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Effect of Fertilizer Treatments and Planting Dates on Yield and Quality of Barley

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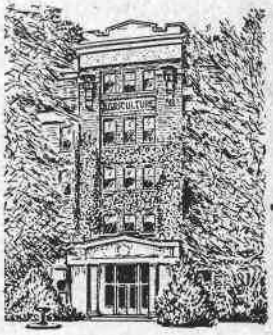

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T. L. Jackson, W. H. Foote, and E. A. Dickason

Summary and Conclusions

Six experiments were established during 1960 and 1961 to evaluate the effect of planting dates and fertilizer treatments on yield, test weight, kernel size, and protein content of Hannchen barley in the presence of yellow dwarf virus disease.

Aphids that transmit the yellow dwarf virus to spring-planted cereal crops did not appear until very late during 1960; consequently, some plots had no yellow dwarf symptoms and others had a light infestation. There was an early infestation with aphids during 1961 (Table 2); this resulted in an extensive and heavy infection with yellow dwarf virus disease in 1961.

Results from these experiments show that:

1. Planting early in the spring resulted in greater yields, higher test weights, and a lower percentage of thin kernels for both years—with little or no yellow dwarf in 1960 and in the presence of yellow dwarf in 1961.

2. Application of nitrogen consistently increased yields. Excessive application of nitrogen decreased test weights and increased the percentage of thin kernels.

3. Banded applications of phosphorus increased yields on the April 30 and May 10 (late) planting dates on the Hyslop farm in 1960.

4. Increases in yield and test weight and decreases in percent of thin kernels were evident from application of both phosphorus and potassium in 1961 when yellow dwarf virus disease was severe. These responses were observed on soils that would normally be considered adequately supplied with both phosphorus and potassium.

   Phosphorus and potassium, banded at planting time, probably produced extra seedling vigor at the time of virus infection. This extra seedling vigor could have increased the ability of the

plants to yield in the presence of infection from yellow dwarf virus disease. These nutrients also may have affected the ability of the plants to resist the virus.

5. Banding phosphorus close to the seed at planting time resulted in much greater increases in yield than broadcasting it ahead of planting. This effect was observed on a soil where response from phosphorus would normally be expected in 1961 and on the late planting on a soil where phosphorus response would not have been expected in 1960.

6. The combination of NPKS[1] fertilizer at the 40 pounds per-acre rate of nitrogen resulted in a protein content equal to or lower than the check plots in 1961.

7. It is not likely that a successful crop of Hannchen barley can be produced in the Willamette Valley if it is planted later than mid-April in years when yellow dwarf virus affects the barley crop.

8. Results of these experiments provide evidence that infection with yellow dwarf virus disease appreciably alters response from phosphorus and potassium.

Introduction

The Willamette Valley of Oregon is one of the principal malting barley growing areas in the Pacific Northwest. However, the increase of yellow dwarf virus disease since 1957 has placed the production of Hannchen barley, the important malting variety, in a very precarious position. Where heavy aphid infestations and virus infections developed during the early seedling stages of growth, yields of only 300 to 500 pounds of barley per acre have been obtained.

Serious yield losses have aroused interest in the possibilities of early planting dates for spring grains as a means of reducing the effects of this disease. Observations have indicated that losses in yields from yellow dwarf virus disease are less severe when barley is seeded early in the spring. Chemical control of aphid vectors has not reduced the incidence of the virus disease and the varieties that have resistance to yellow dwarf are not suitable for malting. This means that early-seeded spring barley with optimum fertilizer applications could offer a possibility for producing malting quality barley in the Willamette Valley with minimum damage from the yellow dwarf virus disease.

[1] N = nitrogen, P = phosphorus, K = potassium, S = sulfur.

Review of Literature

Advantages of early seeding of spring grains have been generally recognized by farmers and agronomists. This practice has received wider acceptance in the Midwest where the winter months receive a smaller percent of the annual precipitation. Wet and poorly drained soils are a problem in the spring in the Willamette Valley where 75% of the 40-inch annual precipitation is distributed between November 1 and April 1. This is in contrast to Lafayette, Indiana, where 35% of the 38-inch annual precipitation is distributed between November 1 and April 1 (9).[1]

Late seeding usually results in reduced yields of spring grains. The probability of losses from weather, weeds, and diseases is increased (13, 11, 12, 5). Wiggans (12) observed that the differences between sowing dates of spring oats were more marked in years of heavy stem rust and crown rust infestation. He also reported a consistent reduction in test weight and height of plants with postponement of seeding dates. Woodward (13) and Wahhab (11) have observed the trend of lower yields with later planting dates of spring grains even under irrigation.

