AN ABSTRACT OF THE THESIS OF

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Title The Effects of Ryegrass Competition and Different Nitrogen Levels on the Growth and Yields of Semi-Dwarf Wheat Varieties

Abstract approved ______________

A major objective of wheat improvement in the Pacific Northwest has been the development of shorter-strawed wheat varieties. In anticipation of the eventual release of a semi-dwarf type wheat for producers in western Oregon, an agronomic study comparing two semi-dwarf selections with three standard varieties was conducted at Corvallis, Oregon, from 1958 to 1961.

Five varieties of winter wheat were grown in these experiments. The standard varieties were Burt, Druchamp, and Cappelle Desprez. The semi-dwarf selections were 55-1673 (CI 13273) and 55-1744 (CI 13275).

These varieties were compared by determining the effects of different rates and dates of nitrogen fertilization and different levels of ryegrass overseeding. In addition, nurseries of space-planted rows were established for morphological measurements on individual plants. The responses of the five wheats to various treatments were determined from measures of agronomic characters such as grain yield, straw yield, height, lodging, tillering, and bushel weight of wheat and seed and straw yield of ryegrass.

No direct differences between the semi-dwarf selections and the standard varieties were observed in the ability to respond to nitrogen. Lodging and disease resistance proved to be important indirect factors in determining yield. When there was no lodging, good yield responses were obtained from the use of as much as 80 pounds of nitrogen per acre. When lodging was serious, yields declined with increasing nitrogen.

The semi-dwarf selections outyielded the standard varieties by 20 per cent in the fertility experiments over the two-year period,

primarily due to their outstanding lodging resistance. Nitrogen fertilization of the semi-dwarf wheats used can be expected to increase yield without appreciable risk of lodging.

The data suggest that early spring nitrogen application favors relatively high wheat straw yields and late nitrogen application favors relatively high grain yields.

Common ryegrass overseeded in winter wheat at the rate of 4, 8, and 16 pounds per acre decreased wheat grain yields 19, 36, and 50 per cent, respectively. Wheat straw yields were reduced almost as much. Ryegrass competition caused yield reductions through reduced tillering, increased lodging, and other effects not studied, but did not appreciably influence plant height or bushel weight.

Grain yields were reduced about 5 per cent more in the semi-dwarf selections than in the standard varieties at each of the given ryegrass levels of seeding. Most of the difference between the semi-dwarf and standard wheats was contributed by Selection 55-1673, the shortest variety studied.

When yields of ryegrass grown in wheat were used as measures of competitive ability, the semi-dwarf varieties were consistently less competitive. Ryegrass yields in wheat exhibited a definite inverse relationship with wheat plant height.

Distinct differences in competitive ability between the two semi-dwarf selections were indicated. This suggests that semi-dwarf selections might be isolated which would be equal to standard varieties in competitive ability.

Significant differences between wheat varieties were found for both years in spike length. In addition, small but significant differences in number of heads per plant, number of kernels per plant, and weight per kernel were found in one of the two years studied.

THE EFFECTS OF RYEGRASS COMPETITION AND DIFFERENT NITROGEN LEVELS ON THE GROWTH AND YIELDS OF SEMI-DWARF WHEAT VARIETIES

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INTRODUCTION

During the past decade, one of the major objectives of wheat improvement in the Pacific Northwest, and other areas as well, has been the development of shorter-strawed wheat varieties. Such short-stemmed varieties must equal or exceed the yield and quality of the taller varieties and they would have, in addition, stiffer straw and the advantages of superior lodging resistance and less straw to handle during and after harvesting.

Recent yield trials of selections derived from crosses with the Japanese variety Norin-10 have appeared quite promising, and the first semi-dwarf variety, Gaines, recently has been released. It is fairly certain that these semi-dwarf varieties eventually will be widely accepted for wheat production in the Pacific Northwest as were the varieties such as Brevor, Elmar, Omar, Burt, and Druchamp.

The widespread acceptance of semi-dwarf wheat varieties for production in western Oregon could pose some special problems in production until the cultural behavior of these wheats has been observed under humid conditions. It is already apparent from studies made in the Palouse area of eastern Washington that emergence problems exist with some of the semi-dwarf selections under dry seeding conditions and that optimum seeding dates are different from those of the current varieties (20, p. 60; 2, p. 74).

Winter wheat is often grown following a ryegrass seed crop in the Willamette Valley of western Oregon. Common ryegrass is a vigorous competitor and is commonly found as a weed in the taller wheat varieties. Before semi-dwarf varieties are released for western Oregon, it is important to know how effectively they are able to compete with ryegrass and other weedy species. Specifically, it would be desirable to compare the semi-dwarf types of wheat with the standard varieties in their ability to maintain yield under varying increments of weed competition.

Lodging is frequently a serious problem with current varieties. The risk of lodging often limits the amount of nitrogen which can be applied to winter wheats in the Willamette Valley, as well as in other high yielding areas. The differences in lodging resistance and the amount of nitrogen which can be economically applied to the semi-dwarf wheats should be determined before they are released to wheat producers.

It also would be advisable to compare the morphological variables which contribute to grain yield to determine whether there are any major differences in plant type, other than height, between the semi-dwarf and the standard wheat varieties.

The objectives of this study were to evaluate the agronomic performance of two semi-dwarf wheat selections and three winter wheat varieties for western Oregon with respect to (1) competitive ability at known levels of ryegrass overseeding; (2) lodging resistance and grain yields at varying increments of nitrogen fertilization; and (3) morphological variables which may contribute to grain yield.

REVIEW OF LITERATURE

Semi-Dwarf Growth Habit

Early workers with plant height in wheat found discontinuous variation for that character and were unable to isolate progeny which were stable and productive and yet intermediate in height between the "grass-clump" type of dwarf and the standard varieties. The grass-clump dwarfs averaged about 9 inches tall and had little or no agronomic value because of low seed yields.

The introduction of the Japanese variety, Norin-10 (CI 12699), in 1948 by Dr. S. C. Salmon (36, p. 76) provided the first variety which approached the desired combination of plant height, lodging resistance and kernel type, although the grain yield was only average. Norin-10 was a true dwarf type wheat which reached a height of 24 to 27 inches under favorable conditions. This is about one half as tall as the standard "short" commercial varieties. Although Norin-10 was not a desirable variety, selections from crosses of Norin-10 with adapted varieties have been found which are stable for plant height and superior to either parent in straw strength and grain yield.

Carlson (7, p. 38-39) at Pullman, Washington, found continuous variation in the shorter plant heights in crosses using

Norin-10 X Baart, Norin-10 X Hymar, and Norin-10 X Brevor. He also found transgressive segregation in the F_2 and F_3 of two of the three crosses. He concluded that, if other crosses behave similarly, dominance and environmental variation should not greatly impede progress by selection toward the desired plant types.

Many of the semi-dwarf wheat selections that appear to have promise for the Pacific Northwest have been derived from crosses involving Norin-10. Vogel et. al. (36, p. 76) compared some agronomic characters of the short and very short-strawed varieties, Elgin, Elmar, and Brevor, with two semi-dwarf selections, 14 and 17 (from Norin-10 X Brevor), in eastern Washington. With selections that were approximately two-thirds as tall as Brevor (or about 30 inches), Vogel found that none of the semi-dwarfs equaled Brevor in total production of dry matter; but, using the straw-to-grain ratio as a measure to grain production efficiency, the semi-dwarfs were the most efficient and highest in grain yields.

Muir (23, p. 44), also at Pullman, Washington, studied the agronomic performance of semi-dwarf Selections 11, 14, and 17 from the cross of Norin-10 X Brevor and compared these selections with the standard type varieties, Uma, Brevor, 27-15 X Rex-Rio-41, Elmar, and Hymar. Muir also noted the reduced straw tonnage of the semi-dwarfs, but concluded that although the semi-dwarfs are shorter in height, they are about equal to the standard varieties in root penetration and water-drawing ability. The semi-dwarf selections had the highest grain yields.

Response to Nitrogen Fertilization

Increases in wheat yield resulting from nitrogen fertilization have been reported by many workers, including Baker (1, p. 138) in Idaho; Blackett (4, p. 19) in Scotland; Eck and Stewart (8, p. 16) in Oklahoma; Fernandez and Laird (10, p. 33) in Mexico; Hobbs (11, p. 39) in Kansas; Hunter (13, p. 311) in the Columbia River Basin of Oregon; Long and Ewing (19, p. 2) in Tennessee; Mallory (20, p. 59) in eastern Washington; and Peterson (29, p. 19) in Utah. The optimum rate of nitrogen fertilization for winter wheat has varied widely, depending upon soil and climatic conditions prevailing at the experimental site. More often than not, the suggested rate of nitrogen fertilization on winter wheat has varied from 40 to 80 pounds of nitrogen per acre. In general, nitrogen applied in the spring has given greater yield responses than a like amount of nitrogen applied in the fall. Rankin (31, p. 387) pointed out that a very large part of the dry weight of wheat plants is produced in March and April. In his work, the number of spikes, number of kernels per spike, and weight of kernels were all influenced by stage of growth at which nitrogen was supplied.

The literature on differential response of varieties to nitrogen fertilization is not extensive. Lamb and Salter (14, p. 142) found that wheat varieties responded differently to varying levels of fertility. Of the varieties used, however, none was definitely superior at only the high or at only the low fertility levels. The data of Lamb and Salter do not exclude the existence of such varieties.

Worzella (40, p. 123) also found a differential varietal response in grain yield associated with different fertility levels in the majority of trials. The wheats tended to fall into distinct groups according to response to fertility. Some were more efficient on well-fertilized plots, while some were relatively more efficient on low fertility plots. While the variety X fertility level interactions for grain yield were significant, the interactions were not great enough to change yield ranks and, therefore, the same adapted variety was recommended for all productivity levels of a soil.

Widdowson (39, p. 18-19) at Rothamsted studied the effects of nitrogen upon the three stiff-strawed winter wheat varieties, Heines 7, Hybrid 46, and Minister. There was some evidence that these varieties responded differently to additional increments of nitrogen. That is, Hybrid 46 always made better use of additional nitrogen than Heines 7 or Minister. All were stiff-strawed varieties, so lodging did not become a complicating factor. Widdowson concluded: "It appears that the optimum level of manuring must be related to the variety being cultivated, even when comparisons are restricted to modern stiff-strawed varieties which have been bred for conditions of high fertility."

Lodging is often a complicating factor in experiments with nitrogen fertilization in winter wheat. Black et. al. (3, p. 396) noted a tendency of wheat to lodge when the rates of fertilization used were near or in excess of the amount required to produce maximum yield. Skepasto and Klinck (33, p. 2) found definite increase in lodging with increasing nitrogen levels in weak-strawed barley varieties. Mulder specifically studied the effect of mineral nutrition on lodging of cereals. He obtained yield losses from lodging as high as 60 per cent (24, p. 305). Mulder states that lodging is often the limiting factor in attaining maximum yields by increased nitrogen supply, particularly under humid conditions prevailing during the greater part of the growing season of the cereal (24, p. 300). The combination of a favorable moisture supply, relatively high temperatures, cloudiness, and an excess supply of nitrogen gives rise to a very rapid growth of the young cereal plant which results in the formation of long and weak lower internodes. Then, a mere wettening of the foliage and ears by a light rain may flatten the crop. The yield depressions resulting from lodging depend upon (a) the growing stage at which the crop lodged and (b) the weather conditions prevailing after the lodging has taken place (24, p. 293). Norden and Frey (25, p. 335) found large culm diameter and large cross section area of tissue to be most closely associated with high lodging resistance in oats. A significant negative association was obtained between culm height and lodging resistance.

Beutler (2, p. 74) studied semi-dwarf Selections 9 and 12 (from Norin-10 X Brevor) and standard varieties, Burt and Omar, at the Pendleton Branch Experiment Station in eastern Oregon. The semi-dwarf selections demonstrated superior resistance to lodging at nitrogen levels up to 120 pounds per acre. The varieties and selections differed also in their yield response to nitrogen and to date of seeding. Selection 12 outyielded the standard varieties. The yield of semi-dwarf Selection 12 increased in a linear manner with earlier seeding, whereas the yields of the standard varieties declined when seeded early. Both semi-dwarf selections, however, demonstrated an inability to emerge uniformly when seeded four to five inches deep with low soil moisture.

Mallory (20, p. 59) compared two semi-dwarf wheats with standard varieties under various fertility levels and at different dates of seeding in eastern Washington. In this study, the semi-dwarf selections removed moisture and nitrogen from a depth of six feet as effectively as the standard varieties. They could be fertilized with much heavier rates of nitrogen without being adversely affected by lodging. Mallory (20, p. 60) concluded that "the semi-dwarf can come much closer to producing the maximum yields permissible by climate and soil conditions with the use of earlier seedings and heavier rates of nitrogen than the standard varieties. But management for good stands from early seedings and heavy fertility applications are not easy because of poor (dry-land) emergence."

Fajersson recently reviewed the world literature on the effect of nitrogen fertilization on wheat quality. It has been clearly shown (9, p. 11) that for North America, at least under some environmental conditions, it is possible to increase both protein content and yield by nitrogen fertilization. Fajersson states (9, p. 12) that, in general, late applications of nitrogen increase protein content more than yield and have little effect on plant morphology (i.e., tillers, height). Early nitrogen applications increase tiller number, stimulate vegetative growth (including more and larger heads and increased plant height), and also increase the risk of lodging. Early applications of nitrogen may result in an increase or decrease in protein content depending on conditions prevailing.

Hobbs (11, p. 40) reported that season had a greater effect on yield, growth characteristics, and protein content than either fall or spring treatment with fertilizer.

Hunter et. al. (13, p. 311) studied the effect of nitrogen fertilizer on the relationship between increases in yield and protein content of pastry-type wheats. He concluded that yield responses to nitrogen in the Columbia Basin of Oregon are closely associated with availability of moisture and that protein content is not raised to objectionably high values until more nitrogen is applied than that needed to produce "maximum yield." When nitrogen applications increased the yields significantly, yields increased at a greater rate than protein content; however, nitrogen applications greater than that needed for maximum yield caused protein content to increase more rapidly than yield.

