AN ABSTRACT OF THE THESIS OF

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Title: EFFECT OF ROW SPACINGS, SEEDING RATES AND NITROGEN FERTILIZER RATES ON THE AGRONOMIC PERFORMANCE OF YAMHILL AND HYSLOP WHEAT (*Triticum aestivum* L.)

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The response of two newly released cultivars of winter wheat when grown under different row spacings, seeding rates and nitrogen levels were investigated. Measurements made included grain yield, tiller number per unit area, plant height, 300 kernel weight, bushel weight and protein content of the grain. Hyslop and Yamhill cultivars were selected since they represent different plant types and may respond differently to various cultural practices.

Results indicated that optimum grain yield under the growing conditions of this study was obtained with 15.24 cm row spacing and 134.5 kg/ha seeding rate. Also at the 15.24 cm row spacing, 112 kg/ha of nitrogen gave the greatest yield response. This was true for both cultivars tested.

More culms per square meter were produced by the 15.24 cm row spacing. The largest number of culms being attained with 15.24 cm spacing and 134.5 kg/ha seeding rates with both cultivars responding in a similar pattern.

The plant height for both Hyslop and Yamhill remained the same at all row spacings; however the higher seeding rates resulted in increased plant height.

Yamhill had a higher 300 kernel weight and a lower bushel weight than Hyslop regardless of the treatments. Different row spacings did not influence either 300 kernel weight or the bushel weight. Increased seeding rates did result in a variable 300 kernel weight and in a higher bushel weight for both cultivars.

Protein content of the grain was not affected by either row spacing or seeding rates, but was influenced by nitrogen application. With the exception of the first 56 kg/ha nitrogen application, the other additional applications of nitrogen resulted in an increased protein content.

Despite different growing patterns, both Hyslop and Yamhill responded similarly to the cultural practices imposed.

It would appear that maximum grain yield, under the growing conditions observed in this study can be obtained by increasing the number of spikes per unit area. This could be achieved by using 15.24 cm row spacing and 134.5 kg/ha as a seeding rate with 112 kg/ha of nitrogen.

A mean of disseminating such information to the growers was also considered in this study.

Effect of Row Spacings, Seeding Rates and Nitrogen Fertilizer Rates on the Agronomic Performance of Yamhill and Hyslop Wheat (*Triticum aestivum* L.)

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INTRODUCTION

Successful wheat production depends upon several factors in addition to improved cultivars. Such factors as the amount and distribution of rainfall, temperature, daylength and soil fertility can all greatly influence final yield.

In order to maximize profits, a package of cultural practices must be identified that enables cultivars to attain maximum grain yield in commercial production. This package of cultural practices should help create or modify the environmental conditions required for the expression of the total genetic capacity of a cultivar.

With the developement of new wheat cultivars, particularly those which may have slightly different growth patterns, additional information is needed concerning such cultural practices as seeding rates, row spacing and fertilization. Improper seeding rates or soil fertilization, besides adding to the cost of production, may reduce both quality and quantity of the crop.

It was the objective of this study to identify the optimum row spacing, seeding rates and nitrogen fertility levels for two new winter wheat cultivars.

These cultivars represent standard height and semi-dwarf genotypes with both having stiff straw and good lodging resistance. However, they do have different growth patterns and may respond differently to various cultural practices.

A further objective was to develop a program whereby information obtained from this study could be effectively disseminate to wheat producers.

REVIEW OF LITERATURE

Influence of Seeding Rates on Grain Yield

Trials on rates of seeding with standard height wheat cultivars have been conducted since the 1920's in several areas of the United States. At the Delaware Experiment Station, Grantham (12) pointed out that heavy seeding may become decidedly detrimental to yield if varieties of low tillering capacity are used. In some of his experiments he found that lower rates of seeding will produce as great a yield as a much higher rate since plants develop more fully under lower seeding rates.

Quisenberry (30, p. 148-149) in summarizing the results of many trials stated that no seeding rates above a critical optimum could be judged to be outstanding. Sixty to 90 pounds of seeds per acre generally produced the highest net yield in both winter and spring wheat.

In Michigan, Kinra et al. (20) mentioned a need to determine an optimum seeding rate to obtain maximum yield. In some of their experiments they found that a 90 pound rate outyielded a 60 pound rate by about eight bushels per acre.

Middleton (24), working on winter barley, found that decreasing the seeding rate decreased the number of fertile heads per unit area which is related to the grain yield.

Wilson and Swanson (35) reported that moisture and seeding date of winter wheat greatly influenced the optimum rate of seeding.

High moisture and late seeding favor higher seeding rates, while light rates are common where low moisture and early seeding prevail. In central Kansas, 45 and 60 pound rates are adequate for wheat but some reduction in yield may occur upon lowering the rate under 45 pounds per acre. In western Kansas and eastern Colorado, where limited subsoil moisture exists, not more than 30 pounds are needed per acre.

Pendleton (27) reported that in England and Western Europe, under high rainfall conditions, seeding rates varied from 180 to 240 pounds of wheat per acre. In summarizing several experiments in the United States including some of his own, he reported that 90 pounds gave the highest yield per acre. He also stated that seeding rates had a greater effect on number of fertile heads per plant than either nitrogen rate or the cultivar used.

In Australia, where there is low rainfall, a short growing season and consequently low yield, Percival (28, p. 430-431) reported that less than 60 pounds of wheat per acre was an optimum seeding rate.

Guitard <u>et al</u>. (13) found that as seeding rates increased, there was a linear increase in the number of plants per acre. This is true for wheat, oats and barley at lower seeding rates. However, the increase in plant number was accompanied by a strong curvilinear decrease in the number of fertile heads per plant.

Guitard, working with cultivars adapted to several locations in Canada, reported that 90 pounds per acre was an optimum rate for wheat. When seeding rates surpassed this amount, wheat yield was sometimes unstable, it decreased and increased depending on the particular growing conditions.

Experimenting in south Soudan on wheat production, M. A. Khalifa (19) found that 25 kg per Feddane gave significantly more grain yield than 50 and 75 kg for the same unit area because the number of grains per head decreased with the higher seeding rate. However, he reported that other workers under a wide range of conditions found that varying the seed rates produced little difference in grain yields.

Influence of Seeding Rate on Tiller Number

In any study of this type, the tillering capacity of the variety must be taken into consideration. Some cultivars are genetically low, moderate or high in tillering capacity.

As early as 1917, Grantham (12) suggested that tillering is an inherent character, a cultivar that is known to have a high tillering capacity will have a relatively high number of tillers under varying environmental conditions and cultural practices.

Another factor influencing grain yield is the fertility of the spike. Some tillers produce large heads with many kernels, some only few kernels per head and others may not produce any. The above cases have been investigated with regard to seeding rates and different conclusions have been drawn about the effect of this practice on tiller number. Working on winter barley, Middleton, Hebert and Murphy (24) observed that decreasing the seeding rate decreased the number of fertile heads per unit area but increased the number of seeds per head.

Grantham (12) reported that the tiller number decreased as the seeding rates increased from 60 to 120 pounds per acre for winter wheat.

Percival (28, p. 430-431) and later Guitard (13) obtained an increase in number of fertile heads by decreasing plant density for wheat, barley and oats.

Khalifa (19) in Soudan reported that the effect of seeding rate on productive tillers was negligible. Pendleton (27) planted winter wheat by varying the seed rates from 45 to 270 pounds per acre. He found that lower rates resulted in more large heads per plant, but that the total yield was reduced. Clement (7, p. 223-233) reported similar results in spring wheat trials.

<u>Effect of Seeding Rates on Plant Height, 1000 Kernel and Bushel Weight</u>

Short or tall strawed variety is an inherent character; however, plant density may affect plant height within the same variety.

Clement (7, p. 223-233) found that lowering the seeding rates of Marquis spring wheat to one-half resulted in greater plant height. By varying the rates from 45 to 270 pounds per acre, Pendleton (27) observed taller plants at the lower seeding rates. Similar results were reported by Wilson and Swanson (35). However, Kinra <u>et</u> <u>al</u>. (20) reported that increasing the seeding rates resulted in an increased plant height due to competition for more light.

Working with three varieties of winter barley, Middleton (24) found that the weight of 1000 seeds and test weight per bushel were not changed significantly by decreasing the rate of seeding per acre within the same variety. But when different cultivars (short and tall) were compared to each other, the differences in kernel weight were highly significant. Wilson (35) did not find any difference among treatments of some wheats, but he stated that a lower kernel weight was apparent with reduced plant density.

Guitard and Newman (13) reported that the response of 1000 kernel weight to seeding rates was not greatly influenced in wheat; however, a small linear decrease in kernel weight was noted by decreasing seeding rates for oats. No significant difference was recorded, but a moderate linear decrease in kernel weight was found for barley when seeding rates were decreased.

Khalifa (19) noted a negligible effect of seeding rates on 1000 kernel weight in wheat. Coffman (6) observed an increase in test weight of Komed winter wheat as seeding rates increased from 15 to 75 pounds per acre.

Influence of Row Spacing on Grain Yield

Working with oats, Foth, Robertson and Brown (8) observed a higher yield of grain and straw in plots with the narrowest row spacing. This was a result of better growth, better utilization of nutrients, and competition for light.

Middleton (24) did not find significant differences in yield of winter barley between eight and 16 inch row spacings for the same rate of seeding and at different levels of planting. Working with winter wheat, Percival (28, p. 430-431) found that increasing the area for a single plant from 6, 18, 36, 72 and 144 square inches gave progressively lower yield. Wilson and Swanson (35) found that reduction of wheat population below 20 plants per square foot through systematic spacing of individual plants produced progressively lower yield at each level. The yield was higher when the number of plants per square foot was increased.

Kinra _et al_. (20) noted a reduction in yield by increasing the row width in all cases. From a practical standpoint, he found that the optimum row spacing for winter wheat in Michigan was 11 inches or less at a seeding rate of 90 pounds per acre.

Quisenberry (30, p. 151-152) reported that wheat yields in Nebraska at 7, 10 and 14 inches of row width were 25.8, 23.8 and 23.3 bushels per acre, respectively.

Stickler and Ten Pas (31) reported that for dryland farming the greater the amount of moisture available, the narrower the optimum row width.

Effect of Row Spacing on Tiller Number

Grantham (12), referring to the work of Teschenki (1911) pointed out that plants with large numbers of tillers lose a large amount of energy in producing barren culms. None of those which had an average of 20 culms produced more than 12 culms with spikes. He also reported that very wide planting produced a large amount of tillers per plant. When seeds are put very close together in drill rows, the individual plants suffer severe competition for moisture, plant food and sunlight; hence the rate of tillering decreases.

Kinra (20) observed that row spacing greater than seven inches resulted in fewer culms per square foot in three of four cases. Stickler (31) reported that in North America, spring wheat was grown in closer rows than winter wheat. When planted in the spring, it tillers less, and so, must be seeded thicker than winter wheat. In oats, Foth (8) noted a decrease in number of panicles per square foot when distance between rows increased. He thought that this may be due to the more efficient use of the available sunlight between rows for vegetative development at the closer row spacings.

According to Wilson (35), reducing the population by five or more plants per square foot in winter wheat resulted in more tillers and subsequently more heads were produced in the thinned plots. It is to be expected that yield per plant is governed by the number of tillers only if the size of spikes and the quality of grains remain the same.

Effect of Row Spacing on Plant Height, 1000 Kernel and Bushel Weight

Greater growth was recorded by Foth (8) in oats under narrow row width. Kinra (20) measured the plant height in the fall and found that when the distance between rows of winter wheat was increased from seven to 11 inches, the plant height decreased. He concluded that wide spacing would tend to increase the light intensity and cause a reduction in plant height. However, increasing the number of seeds in the same row offsets this reduction.

Foth (8) reported that among the yield components of oats, the weight of hundred seeds was the least affected by row spacing and showed a slight relationship with the grain yield.

Middleton (24) found a significant difference in the weight of 1000 seeds between varieties of winter barley grown in eight and 16 inch row spacings, but the combined analysis showed an interaction between varieties x years and row width x varieties x years. A significant difference in bushel weight was also recorded between varieties and x row width.

Wilson (35) reported a trend toward lower test weight in winter wheat when plant number per square foot was reduced. No consistent effect on test weight was noticed by Kinra (20) under different row spacings.

Influence of Nitrogen Fertilizer on Wheat Production

Nitrogen is one of the basic elements in wheat nutrition and is usually the most limiting factor. Several studies have been carried out to determine the requirements of wheat for nitrogen and the influence of different levels of fertilization on yield components. A review of some results and conclusions from these studies would give a better understanding of the nitrogen problem.

Nitrogen and Yield in Wheat

It has been well documented by many investigators that nitrogen increased yields in spring and winter wheat under different conditions.

Quisenberry (30, p. 125-130) formulated the following law concerning single nutrient addition to the crop. "There is enough nitrogen present in the soil to produce a given yield; if the variety and the climatic conditions permit a higher yield, additional nitrogen must be added in order to obtain that yield." The same author reported that efficiency of nitrogen utilization in wheat ranges from 60 to 80%, at moderate levels of fertilization, on typical wheat land soil. Nitrogen efficiency decreases with increasing increments of applied nitrogen beyond an optimum level.

Black (2) obtained an increase in spring wheat yields by adding nitrogen along with addition of phosphorus. Higher rates of phosphorus, with or without added nitrogen failed to further increase grain yield.

Williams and Smith (34) attributed the increase in winter wheat yields at four locations to the use of nitrogen fertilizer. By increasing the rates of nitrogen from 25 to 50 and 100 pounds per acre, they found a corresponding increase in grain yields.

