yield of flax grown on stubble land, 1964

Source of Variance	D.F.	M.S.	F
Replicates	3	5.91	2.20
Densities	7	14.52	5.41**
Error	21	2.68	
Total	31		

** Significant at 1% level of probability
* Significant at 5% level of probability

Appendix 12

Analysis of Variance. The effect of various densities of wild oats on the yield of flax grown on stubble land, 1965

Source of Variance	D.F.	M.S.	F
Replicates	3	4.13	2.91
Densities	7	70.89	49.92**
Error	21	1.42	
Total	31		

** Significant at 1% level of probability
* Significant at 5% level of probability

Appendix 13

Analysis of Variance. The effect of stage of wild oat growth at the time of removal on flax yield, 1964

Source of Variance	D.F.	M.S.	F
Replicates	3	195.66	6.52**
Density	3	200.36	6.67**
Error A	9	30.03	
Main Plots	15		
Stages	5	118.06	24.19**
Stages x density	15	15.51	3.18*
Error B	60	4.88	
Total	95		

** Significant at 1% level of probability
* Significant at 5% level of probability

Appendix 14

Analysis of Variance. The effect of stage of wild oat growth at the time of removal on flax yield, 1965

Source of Variance	D.F.	M.S.	F
Replicates	3	119.12	4.30
Densities	3	444.71	16.07**
Error A	9	27.68	
Main Plots	15		
Stages	6	181.04	49.46**
Stages x density	18	20.95	5.72*
Error B	72	3.66	
Total	111		

** Significant at 1% level of probability
* Significant at 5% level of probability

Appendix 15

Analysis of Variance. The effect of wild oat competition on the yield of flax following various seeding dates, 1964

Source of Variance	D.F.	M.S.	F
Replicates	3	7.91	1.16
Densities	3	371.33	54.53**
Error A	9	6.81	
Main Plots	15		
Dates of Seeding	3	216.38	60.11**
Den. x Dates of Seeding	9	3.43	.95
Error B	36	3.60	
Total	63		

** Significant at 1% level of probability
* Significant at 5% level of probability

Appendix 16

Analysis of Variance. The effect of wild oat competition on the yield of flax following various seeding dates, 1965

Source of Variance	D.F.	M.S.	F
Replicates	3	19.85	10.39**
Densities	3	786.20	411.62**
Error A	9	1.91	
Main Plots	15		
Dates of Seeding	3	86.53	254.50**
Den. x Dates of Seeding	9	13.45	39.56**
Error B	36	.34	
Total	63		

** Significant at 1% level of probability
* Significant at 5% level of probability