Effects of Weed Competition on Wheat Performance

The extent to which grain yields are reduced by weed competition is generally underestimated. Most investigations are concerned with methods of weed control or the ecological factors of competition, and only a few reports give the quantitative effects of weed competition on yield and other agronomic characters under controlled conditions.

Walcott and Carlson (37, p. 483) reported studies on the effects of Quackgrass (Agropyron repens (L.) Beauv.) and Canada Thistle (Circium arvense (L.) Scop.) on small grains in Michigan. With paired plots of oats in naturally infested fields, they found that quackgrass reduced grain yield 30 per cent when compared with the yield in adjoining weed-free check areas if quackgrass constituted 23 per cent of the dry matter yield of the plot. Total green weight of oats and quackgrass combined was 13 per cent less than the weight of oats alone when grown on an equal area without weed competition. Canada thistle reduced the yield of mixed oats and barley 30 per cent when Canada thistle comprised 34 per cent of the vegetative matter of the plots on a dry matter basis. The total green weight of barley, oats, and thistles was 46 per cent greater than the weight of small grain grown alone. An apparent 28 per cent infestation of quackgrass (based on green plant material) reduced grain yields as much as a 53 per cent infestation of Canada thistle.

Pande (26, p. 303) studied the effect of hand-weeding one month after sowing wheat, using a uniform sowing time, seeding rate, and weeding date on three varieties of wheat. Hand-weeding increased significantly the number of ear-bearing tillers per plant, the grain yield per plant, and yield per acre. The percentage increase in grain yield was influenced by the degree of weed infestation. The increase in grain yield per acre from hand-weeding averaged about 24 per cent over the three-year period. The differences between varieties were significant only for ear-bearing tillers per plant. Pande found the response of the crop to weeding to be significantly greater under low fertility than under high fertility, indicating that competition was more severe when plant nutrients were scarce.

Blackman and Roberts (5, p. 69) obtained increases in wheat yield ranging from 6 to 113 per cent with an average increase of 23 per cent by selectively controlling annual weeds in winter wheat. In another study, Blackman and Templeman (6, p. 247) investigated the principal factors governing competition and yield depression. They concluded that (1) the most effective weed control treatment increases the yield of cereals on an average by some 25 per cent; (2) the presence or absence of weeds has no appreciable effect on the height of the crop; (3) intensity of competition is dependent upon the species of weed, but that accurate comparisons of relative competitive powers are difficult unless the tests are carried out in the same field, on the same crop, and in the same season; (4) nitrogen is an important factor in weed competition since nitrogen is able to counteract the depressing effect of weeds on tiller production; and (5) light is operative as a competitive factor only when the weed species is tall growing and the density is high.

Holmes and Tahir (12, p. 122) reported a significant interaction between weed control and density of wheat. They found no evidence that yield of a sparse stand of winter wheat can be increased further by altering the normal nitrogen fertilizer application or by altering the time of fertilizer application. They also found that, for good results, weed control is most essential where plant populations are low.

Pavlychenko and Harrington (28, p. 151) found moisture to be the most important factor in weed vs. crop competition in the plains of western Canada. Here, the yield of Marquis wheat was 40 per cent lower in plots infested with wild mustard than in weed-free plots. They reported that single plants of barley, wheat, and wild oats grown alone in areas 10 feet square attained approximately 10 times as large a growth of root system and top as plants seeded at the normal rate in 6-inch rows. They feel that competition commences when root systems overlap and immediately manifests itself in retarded development of top growth and becomes intensified by top growth competition only after shading of one plant by another takes place. In another study (27, p. 77), they rank Marquis wheat and Banner oats third in competitive ability behind Hannchen barley and Prolific spring rye. They concluded that crop varieties and weed species differ greatly in competitive ability.

Mann and Barnes (21, p. 273) studied the effect of creeping bent grass (Agrostis gigantea L.) on different planting rates of barley. They found that increasing the density of planting of barley reduced the crop loss due to competition. Bent grass could, nevertheless, diminish the yield of close-planted barley by one-fourth. In a sparse crop of barley, any increased bent grass growth was reflected in an almost equal reduction in yield of barley.

In the only study found in which date of removal of weed competition was studied, Shadbolt and Holm reported on some quantitative aspects of weed competition in vegetable crops (32, p. 122) and found that carrots, onions, and beets differed greatly in their ability to recover from the effects of weed competition after the weeds were removed. They found the period from emergence to four weeks to be a critical stage for these row crops in their competition with weeds.

Evidence of varietal difference in competitive ability is offered by Montgomery (22, p. 21) in an early study in 1912. When two varieties of wheat were planted in competition, one variety was very apt to have an advantage which, if continued, over a period of years, would cause it to practically replace the other. It appeared the one yielding best alone would not always be the one surviving under competition.

Muir (23, p. 44) studied three semi-dwarf selections in comparison with selected standard-type varieties in order to establish the relative competing ability of three varieties at Pullman, Washington. Muir used natural weed populations and weeded vs. non-weeded plots and used yield, plant height, straw tonnage, number of heads per row, and weight of air-dried weeds as measures of the weed competing ability of the varieties. The results indicate that the semi-dwarf selections compared favorably in weed competing ability with the standard varieties following early seeding. The semi-dwarf lines appeared to have a lower competing ability than the standard varieties following late seeding only when the weight of air-dried weeds was used as a measure. It was concluded that no variety was superior in weed competing ability. Weed removal increased the number of heads per row, straw tonnage per acre, grain yield and plant height, but not in one variety more than another. Lodging was severe following early seeding, with the semi-dwarfs averaging 36 per cent lodging while the five standard varieties averaged about 70 per cent (23, p. 14). With late seeding, the semi-dwarfs had no lodging and the standard varieties had about 20 per cent.

Components of Yield

There is good agreement in the literature as to the components of grain yield in wheat. Sprague in 1921 and 1922 (35, p. 995) found a high positive correlation between yield per unit area and average number of spikes per unit area. Smaller positive correlations were found for yield per unit area with grain yield per spike and weight per kernel. Quisenberry (30, p. 498) reported number of heads per unit area as one of the most important factors in determining yield, closely followed by number of kernels per head or size of head. Plumpness of grain or weight of 1,000 kernels was not as important a factor as the other two mentioned. He found that number of heads, number of kernels, and weight of 1,000 kernels accounted for 73 - 82 per cent of the variability in yield in five experiments conducted in 1926 in Oklahoma, Kansas, Nebraska, and Montana.

Locke (18, p. 644) states that a number of tillers sufficient to produce a large number of heads per unit area is the first requirement for a good yield. For the conditions covered by his study, the number of kernels per unit area, which is the product of the two characters, number of heads per unit area X the number of kernels per head, was found most practical for estimating yields. When kernel numbers were not considered, number of heads per unit area and plant height provided the most useful estimate. Kernel weight was never sufficiently low to upset this estimate. Plants per unit area do not usually plant an important part in determining number of heads per unit area because they are compensated for by the number of heads per plant.

Laude (15, p. 610) believes it to be axiomatic that the plant always does the best that is possible under the conditions that surround it. In this regard, adverse conditions (1) at seeding lead to fewer plants; (2) during early growth lead to fewer heads per plant; (3) during intermediate growth stages lead to smaller size heads; and (4) during later growth stages lead to smaller kernel size. Any of these will reduce yield and, therefore, all are critical ecologically.

MATERIALS AND METHODS

Definitions

Semi-dwarf wheat shall be arbitrarily defined as those varieties which normally attain a mature plant height of from 30 to 40 inches. Although there seems to be no clearly defined dividing line between a semi-dwarf and a very short variety nor between a semi-dwarf and a true dwarf, varieties or selections taller than or shorter than this range in height shall be considered as standard and dwarf wheats, respectively.

Standard variety shall be used to describe those varieties which have been or are now recommended for production. All standard varieties normally attain a height of 45 inches or more in western Oregon. Many of these varieties were previously classed as short or very short and were shorter than the varieties they replaced, but are considered relatively tall by present-day standards.

Plant Materials

Two varieties and two experimental selections of winter wheat were studied in these experiments. Selections 55-1673 (CI 13273) and 55-1744 (CI 13275) were chosen as semi-dwarf types for comparison with the recommended varieties Burt and Druchamp. An additional variety, Cappelle Desprez, was used the first year but was discontinued the second year as its height and behavior were very similar to that of Druchamp.

The semi-dwarfs, Selection 55-1673 and Selection 55-1744, are soft red winter selections from a Norin-10 X Staring cross made by Dr. W. H. Foote of the Oregon Agricultural Experiment Station. They have shown good straw strength and yield potential in preliminary trials and are representative of the type of wheat being developed for release in the Willamette Valley. Selection 55-1673 has a mature height of about 34 inches, and Selection 55-1744 has a height of about 39 inches.

Druchamp is a European short-strawed, soft white winter variety which has been grown recently in the Willamette Valley. Druchamp grows to a height of about 48 inches.

Burt is a soft to semi-hard, white winter variety of medium height, about 54 inches, at maturity.

The plant heights of all the varieties varied somewhat from year to year, depending upon environmental conditions.

Experimental Locations

The data reported in this study are from four experiments. They will be discussed as Experiment I - Nitrogen Fertilization, Experiment II - Ryegrass Competition, Experiment III - Greenhouse Competition, and Experiment IV - Components of Yield.

All the field investigations were conducted on the Hyslop Agronomy Farm located about six miles north of Corvallis, Oregon, except those of the second year (1959-1960) of Experiment IV. In the second year of Experiment IV, the wheat was planted on the Oregon State University East Farm about one mile east of Corvallis. The soil at the Hyslop Agronomy Farm is classed as a Willamette Silt Loam, typical of the valley floor soils of the Willamette Valley. It is a moderately heavy soil with about 2 per cent organic matter, a pH of about 5.5, and imperfect drainage in the winter. The soil at the East Farm is classed as a Chehalis Sandy Loam with a pH of about 6.2. In Experiment IV, the wheat was planted on the East Farm the second year in order to avoid localized root-rot areas in the field at the Hyslop Agronomy Farm. The experimental areas were fallowed the summer before seeding. The previous crop sequence for the four years prior to these experiments was winter grain-red clover-red clover-summer fallow.

The crop year 1958-59 was fairly normal in amount and distribution of rainfall (Table 1). Rainfall was ample for good crop yields and temperatures were near normal. March and April were relatively dry for those months. This resulted in short, strong

Table 1. Monthly precipitation amounts and temperature means from September 1958 through August 1960, with comparisons to normal, as measured at the Hyslop Agronomy Farm, Corvallis, Oregon.

Month	Precipitation			Mean Temperature		
	'58-'59	'59-'60	Normal	'58-'59	'59-60	Normal
September	1.30	1.60	1.57	62.0	58.9	61.0
October	2.68	1.57	2.88	54.5	55.8	53.1
November	8.49	2.58	6.43	46.2	43.9	45.4
December	4.15	3.35	6.14	44.0	39.5	40.8
January	10.52	4.38	6.47	41.7	35.5	39.3
February	4.56	6.49	5.15	42.2	41.9	42.3
March	3.99	7.18	4.13	45.1	44.5	46.2
April	0.84	3.29	2.56	50.2	49.5	50.9
May	2.20	3.92	1.88	53.1	52.4	55.7
June	1.31	0.22	1.14	60.3	61.6	60.9
July	0.32	Tr	0.28	67.6	67.2	66.2
August	Tr	0.64	0.43	65.9	63.6	66.6
Annual	40.36	35.22	39.06	52.7	51.2	52.4

plants with no lodging of any consequence. The 1959-1960 growing season was also a favorable one with respect to rainfall and temperature, and no serious disease problems were encountered. However, rainfall during March, April, and May of 1960 was 5.82 inches above normal, and temperatures were below seasonal means. There were 26 cool, rainy days in May, coupled with some wind--all of which promoted luxuriant and prolonged vegetative growth of the wheat, which resulted in serious lodging in the two taller varieties.

A major problem encountered in the field studies in 1958-1959 was occasioned by two diseases occurring in localized portions of the experimental area. Examination of individual plants indicated that both yellow dwarf disease and root rots (undetermined species probably of *Fusarium*, *Cercosporella*, *Ophiobolus*, or *Rhizoctonia*) were present. The two diseases were not readily separated by visual observation of plant symptoms, as both give the plant a stunted, yellowed appearance. This situation will be referred to as a disease complex in subsequent discussion.

Nitrogen Fertilization - Experiment I

Experiment I was an evaluation of the semi-dwarf and standard wheats under five rates of nitrogen fertilization at three dates of application. A split plot factorial design with four replications was used. To facilitate seeding, varieties were used for main plots. The subplots consisted of combinations of rate and date of nitrogen application. The rates of nitrogen were 0, 20, 40, 80, and 160 pounds of nitrogen per acre applied as ammonium nitrate. The three dates of application were March 7, April 3, and April 28, 1959, for the first year and November 5, 1959, and March 21 and April 28, 1960, for the second year. The 15 possible treatments were randomized within each main plot each year.

The five varieties of wheat (four in 1960) were seeded September 29, 1958, and October 5, 1959, at 90 pounds per acre with a commercial grain drill in 6-inch rows.

The fertilizer was weighed separately and hand broadcast on each subplot.

The wheat was harvested July 30 and 31, 1959, and July 23, 25, and 28, 1960, in Experiment I. Prior to harvest in 1959, disease ratings were taken on a scale of 0 - 3, with the former indicating no symptoms and the latter severe symptoms. Plant heights were measured by taking three random height measurements for each subplot. Plant height was measured from ground level to the apex of the spike, excluding awns, if any. Per cent lodging was estimated by visual observation.

The harvested area for each subplot was 40.5 square feet, excluding approximately a 20-inch border around each subplot. The total weight of the grain and straw was taken for each subplot. The straw weight was obtained by subtracting grain yield from the total weight. Bushel weights were taken on the grain from each subplot by the standard method.

Ryegrass Competition - Experiment II

Experiment II was a competition study with the same wheat varieties as in Experiment I overseeded with common ryegrass (*Lolium multiflorum* Lam.). In 1958-1959, five varieties of wheat were used in a split plot design with four replications and three levels of ryegrass overseeded at 0, 8, and 16 pounds per acre. In 1959-1960, Cappelle Desprez was discontinued as a variety, and an additional increment of ryegrass, 4 pounds per acre, was added. In both years, main plots were varieties of wheat and subplots were levels of ryegrass randomized within each main plot.