Gingrich and Smith (11) reporting on four varieties of wheat and three varieties of oats, grown in different soil types in Kansas, observed that different levels of nitrogen increased the grain yield up to 50 pounds per acre. In some cases the relative efficiency of the 100 pounds of nitrogen was below that of the lower rates. With oats, the application of 50 pounds of nitrogen per acre doubled the grain yield in this study.

In Tunisia, the Wheat Improvement Project has been working on Mexican wheat varieties since 1967. Several experiments have been conducted on nitrogen fertility. Results from the 1969-1970 season (5, p. 88-91) showed an increase in yield ranging from zero to 23.4 quintals per hectare (equivalent of 308 percent) depending on different levels of fertility. During the 1970-71 season, tests have been conducted with 0, 33, 67, 90 and 133 kg of nitrogen per hectare. The results showed an increase in yield up to 67 kg rate in areas from 300-500 mm rainfall. For areas of more than 500 mm, yield increased up to the 90 kilo rate. It appeared that these two levels of fertility have been adopted as optimum for field use.

Highly variable responses of wheat to nitrogen have been observed in Turkey, especially in the central plateau area. Olson and Drier (26, p. 124-146) reported that this variation was related to differences in mean annual rainfall. At the coastal regions of Turkey where there is a high amount of rain, it was recommended that 120 kg per hectare be a standard rate for Mexican wheats.

In Oregon, Pumphrey (29) stated that "in spite of variations in rainfall, soil and management, especially in the Northeast, wheat required addition of nitrogen fertilizer for maximum yield." He also reported that 30 pounds of nitrogen increased the yield by about nine bushels per acre, while 60 pounds yielded 17 additional bushels.

Ninety and 120 pounds produced very little increase in yield over the 60 pounds level. In regions of low rainfall, the increase in grain yield for 30 and 60 pounds of nitrogen was three and four bushels per acre, respectively. Higher rates produced slightly less yield.

Pumphrey concluded that not all effects of nitrogen are beneficial. As the rate of application increases above what is needed for grain yield, the growth of straw becomes excessive if there is adequate moisture available. Lodging and diseases may result as well as delay in maturity and reduction in yield. Test weight may also be lowered by excessive nitrogen application.

Some residual nitrogen is available in the soil as stated by Quisenberry (30, p. 121-130). Therefore it is important to analyze the soil in order to determine the correct amount of nitrogen needed for the crop. Miller et al. (25) pointed out that only a moderate amount of nitrogen should be added to a high organic soil to avoid lodging.

In Eastern Washington, nitrogen applied to winter wheat is based upon estimated yield (21, p. 35-37), soil moisture and nitrogen supplying capacity of the soil.

Stickler and Ten Pas (31) also reported that response of wheat crop to nitrogen application is somewhat avariable. On soils deficient in nitrogen, each 20 kilograms per hectare produced 300 to 400 kilos of additional yield until the 40 kilo level was reached. On some soils, yield increases were noted up to 60 kilos per hectare. Varietal difference is another factor affecting the response to nitrogen application. Some varieties need more than one application because of their long vegetative cycle (winter wheat). Short statured varieties react differently from tall ones to nitrogen fertility (36).

Working on wheat in Logan, Utah, Woodward (36) studied the yield of three spring semi-dwarf varieties and observed that it increased more than that of three tall spring wheat varieties as result of nitrogen application. Lamb (22) stated that while the variety x fertilizer level interaction was statistically significant, this interaction was not great enough to change the yield ranking of the varieties he studied. Vorzella (33) found that the tendency for variety x fertilizer interaction was not great enough to alter the yield ranking of winter wheat. Similar results have been obtained by Pendleton and Dugan in Illinois and Eck et al. in Oklahoma (22, 36).

In Iran, Hojjati and Maleki (15) observed no effect on wheat grain yield by application of 50 or 100 kilos per hectare of nitrogen, but they observed a decrease in yield at the 200 kilos level. The nitrogen stimulated the vegetative growth much more than the seed production.

In Lebanon, Fuehring (10) reported that grain yield of a Mexican semi-dwarf wheat was increased economically by nitrogen application up to 300 kg/ha for yields of the order of nine metric tons per hectare.

Grain Yield and Protein Content in Relation to Nitrogen Fertility

Different observations have been made on the effect of nitrogen on protein content of grain. Kinra (20) reported that some investigators have failed to find an increase of protein content when 100 pounds or more per acre of nitrogen were applied. Pendleton (27) showed that nitrogen had a significant effect on protein content of wheat grain. H.B. Peterson (16) noted an increase of protein ranging up to 3.4% by nitrogen application. During a four year study on spring wheat, Woodward (36) reported an increase from 13.2 to 15.8% in protein content for standard height varieties by applying nitrogen in an early stage of growth. Less increase was noted for semi-dwarf varieties.

Various findings about protein content and increase in grain yield are not in agreement. H.B. Peterson (16) found in Utah that nitrogen application increased either one or the other but not both. They explained that utilization of this nutrient in more grain and straw production leaves an insufficient amount to increase the protein content.

In the Oregon Columbia Basin (1) protein content stayed below

10% with increased application of nitrogen; however, protein content increased above 10% when more nitrogen was applied than was needed for maximum yield. Where nitrogen had no effect on yield, the protein content markedly increased above 10% with each increment added.

In contrast to the concept of H. B. Peterson that nitrogen increases either yield or protein content but not both (16), Hucklesby, Brown and Howell (17) brought out a challenging concept that grain yield and percent protein are not negatively correlated. They found that it is possible to increase both yield and percent protein of the grain with a better choice of wheat varieties which are resistant to lodging, and with management of nitrogen application. In their experiment with three wheat varieties, all nitrogen treatments caused a significant increase in protein content (about 63%) along with increase in yield.

At Aberdeen, Idaho (32) several irrigated hard red winter wheat selections grown under high fertility yielded over 100 bushels grain per acre and contained 14 to 15% protein. Further breeding is underway at Aberdeen to develop good quality, high protein wheat varieties that will yield over 140 bushels/acre under irrigation.

MATERIALS AND METHODS

Plant Materials

Two soft white winter wheat cultivars, Hyslop and Yamhill were utilized in this investigation. Both cultivars were developed at OSU Experiment Stations and are superior in yield when compared to the commercial varieties currently in production. Hyslop is semi-dwarf in height, with high tillering capacity. It was developed from a cross between Nord Desprez and Pullman selection 101 with an additional backcross to Pullman Selection 101. Hyslop is adapted to the winter wheat growing area of the Pacific Northwest. Foundation seed was made available to certified growers in Oregon, Washington and Idaho in 1971.

Yamhill is a midtall cultivar with moderate tillering capacity. It was developed from a cross between Heines VII and Redmond (Alba) made in Oregon in 1960. It is adapted to the winter wheat growing area of Western Oregon. It was developed to replace the variety Druchamp and to some extent Gaines and Nugaines. Foundation seed was produced from breeder seed planted in 1968.

Hyslop and Yamhill were selected for this study because they obtain their grain yield through different morphological characters and patterns of development. If maximum yields are to be attained, it may be necessary to recommend cultural practices specific to each cultivar since each may respond differently to different management systems.

Experiments

This investigation consisted of two experiments, the first will be noted as Experiment I. It was designed to study the effect of row spacing and seeding rates on grain yield and the yield components, culm number and kernel weight. Other characters studied were plant height, bushel weight and protein content. Seeding rates were 22.4, 67.3, 134.5 and 201.7 kg/ha. Spacing between rows was 15.24 and 30.48 cm. Each plot consisted of four 4.57 meter rows with four replications. The experimental design was a split-split-plot with cultivars as main plots and row width as sub-plots. The seeding rates (sub-sub-plots) were placed at random within the sub-plots.

The second experiment will be identified as Experiment II. It was conducted to study the effect of nitrogen fertilizer on the yield and protein content of the grain. This trial had a similar design to Experiment I; however only one rate of seeding was used. The nitrogen was applied at four levels: 0, 56, 112, 224 kg/ha.

Location and Soil Preparation

Both experiments were conducted at the North Willamette

Experiment Station. The amount of rainfall for the 1970-1971 growing season was 1452 millimeters. The soil is classified as a Willamette sandy silt loam.

Adequate levels of phosphorus and potassium were present in the soil and it was not necessary to apply these elements. No nitrogen fertilization was applied in the fall, since sufficient residue nitrogen remained in the soil following beans, the previous crop. Both experiments were planted on October 15, 1970. Ammonium nitrate was broadcast on March 19, 1971 at the rate of 134 kg/ha for Experiment I, and the four nitrogen rates (0, 56, 112, 224 kg/ha) were applied to Experiment II.

Weeds were controlled by the use of "Karmex" applied at two pounds per acre in November. 2-4-D was used at 0.5 lb/acre in early May to control broadleaf weeds.

Measurements

The ends of the plots were trimmed to eliminate a border effect and the following measurements were recorded on the two center rows: Plant height was measured in centimeters from ground level to the top of the spike; an average of six random plants within each plot was used for the analysis of variance.

Culm number was obtained by counting the number of culms within a 60 centimeter sample of row in each of the two center rows.

The average number of culms per square meter was determined and used in the analysis.

Grain yield in kg/ha was obtained by harvesting 2.4 meters within each row. For a total of 4.8 meters of row per plot, the seeds were threshed, cleaned and weighed for analysis. Two other measurements were also determined: bushel weight from a bulk sample of four replications, and 300 kernel weight by counting and weighing 300 seeds from each plot.

Another sample was taken from each plot for determining protein content. The method used for Experiment I was the Udy Dye. The basis for this method is a reaction to an Azo dye and three dibasic amino acid residues of protein. The monosulfonic Azo dye (acid orange G) reacts with the protein to form an insoluble complex. The estimate of protein is based on a colorimetric measurement of unbound dye and its direct relationship to the total nitrogen.

For Experiment II involving fertility trial, percent protein was determined by the Micro-Kjeldahl digestion and steam distillation method. The formula used for titration was:

$$\text{Percent Protein} = \frac{(\text{titer-blank titer}) \times \text{Normality of Acid} \times 1.4 \times 5.7}{\text{Sample weight in grams}}$$

Mean values of the various data collected were compared by using the analysis of variance and the Least Significant Difference (LSD) tests. Correlations between yield and other factors also were determined. Coefficient of variation were calculated for the data to give a measure of precision in the two experiments.

EXPERIMENTAL RESULTS

The analysis of variance for grain yield, number of tillers, plant height, 300 kernel weight and protein content for Experiment I are presented with respective means square values in Table 1. The analysis of variance for grain yield and protein content in relation to nitrogen fertility is presented in Table 2. Mean values and tests of the Least Significant Difference for seeding rates, row spacing and nitrogen fertilizer rates are presented in Tables 3, 4 and 5. Correlation coefficients are presented in Tables 6 and 7. The mean values for each analyzed factor are presented in graphic forms from Figures 1 through 19.

Grain Yield

There was no significant differences between the two varieties for grain yield. However, Yamhill slightly outyielded Hyslop by a small amount (600 kg/ha).

A highly significant difference was noted when row spacings and seeding rates were compared (Table 1). An increase in row width from 15.24 to 30.48 cm resulted in a decrease in yield (Figure 1). The LSD test at the 5% level of significance confirms this result indicating that higher grain yield was obtained with narrow spacing (Table 3).

Table 1. Experiment I. Summary of the observed mean squares from analysis of variance for grain yield, tiller number, plant height, kernel weight and percent protein.

Source of Variation	Yield	Tiller number	Plant height	Kernel wt.	Protein content
Varieties	5790640.6	2889.06	3609.00**	54.39**	.196
Spacing	2658122.6**	171810.25**	8.42	.121	.070
Seeding rates	18598539.3**	161724.08**	91.42*	.093	.580
Varieties x spacing	71623.12	33.06	9.15	.030	3.20
Varieties x rates	604739.93	1047.72	27.60	.600**	.140
Spacing x rates	1521130.16*	10516.50**	31.38	.140	.580
Varieties x spacing x rates	3024443.4**	9336.92**	38.30	.300*	.730
Coefficient of Variation	12%	7%	6%	3%	11%

*Significant at the 5% level.

**Significant at the 1% level.

Table 2. Experiment II. Summary of the observed mean squares from analysis of variance for grain yield and protein content.

Source of variation	Yield	% Protein
Varieties	374643.62	.070
Spacing	759436876.12**	.226
Fertilizer	359230278.16**	109.77**
Varieties x spacing	330997.75	1.260
Spacing x fertilizer	35405181.5**	.595
Varieties x fertilizer	2266316.41**	.030
Varieties x spacing x fertilizer	1623416.58**	.370
Coefficient of Variation	3%	9.5%

**Significant at the 1% level.

Table 3. Experiment I. Mean grain yield and number of culms at four rates of seeding.

Seeding rates	Yield	LSD_{05}	Tillers	LSD_{05}
201.73	7924.75	a	542.06	a
134.50	7862.06	a	457.56	a
67.26	6623.18	a	394.93	a
22.41	5677.56	a	303.93	a

a = Mean values having significant LSD at the 5% level.

Table 4. Experiment I. Mean grain yield and number of culms per square meter at two row spacings.

Row spacing	Grain yield kg/ha	LSD_{05}	Culm number per m^2	LSD_{05}
30.48	6818.09	a	372.8	a
15.24	7225.68	a	476.4	a

a = Mean values having significant LSD at the 5% level.

Table 5. Experiment II. Mean grain yield and percent protein at four nitrogen fertility levels.

N_2 Level kg/ha	Yield	LSD_{05}	% Protein	LSD_{05}
0	3402.95	a	7.53	a
56.04	7638.45	a	7.40	b
112.09	10998.12	a	8.78	a
224.17	11954.54	a	12.00	a

a = Mean values having significant LSD at the 5% level.

b = Mean values not having significant LSD at the 5% level.

Table 6. Experiment I. Coefficients of correlation between grain yield, percent protein, culm number, plant height and kernel weight.