Hill (6) and Foote and Batchelder (4) have pointed out the benefits derived from application of N on yields of malting barley in the Willamette Valley. The latter, however, have called attention to the fact that responses from nitrogen on nonirrigated spring-sown barley will be limited by moisture during the growing season.

Responses of small grains to P, K, and S have been observed in recent experiments in the Willamette Valley (7), and tentative relationships between soil test values for P and K and responses from these nutrients have been established.

Assessment of malting quality and effects of fertilizers on the quality of barley have been reviewed and discussed elsewhere (10). It has been pointed out that as the availability of N to the plants increases, the following effects are usually noted: (a) The protein content in the grain increases, (b) the percent of thin kernels increases, (c) the total extractable material (starch) decreases, (d) the number of plump kernels decreases, and (e) the test weight decreases. Lodging has been frequently associated with high N content (2). P has on occasion been shown to minimize or counteract some of the undesirable effects of abundant N (8).

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[1] Numbers in parentheses refer to literature cited, pages 19-20.

Consideration of the factors that affect yield and quality of barley led to the establishment of a series of experiments designed to evaluate their importance for the production of Hannchen barley in the Willamette Valley.

Materials and Methods

Six experiments were established in 1960 and 1961 to evaluate the effect of different planting dates and applications of fertilizer on the yield, test weight, protein content, and kernel size of Hannchen barley in the presence of yellow dwarf virus disease.

The location, series names, and chemical characteristics of the soils are given in Table 1. Soil samples were taken from each replication for chemical characterization before fertilizers were applied. The samples were analyzed by the Oregon State University Soil Testing Laboratory (1); Olsen's sodium bicarbonate method was used to measure phosphorus and exchangeable bases were extracted with 1 N ammonium acetate buffered at pH 7.0.

Barley was seeded about 2 inches deep at 90 pounds per acre using an experimental drill attached to a Model G Allis Chalmers tractor. The drill was equipped with eight Allis Chalmers double disc fertilizer-grain drill openers spaced seven inches apart. These openers placed the fertilizer about ½ inch to the side of the seed at planting time. The fertilizer was applied with endless belt distributors that allowed uniform application. Plots were either 30 or 40 feet long.

A split-plot experimental design was used with planting dates as main plots and fertilizer treatments as sub-plots. Three planting dates were used in 1960 and two planting dates were used in 1961. The experiments were replicated three times each year.

Combinations of nitrogen, phosphorus, and potassium fertilizer treatments used

1960. A factorial combination of 0, 30, and 60 pounds of phosphate (P_2O_5) per acre with 40 and 80 pounds of N per acre was applied. Broadcast and banded comparisons were included for P treatments. Additional treatments consisted of a check, 40-0-0, 80-60-60, and 120-60-0 of N, P_2O_5 and K_2O, respectively.

1961. A factorial combination of 0 and 80 pounds of phosphate (P_2O_5) per acre and 0 and 60 pounds of potash (K_2O) per acre, and 40 and 80 pounds of N per acre was applied. Additional treatments consisted of a check, 120-80-60 pounds of N, P_2O_5, and K_2O respectively, 80-80-60 plus boron, and 120-80-60 plus boron. A comparison of

TABLE 1. LOCATION, CHEMICAL ANALYSES OF SOILS, AND SOIL SERIES FOR THE EXPERIMENTAL SITES

Farm	Year	County	Soil series[1]	Soil pH	Phosphorus lb/A	Exchangeable bases me/100 grams soil				
						K	Ca	Mg	Total	CEC[2]
East	1960	Linn	Chehalis	6.2	25.0	0.50	9.2	4.80	14.5	19.3
East	1961	Linn	Chehalis	5.9	30.0	0.49	7.1	3.90	11.5	15.6
Hyslop	1960	Benton	Willamette	5.6	46.0	0.34	5.6	1.30	7.2	17.0
Hyslop	1961	Benton	Willamette	5.5	60.0	0.42	5.7	1.35	7.5	15.5
Simmons	1961	Marion	Willamette	5.7	40.0	0.34	6.3	1.45	8.1	15.0
Reimer	1961	Polk	Salkum	5.8	10.0	0.47	4.8	1.75	7.0	16.0

[1] Soil series names designated in published county soil survey reports.
[2] Cation exchange capacity.

broadcast versus banded P at 40 pounds of P_2O_5 per acre was included at one location.