The wheat was planted on land free from volunteer ryegrass in Experiment II, so there was no ryegrass competition in the zero-level subplots. The wheat was seeded at the same time and in the same manner as that in Experiment I. The ryegrass was hand broadcast on October 4, 1958, and October 13, 1959. The ryegrass was weighed for each subplot and hand broadcast with sand to insure even seeding. All plots were cultipacked twice after broadcasting the ryegrass. It was necessary to irrigate on October 13, 1958, to provide moisture for germination, since the wheat was germinating while the ryegrass was not in the moisture zone. In 1959, the ryegrass was seeded after a good rain on moist soil and no irrigation was necessary.

Excellent stands of wheat and ryegrass were obtained both years. The ryegrass germinated and emerged at approximately the same time as the wheat, as it does when ryegrass seed shatters and volunteers as a weed in winter wheat.

A uniform application of 67 pounds of nitrogen per acre (200 lbs. NH_4NO_3) was applied on April 7, 1959, and March 23, 1960. Height, lodging, and bushel weight data were taken for each subplot in the same manner as described for Experiment I.

After cutting alleyways, a 2- x 6-foot area was hand-harvested from the end of each subplot to serve as a subsample for hand separation. A 36-inch plot combine was then used to harvest the grain from the balance of the subplot, consisting of 59.25 square feet. For the 1960 harvest, a new 7-foot plot combine was available and yields were based on a harvested area of 154 square feet.

In an attempt to determine the time when the major competitive effects of ryegrass are exerted upon the wheat, another treatment was added to the 8-pound level of ryegrass in 1960. Subplots of the 8-pound level were divided into six sub-subplots measuring 8 x 4 feet each. Three of these sub-subplots were used as check plots to measure wheat and ryegrass seed yield for the 8-pound level of ryegrass. The other three sub-subplots were used for a date of removal treatment. The ryegrass was hand-weeded from the wheat from one sub-subplot each on December 10, 1959, February 1, 1960, and March 20, 1960. At harvest, areas 6 x 2 feet were hand-harvested from the center of each of the six sub-subplots. Hand separations were made to determine the efficiency of ryegrass removal.

Ryegrass straw was hand-separated from wheat in the subsamples and sub-subplots. After hand separation, the wheat was threshed to determine grain and straw yields.

Since most of the ryegrass seed shatters before winter wheat is mature enough to harvest, no attempt was made to obtain ryegrass seed yields in subsamples or sub-subplots. The only ryegrass seed yields obtained were those from the subplots which were harvested with a combine.

Greenhouse Competition - Experiment III

A greenhouse study was initiated in February, 1961, in order to further study the competitive effect of ryegrass during various vegetative stages of growth.

Selections 55-1744 and 55-1673, along with the standard varieties, Burt and Druchamp, were used in this study in a split-split plot, factorial design with three replications. The main plots were the four varieties above; the subplots were five levels of ryegrass (0, 4, 8, 16, and 32 pounds per acre); and the sub-subplots were four harvest dates.

For the greenhouse plantings, the wheat varieties were vernalized by placing the seed between wet paper toweling in a cold room at 35° F. for 17 days. A four-minute soak in a solution of one-half teaspoon of 50 per cent Captan per pint of 10 per cent absolute alcohol before vernalization was used to control mold growth.

The wheat was planted in a greenhouse ground bed. Soil tests indicated adequate levels of P, K, Ca, and Mg for production of cereal crops in the greenhouse. However, in order to be sure that fertility was not limiting plant growth, 16-20-10 was applied at the rate of 420 pounds per acre.

The vernalized wheat was space-planted in 6-inch rows at 1-1/2-inch intervals in the row (60 pounds per acre). To facilitate separate harvesting, the common ryegrass was seeded also in 6-inch rows between the rows of wheat, so that there were alternate rows of wheat and ryegrass 3 inches apart. To insure uniform seeding of the proper amount of live pure seed per subplot, germination tests were made and the amount of seed required for each 3-foot subplot row was computed and weighed. The 3-foot rows of ryegrass were then seeded from individual seed packets. Each subplot thus consisted of eight 3-foot rows each of wheat and common ryegrass.

Each main plot was irrigated as soon as it was planted to prevent the presoaked seed from drying out. Thereafter, the plots were watered daily until emergence and then periodically throughout the experiment so that moisture was never a limiting factor in the study.

Excellent stands of both wheat and ryegrass were obtained. The wheat emerged in two to three days and the ryegrass in four to five days. Shortly after emergence, all sub-subplots were marked off with string, excluding the border around each plot.

Only limited temperature control was possible. The temperature was set at 60° F. at night and 70° F. during the daylight hours, but the temperature frequently exceeded 70° F. during the warm sunny days in March and April when the ventilation system was not adequate to control temperatures.

The wheat and ryegrass grew rapidly and was harvested separately in each sub-subplot 24, 40, 60, and 82 days after seeding. The plots were harvested row by row with hand shears. All plants were clipped at ground level. Green weights of wheat and ryegrass were taken at harvest time, and dry weight was obtained after drying the material at least one week at 150° F. Wheat tiller counts were taken at the time of the last harvest on a sample of 50 per cent of the wheat plants per sub-subplot.

Space-Planted Rows - Experiment IV

Some morphological characters which contribute to grain yield in wheat were compared in a space-planted experiment using a randomized complete block design with four replications. The five wheat varieties used in other experiments were space-planted four inches apart in rows 10 feet long. Each row was protected by alternate rows of Druchamp wheat drilled with a V-belt seeder at 60 pounds per acre. The interval between all rows was 18 inches. This arrangement provided conditions for good development of the spaced plants and for the expression of morphological characters, as well as a uniform amount of competition to individual plants.

The plots were fertilized with 67 pounds of nitrogen per acre as NH_4NO_3 on April 7, 1959, and on March 24, 1960.

Only those plants which had plants adjacent to them on both sides in the row at 4-inch intervals were harvested. For each plot, a sample of 10 plants was retained for measurements. The 10 plants which appeared to have attained the best development were studied. In 1958-1959, the variety Burt is not reported because of missing plants and inadequate samples for measurement. In 1959-1960, all plots and varieties had adequate samples for measurement.

The following variables were measured on each plant: plant height (longest culm), length of longest spike, number of tillers, number of fertile heads, grain weight, number of kernels, and average weight per kernel.

Statistical Procedures

All measured experimental variables except the straw-to-grain ratios in Fertilization Experiment I were subjected to analysis of variance and "F" test, as described by Snedecor (34, p. 244). The error terms are composed of interactions of the appropriate variables. Duncan's multiple range test (17, p. 238) was used to test differences between individual means where significant differences were indicated by the "F" test. The means in the same group are identified by the same letter. The multiple range test was not used on interaction means involving comparisons of unequal size plots, nor on certain comparisons involving harvests in Experiment III, since these comparisons are not part of the objectives of this study. Year effects were not analyzed. This was deemed to be unnecessary in view of the large differences in the two growing seasons. The mean squares for all the analyses are reported in appendix Tables 1 through 10.

EXPERIMENTAL RESULTS

Response to Nitrogen - Experiment I

The extreme differences between the 1958-1959 and 1959-1960 growing seasons have been noted. In 1958-1959, the two semi-dwarf selections were more seriously affected by the disease complex of yellow dwarf and root rots than the three standard varieties, as determined from individual plot ratings (Table 2). The reasons for this difference are not known. Differences in the genetic background of the varieties may have accounted for the difference in the seriousness of the disease. The two semi-dwarf selections were rated 1.30 (light to moderate infection), while the tall varieties were rated 0.79 (zero to light infection). Many plots of 55-1673 and 55-1744 at the low nitrogen levels were seriously stunted and yellowed long before maturity. The disease symptoms were significantly less in the plots receiving higher rates of nitrogen (Appendix Table 1).

The disease situation which prevailed during the spring of 1959 prevented a precise measure of the yield response of the semi-dwarf varieties in relation to rates and dates of nitrogen application. The average grain yield for all varieties and treatments was 38.4 bushels per acre (Table 3). The only difference in varietal yield was the Selection 55-1673 which was significantly lower

Table 2. Average Disease Rating of Five Varieties of Wheat for Fertilization - Experiment I, 1959.

Variety	Date of Nitrogen Application	Rate of Nitrogen Application					Mean	Variety Means
		0	20	40	80	160		
Burt	Mar. 7	1.25	1.00	0.50	0.00	0.00	0.55	
	Apr. 3	1.25	1.25	1.00	0.75	0.25	0.90	
	Apr. 28	1.75	1.00	0.25	0.50	0.75	0.85	0.77 b
Druchamp	Mar. 7	1.25	1.75	1.00	0.75	0.25	1.00	
	Apr. 3	1.25	0.50	0.50	0.75	0.00	0.60	
	Apr. 28	1.50	0.75	1.00	0.50	0.75	0.90	0.83 b
55-1673	Mar. 7	1.00	1.25	1.75	0.25	0.25	0.90	
	Apr. 3	2.00	1.75	1.50	0.75	1.25	1.45	
	Apr. 28	2.50	1.75	1.50	1.25	1.00	1.60	1.32 a
55-1744	Mar. 7	1.75	1.25	0.75	1.00	0.00	0.95	
	Apr. 3	2.00	1.50	1.00	1.75	1.75	1.60	
	Apr. 28	1.25	0.75	1.50	1.75	1.25	1.30	1.28 a
Cappelle	Mar. 7	1.25	1.25	1.25	0.50	0.75	1.00	
	Apr. 3	0.50	0.50	1.00	0.25	0.00	0.45	
	Apr. 28	1.00	0.50	0.75	1.75	0.50	0.90	0.78 b
Rate Means		1.43a	1.12ab	1.02b	0.83bc	0.58c	1.00	
Date Means		Mar. 7	Apr. 3	Apr. 28				
		0.88	1.00	1.11				

Rating Scale:
0 = none evident
1 = light
2 = moderate
3 = severe

Table 3. Wheat Grain Yields in Bushels Per Acre (Mean of Four Replications) for Fertilization Experiment I, 1959.

Variety	Date of Nitrogen Application	Rate of Nitrogen Application 0	20	40	80	160	Mean	Variety Means
Burt	Mar. 7	27.4	36.0	41.3	51.5	50.2	41.3	
	Apr. 3	29.8	31.1	33.7	52.6	62.4	41.9	
	Apr. 28	23.4	34.8	53.6	51.2	51.4	42.9	42.0 a
Druchamp	Mar. 7	29.7	32.4	35.8	41.6	41.0	36.1	
	Apr. 3	30.5	42.3	46.4	47.5	57.2	44.8	
	Apr. 28	29.9	50.9	37.4	42.5	43.2	40.8	40.6 a
55-1673	Mar. 7	30.0	31.2	27.0	46.3	37.1	34.3	
	Apr. 3	19.8	25.1	29.8	45.1	30.3	30.0	
	Apr. 28	14.7	20.5	34.3	23.9	35.9	25.9	30.1 b
55-1744	Mar. 7	25.9	30.4	35.0	54.5	59.3	41.0	
	Apr. 3	11.0	30.6	36.8	38.3	40.6	31.5	
	Apr. 28	30.8	37.5	39.2	47.1	46.1	40.1	37.5 a
Cappelle	Mar. 7	23.2	32.3	27.6	54.3	45.7	36.6	
	Apr. 3	33.6	49.5	43.7	52.3	50.1	45.8	
	Apr. 28	32.5	34.8	48.8	43.0	53.5	42.5	41.7 a
Rate Means		26.1c	34.6b	38.0b	46.1a	46.9a	38.4	
Date Means		Mar. 7	Apr. 3	Apr. 28				
		37.9	38.8	38.4				

than the other four varieties. This low yield was probably due to the high disease infection. Selection 55-1744 yielded almost as well as the taller varieties in spite of a high incidence of disease. There was evidence of a linear response in yield to rates of nitrogen up to the 80-pound level, but there was only a slight increase at 160 pounds of nitrogen per acre. The date of application of nitrogen had no apparent effect on grain yield.

In 1960, environmental influences were of a different nature. There was no serious yellow dwarf epidemic in the Willamette Valley, and root rot symptoms were visible in only a few scattered areas of the fertility experiment.

The cool, wet spring of 1960 caused serious lodging in the taller varieties, Burt and Druchamp, as is shown in Table 4 and Figure 1. The outstanding straw strength of Selection 55-1673 was very noticeable in 1960 when there was no lodging, even with 160 pounds of nitrogen applied per acre. Selection 55-1744 also had good straw strength, but had some lodging when the higher rates of nitrogen were applied. In general, lodging began first in the tall varieties and with the higher rates of nitrogen. The tall varieties eventually lodged badly with all rates of nitrogen. Selection 55-1744 did not lodge until about two weeks later than the tall varieties, nor did the plants go completely down as did the taller varieties.

Table 4. Average Per Cent Lodging of Wheat in Fertilization Experiment I, 1960.

Variety	Date of Nitrogen Application	Rate of Nitrogen Application					Mean	Variety Means
		0	20	40	80	160		
Burt	Mar. 7	75.0	75.0	69.8	67.5	84.8	74.4	
	Apr. 3	65.0	75.0	87.2	92.2	89.5	81.8	
	Apr. 28	70.0	59.8	69.8	77.5	52.5	65.9	74.0 a
Druchamp	Mar. 7	45.0	70.0	75.0	65.0	62.5	63.5	
	Apr. 3	35.0	75.0	65.0	62.5	62.5	60.0	
	Apr. 28	57.5	57.5	75.0	80.0	52.5	64.5	62.7 a
55-1673	Mar. 7			None			00.0	
	Apr. 3			None			00.0	
	Apr. 28			None			00.0	00.0 c
55-1744	Mar. 7	7.5	10.0	20.0	55.0	77.5	34.0	
	Apr. 3	5.0	5.0	35.0	40.0	87.5	34.5	
	Apr. 28	25.0	12.5	27.5	57.5	85.0	41.4	36.6 b
Rate Means		32.1c	36.6bc	43.7abc	49.8ab	54.5a	43.3	
Date Means		Mar. 7	Apr. 3	Apr. 28				
		43.0	44.1	43.0				

Wheat grain yields in 1960 were more closely associated with degree of lodging than with the genetic yield potential of the varieties (Table 5). The two semi-dwarf selections yielded almost twice as much grain (59.8 vs. 32.0 bu/acre) as Burt and Druchamp.