	Grain yield	% Protein	Tiller number	Plant height	Kernel weight
Grain yield	1.0	-0.09	.82**	0.36	.23
% protein	-0.0019	1.0	-0.36	0.00016	.19
Tiller number	.82**	-0.36	1.0	0.043	-0.049
Plant height	.36	0.00016	0.043	1.0	0.90**
Kernel wt.	.23	0.19	-0.049	0.90**	1.0

**Significant correlation coefficient at the 1% level.

Table 7. Experiment II. Coefficients of correlation between grain yield and percent protein.

	Yield	% Protein
Yield	1.0	.12
% Protein	.12	1.0

Both cultivars produced more grain at higher seeding rates. However, the production curve (Figure 2) showed a leveling of the yield when seeding rate was increased past 134.5 kg/ha.

LSD test at the 5% level of significance with the lowest rate as control (Table 3) indicated that the highest significant yield was obtained at 134.5 kg/ha. A fairly high coefficient of variation supported this observation.

A highly significant interaction between row spacing and seeding rates indicated that at low seeding rates the wide spacing produced higher yield (Figure 3). But when the seeding rates increased the narrow spacing outyielded the wide. However, this is true only to 134.5 kg/ha. Beyond this level there was no appreciable increase in grain yield at either spacings when seeding rates were increased.

The effect of nitrogen levels on grain yield was significant at the 1% level (Table 2). Increased yield was obtained by addition of fertilizer up to 112 kg/ha. Above this level there was little increase in yield. This indicated that under the conditions of this experiment, the cultivars, especially Hyslop, did not make efficient use of nitrogen in excess of 112 kg/ha (Figure 4).

Seeded with 15.24 and 30.48 cm between rows, both Hyslop and Yamhill more at high levels of nitrogen (Figure 5). The rate of increase in yield was higher with the narrow spacing than with the wide. Beyond 112 kg/ha, yield at both row widths began to increase at a slower rate with increased amounts of nitrogen.

LSD tests with zero nitrogen as control indicated that all other levels of nitrogen produced significantly higher yield (Table 5).

Tillers per 60 cm Distance

When the tillering capacity of the two cultivars was considered, no significant difference was noted (Table 1). However, a look at the mean values indicated that Hyslop produced more tillers than Yamhill (Figure 6).

There was a highly significant difference in culm number at the different row spacings (Table 1). Both cultivars produced fewer culms per square meter when row width increased from 15.24 to 30.48 cm (Figure 6).

There was a highly significant difference in culm number at the different seeding rates (Table 1). More culms were produced at higher seeding rates. It is of importance to notice that both cultivars responded similarly up to the rate of 67.3 kilograms of seeds per hectare. When seeding rate was increased to 134.5 kilos per ha, Yamhill showed less tillering capacity than Hyslop. Beyond this level Yamhill had a more rapid increase in number of culms produced than Hyslop (Figure 7).

A highly significant seeding rates x row spacing interaction (Table 1, Figure 8) indicated that number of culms did not respond similarly at each row spacing when the seeding rate was increased. Culm production increased more rapidly at the narrow than at the wide row spacing when seeding rates increased from 22.4 to 67.3 kg per hectare. Also, when seeding rates were increased past 134.5 kilograms per hectare, the culm number increased more rapidly at the narrow than at the wide row spacing.

The Least Significant Difference test with the lowest rate as control supported these results at the 5% level of significance. A low coefficient of variation and a rather high correlation coefficient suggest the importance of row width and seeding rates in relation to the tillering capacity (Tables 1, 3,,and 4) of Hyslop and Yamhill cultivars.

Plant Height

Hyslop is significantly shorter than Yamhill (Table 1 and Figure 9). Both cultivars maintained the same height level at the two different row spacings. A slight increase in plant height was observed for both cultivars as they were seeded at higher rates (Figure 10).

A study of the effect of row width and seeding rates indicated a similar response of both cultivars up to a seeding rate of 134.5 kg/ha; however higher rates showed that both Yamhill and Hyslop tended to grow taller when planted at narrow spacing (Figure 11).

The low coefficient of variation suggested that both cultivars are stable in height within each cultural practice investigated in this study.

Weight of 300 Kernels

Mean 300 kernel weights were 13.3 and 15.2 grams for Hyslop and Yamhill, respectively. A highly significant cultivar x seeding rate interaction was observed (Table 1). Kernel weight for Yamhill increased as seeding rates were increased up to 134.5 kg/ha and then decreased slightly when seeding rates were raised from 134.5 to 201.7 kg/ha (Figure 13). However, Hyslop had slightly lower kernel weight when seeding rates increased from 67.3 to 134.5 kg/ha than at low and high rates of seeding.

Bushel Weight

Test weight per bushel was higher for Hyslop than for Yamhill at the two row spacings and at all seeding rates. The influence of seeding rates on the bushel weight was not expected. When planted at narrow row spacing (Figure 14) the increased seeding rates resulted in a considerable variation in bushel weight for Yamhill and less variation for Hyslop. When planted at the wide row spacing (Figure 15), increased seeding rates increased the variation in bushel weight for Hyslop while Yamhill varied only slightly.

Protein Content

Experiment I. No significant difference was observed in protein content of the grain for any treatment (Table 1). There was a trend, although not significant, toward higher protein content for Hyslop and lower percent protein for Yamhill when row spacing was increased from 15.2 to 30.4 cm (Figure 16).

Experiment II. Nitrogen fertilizer had a highly significant effect on protein content of the grain (Table 2). Addition of the first 56 kg/ha of nitrogen resulted in a slight and non-significant decrease in percent protein for both Hyslop and Yamhill (Table 5, Figure 18). Percent protein increased significantly and in a similar pattern for both cultivars with all further additions of nitrogen. When nitrogen was applied up to 112 kg/ha, the protein was lower than 10%. Further additions of the fertilizer sharply increased the percent protein which passed 10%.

Protein content was nearly equal at the two row spacings

(Figure 19). Again a slight decrease in percent protein occurred at both row spacing with the addition of the first 56 kg/ha of nitrogen fertilizer; thereafter protein increased with each addition of nitrogen.

Correlations

A highly significant correlation coefficient of 0.82 existed between grain yield and number of culms (Table 6). Plotting of the two variables indicated that the more tillers produced a higher grain yield (Figure 17). Correlation coefficients between yield and plant height and yield and kernel weight were rather high but non-significant. A highly significant correlation coefficient (0.90**) existed between plant height and 300 kernel weight. This was expected because Yamhill, the taller of the two cultivars, had the highest 300 kernel weight (Figure 13).

In experiment I, correlation coefficient between percent protein and culm number and protein and plant height were -0.36 and 0.00016, respectively. Both were low and non-significant.

In experiment II, correlation coefficient between grain yield and protein content was not significant which indicated that grain yield and protein were not significantly associated under the treatments utilized in this study.

DISCUSSION

Semi-dwarf wheats are replacing standard height wheat cultivars in the irrigated and higher rainfall production areas of the world. Under high moisture conditions the semi-dwarf types have been found to respond to high rates of nitrogen fertilizer, and thus have higher yield potential than most of the standard height cultivars. Gaines, Nugaines and other semi-dwarf and/or stiff strawed cultivars have been shown to have high yield potential in most all areas of the Pacific Northwest. The advantages of these cultivars have been successfully presented to farmers which has resulted in their being readily accepted. Since then the effort of plant breeders has been oriented toward developing not only improved semi-dwarf but also stiff-strawed standard height cultivars. Hyslop and Yamhill, two newly released cultivars with many superior agronomic characteristics are the result of such effort. In regional yield trials, they have outyielded Gaines, Nugaines and other cultivars currently in commercial production. After several years of testing, Hyslop and Yamhill have been released. Foundation seed is being increased for certified seed of Hyslop while Yamhill is rapidly replacing existing cultivars grown in the Willamette Valley of Oregon.

With the release of Hyslop and Yamhill, several important questions need to be answered from a practical standpoint. That is, what set of cultural practices is needed to obtain maximum yield in their area of adaptation? After release, these cultivars are being submitted to the common cultural practices which now prevail. Will they attain their potential yielding capacity, or are there better cultural practices under which maximum performance will be obtained by Hyslop and Yamhill? More specifically definitive answers do not exist for the following questions:

a. What is the optimum row spacing to grow these cultivars?

b. At what seeding rate will they perform best?

c. To what nitrogen level will they respond best?

Several experiments were conducted in different areas of adaptation with different combinations of the above practices. The investigation conducted in this thesis is designed to provide answers within the growing conditions of Western Oregon. Hyslop and Yamhill were planted at two row spacings, four seeding rates and received four levels of nitrogen fertilization. The purpose of these treatments was to study the effect of these factors on grain yield, tiller number, plant height, protein content, bushel and kernel weight.

Grain Yield

Without exception, there was no significant difference in grain yield between Hyslop and Yamhill cultivars within any level of the various treatments applied in this study. This indicated that Hyslop and Yamhill responded similarly to the cultural practices employed and is surprising since these two cultivars have different patterns of development. Hyslop is high tillering, stiff-strawed and has upright intermediate leaves, Yamhill is intermediate in tillering capacity, is stiff strawed and is a standard height cultivar with very large drooping leaves.

However, both cultivars have large, compact spikes and respond to optimum conditions by increasing the spike size.

In Western Oregon, the common row width found in commercial fields is 15.24 cm. This spacing along with a wider row width of 30.48 cm were included in this study. Both Yamhill and Hyslop consistently produced more grain when planted at 15.24 than at 30.48 cm. Similar results were observed by Percival (28) and Kinra (20) for wheat and Foth et al. (8) for oats. Such results have been attributed to a better plant growth, better utilization of nutrients and competition for light. Obviously row spacing is not the only factor that determines grain yield and final conclusions will be drawn after discussing other cultural practices and their effect on certain traits such as culm number.

Several factors must be considered in determining the optimum seeding rate. One is the amount of moisture and its distribution during the growing season. Plants must have adequate moisture near the end of the growing season so that kernels will be able to fill properly. In this investigation both Hyslop and Yamhill responded with higher yield to increased rates of seeding. At the North Willamette Experiment Station, where this study was located, a high amount of moisture was available during the 1971-72 growing season, more than 1400 mm of rainfall were distributed largely during the winter months with very dry conditions prevailing from the soft dough stage on to maturity. Heavy seeding rates would result in higher grain yields under conditions of such a high moisture. This is in agreement with the concept of Wilson (35). However, the increase in grain yield continued only up to the rate of 134.5 kg/ha. Figure 2 shows that beyond this level the relative increase declined sharply for Hyslop while a net leveling of yield was observed for Yamhill. It would appear that 134.5 kg/ha was a near optimum seeding rate for both cultivars under the conditions of this study.

When the combination row width and seeding rates was considered, an increase in grain yield was observed for increased seeding rates up to 134.5 kg/ha for both row spacings. However, a higher yield was obtained with the narrow row width than with the wide. It may be concluded that a 15.24 cm row spacing and 134.5 kg/ha seeding rate constitute the best combination for these cultivars to attain optimum grain yield.

Nitrogen was the third cultural practice considered in this study. The objective of Experiment II was to investigate the influence of nitrogen on grain yield. For this, only one seeding rate was used while nitrogen was provided at four different levels within narrow and wide row spacings.

For many wheat cultivars, high levels of nitrogen fertilization result in reduction in grain yield (Pumphrey, 29). This was not the situation with Hyslop and Yamhill. Very high levels of nitrogen (up to 224 kg/ha) have been applied and no lodging was observed in the plots. This can be attributed in part to the genetic constitution of these cultivars which conditions traits such as reduced height and/or improved straw strength and efficiency of nitrogen utilization. Also the amount of rainfall received by the crop during the growing season enabled a greater use of the nitrogen applied, particularly at higher rates.

Hyslop and Yamhill showed similar increases in yield in response to the higher fertilizer rates. The application of the first 56 kg/ha of nitrogen more than doubled the grain production. The total application of 112 kg/ha increased the grain yield by about four times compared to zero nitrogen level (Figure 4). Additional application of the fertilizer reduced the relative increase in yield to the point it became negligible for Hyslop cultivar. It is to be noted that Yamhill continued to respond to higher levels of nitrogen by higher grain yield.

Both 15.24 and 30.48 cm row spacings indicated that increased nitrogen up to 112 kg/ha resulted in an increase in grain yield. Beyond this level, both row spacings showed a decline in grain yield. Once more, the 112 level appears to be near the optimum rate of nitrogen application for Hyslop and Yamhill.

Tiller Number

Number of culms per square meter was measured at four seeding rates and two row spacings. Little attention was paid to the size of the head or to the number of kernels per head, but all culms counted were seed bearing. Thus, the culm number does indicate an incidence on the grain yield.

A highly significant difference in the effect of row spacing on culm number was observed. Both Hyslop and Yamhill produced more tillers at the narrow (15.24cm) than at the wide (30.48 cm) spacing. This result is in agreement with the observation of Kinra (20) who reported that row spacing greater than seven inches resulted in fewer culms per unit area in most wheat experiments.

Efficient utilization of moisture and soil nutrients, as well as competition for light would explain the increased culm number. In fact, all these factors are stimulated when seeds are placed at narrow row spacing.

Seeding rates also affected the production of culms. Increasing the amount of seeds from 22.4 to 67.3 kg/ha increased the culm number by more than 30%. The addition of 67.3 kg/ha produced about 20% increase. Further increase in culm number was observed even above the seeding rates of 134.5 up to 201.7 kg/ha, but the last increase in culm number may reflect an excessive amount of seeds in the soil rather than an expression of tillering capacity. If this assumption is true, then the last seeding rate did not help in evaluating tillering capacity and we conclude that 134.5 kg/ha produced near the optimum of culms for both Hyslop and Yamhill.