All of the P and K except for the two broadcast P treatments on the one location in Polk County in 1961 were banded within ½ inch of the seed at planting. The first 40 pounds of N per acre was banded and the remainder broadcast at the first planting date. The boron was broadcast in 1961, and all plots received a broadcast application of 30 pounds of S per acre as gypsum. The following materials were used—ammonium nitrate, concentrated super phosphate, and muriate of potash.

The center of each plot was harvested with an experimental plot harvester after the plots were trimmed to eliminate border effect. The grain was weighed and samples were saved for protein content, test weight (pounds per bushel), and kernel size. The percent of thin kernels was measured as those passing through a 5½/64 × ¾ inch screen. A Kjeldahl determination was made on selected samples from 1961 as a measure of protein content.

Results and Discussion

Yellow dwarf virus disease appeared throughout the Willamette Valley in 1957 and caused reductions in yield during 1958 and 1959 (3). During 1958 and 1959 aphid populations were high, infesting an average of 45 and 58% of the plants in several locations prior to the 5-leaf stage of growth. Aphids migrated into fields as the seedlings emerged in both years. Species of aphid vectors collected have been *Macrosiphum dirhodum* (Walk.), *M. granarium* (Kby.), and *Rhopalosiphum padi* (L.).

Incidence of yellow dwarf virus disease was very low during the 1960 season, and aphid populations did not develop until very late in the season (Table 2, 1960 data). This period of late infestation occurred at the time that plants in the late planting experiment were in the 4- to 5-leaf stage of growth (Table 3). Ladybeetle populations were extremely high and were responsible, at least in part, for the low aphid populations during the early 1960 season.

During the 1961 season, aphids appeared early in the season. Populations were very high (Table 2, 1961 data) and yellow dwarf virus infections were generally widespread in the Willamette Valley. The most striking difference in populations between early and late planting dates was noted at the Hyslop farm (Table 4), where the late-planted barley seedlings had a higher percentage of infestation as well as higher per plant populations. This same relationship was observed during 1959, a year of heavy aphid populations (3).

TABLE 2. 1960 AND 1961 APHID POPULATION LEVELS IN HANNCHEN BARLEY FIELDS[1]

1960—Planted Apr. 6			1961—Planted Apr. 11		
Date	Plants infested	Aphids[2]	Date	Plants infested	Aphids[2]
	Percent	*Number*		*Percent*	*Number*
4/19	0	0	....	....	....
4/25	1	5	4/25	7	9
....	....	....	4/28	17	51
5/2	1	3	....	....	....
5/9	1	1[3]	5/11	14	18
5/17	1	1	....	....	....
....	....	....	5/23	90	226[3]
5/31	3	10	6/1	94	462
6/15	10	26	6/15	4	6
7/1	57	288	....	....	....

[1] Counts were made on plots adjacent to the Hyslop farm plots.
[2] Percent and total based on alate and apterous forms per 100 plants.
[3] Four- to five-leaf stage of growth each year.

TABLE 3. AVERAGE PERCENT OF PLANTS INFESTED WITH APHIDS AT THE 4- TO 5-LEAF STAGE OF GROWTH DURING 1960

Location		Planting dates First	Second	Third
Hyslop farm	Date of count	5/6	6/6	6/20
	Percent of plants infested[1]	1.8	1.2	9.5
East farm	Date of count	5/11	6/2	6/20
	Percent of plants infested[1]	0.2	0	9.5

[1] Average of three replications based on alate or apterous forms per 100 plants per plot.

Although differences were not striking in the other locations (Table 4), the trend was evident at the East farm. Subsequent observations showed that populations developed at the East farm and in the Marion County location were similar to the population pattern presented for the Hyslop farm (1961 data in Table 2). Later populations were not observed to increase at the Polk County location. The Marion County and Polk County plantings were in farmer's fields

Table 4. AVERAGE PERCENT OF PLANTS INFESTED AND TOTAL APHIDS ON EARLY AND LATE PLANTINGS AT FOUR LOCATIONS IN THE WILLAMETTE VALLEY DURING 1961

Sampling date	Location	Early planting[1]			Late planting[1]		
		Number leaves	Percent infested	Total aphids	Number leaves	Percent infested	Total aphids
5/11	Hyslop farm	3-4	18.2	45.8	1	56.2	446.4
5/15	East farm	4-5	23.1	40.8	1-2	29.7	77.5
5/16	Marion County	4	13.4	31.1	2-3	10.3	27.1
5/11	Polk County	4	12.6	23.1	2-3	6.4	15.4

[1] Averages based on three replications based on alate and apterous forms per 100 plants per plot.

surrounded by sizeable areas of spring-planted barley. The Hyslop farm and East farm are Experiment Station farms where the acreage of any one crop is small.