In 1960, yields decreased with increasing rate of nitrogen. This may have been due to earlier and more serious lodging in the high-nitrogen plots. The late date of application resulted in significantly higher yields than those obtained from the November or March applications.

In 1959, when there was little lodging, the wheat straw yields of the two semi-dwarf selections were the lowest of the five varieties studied and were significantly lower than Druchamp and Cappelle (Table 6). Wheat straw yield increased significantly with rate of nitrogen. The March 7 date of application of nitrogen gave the highest straw yield.

In 1960, the only significant differences in straw yield were between Druchamp, the highest, and Burt and 55-1744, the two lowest varieties (Table 7). Rate and date of nitrogen application had no consistent influence on straw yield in 1960.

The straw-to-grain ratios calculated from the grain and straw yields for the two years cannot be taken as conclusive indicators of the efficiency of production of the varieties in this case, since they

Table 5. Wheat Grain Yields in Bushels Per Acre for Fertilization Experiment I, 1960. Mean of Four Replications.

Variety	Date of Nitrogen Application	Rate of Nitrogen Application					Mean	Variety Means
		0	20	40	80	160		
Burt	Mar. 7	33.7	35.2	41.3	35.0	32.1	35.5	
	Apr. 3	38.1	41.1	25.4	33.5	35.1	34.6	
	Apr. 28	44.7	44.2	41.1	31.6	39.8	40.3	36.8 c
Druchamp	Mar. 7	40.2	30.2	25.0	22.3	31.0	29.8	
	Apr. 3	39.4	20.7	23.6	24.7	23.1	26.3	
	Apr. 28	29.1	27.7	20.2	20.4	32.6	26.0	27.3 d
55-1673	Mar. 7	66.3	60.6	55.0	57.1	47.4	57.3	
	Apr. 3	68.1	65.7	54.9	55.9	39.2	56.8	
	Apr. 28	60.4	71.1	80.7	79.2	75.3	73.3	62.5 a
55-1744	Mar. 7	62.4	65.4	69.3	51.3	46.1	58.9	
	Apr. 3	62.8	70.4	56.9	52.8	28.0	54.2	
	Apr. 28	60.1	69.4	60.5	56.6	43.1	58.0	57.0 b
Rate Means		50.4a	50.1a	46.2b	43.4b	39.4c		
Date Means		Mar. 7	Apr. 3	Apr. 28				
		45.3b	43.0b	49.4a				

Table 6. Wheat Straw Yields in Tons Per Acre for Fertilization Experiment I, 1959. Mean of Four Replications.

Variety	Date of Nitrogen Application	Rate of Nitrogen Application 0	20	40	80	160	Mean	Variety Means
Burt	Mar. 7	4.52	5.04	5.21	5.97	5.71	5.29	
	Apr. 3	4.37	4.55	4.83	5.04	5.17	4.71	
	Apr. 28	4.25	4.47	5.22	5.07	5.02	4.80	4.96 b
Druchamp	Mar. 7	5.41	5.99	5.91	6.57	7.18	6.21	
	Apr. 3	5.09	6.28	6.26	5.37	6.04	5.81	
	Apr. 28	5.60	6.17	5.49	5.30	5.96	5.70	5.91 a
55-1673	Mar. 7	4.86	4.50	4.62	5.99	5.74	5.15	
	Apr. 3	4.20	4.19	4.15	5.03	4.89	4.49	
	Apr. 28	3.96	3.46	4.68	5.29	4.82	4.44	4.69 b
55-1744	Mar. 7	3.94	4.27	4.66	4.91	5.26	4.61	
	Apr. 3	3.22	4.43	4.95	4.30	4.49	4.28	
	Apr. 28	4.35	4.73	4.86	4.35	4.85	4.63	4.50 b
Cappelle	Mar. 7	4.58	6.03	5.59	7.64	6.92	6.15	
	Apr. 3	5.40	6.62	5.77	5.91	5.97	5.93	
	Apr. 28	5.79	5.71	5.66	5.14	5.66	5.59	5.89 a
Rate Means		4.64c	5.09b	5.19b	5.46a	5.58a	5.19	
Date Means		Mar. 7	Apr. 3	Apr. 28				
		5.48a	5.06b	5.03b				

Table 7. Wheat Straw Yields in Tons Per Acre for Fertilization Experiment I, 1960, Mean of Four Replications.

Variety	Date of Nitrogen Application	Rate of Nitrogen Application					Mean	Variety Means
		0	20	40	80	160		
Burt	Mar. 7	6.83	6.03	5.91	5.45	7.26	6.30	
	Apr. 3	6.19	4.69	6.54	6.47	6.71	6.12	
	Apr. 28	7.16	7.80	7.45	7.31	5.66	7.07	6.50 b
Druchamp	Mar. 7	9.16	8.72	6.61	7.82	6.29	7.68	
	Apr. 3	9.00	7.09	8.07	8.58	6.70	7.93	
	Apr. 28	9.22	8.30	7.58	9.27	8.48	8.57	8.06 a
55-1673	Mar. 7	7.43	6.94	6.34	7.40	7.15	7.05	
	Apr. 3	7.27	7.51	7.26	7.01	6.66	7.14	
	Apr. 28	6.32	7.53	7.67	7.69	7.80	7.40	7.20 ab
55-1744	Mar. 7	6.08	6.69	6.91	7.91	5.16	6.58	
	Apr. 3	6.90	6.34	7.72	6.18	5.82	6.59	
	Apr. 28	5.47	6.37	6.29	7.40	6.60	6.39	6.52 b
Rate Means		7.25	7.00	7.03	7.37	6.69	7.07	
Date Means		Mar. 7	Apr. 3	Apr. 28				
		6.90	6.94	7.37				

reflect the unusually low yields of 55-1673 in 1959 and Burt and Druchamp in 1960 (Tables 8 and 9). It might be worth noting that over the two-year period, the straw-to-grain ratio of the semi-dwarfs was 4.36 compared to 6.34 for Burt and Druchamp. Also, the straw-to-grain ratio followed a trend opposite to that of grain yield; that is, it decreased in 1959 as grain yield increased with increasing rate of nitrogen application, and it increased in 1960 as grain yield decreased as a result of higher rates of nitrogen application.

Due to conditions favoring vegetative growth, all varieties were taller in 1960 than in 1959, as shown in Tables 10 and 11. The differences in average height between years ranged from 2.5 inches for Druchamp to 7.8 inches in Selection 55-1744. The differences between varieties in height across years was relatively constant, except for Selection 55-1744 which did not differ significantly from Druchamp in 1960. The stimulation of plant height by nitrogen fertilization varied with year and level of nitrogen in the same manner as wheat grain yields.

There were significant differences in bushel weight due to varieties and due to rates of nitrogen application in both years, and between dates of nitrogen application in 1960 only (Tables 12 and 13 and Appendix Tables 1 and 2). Burt was consistently high in bushel

Table 8. Average Straw-To-Grain Ratio for Fertilization Experiment I, 1959.

Variety	Date of Nitrogen Application	Rate of Nitrogen Application					Mean	Variety Means
		0	20	40	80	160		
Burt	Mar. 7	5.68	4.84	4.35	4.00	3.93	4.42	
	Apr. 3	5.07	5.04	4.95	3.31	2.86	3.94	
	Apr. 28	6.27	4.42	3.36	3.42	3.37	3.86	4.07
Druchamp	Mar. 7	6.28	6.38	5.70	5.45	6.03	5.94	
	Apr. 3	5.76	5.12	4.65	3.90	3.65	4.47	
	Apr. 28	6.46	4.18	5.06	4.30	4.75	4.83	5.02
55-1673	Mar. 7	5.61	4.97	5.90	4.47	5.34	5.17	
	Apr. 3	7.33	5.76	4.80	3.84	5.56	5.16	
	Apr. 28	9.28	5.82	4.71	7.64	4.63	5.92	5.39
55-1744	Mar. 7	5.25	4.84	4.60	3.11	3.06	3.88	
	Apr. 3	10.13	5.00	4.63	3.87	3.82	4.69	
	Apr. 28	4.88	4.35	4.28	3.19	3.62	3.98	4.14
Cappelle	Mar. 7	6.80	6.43	6.98	4.85	5.22	5.79	
	Apr. 3	5.55	4.61	4.56	3.90	4.11	4.47	
	Apr. 28	6.14	5.65	4.00	4.12	3.65	4.54	4.88
Rate Means		6.12	5.08	4.71	4.08	4.10	4.67	
Date Means		Mar. 7	Apr. 3	Apr. 28				
		4.99	4.50	4.52				

Table 9. Average Straw-To-Grain Ratio for Fertilization Experiment I, 1960.

Variety	Date of Nitrogen Application	Rate of Nitrogen Application					Mean	Variety Means
		0	20	40	80	160		
Burt	Mar. 7	6.99	5.91	4.94	5.38	7.80	6.13	
	Apr. 3	5.60	3.94	8.90	6.67	6.59	6.10	
	Apr. 28	5.52	6.08	6.25	7.98	4.90	6.06	6.09
Druchamp	Mar. 7	7.85	9.95	9.12	12.11	7.00	8.96	
	Apr. 3	7.88	11.80	11.80	11.97	10.13	10.34	
	Apr. 28	10.93	10.33	12.95	15.65	8.97	11.37	10.16
55-1673	Mar. 7	3.86	3.95	3.97	4.47	5.20	4.25	
	Apr. 3	3.69	3.94	4.56	4.33	5.85	4.34	
	Apr. 28	3.61	3.66	3.28	3.35	3.57	3.48	3.98
55-1744	Mar. 7	3.36	3.53	3.44	5.31	3.86	3.84	
	Apr. 3	3.78	3.11	4.68	4.04	7.17	4.20	
	Apr. 28	3.14	3.17	3.58	4.51	5.28	3.82	3.95
Rate Means		4.96	4.82	5.25	5.87	5.86	5.31	
Date Means		Mar. 7	Apr. 3	Apr. 28				
		5.25	5.57	5.15				

Table 10. Average Plant Height in Inches for Fertilization Experiment I, 1959.

Variety	Date of Nitrogen Application	Rate of Nitrogen Application 0	20	40	80	160	Mean	Variety Means
Burt	Mar. 7	45.8	49.5	50.2	55.8	53.5	51.0	
	Apr. 3	43.8	46.2	47.5	50.0	49.5	47.4	
	Apr. 28	41.5	44.2	48.5	49.2	48.8	46.5	48.3 a
Druchamp	Mar. 7	42.2	41.5	43.5	47.2	46.5	44.2	
	Apr. 3	42.2	44.0	45.5	43.2	43.8	43.8	
	Apr. 28	44.5	44.2	41.8	41.8	41.0	42.7	43.5 b
55-1673	Mar. 7	33.0	34.8	34.8	37.8	36.8	35.4	
	Apr. 3	34.2	34.2	32.5	36.0	34.2	34.2	
	Apr. 28	30.0	32.5	34.5	34.2	34.8	33.2	34.3 d
55-1744	Mar. 7	35.0	36.5	38.8	42.2	42.0	38.9	
	Apr. 3	31.5	37.2	36.5	36.8	36.8	35.8	
	Apr. 28	38.2	37.0	36.0	37.0	38.0	37.2	37.3 c
Cappelle	Mar. 7	41.5	44.5	41.2	50.0	47.5	45.0	
	Apr. 3	45.0	45.2	45.0	45.0	42.0	44.4	
	Apr. 28	43.2	42.2	45.0	40.0	43.2	42.8	44.1 b
Rate Means		39.4d	40.9c	41.4bc	43.1a	42.6ab	41.5	
Date Means		Mar. 7	Apr. 3	Apr. 28				
		42.9a	41.1b	40.5b				

Table 11. Average Plant Height in Inches for Fertilization Experiment I, 1960.

Variety	Date of Nitrogen Application	Rate of Nitrogen Application 0	20	40	80	160	Mean	Variety Means
Burt	Mar. 7	53.5	50.5	53.8	52.0	52.0	52.4	
	Apr. 3	53.2	52.2	51.5	53.0	50.8	52.2	
	Apr. 28	53.5	52.0	51.8	52.2	53.0	52.5	52.3 a
Druchamp	Mar. 7	46.5	46.8	45.8	46.0	44.5	45.9	
	Apr. 3	48.2	43.8	46.0	45.2	45.2	45.7	
	Apr. 28	46.5	47.2	45.0	47.5	45.8	46.4	46.0 b
55-1673	Mar. 7	31.0	31.0	37.5	39.5	37.8	38.4	
	Apr. 3	38.0	39.0	39.0	39.2	38.0	38.6	
	Apr. 28	38.5	38.5	39.0	38.8	39.5	38.8	38.6 c
55-1744	Mar. 7	45.0	46.2	45.8	43.2	44.8	45.0	
	Apr. 3	45.0	43.8	45.2	44.5	44.8	44.6	
	Apr. 28	46.5	44.0	46.5	44.8	46.0	45.6	45.1 b
Rate Means		46.1a	45.2b	45.6ab	45.5ab	45.2b		
Date Means		Mar.7	Apr.3	Apr.28				
		45.4	45.3	45.8				

Table 12. Average Bushel Weights of Fertilization Experiment I, 1959.