The interaction between seeding rates and row spacing indicated that narrow spacing (15.24 cm) with increased rates of seeding resulted in higher culm number per square meter. The near optimum tillering capacity appeared to be attained by combining 15.24 cm row width with 134.5 kg of seeds per hectare.

It should be pointed out that Yamhill produced less tillers than Hyslop in all cases.

Yamhill does not appear to possess as high a tillering capacity as Hyslop in the conditions of this study. However, tillering of both cultivars responded similarly to changes in row spacing and seeding rates. The correlation coefficient between grain yield and culm number was highly significant at 0.82 (Table 6). Both factors appeared to reach an optimum at 15.24 cm row spacing and 134.5 kg/ha of seeds. This could be explained by the fact that, at these levels enough energy and nutrients were provided for the maximum number of tillers to produce maximum grain yield. This is in agreement with the concept that the yield per plant is governed by the number of tillers when the size of spikes and quality of grain remain the same.

Plant Height

A highly significant difference of about 20 cm in plant height between Yamhill and Hyslop was observed (Table 1, Figure 9). Hyslop is classified as a semi-dwarf while Yamhill is classified as a mid-tall.

Plant height has frequently been considered important in plant competition for light and aeration. Row spacing usually affects the height of growing plants and decreased distance between rows generally results in taller plants (Foth, 8 and Kinra, 20). However, changing the row width from 15.24 to 30.48 cm did not affect the height of Hyslop and Yamhill. The non-significant difference found in the analysis could be due to genetic stability of plant height in these cultivars. Both Yamhill and Hyslop increased significantly in height when seeded at higher rates. Kinra (20) observed the same phenomenon in Michigan. He suggested that it was caused by a dense plant population which stimulated more competition for light. This interpretation would explain the results noted in this study.

300 Kernel Weight

Yamhill had significantly higher 300 kernel weight than Hyslop (Table 1, Figure 12). There was no variation in the kernel weight when the cultivars were planted at two row spacings. This result is in agreement with the finding of Foth (8) that row width affects kernel weight less than the other components of yield.

Test Weight

Hyslop showed more weight per bushel than Yamhill even though Yamhill was higher in 300 kernel weight. This can be explained by the fact that Hyslop, having smaller kernel size has more kernels per bushel than Yamhill which results in heavier weight.

As the seeding rate increased, higher bushel weight resulted for both Hyslop and Yamhill. This is in agreement with the observation of Guitard, Newman and Khalifa (13, 19).

Protein Content

Low percent protein is desirable for soft white wheat varieties because they are chiefly milled into flour for cakes, cookies, pastries, crackers and diet foods which require a low protein content (9, p. 15-16). The percent protein of the grain was not effected by changing row spacing or seeding rates. However, the mean values for protein content showed a general non-significant trend to increase with higher seeding rates. Nitrogen applications resulted in a highly significant difference in protein content of the grain in both cultivars. The grain of Yamhill contained less protein than Hyslop at all levels of nitrogen even though the difference was very little. Increased nitrogen levels had a remarkably similar effect on percent protein in both cultivars. The first 56.01 kilos per hectare decreased the protein content, but further additions of nitrogen resulted in an increase. This is in agreement with the results observed by Pendleton, Peterson and Howard (27, 16).

Protein content was lower than 10% for all nitrogen applications up to 112 kg/ha; beyond this level it increased sharply and passed 10%. Grain yield was increased by the application of nitrogen up to 112 kg/ha whereafter it leveled off. It appeared that this level of nitrogen was of importance in regard to yield and protein content in this investigation. At 112 kg/ha of nitrogen the grain yield reached a maximum while the percent protein was below 10%. But further addition of nitrogen resulted in a very small increase in grain yield while the protein content increased sharply and surpassed 10% (Table 5, Figure 18). The same type of results were found by Pumphrey (29) in Oregon, who reported that up to an optimum grain yield, nitrogen application resulted in protein content lower than 10% and when nitrogen was not needed for grain yield the protein content surpassed 10%.

Other concepts on protein content and grain yield are to be considered. Peterson (16) reported that nitrogen applications increased either yield or protein content but not both. This concept was not in agreement with Hucklesby (17) who reported that nitrogen can increase both yield and percent protein. In the present study, it was observed that the application of the first 56 kg/ha of nitrogen per hectare resulted in an increase in yield and a decrease in percent protein. It is likely that the plants utilized the nitrogen to produce more grain yield and an insufficient amount was left to increase protein. This is in agreement with the concept of Peterson (16). However, the addition of the second 56 kg/ha of nitrogen resulted in increasing both yield and protein content, which corresponds to the findings of Hucklesby (17). Therefore two different concepts were observed successively in this investigation. One explanation to this phenomenon is that since yield of these cultivars responded remarkably to nitrogen application, it is probable that low levels of this fertilizer would have been utilized mainly for better plant growth and more grain yield. Once some of the requirements for grain production were met, further addition of nitrogen enabled both cultivars to perform an increase in both yield and protein content. Thus it is concluded that optimum levels of nitrogen could improve the quality as well as the quantity of wheat production.

RECOMMENDING IMPROVED CULTURAL PRACTICES

In agricultural research, scientists work in their laboratories and experiment stations in a continuous race toward finding of new techniques. Their objective is to improve the production by better use of the land, labor, capital and time in more profitable and less expensive ways. The result of this is a continual change in technology which affects the rural society to a large extent. Farmers are exposed to rapidly changing methods of production. If they are aware of such changes, they are faced with major or minor adjustments to the new techniques. But if they are not informed, they become more and more isolated from progress. The effort of research remains fruitless until its results are applied to the field. The role of Extension is to help people make such adjustments and to fill, or at least narrow, the gap between scientists and farmers.

In the first part of this thesis a research study has been conducted and results have been found about row spacing, seeding rates and nitrogen fertilization of two wheat varieties, Hyslop and Yamhill. Having determined the best of these practices to produce maximum yield, it is of importance that farmers be informed about these results and shown the benefit of their application to the field in increasing wheat production. This chapter will present a program planning for recommending the results to wheat growers.

The task of getting farmers to adopt a new technique may be very difficult. The reason is that nowadays, any technical problem should be approached with careful consideration of human, economical, social, religious and cultural problems of the rural life.

An Extension program can be accomplished through four steps:

1) Evaluation of the technique
2) Determine the problems and define the needs
3) Establish the objectives
4) Plan and work for the action

1. Evaluation of the Technique

Before starting any action with the people, the recommendations should be tested several times to prove their efficiency. A one year trial is not enough to draw definite conclusions. The results found must be valuable and not affected by special conditions such as climate fluctuations or soils, or locations. Any effect of this nature should be precisely defined. The economical advantages in adopting such practices should also be determined. If the grower is not going to gain enough money to justify the move and adoption of the new technique, he will simply not cooperate and reject the plan.

2. Determine the Problems and Define the Needs

Some facts in the rural life should be analyzed: Hyslop and

Yamhill are known as high yielding varieties, and some farmers may be tempted to add a few pounds of seeds or fertilizer per acre, thinking it would increase the yield. Such an attitude should be carefully examined, because even though they are using high yielding varieties, wheat production may be lowered by poor cultural practices. The problem is to determine how far farmers are from the recommended techniques.

The goal of wheat growers is to provide the optimum amount of seed and nutrients in the soil in order to insure maximum convenience for plant growth. The application of more seeds than needed may have two consequences: the first is a waste of the seeds in excess, which could be important in the case of large fields. The second and most important consequence is an unbalanced growth and nutrition of the crop. As soon as they germinate, plants start competing for food, moisture and space. This competition is higher when the field is overcrowded. Plants will have a smaller share of nutrients and water from the soil, and this may result in less grain yield. The addition of more fertilizer may not solve the problem because other damages such as excessive vegetation and lodging could occur, which also decreases the grain yield. Facts like this may not be present in the mind of farmers who are not conscious of the danger of inadequate cultural practices. Such facts can easily be detected by the extension worker who knows his job. Pointing out these problems and presenting desirable solutions to the wheat growers may help in convincing them of the benefit they can get in adopting a new technique.

3. Establish the Objectives

Once the situation is analyzed, the objectives of our program planning can be established. Objectives tell us where to go in the extension work. In this case, we want farmers to adopt the improved practices of row spacing, seeding rates and nitrogen fertilizer rates in growing Hyslop and Yamhill varieties. Objectives are totally or partially reached if the adopter bears in his mind that his function is to change the situation from what it is to what is desired.

In addition to the major objectives of the extension program, other factors of wheat production should not in any case be neglected. Attention must be paid to tillage operations, seed bed preparation, weed control, and other practices in order to obtain the desired results.

4. Plan and Work for the Action

Successful planning must consider the educational level of the rural population. Education of farmers in developing countries generally ranges from few years of school to complete illiteracy. The methods of communication should be managed in a simple and comprehensive form according to the levels of education of the farmers.

A considerable number of technicians and community leaders are in charge of Extension in many countries. They constitute a multiple arm to reach a widespread population. It is known that they have a great influence in getting farmers to accept new ideas. If these technicians and leaders are trained on the job, they can provide a substantial help in diffusing the information and carrying out the extension program. Part of the work is therefore to recognize these qualified leaders and to make use of their ability. Any action should be planned with their cooperation in order to get a strong leadership and full involvement of the rural population.

Two aspects of the planning are to be considered:

- Training Extension workers
- Carrying out the action with farmers.

<u>Training of Extension workers:</u>

The purpose of such training is to bring the information in a simplified scientific form. These technicians are usually more receptive and have better understanding of agronomic research than farmers. A short training allows them to become familiar with the improved practices, to be convinced of their importance, and be able to communicate the recommendation to other people. During this training, refreshment of their knowledge about wheat production is provided along with the new practices. They must have the opportunity to work with different machines, adjust them to the desired spacing, seed rates and levels of fertilizers. They should also be trained on the use of communication media, and prepared to campaign for the adoption of the new methods of wheat production. It is important to mention that these Extension workers should be encouraged to carry out the action in the field. They will need motoring and financial facilities to travel throughout the rural communities. Providing them with such facilities contributes a great deal in maintaining their enthusiasm in doing a better job.

Action with Farmers

Proceeding with extension methods is the hardest part of the work. When dealing with the rural public the basic alternatives for success are skills, money and time. Several media are needed for a large scale operation. The more people that are exposed to a new idea through a variety of channels, the more likely the recommendations will be adopted.

When extension methods are used in increasing numbers, they have more effect on changing people's behavior. An estimation of this effect has been done (Guide for Village Workers, Extension Methods ESC 562) and has shown the following results:

One method changed 35% of the behavior

Three methods changed 64% of the behavior

Five methods changed 86% of the behavior

Nine methods changed 98% of the behavior

What Extension methods to use in recommending improved cultural practices? We want our recommendations to be adopted by as many farmers as possible. Therefore we want the information to be widely spread among the rural people. The methods to use should be strong enough to hold their interest, full of motivation to obtain their concern and rewarding enough to insure a complete adoption of the technique.

Some methods have better impact on a man or group of farmers such as radio talks, newspapers, television and movie shows, posters, meetings, etc; others are more effective on individuals such as farm visits, field days, demonstrations and personal contacts. The use of both types of methods provides better coverage of the entire rural area and allows better involvement of wheat growers. However, the use of numerous methods requires selection of the best and coordination for better success. A valuable way of using extension methods is to plan for a campaign throughout the year where priority and coordination can be brought on different methods.

Campaigning for improved cultural practices should include three phases: 1) Preparation of the public opinion, 2) Giving evidence of the action, 3) Follow-up campaign.

Preparing Public Opinion

With the help of extension agents and trained community leaders, start a community campaign well before the planting season, by writing articles and short stories in local newspapers. The language should be simple and accurate. Give some radio talks introducing the operation, distribute simplified leaflets and circular letters, organize meetings to discuss the new practices and show photographs from the experiment. At the same time, contact people and make lists of farmers who are interested in trying the new recommendations.

Giving Evidence of the Action

a. Pilot Fields. Several farms can be chosen to conduct the improved practices. They must belong to farmers who have the confidence and respect of their neighbors and are willing to improve their methods. The trained village workers should visit with them and set up demonstration plots side by side, one will show the new way, the other the old one. Government stations cannot be used unless they have good reputation and have proven success in the community. All necessary materials should be provided and special care should be taken of the work that is done.

People are invited to attend the demonstrations where all practices are shown to them. Records are kept for those plots and large signs indicate the objectives of the operation. If the demonstrations are succeeding, news stories and photographs will give publicity for farmers during the season.

b. Field Days. They are scheduled when the results can be seen. A series of farms and demonstration plots are included in the visits. Attendance of interested farmers and wheat growers is important, and reminders about the demonstration are given early in the season. Striking differences between improved and old practices should be shown. These differences should justify promising results. Farmers should do all the talking with assistance of the extension agents. The participants should be invited to discuss the matter with deep concern. Large advertisements are then made about these days. Articles in newspapers and radio talks are used to inform people who did not participate in the tours.

c. Result Demonstrations. Result demonstrations are organized at the harvest time. Visits are made to the area and harvest of plots of similar size from the new and old practices is made in presence of farmers. Difference in the production is shown. Have people help measure the results. This will dispel all doubts about the operation.

Discussion is generated to test the public opinion about the new cultural practices. If the success is evident, people should no longer show reluctance or indifference, and the final decision to adopt the new methods is guaranteed. It is time for the extension worker to stand by, summarize the results and promise technical assistance to any individual who wants to try the new recommendations for the next season.

Follow-up and Evaluation

Although the demonstration is over for the season, it is not finished. Continued effort and evaluation are required to complete the extension work. Charts and records of the results should be published in the newspapers. They must constitute topics for radio talks, slide projections, group meetings and individual contacts in order to gain more supporters.