Satisfactory stands of barley were obtained in all locations both years except for the early planting date at the East farm in 1961. The surface soil at the 1961 East farm location was a fine sandy loam; the soils on the other locations were silt loams or clay loams. The lower moisture holding capacity of the sandier soil combined with 14 days of dry weather following the first planting date resulted in some seedling burn from the banded fertilizer. There was some reduction in stand on the unfertilized plots; this indicated the possibility of damage from soil insects or nematodes. The lower moisture holding capacity of the sandy soil at this location, plus the unseasonal hot weather in June that occurred when the grain was in the milk or soft dough stage, give a possible explanation for the reduction in test weight and kernel size.

Greater vegetative growth was clearly manifested in the early seeded barley on all locations both years. The earlier seeded plants attained a greater final height on all locations. Vegetative growth was very rank on the East farm for the first planting date each year and lodging was a problem.

Effects of fertilizers and planting dates on yield, test weight, and kernel size

Effects of fertilizer treatments and seeding dates on grain yield, test weight, and percent of thin kernels are presented in Tables 5, 8, 9, and 10. A summary of the statistical analyses is presented in Tables 6 and 7.

TABLE 5. EFFECTS OF PLANTING DATE ON YIELD, TEST WEIGHT, AND PERCENT OF THIN KERNELS DURING 1960 AND 1961

Location	Planting date	Yield lb./A	Test/wt. lb./bu.	Percent thins
East Farm 1960	4/5	4,140	51.8	3.8
Linn County	4/25	3,480	50.6	6.4
	5/10	3,150	49.5	9.3
Hyslop Farm 1960	4/1	2,680	53.5	3.6
Benton County....	4/30	2,000	50.8	7.7
	5/10	1,290	50.8	6.4
East Farm 1961	3/31	1,750	43.4	54.0
Linn County	4/28	1,170	45.0	43.0
Hyslop Farm 1961	3/31	1,140	48.5	26.0
Benton County....	4/28	290	43.4	42.0
Simmons Farm....1961	4/4	1,580	49.4	16.0
Marion County....	4/28	980	48.2	24.0
Reimer Farm 1961	3/30	1,680	47.9	29.0
Polk County	4/28	1,280	47.3	38.0

The following effects were observed on each location:

Hyslop farm, 1960. Vegetative response from N was evident on all planting dates. Increases in yield were significant (Table 7) and reached a maximum at 80 pounds of N per acre. Application of 120 pounds of N per acre consistently caused lodging, reduction in yield, reduction in test weight, and an increase in percent of thin kernels (Tables 8 and 9).

The increase in yield from banded P on the N plots was significant on the second and third planting dates (Table 7), but the effects on test weight and percent of thin kernels was not significant. The P response was originally attributed to adverse weather conditions during May of 1960. However, results obtained in 1961 suggest that the mild yellow dwarf virus disease infection did have an effect on the second and third plantings. It became evident during 1961 that plants infected with yellow dwarf showed response from both P and K on soils that would normally be considered well supplied with these nutrients.

East farm, 1960. All seedlings appeared remarkably uniform in vigor and color, regardless of fertilizer treatment. They developed

somewhat faster than comparable stands at the Hyslop farm. The residual effect of N from Ladino clover that preceded the barley crop was evident throughout the season.

The small increases in yield from application of 40 pounds of N per acre were not significant. Reduction in yield on plots receiving 80 pounds of N per acre was significant. Increasing N rates reduced test weights and tended to increase the percent of thin kernels.

Neither yield, test weight, nor percent of thin kernels were significantly altered by rates or methods of applying P. All cases of lodging were associated with higher rates of N and with banded P; thus indicating more luxuriant vegetative growth. However, P was not found to be a limiting factor on this location, and it proved to have no effect on the quality of the grain.