Variety	Date of Nitrogen Application	Rate of Nitrogen Application					Mean	Variety Means
		0	20	40	80	160		
Burt	Mar. 7	59.4	59.6	59.4	61.5	60.9	60.2	
	Apr. 3	59.3	58.6	59.5	61.0	61.3	59.9	
	Apr. 28	58.0	59.8	61.8	61.2	61.1	60.4	60.2 a
Druchamp	Mar. 7	55.6	55.1	56.2	56.3	56.6	56.0	
	Apr. 3	54.8	55.8	55.5	57.1	57.5	56.1	
	Apr. 28	55.0	56.4	56.6	56.6	55.6	56.0	56.0 b
55-1673	Mar. 7	56.5	57.6	57.0	57.1	57.3	57.1	
	Apr. 3	54.2	56.8	56.2	57.8	55.4	56.0	
	Apr. 28	54.6	54.8	56.7	54.5	56.4	55.4	56.2 b
55-1744	Mar. 7	53.4	52.8	54.3	55.4	55.0	54.2	
	Apr. 3	52.4	52.7	52.2	54.0	53.3	52.9	
	Apr. 28	52.7	52.4	52.9	54.9	55.7	53.7	53.6 c
Cappelle	Mar. 7	55.2	55.9	56.2	57.9	56.8	56.4	
	Apr. 3	56.5	57.3	57.6	57.7	57.4	57.3	
	Apr. 28	55.7	55.1	55.8	57.0	56.6	56.0	56.6 b
Rate Means		55.5d	56.0cd	56.5bc	57.3a	57.1ab	56.5	
Date Means		Mar.7	Apr.3	Apr.28				
		56.8	56.5	56.3				

Table 13. Average Bushel Weights for Fertilization Experiment I, 1960.

Variety	Date of Nitrogen Application	Rate of Nitrogen Application 0	20	40	80	160	Mean	Variety Means
Burt	Mar. 7	61.8	60.3	61.9	61.0	60.8	61.2	
	Apr. 3	61.0	61.0	60.4	60.6	58.7	60.3	
	Apr. 28	61.0	61.5	60.7	60.4	60.5	60.8	60.8 a
Druchamp	Mar. 7	59.8	58.2	57.5	57.8	58.2	58.3	
	Apr. 3	59.1	58.3	58.6	57.2	56.7	58.0	
	Apr. 28	59.0	58.9	58.1	58.4	58.5	58.6	58.3 b
55-1673	Mar. 7	61.0	60.8	60.4	61.0	60.0	60.7	
	Apr. 3	61.1	61.0	60.7	60.7	58.9	60.5	
	Apr. 28	61.1	60.6	61.1	60.2	59.6	60.5	60.5 a
55-1744	Mar. 7	59.0	58.6	58.8	58.7	58.3	58.7	
	Apr. 3	58.9	58.5	58.8	58.5	57.9	58.5	
	Apr. 28	59.0	58.5	58.5	58.2	57.5	58.3	58.5 b
Rate Means		60.2a	59.7b	59.6b	59.4b	58.8c	59.5	
Date Means		Mar. 7	Apr. 3	Apr. 28				
		59.7a	59.3b	59.6a				

weight and Selection 55-1744 tended to be low. Bushel weights were significantly higher in 1959 with high nitrogen levels, but were significantly lower with high nitrogen when lodging became a factor in 1960.

There is no evidence that the semi-dwarf selections responded to nitrogen differently from the standard varieties, except for lodging. Variety X treatment interactions for wheat grain yield and plant height were significant in 1960; however, an examination of the means reveals that for wheat grain yield no one variety contributed more to the interaction than the others. It was one semi-dwarf selection (55-1744) and one standard variety (Druchamp) which behaved inconsistently with respect to plant height and rates of nitrogen application.

Response to Ryegrass Competition - Experiment II

The ryegrass competition experiment was conducted on an area adjacent to the fertilization experiment and was subjected to the same general environmental conditions. Disease symptoms were not manifested to the same extent as in the fertilization experiment of 1959, however, and no ratings were taken. The competition experiment received a uniform application of 67 pounds of nitrogen per acre, which may account for the apparent lack of disease symptoms since the two were inversely related in the fertilization experiment.

Lodging was serious in 1960, especially in the standard varieties and with higher levels of ryegrass. Lodging notes were taken both years.

Wheat grain and straw yield and ryegrass seed and straw yield were used as measures of the competitive abilities of the wheat varieties.

The analysis of variance in Experiment II reveals that the level of ryegrass infestation had significant and profound effects on all the variables measured except plant height and bushel weight (Appendix Tables 3 - 6). This was true both years.

Wheat Grain Yield. Average wheat grain yields (Table 14) for all varieties were reduced in every case by increasing levels of ryegrass infestation, although the difference between the 4- and 8-pound levels of ryegrass was not significant at the 5 per cent level in 1960. The magnitude of the yield depression is surprisingly large considering the fact that these were not considered high levels of ryegrass competition. In fact, the ryegrass present in the field plots at the 4- and 8-pound levels was hardly noticeable, except at maturity when scattered recemes of ryegrass were to be seen.

Cappelle, Druchamp, and 55-1744 were the highest yielding varieties in 1959 across all levels of ryegrass (Table 14).

Table 14. Average Wheat Grain Yield in Bushels Per Acre by Variety and Level of Ryegrass in Competition Experiment II. Mean of Four Replications.

Level	Burt	Druchamp	55-1673	55-1744	Cappelle	Level Average
1959:						
0	51.1	47.3	50.8	47.3	54.4	50.2 a
8	24.6	35.9	16.9	37.5	31.5	29.3 b
16	19.2	27.0	16.3	24.5	28.0	23.0 c
Var. Avg.	31.6ab	36.7a	28.0b	36.4a	38.0a	
1960:						
0	53.9	36.3	62.8	84.9		59.5 a
4	42.0	33.8	53.0	64.3		48.3 b
8	38.4	25.3	32.5	69.0		41.3 b
16	27.6	28.8	35.0	40.0		32.9 c
Var. Avg.	40.5c	31.1d	45.8b	64.6a		
2-Yr. Avg.	36.7	33.5	38.2	52.5		

Selection 55-1673 had the lowest average yield here, as it did in Fertility Experiment I, but was among the highest yielding varieties at the zero ryegrass level. The position of Burt is intermediate and not significantly different from any of the other varieties. In 1960, the semi-dwarf selections significantly outyielded the standard varieties by nearly 20 bushels per acre, considering all ryegrass levels. The more serious lodging of the tall varieties is believed to be responsible for this large difference in yield (Table 15).

An insight into the relative competitive abilities of the semi-dwarf vs. standard varieties might be gained from examination of the data in Table 16. It should be noted when comparing yields (in terms of percentage of the zero ryegrass level) that the yields always decreased to a greater extent in the semi-dwarf selections than in the standard varieties. This yield decrease was about 5 per cent greater in the semi-dwarf varieties. A large portion of this decline in yield in the semi-dwarfs was contributed by Selection 55-1673, the shortest variety studied. Selection 55-1673 was overtopped by the ryegrass and performed poorly at the ryegrass levels of 8 and 16 pounds. When Selection 55-1744 alone is compared with the standard varieties, its yield was maintained as well as the taller varieties with increasing ryegrass competition.

Table 15. Average Percentage Lodging of Wheat as Estimated by Visual Observation in Ryegrass Competition Experiment II.

Level	Burt	Druchamp	55-1673	55-1744	Level Average
1959:					
0	0	0	0	0	0
8	2	1	4	5	3
16	30	1	10	11	13
Var. Avg.	11	1	5	5	
1960:					
0	80	58	0	6	36 b
4	92	68	2	25	47 b
8	72	68	4	8	38 b
16	92	65	20	65	61 a
Var. Avg.	84a	65b	6d	26c	
2-Yr. Avg.	53	37	6	17	

Table 16. Relative Wheat Grain Yields of Semi-Dwarf Selections 55-1673 and 55-1744 vs. Burt and Druchamp by Level of Ryegrass. Zero Ryegrass Level = 100 % Yield.

Level of Ryegrass	Varieties	
	Semi-Dwarf	Standard
1959:		
0	100	100
8	56	62
16	42	47
1960:		
0	100	100
4	80	86
8	67	70
16	52	65

The grain yields, as estimated from the hand-harvested subsamples (Table 17), are very similar to those obtained with the plot combine.

The significant variety X level interaction for grain yield in 1960 (Appendix Table 6) is due to the fact that Selection 55-1744 yielded slightly higher with ryegrass at the 8-pound level than at the 4-pound level, and Selection 55-1673 and Druchamp had slightly higher yields with ryegrass at the 16-pound level than the 8-pound level.

Wheat Straw Yields. Wheat variety and level of ryegrass were the important causes of variation in straw yield. Average yields of wheat straw for all varieties decreased with increasing ryegrass level in every case, with the exception of ryegrass seeded at the 16-pound level in 1960 (Table 18). The straw yields of the semi-dwarfs were the lowest of the five varieties in 1959, and were significantly lower than Cappelle and Druchamp, but only 55-1673 was significantly lower than Burt. Selection 55-1673 had the lowest straw yields both years. In 1960, the differences in straw yields were not as well defined between the semi-dwarfs and the standard varieties. The higher experimental error in 1960 was probably due to the increased lodging. Druchamp, however, maintained a high straw yield in spite of an average of 65 per cent lodging in

Table 17. Average Wheat Grain Yield in Bushels Per Acre as Measured from Hand-Harvested Subsamples in Ryegrass Competition Experiment II. Mean of Four Replications.

Level	Burt	Druchamp	55-1673	55-1744	Cappelle	Level Average
1959:						
0	55.1	46.6	59.7	59.6	64.9	57.1 a
8	27.8	34.4	19.4	27.4	41.8	30.2 b
16	18.8	26.2	13.6	43.5	33.1	27.0 b
Var. Avg.	33.9bc	35.7abc	30.9c	43.5ab	46.6a	
1960:						
0	40.5	33.3	62.6	78.3		53.7 a
4	27.3	21.9	51.0	56.2		39.1 b
8	25.2	22.8	27.7	57.7		33.4 b
16	24.4	23.1	19.7	50.0		29.3 b
Var. Avg.	29.4bc	25.3c	40.2b	60.6a		
2-Yr. Avg.	31.3	29.8	36.2	53.2		

Table 18. Average Wheat Straw Yield in Tons Per Acre as Measured from Hand-Harvested Subsamples in Field Competition Experiment II. Mean of Four Replications.

Level	Burt	Druchamp	55-1673	55-1744	Cappelle	Level Average
1959:						
0	5.25	6.00	5.48	5.10	6.62	5.69 a
8	3.26	4.53	2.39	3.08	4.43	3.54 b
16	2.72	4.11	2.00	3.24	4.45	3.30 b
Var. Avg.	3.74b	4.88a	3.29c	3.81b	5.17a	
1960:						
0	5.86	6.63	5.83	5.34		5.92 a
4	4.70	5.50	4.97	4.80		4.99 b
8	3.73	5.13	2.97	5.02		4.21 c
16	4.48	5.85	3.21	4.53		4.52 bc
Var. Avg.	4.69b	5.78a	4.25b	4.92ab		
2-Yr. Avg.	4.29	5.39	3.84	4.44		

1960, and was significantly higher in straw yeild than Burt and 55-1673. There is some indication (Table 19) from the straw yields in 1959 that the competitive effects of the ryegrass reduced straw yields more in the semi-dwarf selections than in the standard varieties, but this trend is apparent only for Selection 55-1673 in 1960.

Ryegrass Seed and Straw Yields. Ryegrass seed and straw yields increased significantly with increased levels of ryegrass seeding in every case for both years (Tables 20 and 21). Ryegrass seed yield and ryegrass straw yield give perhaps the best measure of the competitive ability of a wheat variety because the only variety effects measured are actual competitive effects. The differences in ryegrass seed yield between varieties in 1959 were not significant. In 1960, the semi-dwarf selections permitted the greatest ryegrass seed yields. Selection 55-1673 permitted significantly higher ryegrass seed yields than any other variety. The yield with Selection 55-1744 was not significantly higher than with Burt. The lower ryegrass seed yields with Burt and Druchamp may have been due to the increased lodging since wheat grain yields were also low. In any event, ryegrass seed yield is not a precise measure, since most of the seed had shattered before the wheat could be combined.

The ryegrass straw yields followed the same trend as seed yields. The straw yield differences in 1959 were inconclusive

Table 19. Relative Wheat Straw Yield of Semi-Dwarf Selections 55-1673 and 55-1744 vs. Burt and Druchamp by Level of Ryegrass. Zero Ryegrass = 100% Yield.

Level of Ryegrass*	55-1673 and 55-1744	Burt and Druchamp
1959:		
0	100	100
8	52	69
16	53	60
1960:		
0	100	100
4	88	82
8	73	71
16	70	82

* Pounds of ryegrass seeded per acre.

Table 20. Average Ryegrass Seed Yields in Pounds Per Acre from Subplots Combined in Ryegrass Competition Experiment II. Mean of Four Replications.

Level	Burt	Druchamp	55-1673	55-1744	Cappelle	Level Average
1959:						
0*	46.2	25.4	24.6	38.6	27.9	32.5 c
8	137.8	115.2	177.0	158.0	143.0	146.2 b
16	234.2	184.4	147.8	183.5	150.4	180.1 a
Var. Avg.	139.4	108.3	116.5	126.7	107.1	
1960:						
0*	14.7	10.3	16.1	16.7		14.4 c
4	30.1	20.6	103.2	55.6		52.4 b
16	74.8	35.7	117.1	83.6		77.8 a
Var. Avg.	39.9b	22.2c	78.8a	52.0b		
2-Yr. Avg.	89.6	65.3	97.6	89.3		

* These figures represent carryover in the combine while harvesting and miscellaneous weed seed.

Table 21. Average Ryegrass Straw Yields in Pounds per Acre as Estimated from Hand-Harvested Subsamples in Ryegrass Competition Experiment II. Mean of Four Replications.

Level	Burt	Druchamp	55-1673	55-1744	Cappelle	Level Average
1959:						
0	00	390*	100*	00	00	98* c
8	6040	4680	6540	4570	4310	5228 b
16	7044	5400	6580	5440	5190	5931 a
Var. Avg.	4361a	3490b	4407a	3337b	3167b	
1960:						
0	00	00	00	00		00 d
4	550	112	1760	936		840 c
8	550	250	3094	1460		1339 b
16	866	940	4760	1932		2124 a
Var. Avg.	492c	326c	2404a	1082b		
2-Yr. Avg.	2150	1682	3262	2048		

since one standard variety (Burt) and one semi-dwarf (55-1673) permitted significantly higher ryegrass straw yields (Table 21). In 1960, the semi-dwarf selections definitely permitted higher ryegrass straw yields than the standard varieties, but it is not clear whether this is due to the effects of lodging or to actual differences in competitive ability. Since straw yields tend to be influenced less by lodging than grain yields, these differences could very well be due to competitive effects. The significant level X variety interactions (Appendix Tables 5 and 6) for ryegrass seed and straw yield in 1960 seem to indicate this. The reason these interactions are significant is that the two semi-dwarf selections (especially 55-1673) permitted much greater ryegrass seed and straw yields with increasing ryegrass level than did the standard varieties.