Extension agents should make list of those who will need help for the coming season. Technical assistance is then scheduled so that every new adopter gets his share. This also permits determination of all the shortcomings and strengthens the success with new farmers. This makes it easier for rural people to accomplish the change and avoid future failure.

SUMMARY AND CONCLUSIONS

The objective of this investigation was to determine the influence of various cultural practices on several agronomic traits involving two recently released winter wheat cultivars.

Cultural practices utilized included two different row spacings, four seeding rates and four levels of nitrogen fertilizer.

Data were obtained for grain yield culm number, plant height, weight of 300 kernels, test weight and protein content.

The cultivars were Hyslop, a stiff strawed high tillering semi-dwarf and Yamhill, a moderate tillering, stiff strawed, selection which is mid tall in height. Both cultivars are potentially very high yielding; however they appear to obtain this yield through different morphological characteristics.

The effects of different cultural practices on the various agronomic traits measured are summarized as follows:

Grain Yield

1) A significant influence for both row spacings and seeding rates was noted. The narrow spacing (15.24 cm) resulted in higher grain yield as did the 134.5 kg/ha seeding rate. Higher seeding rates either did not increase the yield or resulted in a decline. Both Hyslop and Yamhill responded in a similar manner.

2) A large response in grain yield was noted with progressive applications of nitrogen fertilizer for both cultivars. With the addition of the first 56 kg/ha of nitrogen, a doubling in grain yield was noted and this was quadrupled with the application of 112 kg/ha. This latter rate appears to be the optimum rate of nitrogen for maximum grain yield.

3) The interaction between row spacing and nitrogen indicated that the narrow spacing outyielded the wider spacing at all levels of nitrogen.

Culm Number

1) Both Hyslop and Yamhill had a high tillering capacity; however Yamhill had fewer culms per unit area for each of the various treatments. Culm number was less when the row spacing increased from 15.24 cm to 30.48 cm. But increased seeding rates up to 134.5 kg/ha resulted in higher culm number.

2) A high correlation was observed between grain yield and culm number and confirmed the above combination as being the optimum cultural practices.

Plant Height

1) Plant height was not influenced by the different row spacing.

2) Increased seeding rates affected the height of both Hyslop and Yamhill. It appeared that high plant density stimulated plant competition for light which resulted in increased height.

300 Kernel and Test Weight

1) Yamhill consistently had higher 300 kernel weight than Hyslop because of its larger kernel size in all treatments.

2) The row spacing had no effect on kernel weight.

3) The 300 kernel weight increased for Yamhill and decreased for Hyslop up to the 134.5 kg/ha seeding rate.

4) The bushel weight was higher for Hyslop than for Yamhill for all treatments.

5) No effect of row spacing on bushel weight was observed.

6) Increased seeding rates resulted in higher bushel weight for both cultivars.

Protein Content

1) There was no significant effect of row spacing and seeding rate on protein content, but levels of nitrogen had a highly significant effect.

2) Yamhill had slightly lower protein content than Hyslop for all cultural practices.

3) The first 56 kg/ha of nitrogen resulted in a decrease in protein content, but all additional applications of nitrogen resulted in an increase.

4) When nitrogen applications increased grain yield, the protein content remained below 10%. When additional nitrogen

application did not result in increased grain yield, the protein content exceeded 10%.

5) Low levels of nitrogen increased yield and decreased protein content, but higher levels of nitrogen increased both yield and protein. This indicated that nitrogen can increase both quantity and quality of wheat.

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APPENDIX

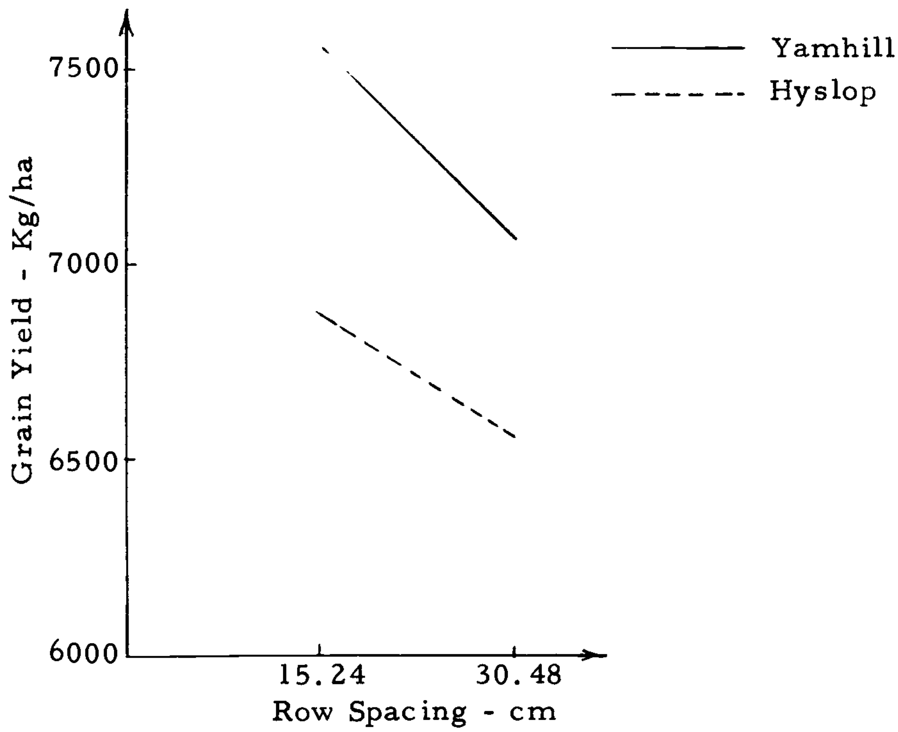

Figure 1.- Experiment I. Effect of row spacing on grain yield.

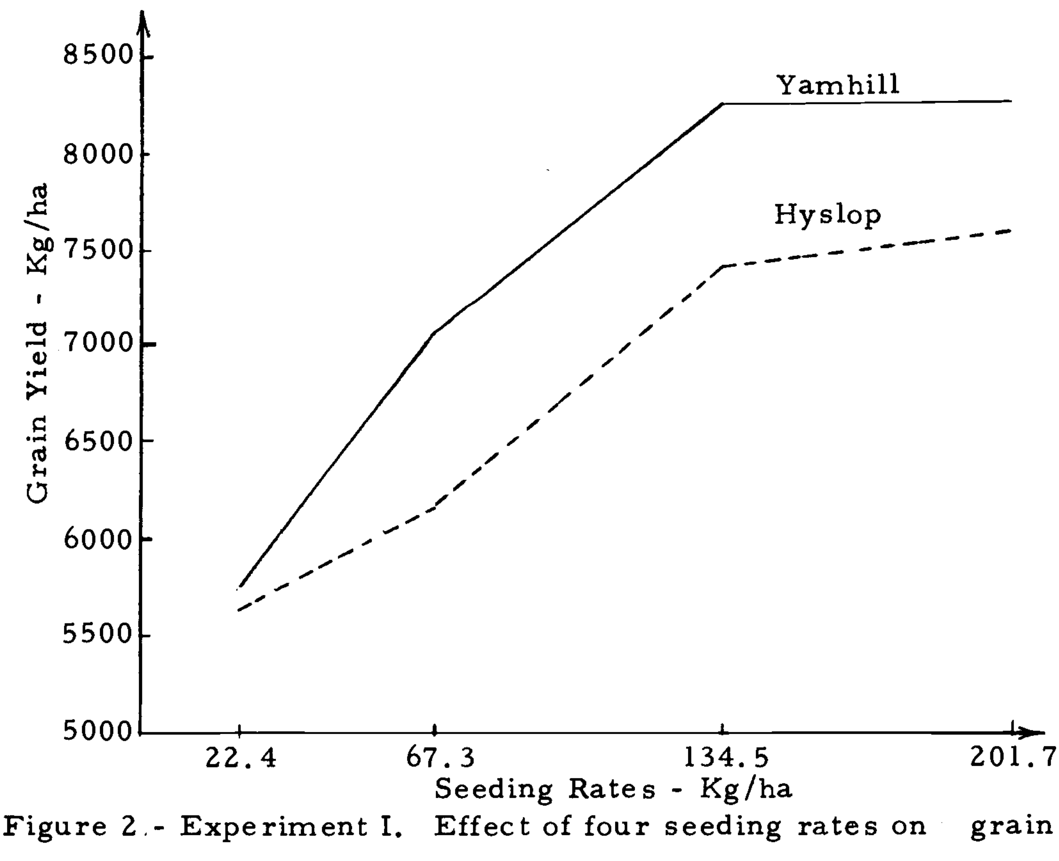

Figure 2.- Experiment I. Effect of four seeding rates on grain yield.

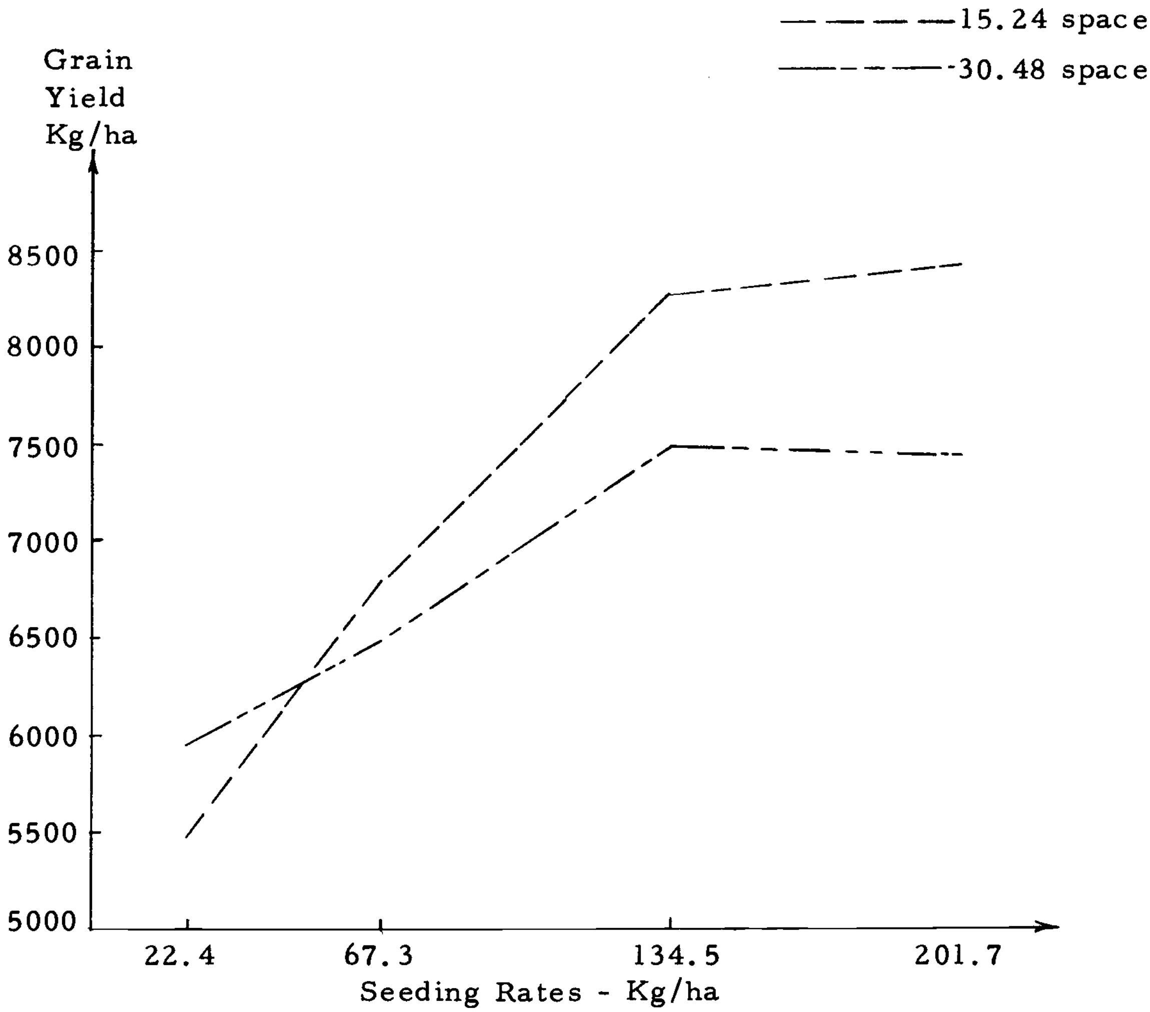

Figure 3 - Experiment I. Effect of seeding rates and row spacing on grain yield.