East farm, 1961. All seedlings appeared vigorous at 4 weeks of age and indicated the potential for a good yield of barley. Response from N was evident on both planting dates. Vegetative responses from other nutrients were not marked on this location.

TABLE 6. SUMMARY OF STATISTICAL ANALYSES FOR EAST AND HYSLOP FARMS FOR 1960

Factors studied	Grain yield		Test weight		Thin kernels	
	East	Hyslop	East	Hyslop	East	Hyslop
Planting dates (D)	**	**	**	**	**	**
Nitrogen rates (N)	*	**	*	**	....	**
Phosphorus rates (P)	....	**	....	....	....	....
Placement method (Pm)	....	**	....	....	....	....
D X N	....	....	....	*	....	**
D X Pm	....	*	....	....	....	....
D X P	....	....	....	....	....	....
N X Pm	....	....	....	....	....	....
N X P	....	....	*	....	*	*
Pm X P	....	*	....	*	....	....
D X N X Pm	....	**	....	**	*	**
D X N X P	....	**	*	**	**	**
N X Pm X P	....	**	*	*	*	*
D X Pm X P	....	**	*	**	*	*

* Differences significant at 5% level.
** Differences significant at 1% level.

TABLE 7. SUMMARY OF THE STATISTICAL ANALYSES FOR EAST, HYSLOP, REIMER, AND SIMMONS FARMS FOR 1961

Factors studied[1]	Grain yield				Test weights				Percent thin kernels			
	East	Hyslop	Reimer	Simmons	East	Hyslop	Reimer	Simmons	East	Hyslop	Reimer	Simmons
PD	**	**	**	**	**	**	....	**	**	**	**	**
P (Pm)			**				....				*	
Dates X Trts.	....	**	**	**	....	*	**	**	....	**	**	**
N	....	....	**	**	*	**	**	....	....	**	**	....
P	**	**	**	**		**	**	**			**	**
NP	....	....	....	*	*	....	....	....	*	....	**	....
K	....	*	**	**	....	....	....	*	....	....	**	**
NK	....	....	....	....	....	....	....	....	....	....	....	....
PK	....	*	*	*	....	....	....	*	....	....	**	....
NPK	....	....	....	....	....	....	....	*	....	*	....	....
Boron	....	....	....	....	....	....	....	....	....	....	....	....

[1] Factors studied: PD = planting dates, N = nitrogen rates, P = phosphorus rates, K = potassium rates, B = boron rates; P (Pm) = placement of phosphorus.
* Significant at the 5% level.
** Significant at the 1% level.

TABLE 8. EFFECT OF FERTILIZER TREATMENTS AND DATE OF PLANTING ON TEST WEIGHT, YIELD, AND KERNEL SIZE OF HANNCHEN BARLEY ON THE EAST AND HYSLOP FARMS IN 1960

Fertilizer treatments[1]	YIELD						TEST WEIGHT						THIN KERNELS					
	East			Hyslop			East			Hyslop			East			Hyslop		
	4/5	4/25	5/10	4/1	4/30	5/10	4/5	4/25	5/10	4/1	4/30	5/10	4/5	4/25	5/10	4/1	4/30	5/10
	Pounds per acre						*Pounds per bushel*						*Percent*					
S (Ch)	4,270	3,730	3,180	1,600	1,480	930	52.8	51.7	49.8	54.3	52.2	51.4	2	3	6	2	3	5
P_1S	4,410	3,630	3,270	1,720	1,650	1,030	52.9	52.6	50.0	54.0	52.1	52.4	1	4	9	3	4	5
N_1S	4,680	3,320	3,180	2,770	1,960	1,140	52.5	50.4	50.1	53.4	50.8	51.2	3	6	7	2	8	6
N_1P_1S	4,460	3,700	3,520	2,800	2,060	1,190	52.7	50.0	49.7	54.2	51.3	51.1	3	8	9	3	5	7
N_1P_2S	4,470	3,910	3,050	2,840	2,330	1,570	51.9	51.6	49.2	53.9	51.2	50.0	3	4	10	2	7	8
N_2S	4,170	3,330	3,290	3,170	2,120	1,130	51.6	50.0	48.9	52.7	50.1	50.5	3	9	9	4	11	6
N_2P_1S	3,890	3,620	3,050	2,810	2,360	1,480	51.0	50.3	50.9	52.7	50.1	50.7	6	5	8	5	11	7
N_2P_2S	4,000	3,820	3,140	3,290	2,310	1,620	51.3	50.1	48.8	52.7	49.9	50.6	6	8	11	5	9	7
N_2P_2KS	3,690	....	....	3,250	....	....	51.2	....	....	53.6	....	....	6	....	....	3	....	....
N_2P_2	3,290	3,340	3,260	3,070	2,150	1,380	50.4	50.7	49.5	52.7	50.7	50.9	9	6	13	5	7	8
N_3P_2S	3,690	3,010	2,890	2,670	2,070	1,610	50.4	49.3	48.2	51.6	49.4	49.9	8	13	16	10	13	10
P_1*S	4,290	3,460	3,070	1,650	1,490	1,010	52.5	51.9	50.2	54.0	51.9	51.6	3	3	8	2	4	4
N_1P_1*S	4,420	3,460	2,990	2,830	1,920	1,360	51.3	50.6	49.7	53.3	51.0	50.9	3	7	9	2	7	5
N_1P_2*S	4,100	3,540	3,310	2,750	2,020	1,220	52.6	50.9	49.8	54.0	51.3	51.0	2	5	9	2	7	6
N_2P_1*S	4,250	3,170	3,350	3,020	1,980	1,270	51.8	50.4	49.9	52.7	50.0	50.2	3	6	8	4	10	7
N_2P_2*S	3,710	3,100	2,960	3,210	2,090	1,350	51.6	49.3	49.6	52.9	50.2	50.6	3	10	8	3	9	7
Average	4,110	3,480	3,170	2,720	2,000	1,290	51.8	50.7	49.6	53.3	50.8	50.9	4	6	9	4	8	7