Plant Height and Bushel Weight. The height and test weight measurements taken for Competition Experiment II are summarized in Tables 22 and 23. The level of ryegrass had no significant influence on plant height or bushel weight of any of the wheat varieties. The differences in height between varieties and years are similar to those observed in Fertilization Experiment I. Again, Burt and Selection 55-1673 were consistently high in test weight, and Selection 55-1744 was consistently low.

Table 22. Average Plant Height of Wheat in Inches by Variety and Level of Ryegrass in Ryegrass Competition Experiment II.

	Level of Ryegrass								
	1959				1960				
Variety	0	8	16	Mean	0	4	8	16	Mean
Burt	49.2	50.2	49.0	49.5 a	55.0	53.2	54.8	53.5	54.1 a
Druchamp	42.5	43.7	43.2	43.1 b	48.8	47.8	48.2	49.0	48.2 b
55-1673	34.8	34.0	35.2	34.7 d	41.0	40.0	39.0	39.8	39.9 d
55-1744	38.8	39.8	39.8	39.5 c	45.8	46.2	46.8	44.8	45.9 c
Cappelle	43.2	44.5	45.5	44.4 b	-	-	-	-	-
Level Avg.	41.7	42.4	42.5	42.2	47.6	46.8	47.0	46.8	47.0

Table 23. Average Bushel Weight of Wheat by Variety and Level of Ryegrass in Ryegrass Competition Experiment II.

	Level of Ryegrass								
	1959				1960				
Variety	0	8	16	Mean	0	4	8	16	Mean
Burt	60.5	60.0	59.9	60.1a	60.9	61.2	61.6	61.0	61.2a
Druchamp	57.0	57.6	58.7	57.8b	58.0	58.5	58.6	58.3	58.3c
55-1673	59.3	57.9	58.3	58.5b	60.5	60.8	60.2	60.5	60.5b
55-1744	53.6	54.7	55.1	54.5c	58.3	58.2	58.3	58.2	58.2c
Cappelle	58.2	58.2	58.9	58.4b	-	-	-	-	-
Level Avg.	57.7	57.7	58.2	57.9	59.4	59.7	59.7	59.5	59.6

Influence of Date of Removal of Ryegrass. Ryegrass is somewhat difficult to identify and remove from wheat, especially in the wheat rows and at the early stages of growth. Ryegrass straw yields were taken by hand separations to determine the efficiency of ryegrass removal from the wheat. The ryegrass straw yields for the date of removal study are summarized in Table 24. It would appear that hand-weeding was more complete at the later dates of removal, although this was not evident at the time of removal. The check plots where the ryegrass was not removed had the highest ryegrass straw yields, as one would expect if the weeding were effective at all. The two semi-dwarf selections again permitted greatest ryegrass growth, as shown by this series of measurements when all dates are considered, although only Selection 55-1673 is significantly higher. Wheat grain yields were lowest in the check plots and highest where the ryegrass was more completely removed (Table 25). One was not able to measure precisely the effects of ryegrass competition over time from this field experiment as was hoped. It does indicate that if the ryegrass competition is prevented (or a portion of it in this instance) as late as March 17th, when the wheat varieties were 18 to 24 inches tall, the wheat can still recover and give nearly a full grain yield (51.1 vs. 53.7 bushels per acre, estimated from subsamples).

Table 24. Ryegrass Removal Date X Variety Means for the 1960 Measurement of Ryegrass Straw Yield in Pounds Per Acre at the 8-Pound Ryegrass Level in Competition Experiment II.

Date of Removal	Burt	Dru-champ	55-1673	55-1744	Date Avg.
December 8	884	340	2320	1080	1156 ab
January 26	660	400	1840	520	855 b
March 17	200	110	980	440	432 c
Not removed	550	250	3094	1460	1338 a
Variety Avg.	547b	275b	2058a	875b	945

Table 25. Ryegrass Removal Date X Variety Means for the 1960 Measurement of Wheat Grain Yield in Bushels Per Acre at the 8-Pound Ryegrass Level in Competition Experiment II.

Date of Removal	Burt	Dru-champ	55-1673	55-1744	Date Avg.
December 8	47.8	33.1	37.8	74.7	48.4 ab
January 26	39.8	35.0	39.8	74.4	47.2 ab
March 17	42.1	35.6	47.9	78.9	51.1 a
Not removed	38.4	25.3	32.5	69.0	41.3 b
Variety Avg.	42.0b	32.2b	39.5b	74.2a	47.0

Differences in wheat straw yield were not significant between dates of removal but were significantly higher than the check plots by about 1-1/3 tons per acre (Table 26). Druchamp again had the

Table 26. Ryegrass Removal Date X Variety Means for the 1960 Measurement of Wheat Straw Yield in Tons Per Acre at the 8-Pound Ryegrass Level in Competition Experiment II.

Date of Removal	Burt	Dru-champ	55-1673	55-1744	Date Avg.
December 8	5.66	5.96	4.76	5.40	5.44 a
January 26	6.00	6.29	5.01	5.22	5.63 a
March 17	5.48	6.32	5.76	5.13	5.67 a
Not removed	3.73	5.13	2.97	5.02	4.21 b
Variety Avg.	5.22b	5.92a	4.62c	5.19b	5.24

highest straw yield and Selection 55-1673 had the lowest. The straw yield of Selection 55-1673 was reduced to a greater extent in the plots in which ryegrass was not removed than any of the other varieties, whereas Selection 55-1744 maintained its straw yield above five tons per acre in the check plots. The significant date X variety interactions for wheat and ryegrass straw yield (Appendix Table 7) are due to the large differences in yield between the dates of removal and the check plots, where the ryegrass competition was not removed before harvest.

Burt and Selection 55-1673 were again significantly higher in test weight than Druchamp or Selection 55-1744 (Table 27). Date of removal of ryegrass had little effect on test weight.

Greenhouse Competition - Experiment III

An attempt was made in this experiment to determine when the effects of ryegrass competition become measurable on the wheat and ryegrass in terms of reduced growth, and to determine in a more precise manner than was possible in the field experiments whether the semi-dwarf selections compete as effectively as the standard varieties during four different periods of vegetative growth. The approximate stages of growth and development of the wheat and ryegrass are indicated in Table 28.

The ample supplies of moisture and fertility and the warm day temperatures stimulated rapid growth and development of the wheat and ryegrass in the greenhouse. As a result of the rapid growth, the plants were succulent, and lodging began in the taller varieties, Burt and Druchamp, as early as the third harvest. Lodging was not serious, however, until the fourth harvest, when the green weight of ryegrass on some plots actually declined from the third harvest. The second and third harvests provided excellent measures of the competitive effects. At the time of the first

Table 27. Ryegrass Removal Date X Variety Means for the 1960 Measurement of Wheat Bushel Weight at the 8-pound Ryegrass Level in Competition Experiment II.

Date of Removal	Burt	Dru champ	55-1673	55-1744	Date Avg.
December 8	60.9	58.2	60.5	58.5	59.5 ab
January 26	60.2	58.8	59.8	57.8	59.2 b
March 17	60.7	58.6	59.8	58.3	59.4 ab
Not removed	61.6	58.6	60.2	58.3	59.7 a
Variety Avg.	60.8a	58.6b	60.1a	58.2b	59.4

Table 28. Approximate Average Height of Wheat and Ryegrass in Inches at the Time of Vegetative Harvests in Greenhouse Competition - Experiment III.

Harvest	Date	Variety				
		55-1673	55-1744	Druchamp	Burt	Ryegrass
I	3/22/61	11	11	12	14	8
II	4/ 8/61	16	17	19	20	14
III	4/27/61	19	20	23	25	20
IV	5/20/61	23	24	26	28	29

harvest, the plants were still too small for many of the effects of competition to be measurable. The fourth harvest gave irregular results due to lodging in the taller varieties. There was no appreciable lodging in the semi-dwarf selections.

In spite of the difficulties with lodging at the last harvest, some trends are unmistakable. The green and dry weight yields of wheat are summarized in Tables 29 and 30. The average green and dry weight yield of wheat across levels and harvests is in direct proportion to the mature plant height, with Burt and Druchamp producing the most plant material and the two semi-dwarf selections the least. In each harvest, Selection 55-1673 ranked fourth in dry matter production, and Selection 55-1744 ranked third (Table 30). With the exception of Harvest I, Burt always ranked first and Druchamp second in dry matter production. The green weight yields and ranking are very similar.

Green and dry weight yields of wheat declined only slightly with increasing ryegrass levels across all harvests. The differences in dry weight across levels are not significant. If the data are presented in a slightly different manner, as in Table 31, and the mean wheat green weight yields are examined by level across varieties within Harvests II and III, the trends are apparent toward lower vegetative yields of wheat under increasing ryegrass levels.

Table 29. Average Green Weight Yield of Wheat in Grams for Greenhouse Experiment III.

Harvest	Variety	Level of Ryegrass 0	4	8	16	32	Mean
I	Burt	40.7	44.7	50.7	48.0	46.0	45.8
	Druchamp	47.0	52.0	53.7	48.3	47.0	49.4
	55-1673	41.0	38.3	42.0	49.7	45.3	43.1
	55-1744	46.3	44.7	47.7	48.7	47.3	46.9
II	Burt	451.3	423.0	363.7	316.3	348.7	380.4
	Druchamp	341.0	354.0	375.0	437.7	317.3	364.6
	55-1673	327.3	317.7	322.0	317.7	322.0	321.1
	55-1744	377.7	335.0	361.3	336.0	277.7	337.4
III	Burt	776.0	818.7	767.0	680.0	742.7	756.9
	Druchamp	791.3	1003.0	782.3	787.0	672.3	807.2
	55-1673	749.0	531.7	703.7	585.7	536.0	621.2
	55-1744	888.3	618.7	664.7	686.0	612.7	694.1
IV	Burt	1148.0	964.7	779.7	1450.7	1011.7	1070.9
	Druchamp	906.0	867.0	1027.3	1060.0	900.7	965.5
	55-1673	1315.0	724.7	1153.0	606.7	538.0	867.5
	55-1744	1092.7	911.7	976.7	943.3	930.7	971.0
Level Means		583.7a	503.0b	529.4ab	525.1ab	462.3b	

Variety Means	
Burt	563.5a
Druchamp	546.7a
55-1673	463.2b
55-1744	512.4ab

Harvest Means	
Harvest I	46.3
Harvest II	350.9
Harvest III	719.8
Harvest IV	968.7

Table 30. Average Dry Weight Yield of Wheat in Grams for Greenhouse Experiment III.

Harvest	Variety	Level of Ryegrass 0	4	8	16	32	Mean
I	Burt	4.93	5.33	5.70	5.53	5.27	5.35
	Druchamp	5.07	5.80	5.90	5.53	5.03	5.46
	55-1673	4.77	4.40	4.87	5.33	5.03	4.87
	55-1744	5.23	5.07	5.20	5.40	5.27	5.23
II	Burt	39.50	40.00	32.17	29.83	33.17	34.93
	Druchamp	32.83	34.33	35.77	37.50	29.50	33.99
	55-1673	30.67	27.67	31.10	29.33	30.00	29.75
	55-1744	34.33	30.67	32.17	30.83	25.50	30.70
III	Burt	85.33	96.33	84.17	78.33	81.17	85.07
	Druchamp	74.33	104.33	79.33	76.17	60.67	78.97
	55-1673	80.50	58.83	74.33	65.33	60.67	67.93
	55-1744	89.67	66.17	71.33	74.00	64.67	73.17
IV	Burt	155.67	147.33	122.00	201.33	143.33	153.90
	Druchamp	119.33	115.33	138.67	140.00	151.67	133.00
	55-1673	166.33	104.00	148.00	88.00	81.00	117.50
	55-1744	139.67	121.00	128.67	121.67	116.00	125.40
Level Means		66.76	60.41	62.46	62.13	56.12	

Variety Means		Harvest Means	
Burt	69.81a	Harvest I	5.23
Druchamp	62.86b	Harvest II	32.34
55-1673	55.01c	Harvest III	76.28
55-1744	58.62bc	Harvest IV	132.45

Table 31. Comparison of Green Weight Yields in Grams Per Plot of Four Wheat Strains Under Five Levels of Common Ryegrass Competition.

Variety Across Levels	Harvest I		Harvest II		Harvest III		Harvest IV	
	Wheat	Ryegrass	Wheat	Ryegrass	Wheat	Ryegrass	Wheat	Ryegrass
Burt	45.8	15.5	377.3	96.7	757	113	1071	81
Druchamp	46.5	14.0	364.6	103.2	807	118	966	102
55-1744	46.9	16.0	337.4	110.3	694	166	971	184
55-1673	41.6	17.0	309.5	114.9	621	181	868	225
Level Across Varieties								
0	43.6	0.0	369.6	0.0	801	0	1132	0
4	42.9	8.3	342.8	77.4	743	101	867	82
8	44.6	14.5	355.4	122.2	729	163	984	202
16	48.5	23.5	351.5	140.9	684	212	1015	187
32	46.3	31.8	316.1	190.9	641	245	845	205

Green and dry weight yields of ryegrass increased significantly with increasing level of seeding as would be expected (Tables 32 and 33). The critical measurement here, as it related to competitive ability, is the amount of ryegrass which is permitted to grow in the various wheat varieties. Considering all levels and harvests, the two semi-dwarf selections permitted significantly more ryegrass to grow in competition with them than the standard varieties. When the variety means across levels within harvest are examined (Table 31), Selection 55-1673 always ranked first and Selection 55-1744 second in the green weight of ryegrass allowed to grow per plot. With the exception of Harvest I, Druchamp always ranked third and Burt fourth in the amount of ryegrass permitted per plot. Dry weight yields are similar, except that Burt ranked third and Druchamp fourth in both Harvest I and Harvest III.