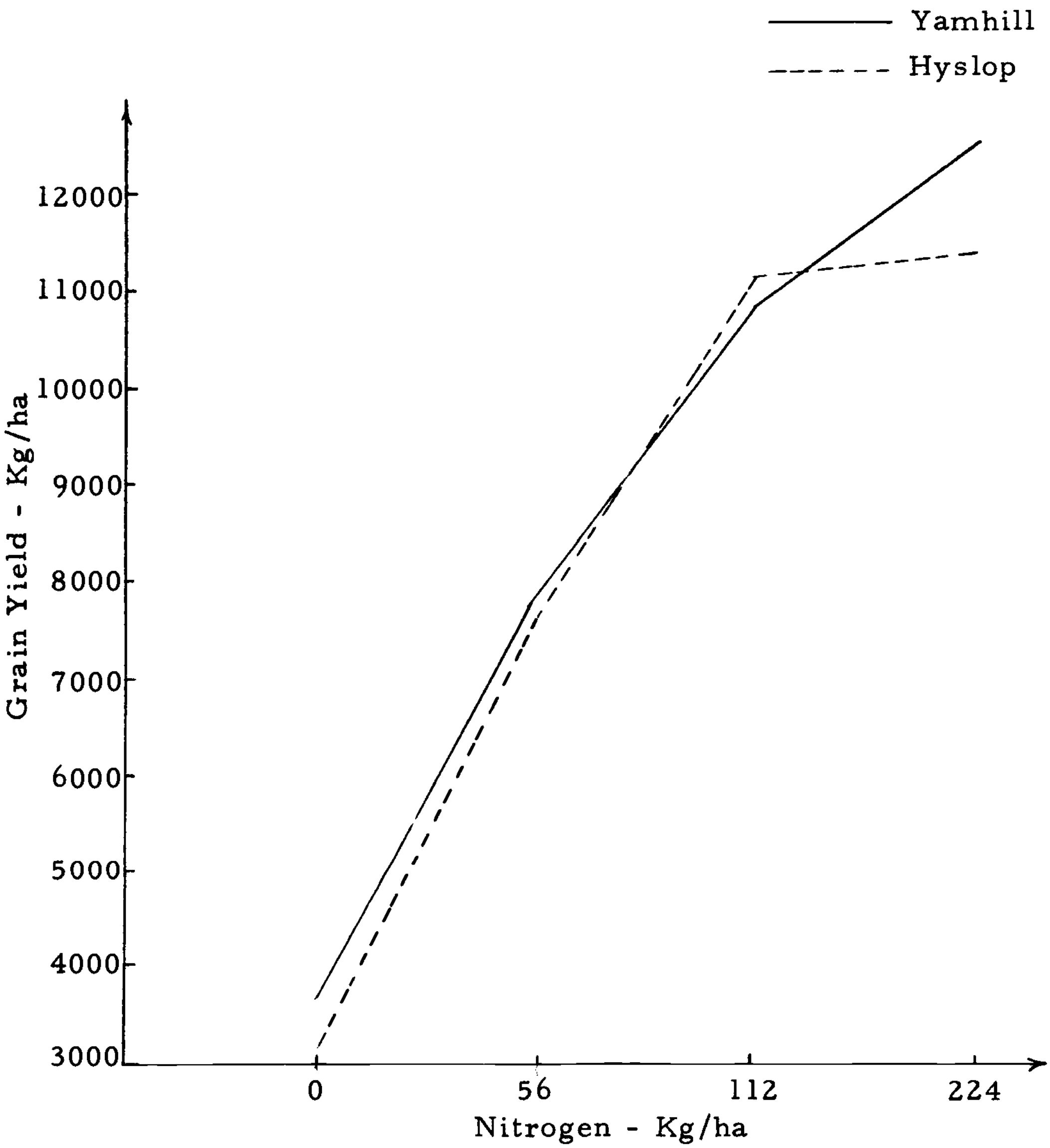

Figure 4.- Experiment II. Effect of four levels of nitrogen application on wheat grain yield.

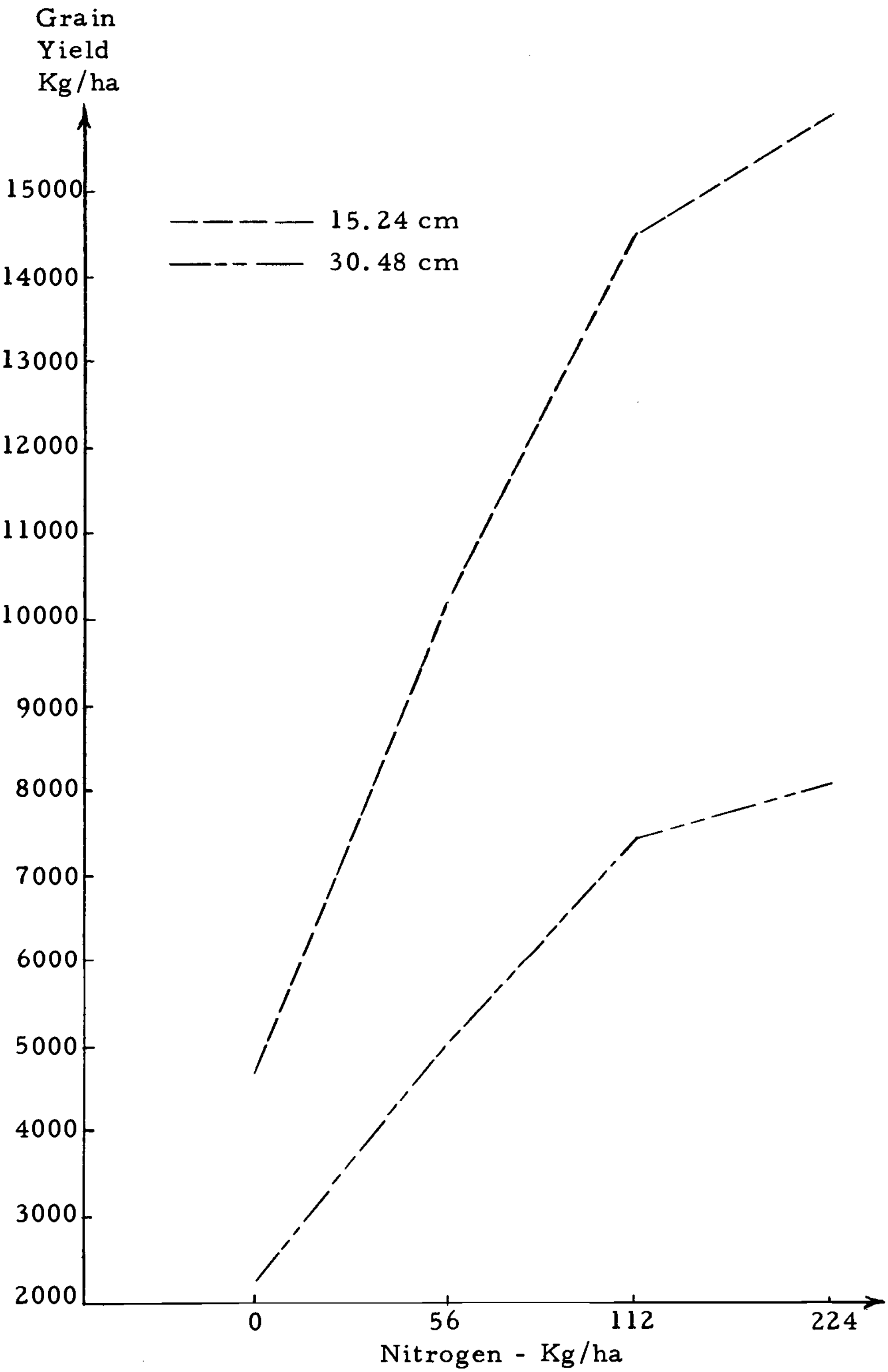

Figure 5 - Experiment II. Effect of two row spacings x four levels of nitrogen fertility on grain yield.

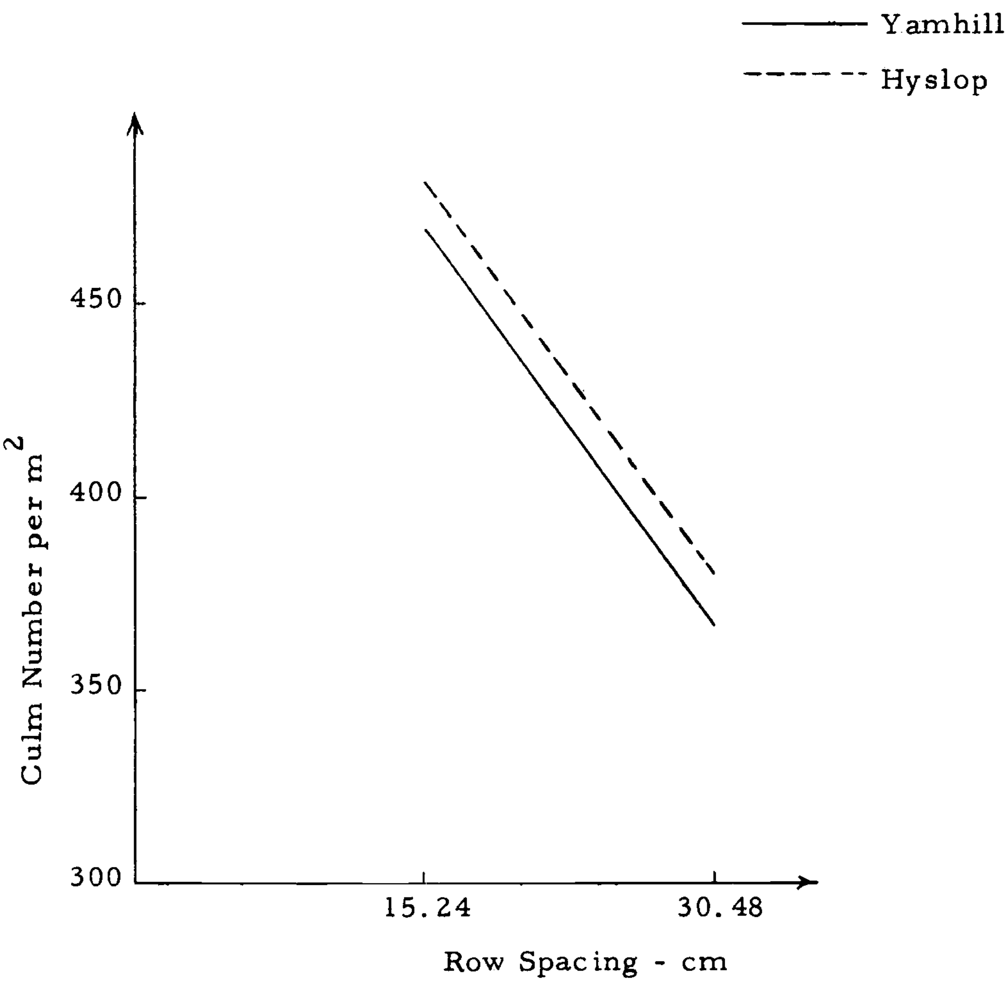

Figure 6 - Experiment I. Effect of two row spacings on number of culms per square meter.

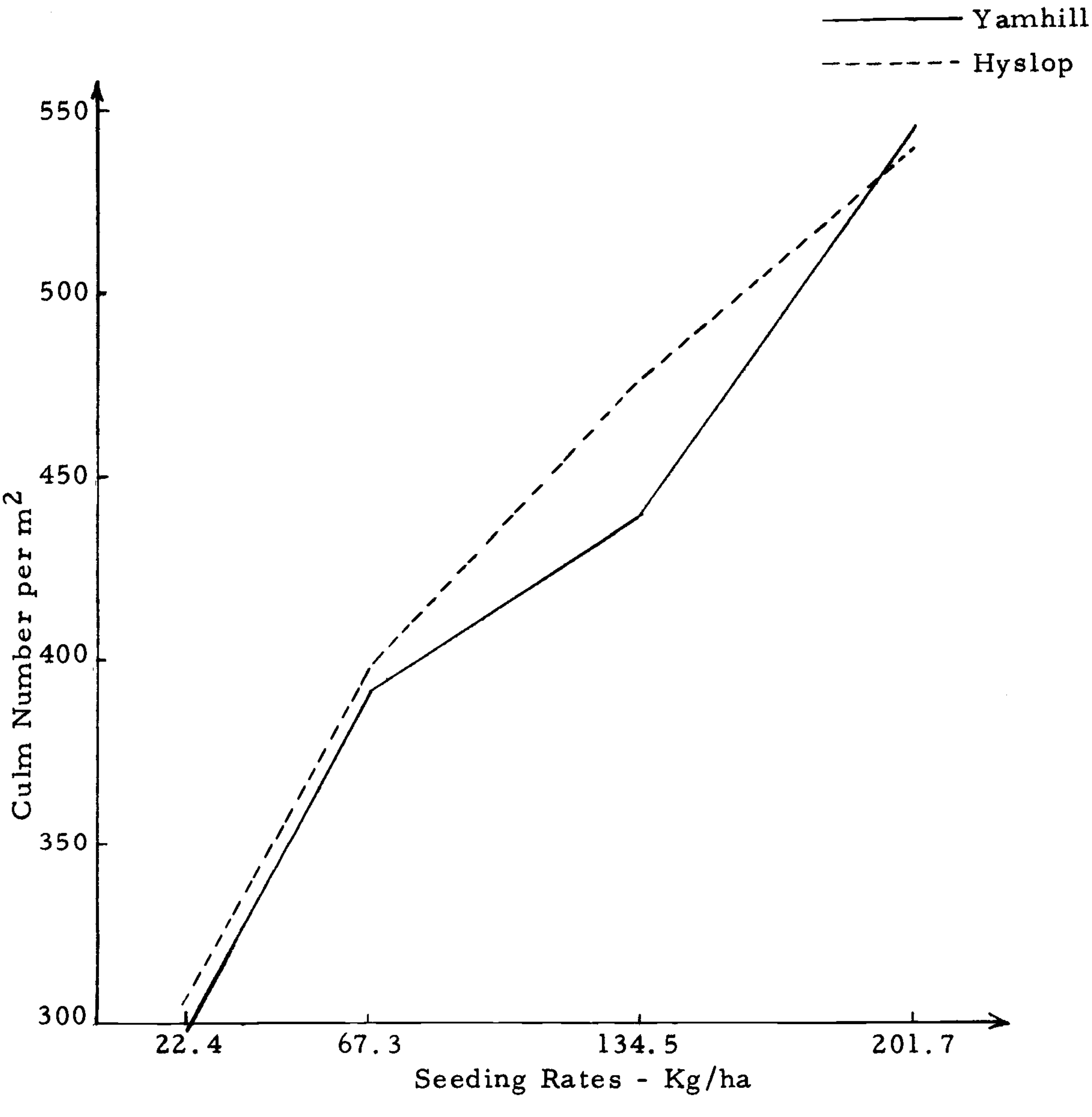

Figure 7 - Experiment II. Effect of four seeding rates on production of culms per m^2.