[1] N_1, N_2, N_3 = 40, 80, 120 pounds nitrogen per acre; P_1, P_2 = 30, 60 pounds phosphate (P_2O_5) per acre; K = 60 pounds potash (K_2O) per acre; all plots received 30 pounds of sulfur per acre; P = banded phosphorus; P^* = broadcast phosphorus.

TABLE 9. THE EFFECTS OF FERTILIZER TREATMENTS AND DATE OF PLANTING ON THE YIELD, TEST WEIGHT, PROTEIN CONTENT AND KERNEL SIZE OF BARLEY ON THE EAST AND HYSLOP FARMS IN 1961

Fertilizer treatments[1]	YIELD				TEST WEIGHT				THIN KERNELS				PROTEIN			
	East		Hyslop		East		Hyslop		East		Hyslop		East		Hyslop	
	3/31	4/28	3/31	4/28	3/31	4/28	3/31	4/28	3/31	4/28	3/31	4/28	3/31	4/28	3/31	4/28
	Pounds per acre				*Pounds per bushel*				*Percent*				*Percent*			
Check	1,240	1,210	540	230	44.9	46.2	48.4	46.8	39	34	17	35	12.0	13.1	13.3	15.0
N_1	1,740	1,130	960	150	43.2	45.0	49.8	45.6	57	45	14	40				
N_1P_2	1,880	1,430	960	210	44.4	45.9	49.8	46.6	53	36	15	44				
N_1K_1	1,620	1,400	790	370	43.1	44.9	49.0	47.1	59	43	20	36				
N_1P_2K	1,770	1,670	1,560	290	43.1	45.9	49.8	47.6	59	40	22	32	12.5	13.1	12.8	14.7
N_2	1,700	830	540	180	43.5	44.3	47.3	45.9	49	46	21	46				
N_2P_2	1,800	1,360	1,200	270	42.5	44.5	49.2	46.4	58	48	26	41				
N_2K	1,930	930	850	270	45.0	44.3	48.1	46.6	49	44	21	38				
N_2P_2K	1,880	1,310	1,320	220	41.3	44.7	18.8	46.3	61	46	31	47	14.7	16.2	14.8	15.5
N_3P_2K	1,780	940	1,490	320	43.5	44.5	47.9	45.7	53	43	39	40	16.0	16.6	17.2	16.4
N_2P_2KB	1,950	900	1,640	420	42.8	44.6	47.6	54.9	60	46	42	51				
N_3P_2KB	1,760	940	1,790	520	45.8	44.7	46.4	45.8	53	46	51	58				
Average	1,754	1,170	1,136	287	43.48	45.0	48.5	43.4	54	43	26	42				

[1] N_1, N_2, N_3 = 40, 80, 120 pounds nitrogen per acre; P_2 = 80 pounds phosphate (P_2O_5) per acre; K = 60 pounds potash (K_2O) per acre; B = 2 pounds boron per acre; all plots received 30 pounds sulfur per acre.