Tiller counts of one-half of the wheat plants harvested in Harvest IV indicate differences between varieties (Table 34). The two semi-dwarf selections averaged 1.5 tillers less per plant than the standard varieties. Selection 55-1673, with an average of 5.67 tillers per plant, was significantly lower than the other varieties. Selection 55-1744 and Druchamp averaged 6.82 and 7.33 tillers per plant respectively, and they were significantly lower than Burt,

Table 32. Average Green Weight Yield of Ryegrass in Grams for Greenhouse Experiment III.

Harvest	Variety	Level of Ryegrass 0	4	8	16	32	Mean
I	Burt	0.00	8.33	17.00	18.00	34.00	15.5
	Druchamp	0.00	8.33	14.77	22.33	28.67	14.8
	55-1673	0.00	9.77	16.17	28.67	32.17	17.4
	55-1744	0.00	8.67	14.00	24.83	32.33	16.0
II	Burt	0.00	74.00	110.00	129.00	170.67	96.7
	Druchamp	0.00	85.00	156.13	106.00	191.33	107.7
	55-1673	0.00	104.00	106.67	180.67	205.33	119.3
	55-1744	0.00	69.00	138.33	148.00	196.33	110.3
III	Burt	0.00	98.67	133.33	147.00	185.00	112.8
	Druchamp	0.00	90.33	127.00	165.33	204.50	117.5
	55-1673	0.00	124.33	203.33	302.00	273.67	180.7
	55-1744	0.00	91.00	188.00	232.67	318.33	166.0
IV	Burt	0.00	37.33	70.33	137.33	162.00	81.4
	Druchamp	0.00	29.67	146.67	125.00	208.33	101.9
	55-1673	0.00	122.33	350.33	362.00	292.33	225.4
	55-1744	0.00	139.67	241.33	298.00	241.00	184.0
Level Means		0.00d	68.78c	127.09b	151.68ab	173.50a	

Variety Means	
Burt	76.7b
Druchamp	85.5b
55-1673	135.7a
55-1744	119.1a

Harvest Means	
Harvest I	15.9
Harvest II	108.5
Harvest III	144.2
Harvest IV	148.2

Table 33. Average Dry Weight Yield of Ryegrass in Grams for Greenhouse Experiment III

Harvest	Variety	Level of Ryegrass					Mean
		0	4	8	16	32	
I	Burt	0.00	0.98	1.97	2.05	3.72	1.75
	Druchamp	0.00	0.99	1.77	2.50	3.30	1.71
	55-1673	0.00	1.09	1.80	2.89	3.84	1.92
	55-1744	0.00	1.02	1.58	2.55	3.62	1.75
II	Burt	0.00	6.73	8.89	10.89	14.65	8.23
	Druchamp	0.00	7.80	12.47	8.55	15.71	8.91
	55-1673	0.00	8.73	9.55	14.90	18.37	10.31
	55-1744	0.00	6.12	11.45	12.84	17.29	9.54
III	Burt	0.00	11.00	13.77	15.57	20.28	12.13
	Druchamp	0.00	10.09	13.47	16.84	18.87	11.85
	55-1673	0.00	14.18	22.51	33.76	32.27	20.54
	55-1744	0.00	10.42	21.57	26.20	35.20	18.68
IV	Burt	0.00	7.67	13.33	25.00	22.00	13.60
	Druchamp	0.00	5.33	21.00	19.33	38.33	16.80
	55-1673	0.00	17.67	45.00	54.67	43.00	32.10
	55-1744	0.00	19.33	33.67	45.00	40.00	27.60
Level Means		0.00d	8.07c	14.61b	18.35a	20.65a	-

Variety Means		Harvest Means	
Burt	8.93b	Harvest I	1.78
Druchamp	9.82b	Harvest II	9.25
55-1673	16.22a	Harvest III	15.80
55-1744	11.51b	Harvest IV	22.52

Table 34. Average Number of Tillers Per Wheat Plant at the Time of Harvest IV Greenhouse Experiment III. Each Figure is a Mean of 48 Plants.

Variety	Level of Ryegrass 0	4	8	16	32	Var. Avg.
Burt	7.62[1]	8.81[3]	7.00[2]	8.48[3]	8.92[2]	8.17 a
Druchamp	7.69[1]	7.06[3]	8.06[2]	8.13[2]	5.71[3]	7.33 b
55-1673	6.00	5.89[1]	5.65	5.36	5.44	5.67 c
55-1744	8.23	6.62	6.92	5.96	6.39	6.82 b
Level Average	7.39	7.10	6.91	6.98	6.61	7.00

1 One replication lodged.
2 Two replications lodged.
3 Three replications lodged.

which had 8.17 tillers per plant. The differences in tiller number by level of ryegrass were not significant at the 5 per cent level.

Yield Components - Experiment IV

This very limited study indicates that there are small, but significant, differences between the five varieties studied in some of the major components which contribute to grain yields (Table 35). The analysis of variance indicates significant differences in the length of longest spike for both years, for fertile heads per plant in 1959, and for weight per kernel in 1960. Kernels per plant were significantly different at the 10 per cent probability level in 1960; all the other differences mentioned were significant at the 1 per cent level, except number of fertile heads per plant, which was significant at the 5 per cent level. There were no significant differences in yield as measured by grain weight per plant in the spaced plantings.

Although not all the means are significantly different at the 5 per cent level, there is some indication that individual varieties do differ somewhat in the behavior of the major components of grain yield. For example, Burt appears to have the shortest spike length and the fewest kernels per plant, but this is compensated for in total yield by large, heavy kernels. Cappelle-Desprez had the

Table 35. Average Values of the Seven Variables Measured on the Five Varieties in Spaced Plantings in Experiment IV, 1959 and 1960.

Variety	Tillers per Plant	Fertile Heads per Plant	Length Longest Spike (Inches)	Grain per Plant (Grams)	Kernels per Plant	Weight per Kernel (mg)	Plant Height (Inches)
1959:							
Burt*	--	--	--	--	--	--	--
Druchamp	12.25	8.15a	3.96c	9.96	274.0	36.62	41.28 ab
55-1673	10.68	6.25b	4.05b	9.80	276.5	36.28	35.02 c
55-1744	12.32	6.42b	4.00c	8.70	232.8	37.52	38.58 b
Cappelle	11.30	7.22ab	4.54a	10.24	260.5	39.02	42.42 a
1960:							
Burt	13.82	12.10	3.90c	27.42	554.5	48.58a	49.92 a
Druchamp	14.70	12.95	4.39b	27.60	621.8	44.28b	45.98 b
55-1673	15.55	12.82	4.38b	30.05	742.0	40.50c	36.18 d
55-1744	13.95	11.78	4.38b	30.42	770.0	39.58c	40.15 c
Cappelle	13.90	12.28	4.87a	34.48	737.0	46.72a	48.72 a

* Not reported because of insufficient sample size.

longest spike length both years, and the second highest weight per kernel, but was intermediate in kernels per plant and heads per plant. Druchamp was highest in number of fertile heads per plant both years, but was intermediate in spike length, kernels per plant, and low to intermediate in weight per kernel. The semi-dwarfs tended to be intermediate to slightly low for the characters measured. These are only trends, however, based on some nonsignificant differences, and they should not be accepted with a high degree of confidence.

It would seem from these data that the two semi-dwarf selections studied possess no particular attributes or serious faults with respect to the major components of grain yield.

DISCUSSION

The standard wheat varieties ranging from 48 to 60 inches in height will undoubtedly soon be replaced by semi-dwarf varieties which are 30 to 40 inches in height. Prior to the release and adoption of semi-dwarf wheats for western Oregon, certain important questions need to be answered which cannot be answered from regular breeding procedures: (1) Will the semi-dwarf wheats be able to compete as effectively with weeds as their taller counterparts? (2) Will the semi-dwarf wheats respond to nitrogen fertilization as well as the standard varieties, without lodging which is common to the latter? (3) Do the semi-dwarf wheats differ appreciably in the morphological variables which contribute to grain yield?

A series of experiments designed to provide answers for the above questions were conducted with five wheat varieties which provided a 20-inch range in plant height. Common ryegrass was chosen as a source of competition because it is a vigorous competitor that is easily established and well-adapted to this area. Also, its growth habit and life cycle are very similar to that of winter wheat, and it is a common weed in winter wheat rotations.

The results from the fertilization experiment are so different between years that each year should be discussed individually. In

1959, good yield responses were obtained with increasing nitrogen levels up to 80 pounds, but nitrogen levels above 80 pounds per acre gave only a small additional yield. The dates of nitrogen application had no significant effect. The semi-dwarf selections appeared to respond to nitrogen as well as the standard varieties, although yields in the semi-dwarfs were somewhat lower in 1959. This difference in yield is believed to be due to a significantly higher disease infection in the semi-dwarfs rather than a difference in yield potential or inability to respond to nitrogen.

Lodging is one of the chief hazards in producing the standard wheat varieties under humid conditions and on soil that is moderate to high in fertility. The growing season in 1960 gave a critical test of the varieties under environmental conditions favoring serious natural lodging. The semi-dwarf wheats were outstanding in lodging resistance; they lodged significantly less than the standard varieties and yielded significantly more grain. This points out an important advantage of the semi-dwarf wheat in a growing season conducive to lodging. Selection 55-1673 did not show any tendency toward lodging and Selection 55-1744 lodged very little, except at the higher nitrogen levels. The standard varieties lodged badly at all levels of nitrogen in 1960. These large differences in lodging resistance undoubtedly account for superiority in yield of the semi-dwarf selections in 1960.

The reasons for the decline in grain yields associated with increasing nitrogen applications are not clear. This could have been due to earlier and more serious lodging in the standard varieties, except that Selection 55-1673 had no lodging and yet it still exhibited declining yields with increasing rates of nitrogen application at two of the three dates of application.

When there was no lodging, straw yields increased significantly with rate of nitrogen, with the standard varieties producing the most straw. The straw-to-grain ratios are a function of both grain and straw yields and are considered to be an indication of the production efficiency of a variety. In 1959, the straw-to-grain ratios were about the same when the standard varieties outyielded the semi-dwarfs in both grain and straw. When lodging was a factor in 1960, the straw-to-grain ratio of the semi-dwarf was less than one-half that for the standard varieties. The grain yields of the standard varieties were reduced to a much greater extent by lodging than were the straw yields, thus widening the straw-to-grain ratio.

Yield is a principal criterion of competitive effect, both because of its economic significance and because it reflects the sum total of many other effects. The significant yield reductions in the competition experiments prove the ryegrass in winter wheat is expensive. Farmers often have a tendency to ignore ryegrass as a weed in winter wheat, combine the two crops together, and then separate the ryegrass seed from the grain in the cleaning process. They think there is just as great a return per acre from this combination as in clean fields of winter wheat. In both years, most of the ryegrass seed had shattered before the wheat was ready to combine. The highest ryegrass seed yields obtained were only 180 pounds per acre at the seeding level of 16 pounds in 1959. The average ryegrass seed yields of all seeded plots was 114 pounds per acre. The value of this ryegrass seed is far less than the loss that resulted in wheat production.

The reductions in wheat grain yields are surprisingly large from what was considered as only light to moderate ryegrass competition. Even at the level of 4 pounds of ryegrass in 1960, wheat yield was reduced 19 per cent. At the level of 16 pounds of ryegrass over the two-year period, wheat yields were cut in half. When the varieties are compared relative to competitive ability, there is an unmistakable indication that the semi-dwarf wheats, especially Selection 55-1673, are less competitive against common ryegrass than the standard varieties. This trend is indicated by several of the variables measured in both the field and the greenhouse. In both years, grain yields were always reduced more (on a percentage basis) with increasing ryegrass competition in the semi-dwarfs than in the standard varieties. Most of this difference is contributed by Selection 55-1673. When Selection 55-1744 is compared against the standard varieties, it maintained its yield about as well as the standard varieties.

Selection 55-1673 consistently declined more in straw yield under competition than did the standard varieties. Although Selection 55-1744 also showed larger declines in straw yield than the standard varieties in 1959, this selection maintained its straw yield as well as Burt and Druchamp in 1960.

The significantly higher ryegrass seed and straw yields with Selection 55-1673 in 1960 also indicate that it is lacking in competitive ability. Selection 55-1744 appears to be intermediate in this respect since it permitted significantly higher ryegrass seed yields than Druchamp, but not Burt, and significantly higher ryegrass straw yields than both Druchamp and Burt in 1960. The differences in resultant ryegrass straw yields between Selection 55-1744 and the standard varieties were not significant in 1959, however.

The study on date of removal of ryegrass lends further evidence that Selection 55-1673 is less effective as a competitor than the other varieties, since ryegrass straw yields were significantly higher in it and wheat straw yield significantly lower with it than in the standard varieties when ryegrass was not removed. Selection 55-1744 was not significantly different from the standard varieties when these two variables were considered.

Wheat and ryegrass dry matter production followed the same trends in the greenhouse experiment as in the field competition experiment. The semi-dwarf selections produced less dry matter than the standard varieties, although Selection 55-1744 was intermediate in dry matter production and not always significantly lower. The green and dry weight yields of ryegrass exhibited a definite inverse relationship with plant height. The semi-dwarfs permitted significantly higher vegetative ryegrass yields than the standard varieties. The semi-dwarf selections also averaged 1.5 tillers per plant less than the standard varieties across all levels of competition, with Selection 55-1673 having significantly less tillers than the other varieties. In individually spaced plantings, the semi-dwarfs were not significantly different from the standard varieties in tiller number.

The study of individually spaced plants was used to determine whether there were major differences in the genetic background of the five wheat varieties with regard to variables contributing to grain yield. The fact that there were no significant differences in grain yield per plant would indicate that these varieties had been selected for about the same genetic yield potential. There were small but significant differences in number of heads per plant, spike length, kernels per plant, and kernel weight. The largest differences between the semi-dwarfs and the standard varieties were in plant height.

All these experiments indicate that the semi-dwarf selections did not compete with ryegrass as effectively as the standard varieties. Selection 55-1673 was particularly deficient in this respect. Selection 55-1744 tended to be intermediate in competitive ability. The differences between the two semi-dwarf selections were greater than the differences between the varieties, Burt, Druchamp, and Cappelle-Desprez. These data suggest that the wheat producer will need to do a better job of controlling weeds if varieties such as Selection 55-1673 are brought into commercial production. The fact that there were often significant differences between the two semi-dwarf selections suggests, however, that it will be possible to isolate semi-dwarf lines with even better competitive ability than those now available and perhaps some equal to that of the standard varieties.