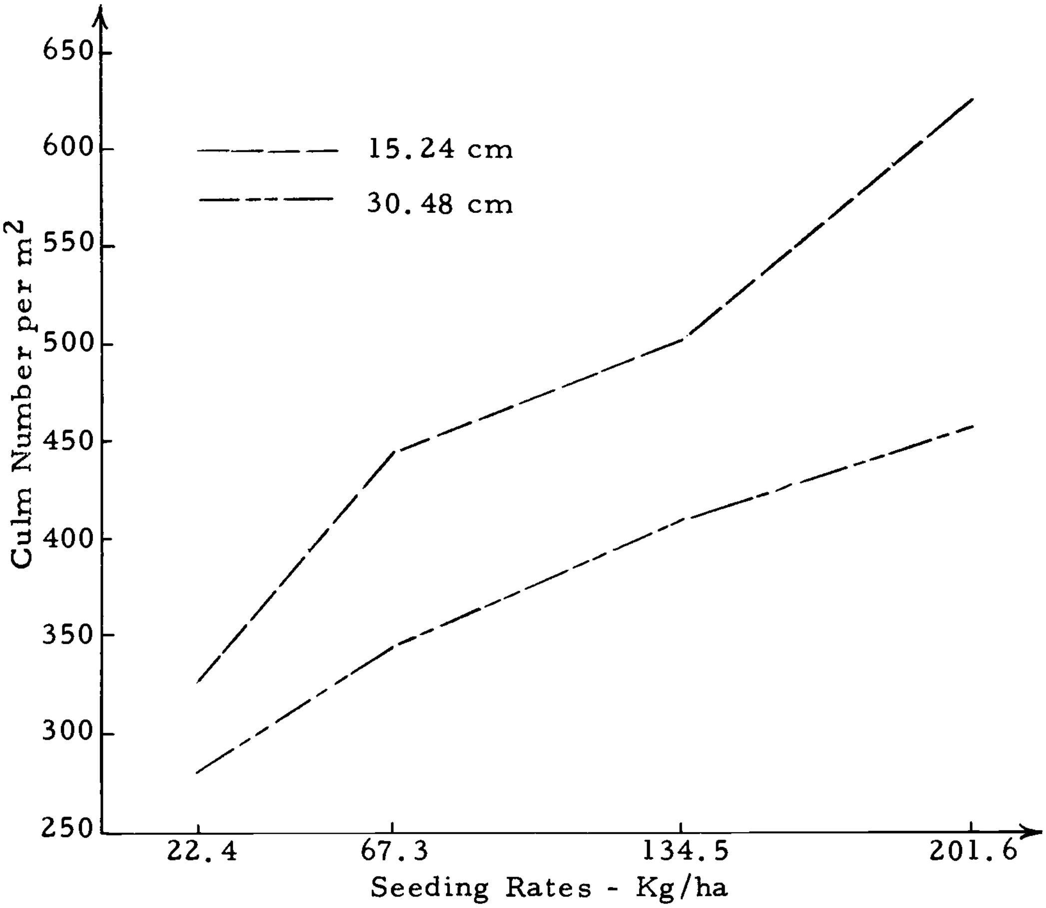

Figure 8 - Experiment I. Effect of four seeding rates and two row spacings on production of culms per square meter.

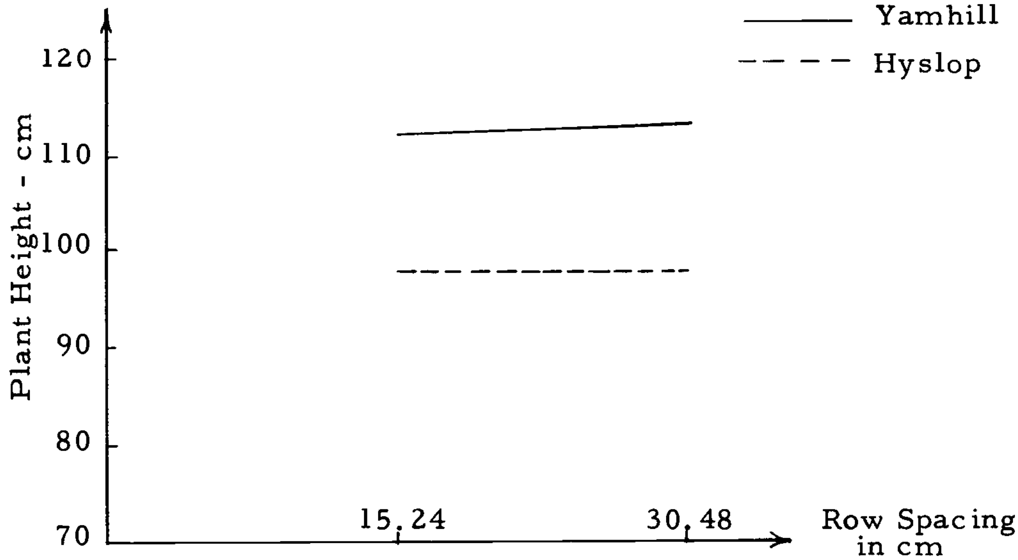

Figure 9 - Experiment I. Effect of two row spacings on plant height.

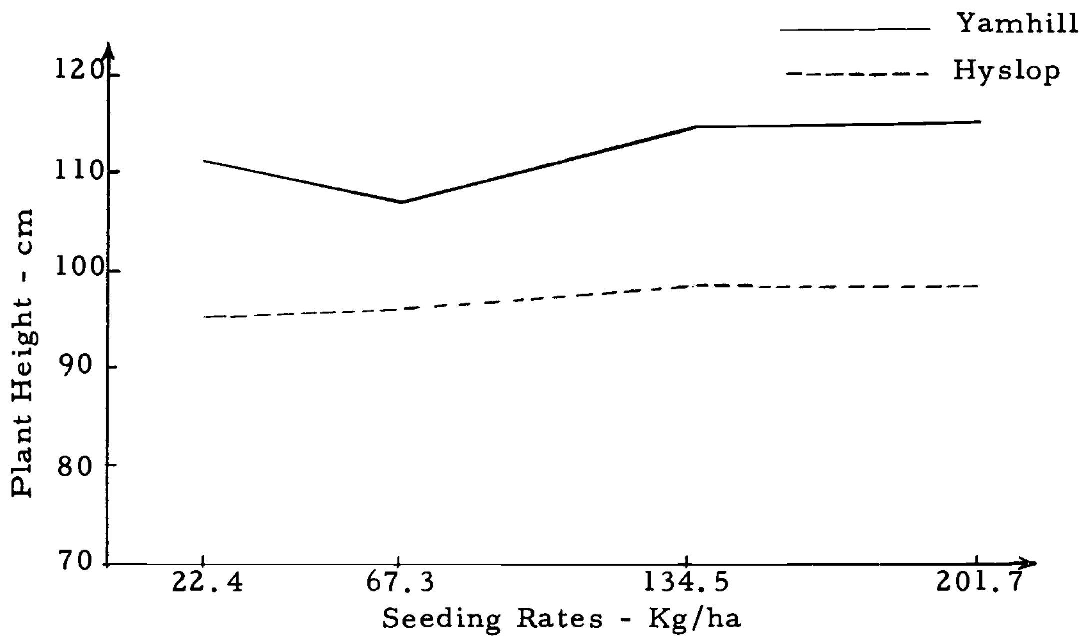

Figure 10 - Experiment I. Effect of four seeding rates on plant height.

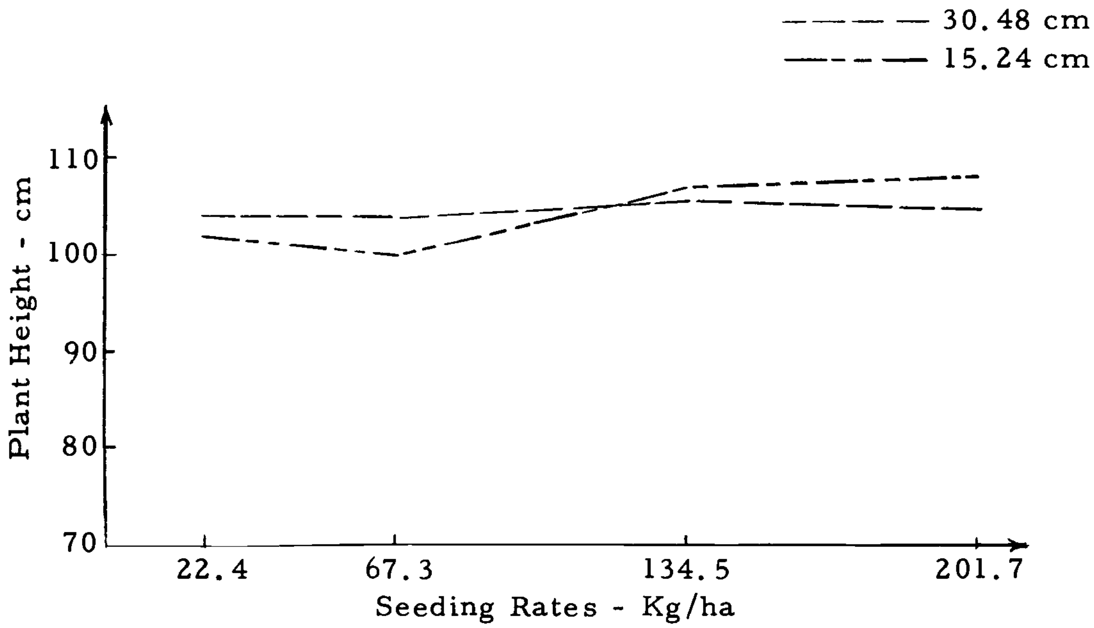

Figure 11 - Experiment I. Effect of four seeding rates and two row spacings on plant height.

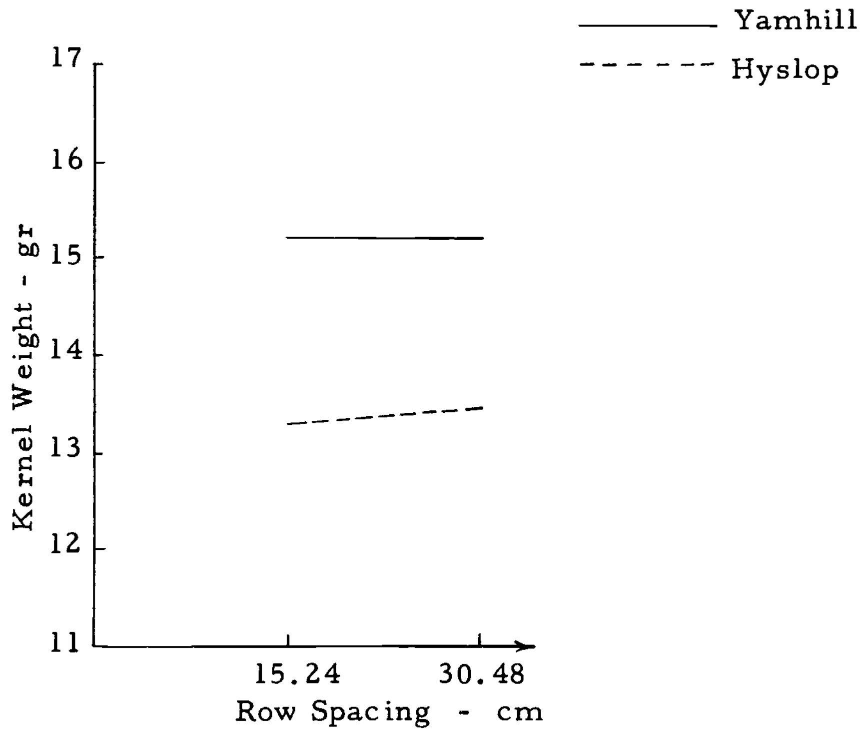

Figure 12 - Experiment I. Effect of two row spacings on 300 kernel weight.

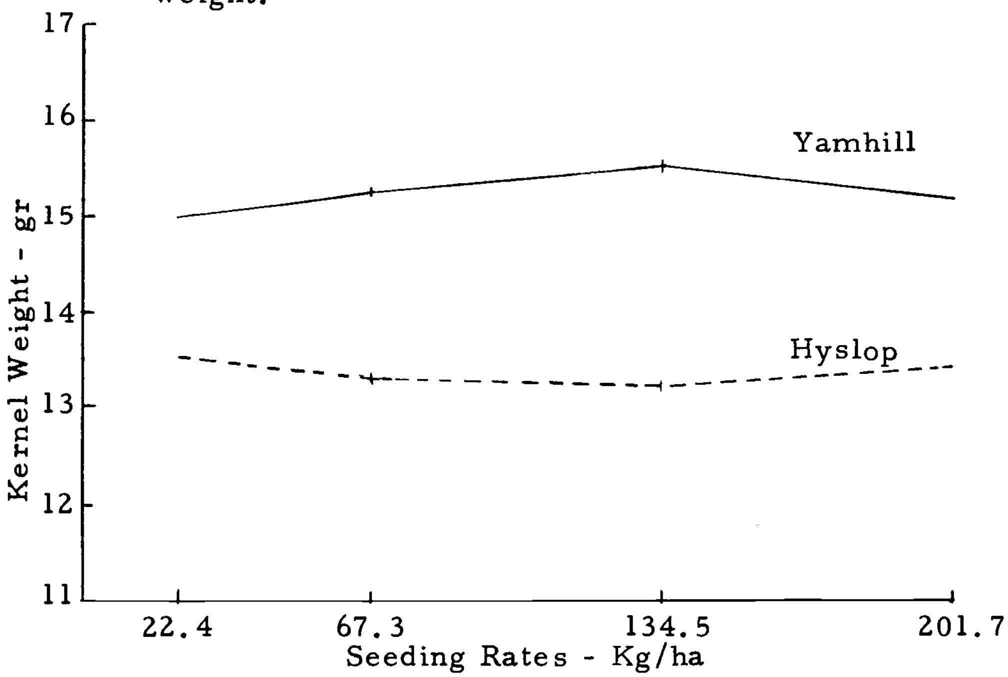

Figure 13 - Experiment I. Effect of four seeding rates on 300 kernel weight.

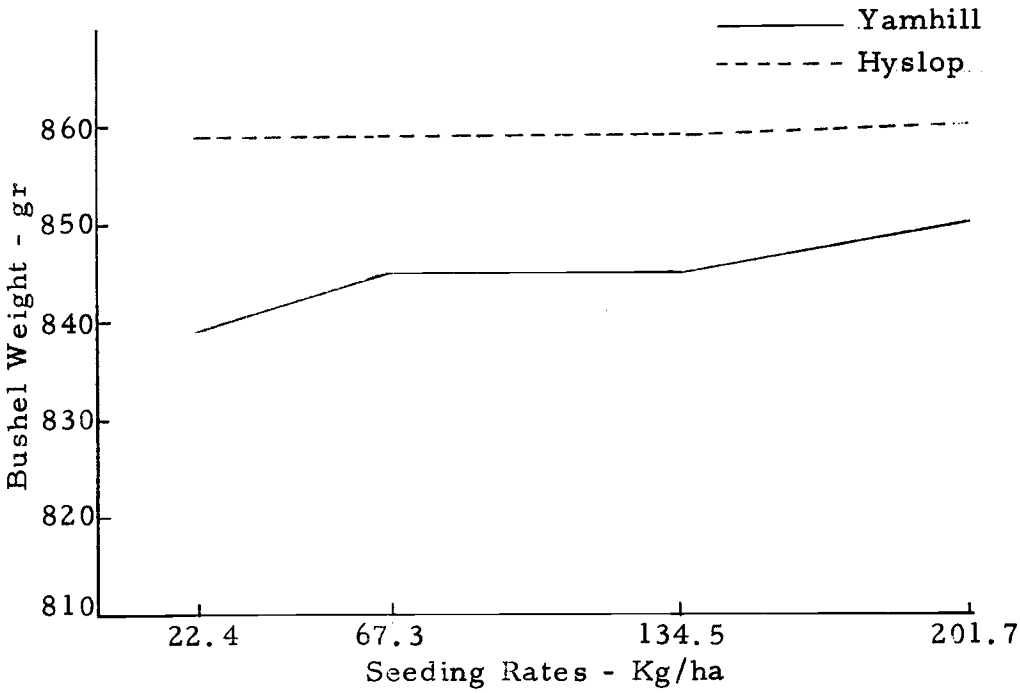

Figure 14 - Experiment I. Effect of four seeding rates on the bushel weight at 15.24 cm row spacing.

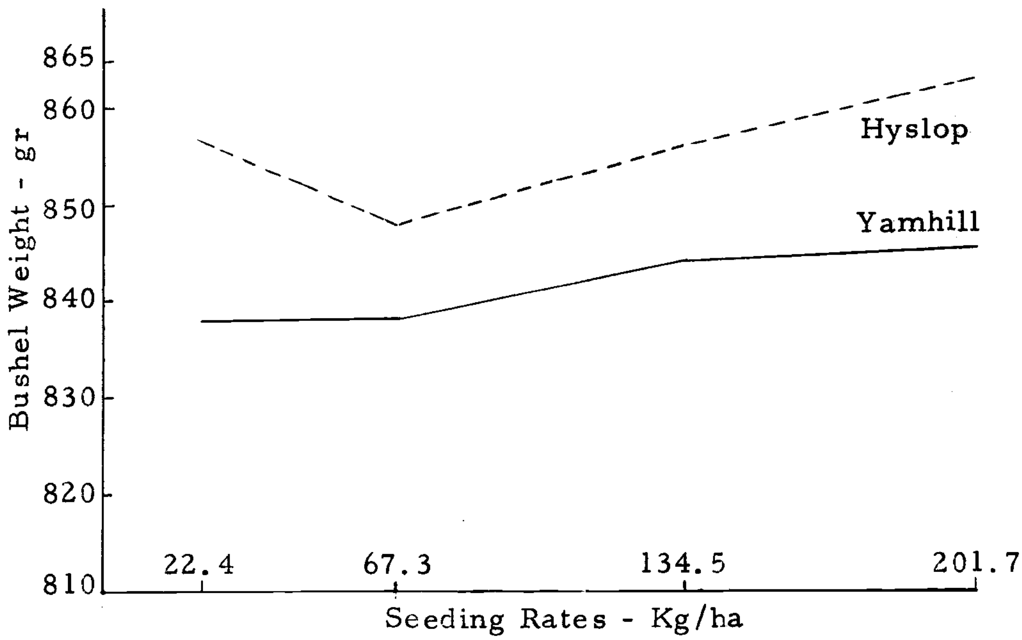

Figure 15 - Experiment I. Effect of four seeding rates on the bushel weight at 30.48 cm row spacing.

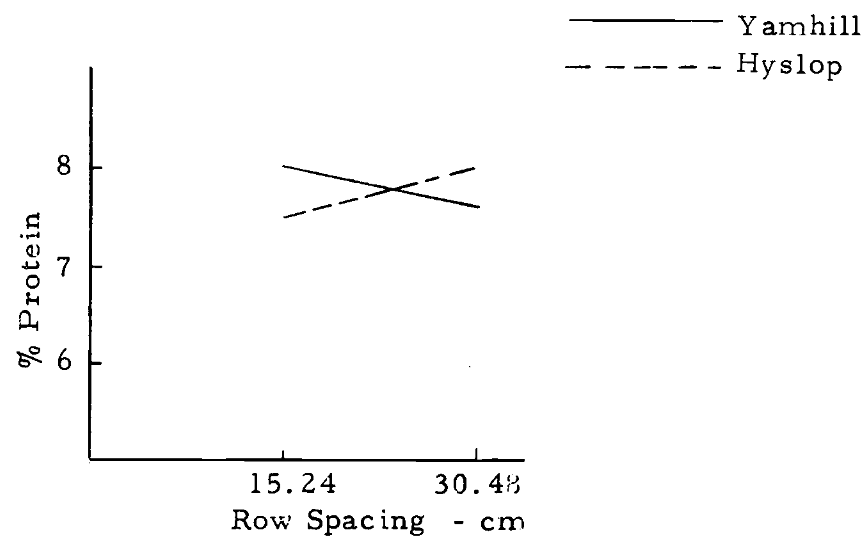

Figure 16 - Experiment I. Effect of row spacing on protein content of Hyslop and Yamhill wheat cultivars.

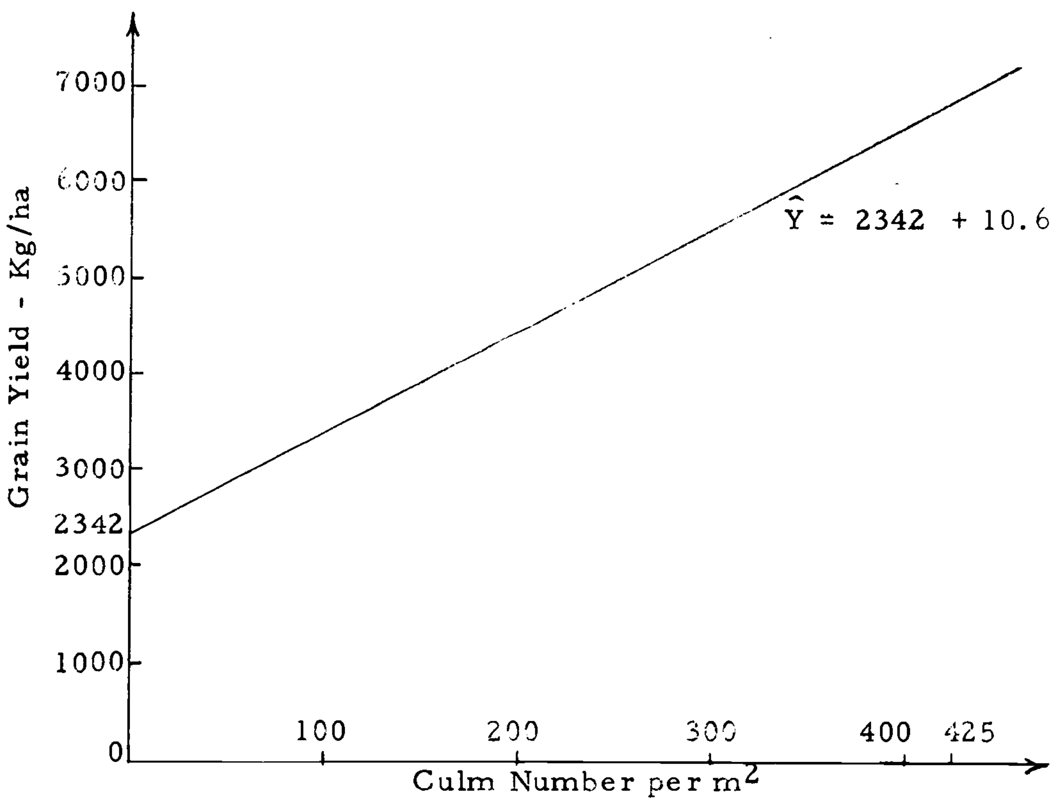

Figure 17 - Experiment I. Correlation between grain yield in Kg/ha and culm number per m^2. r=.82**

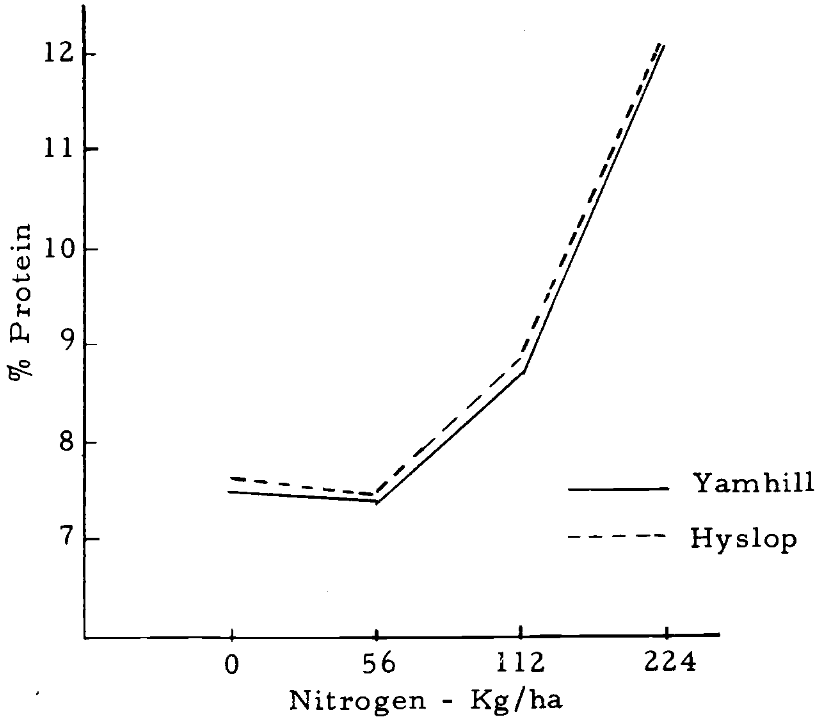

Figure 18 - Experiment II. Effect of four nitrogen applications on the protein content.

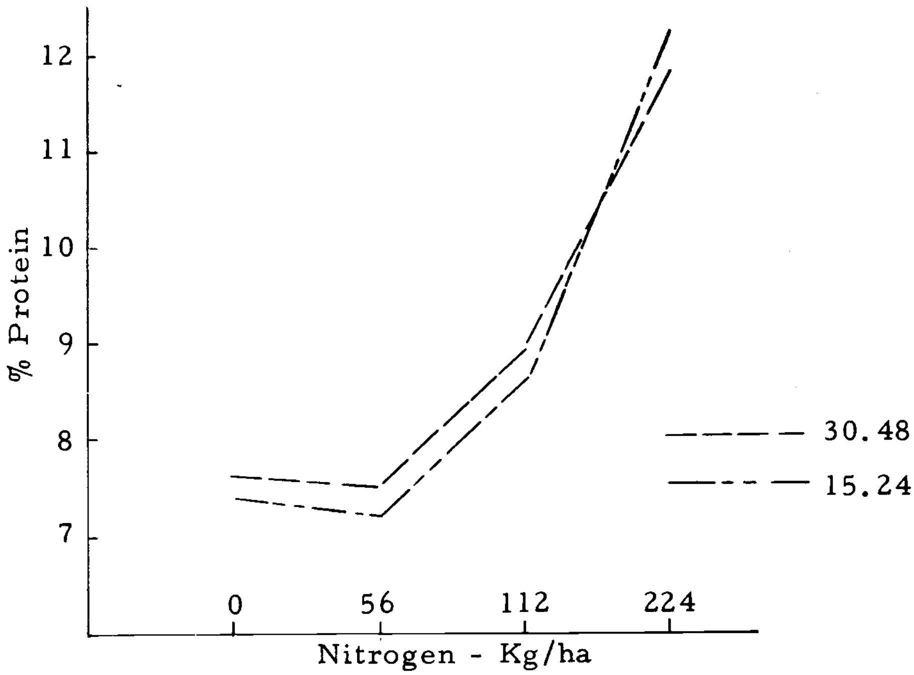

Figure 19 - Experiment II. Effect of four nitrogen levels at two row spacings on the percent protein.