These experiments emphasize the fact that ryegrass should be controlled in winter wheat, even in the standard varieties, since the cost of yield reductions far outweighs the costs of controlling the weed. The philosophy of "living with ryegrass" in wheat is not a good or necessary one. Common ryegrass can be effectively controlled in winter wheat with Karmex diuron at 1.6 pounds of active ingredient per acre as a pre-emergent spray at an applied cost of approximately $7 per acre.[1] The results of this study indicate that such a weed control measure would be profitable even for very light infestations of volunteer ryegrass. One should not forget that grains, being grasses themselves, afford concealment for significant infestations of ryegrass (Figure 3), which, even though inconspicuous, materially reduce grain yield. Farmers often ignore grassy weeds which infest entire fields and go to great lengths to stamp out thistles, which are prominent but usually occur only in scattered patches.

The disadvantage of reduced competitive ability in the shorter wheats may be more than offset by the superior lodging resistance. The two semi-dwarf selections did outyield the standard varieties over the two-year period in both the fertilization and competition experiments. There is little doubt but that these semi-dwarf selections would prevent most of the lodging problems common under high soil fertility and the humid conditions of western Oregon.

1. Personal communication, Dr. W.R. Furtick, Farm Crops Department, Oregon State University.

SUMMARY

A comparative study of the response of semi-dwarf and standard type wheats to nitrogen fertilization and ryegrass competition was conducted with field and greenhouse experiments at Corvallis, Oregon, from 1958 to 1961. Two semi-dwarf selections, 55-1673 and 55-1744, were compared with the varieties, Burt, Druchamp, and Cappelle-Desprez.

In one experiment, three dates and five rates of nitrogen application were used to test varietal response to fertility level. In other experiments, three or more rates of overseeding common ryegrass were used to compare competitive efficiency of the varieties. The important variables that were measured included wheat grain and straw yields, ryegrass seed and straw yields, plant height, percentage lodging, bushel weight, and ryegrass and wheat dry matter yields.

The results and conclusions of these studies are summarized as follows:

1. Yield response to nitrogen fertilization was variable between years. Eighty pounds of nitrogen per acre increased yields 80 per cent in 1959; in 1960, yields declined with increasing nitrogen.

2. No direct differences in ability to respond to nitrogen were observed between the semi-dwarf selections and the standard varieties. Indirectly, lodging and disease resistance were considered important factors in determining yield responses.

3. In one of the two years, there were significantly higher straw yields from early nitrogen application and significantly higher grain yields from late nitrogen application.

4. Over the two-year period, the semi-dwarf selections outyielded the standard varieties in the fertilization experiment by 9.1 bushels per acre (19.5 per cent).

5. The semi-dwarf selections, especially 55-1673, were outstanding in their lodging resistance.

6. With semi-dwarf selections such as those used in these studies, it is believed nitrogen fertilization can be related to economic response without appreciable risk of lodging.

7. Ryegrass overseeded in winter wheat at the rate of 4, 8, and 16 pounds per acre decreased wheat grain yields 19, 36, and 50 per cent, respectively, over the two-year period. Wheat straw yields were reduced 16, 33, and 32 per cent by the same levels of overseeding ryegrass.

8. Ryegrass competition caused yield reductions through (a) reduced tillering, (b) increased lodging, and (c) other effects not determined from this study.

9. Ryegrass competition did not appreciably influence plant height or bushel weight.

10. The data suggest that the main effect of the competition on yield is exerted late in the growing season.

11. Grain yields were reduced about 5 per cent more in the semi-dwarf selections than in the standard varieties at given ryegrass levels. Most of this difference was contributed by Selection 55-1673, the shortest variety studied.

12. When yields of ryegrass grown in wheat were used as measures of competitive ability, the semi-dwarf varieties were consistently less competitive, both in the field and in the greenhouse. Ryegrass yields in wheat exhibited a definite inverse relationship with height of the wheat.

13. Of the two semi-dwarf selections studied, Selection 55-1673 was distinctly less efficient as a competitor than Selection 55-1744. The latter selection performed in some instances as well as the standard varieties under competition.

14. Small, but significant, differences between varieties were found in the morphological variables which contribute to grain yield.

15. Varietal performance under competition was not studied across fertility levels. This would be a worthy subject of future investigations.

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APPENDIX

Appendix Table 1. Analysis of Variance for the Five Variables of Fertilization Experiment I, 1959.

Variation Due To	D.F.	Mean Squares: Wheat Grain Yield	Wheat Straw Yield	Plant Height	Bushel Weight	Disease Rating
Replication	3	2,016,161**	6,658,850**	126.00**	6,073.33**	7.3900**
Variety	4	850,973*	18,983,808**	1,892.16**	66,548.86**	4.6450**
Error A	12	168,468	1,004,805	18.42	629.20	.5761
Treatment	14	--	--	--	--	--
Date of N	(2)	25,393	4,505,028**	156.50**	1,058.45	1.3234
Rate of N	(4)	2,790,420**	5,748,759**	122.09**	6,628.17**	6.0450**
D X R	(8)	126,053	1,532,844**	41.78**	334.46	.9400
Var. X Tr.	56	109,529	461,159	13.25	568.03	.7379
Error B	210	100,634	406,082	12.61	666.05	.8175
Total	299					

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

Appendix Table 2. Analysis of Variance for the Five Variables of Fertilization Experiment I, 1960.

Variation Due To	D.F.	Mean Squares: Wheat Grain Yield	Wheat Straw Yield	Plant Height	Bushel Weight	Per Cent Lodging
Replication	3	457,717*	1,849,467	4.66	1,161	1,839.00
Variety	3	9,869,899**	23,152,315*	1,881.08**	20,678**	22,035.82**
Error A	9	91,349	4,016,179	8.88	336	1,313.86
Treatment	14	--	--	--	--	--
Date of N	(2)	567,938**	3,670,000	6.24	560**	43.52
Rate of N	(4)	627,160**	2,426,848	6.63*	2,395**	5,415.70**
D X R	(8)	159,237**	1,787,954	2.30	318**	572.91
Var. X Tr.	42	150,642**	1,702,758	3.60*	161	1,317.09
Error B	168	55,823	1,500,071	2.37	113	1,605.33
Total	239					

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

Appendix Table 3. Analysis of Variance for Three Variables of Competition Experiment II, 1959.

		Mean Squares		
Variation Due To	D.F.	Wheat Grain Yield	S.S. Wheat Grain Yield	S.S. Wheat Straw Yield
Replications	3	310,392.56*	11,236.82	47,787.87*
Varieties	4	269,592.18*	27,884.10*	468,679.02**
Error A	12	79,973.36	7,650.09	15,596.06
Level	2	5,184,562.55**	288,570.22**	2,087,672.60**
L X V	8	140,110.76	13,145.20	43,481.58
Error B:				
L X R	6	110,980.90	17,077.17	83,395.47
L X V X R	24	68,391.50	8,521.29	41,556.81
Total	59			

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

Appendix Table 4. Analysis of Variance for Four Variables of Competition Experiment II, 1959.

Variation Due To	D.F.	Mean Squares: R.G. Seed Yield	Mean Squares: S.S. R.G. Straw Yield	Mean Squares: Plant Height	Mean Squares: Bushel Weight
Replications	3	697.20	27,055.40	4.91	756.28*
Varieties	4	838.61	64,857.94**	370.89**	10,426.57**
Error A	12	519.08	10,123.66	4.20	214.20
Level	2	45,439.40**	3,168,353.32**	5.22	311.55
L X V	8	984.73	20,718.32	1.53	345.84
Error B:					
L X R	6	1,058.87	14,056.65	4.26	168.08
L X V X R	24	368.87	9,383.46	3.57	121.21
Total	59				

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

Appendix Table 5. Analysis of Variance of Four Variables of Competition Experiment II, 1960.

Variation Due To	D.F.	Mean Squares: Wheat Grain Yield	S.S. Wheat Grain Yield	S.S. Wheat Straw Yield	R.G. Seed Yield
Replications	3	2,445,624**	26,234.40	90,338	424.85
Varieties	3	27,494,547**	209,328.19**	411,203*	13,080.19**
Error A	9	324,925	12,749.58	101,394	842.09
Level	3	17,559,491**	95,462.44**	548,302**	51,796.40**
L X V	9	2,209,377*	12,684.67	83,179	4,193.85**
Error B:					
L X R	9	1,203,344	9,490.83	23,758	541.52
L X V X R	27	936,977	13,186.54	65,214	715.50
Total	63				

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

Appendix Table 6. Analysis of Variance for Four Variables of Competition Experiment II, 1960.

Variation Due To	D.F.	Mean Squares: S.S. R.G. Straw Yield	Plant Height	Bushel Weight	Per Cent Lodging
Replications	3	3,238.85	3.35	8.88	375.89
Varieties	3	224,359.85**	554.35**	7,313.62**	19,956.64**
Error A	9	6,410.86	2.42	96.19	215.96
Level	3	198,033.93**	2.61	59.75	2,032.56**
L X V	9	39,187.22**	2.45	43.40	590.96*
Error B:					
L X R	9	1,907.11	2.06	44.82	336.65
L X V X R	27	4,169.50	3.71	49.38	206.08
Total	63				

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

Appendix Table 7. Analysis of Variance for Four Variables Measured in the Date of Removal Study for the 8-Pound Ryegrass Level of Competition Experiment II.

Source of Variation	D.F.	Mean Squares: Wheat Grain Yield	Wheat Straw Yield	Ryegrass Straw Yield	Wheat Test Weight
Replication	3	43,990.*	57,486.	24,786.	198.
Variety	3	291,491.**	281,075.**	152,641.**	4,961.**
Error A	9	7,874.	21,458.	9,081.	295.
Date of Removal	3	14,505.#	475,460.**	39,177**	175.*
D X V	9	1,992.	69,884.*	10,154.*	120.#
Error B	36	5,580.	31,840.	4,190.	59.
Total	63				

\# Significant at the 10 % probability level.
* Significant at the 5 % probability level.
** Significant at the 1 % probability level.

Appendix Table 8. Analysis of Variance for the Four Variables of Greenhouse Experiment III.

Variation Due To	D.F.	Mean Squares: Green Weight Wheat	Dry Weight Wheat	Green Weight Ryegrass#	Dry Weight Ryegrass#
Replication	2	79,448.	578.10	31,716.76*	244.0730
Variety	3	114,400.*	2,429.94**	58,114.52**	930.4035**
Error A	6	16,291.	219.94	4,843.33	78.2146
Level	4	93,432.*	708.94	97,891.57**	1,449.5410**
V X L	12	46,903.	655.71	3,632.26	64.4028
Error B	32	24,253.	431.77	6,127.11	57.8899
Harvest	3	9,822,014.**	185,365.73**	283,775.40**	5,913.5749**
H X L	12	34,838.*	336.05	10,853.70**	242.6330**
H X V	9	32,665.*	721.41**	17,322.82**	297.0799**
H X L X V	36	42,699.**	631.97**	2,335.93	40.2906
Error C	120	16,380.	277.51	3,996.25	46.1957
Total	239				

\# The following changes were made in degrees of freedom for ryegrass green and dry weight: Level 3, V X L 9, Error B 24, H X L 9, H X L X V 27, Error C 96, and Total 191, due to the fact that there was no ryegrass at the zero level.

* Significant at the 5 % probability level.

** Significant at the 1 % probability level.

Appendix Table 9. Analysis of Variance for Wheat Tiller Counts of Greenhouse Experiment III.

Source of Variation	Degrees of Freedom	Mean Squares
Replication	2	7.676**
Variety	3	16.394**
Error A	6	0.432
Level	4	0.949
L X V	12	2.185
Error B	32	1.328
Total	59	

Appendix Table 10. Analysis of Variance for Seven Variables of Experiment IV - 1959 and 1960.

Variation Due To	D.F.	No. of Tillers	No. Fertile Heads	Length Longest Spike	Grain Wt./ Plant	Kernels Per Plant	Weight Per Kernel	Plant Height
		Mean Squares - 1959						
Replication	3	4.59	0.48	.0845**	2.5557	1131.	33.80*	4.54
Variety	3	2.52	3.02*	.2881**	1.8016	1610.	6.02	43.29**
Error	9	1.46	0.44	.0090	3.2949	3253.	7.64	3.25
Total	15							
Coefficient of variation		10.4 %	9.4%	2.3%	18.8%	21.9%	7.4%	4.6%
		Mean Squares - 1960						
Replications	3	.3432	1.5018	.022178	12.9329	2175.	5.08	15.5340**
Varieties	4	2.1945	.9782	.470582**	32.7353	34209.#	70.33**	137.2045**
Error	12	5.0448	3.0122	.027182	18.1481	11201.	2.29	1.2065
Total	19							
Coefficient of variation		15.6 %	14.0%	3.8%	14.2%	15.4%	3.4%	2.5%

Significant at the 10 % probability level.
* Significant at the 5 % probability level.
** Significant at the 1 % probability level.

Figure 1

Photo 1a--Selection 55-1673 (left) no lodging and Selection 55-1744 (right) lodging at the higher fertility levels. Photo 1b--Druchamp (left) and Burt (right) severe lodging under all fertility levels. Photo 1c--Selection 55-1744 (left) lodging at the 16-pound ryegrass level only in far background, while Selection 55-1673 (right) has no lodging. Photo 1d--Burt (left) and Druchamp(right) lodged regardless of ryegrass level. All photos June, 1960.

Figure 2

Common ryegrass seeded at 16 pounds per acre in Selection 55-1673 one month after seeding (above) and the following spring (below).

Figure 3

Selection 55-1673 was overtopped by ryegrass (above) but the ryegrass is not noticeable in Selection 55-1744 (below), except in the alleyways. Both plots have 16 pounds of ryegrass seeded per acre.

Figure 4

Greenhouse Experiment one week after emergence (upper left); two weeks after emergence (upper right); at Harvest I (lower left); and at Harvest II (lower right).