TABLE 10. THE EFFECTS OF FERTILIZER TREATMENTS AND DATE OF PLANTING ON THE YIELD, TEST WEIGHT, PROTEIN CONTENT, AND KERNEL SIZE OF BARLEY ON THE REIMER AND SIMMONS FARMS IN 1961

Fertilizer treatments[1]	Reimer		Simmons		Reimer		Simmons		Reimer		Simmons		Reimer		Simmons	
	3/31	4/28	4/4	4/28	3/31	4/28	4/4	4/28	3/31	4/28	4/4	4/28	3/31	4/28	4/4	4/28
	Pounds per acre				*Pounds per bushel*				*Percent*				*Percent*			
Check	710	400	840	540	50.2	48.9	50.5	49.1	20	31	11	23	10.8	11.7	10.9	12.3
N_1	760	760	1,110	500	47.5	48.0	49.0	48.4	42	31	18	26				
N_1P_2	1,590	1,240	1,420	640	49.3	48.0	50.3	47.2	16	34	13	33				
N_1K	940	970	1,150	730	46.7	48.8	49.1	48.2	31	27	15	25				
N_1P_2K	2,100	1,710	2,000	1,100	49.9	48.6	51.1	48.9	20	31	9	22	9.7	11.3	11.0	11.8
N_2	1,130	680	1,050	520	44.7	47.6	47.5	48.1	40	37	23	25				
N_2P_2	2,100	1,470	1,620	1,030	49.2	46.2	49.8	47.7	22	46	12	28				
N_2K	1,240	1,040	1,700	630	46.3	47.9	48.7	48.0	33	33	17	23				
N_2P_2K	2,370	1,900	2,260	1,490	48.5	46.3	50.3	48.7	26	43	14	21	11.8	14.4	12.1	12.8
N_3P_2K	2,320	1,340	1,880	1,290	47.2	45.9	48.9	48.2	37	46	23	18	14.3	15.7	14.3	14.8
N_2P_2KB	2,490	1,820	2,130	1,620	49.1	46.2	49.7	47.9	28	46	17	27				
N_3P_2KB	2,430	1,880	1,820	1,660	46.7	45.6	48.2	47.9	43	52	29	25				
Average	1,680	1,280	1,580	980	47.9	47.3	49.4	48.2	29	38	16	24				
N_1P_1K	1,760				48.7				25							
N_2P_1K	2,480				49.2				24							
$N_1P_1{}^*K$	980				48.1				29							
$N_2P_1{}^*K$	1,260				47.6				28							

[1] N_1, N_2, N_3 = 40, 80, 120 pounds nitrogen per acre; P_2 = 80 pounds phosphate (P_2O_5) per acre; K = 60 pounds potash (K_2O) per acre; B = 2 pounds boron per acre; all plots received 30 pounds sulfur per acre; P^* = phosphorus broadcast before planting; P = phosphorus banded at planting.

The aphid infestation was 23% on the first planting date and 30% on the second planting date by May 15. The first planting was in the 4- to 5-leaf stage by that time while the second planting was in the 1- to 2-leaf stage; vigorous plants were present on both planting dates at that time.

The slight reduction in stand and the adverse effects of hot June weather at a critical stage of growth on the early planting date, discussed earlier, makes comparisons between the first and second planting dates somewhat questionable on this location.

The yellow dwarf virus disease affected yield on both planting dates. This is evident when yields for 1960 are compared with 1961 yields. In 1960, the yield of the April 4 planting date averaged more than 2 tons per acre while the best treatment from the April 25 planting yielded 3,910 pounds per acre. This is in contrast to maximum yields of 1,950 and 1,670 pounds per acre on the March 31 and April 28, 1961, planting dates, respectively. Also, a significant response from P was measured in 1961 with a higher P soil test value than for the 1960 location. Test weights above 50 pounds per bushel on the 1960 April planting dates are contrasted with test weights around 45 pounds per bushel in 1961. The percentages of thin kernels averaged 48% in 1961 and 6% in 1960.

Hyslop farm, 1961. Aphid infestation on the second planting date was 56% by May 11 (Table 4) when the plants were in the one-leaf stage; there was an average of eight aphids per plant. The March 31 planting date had developed normal seedlings that were about one foot high by May 11, and there was a much lower aphid infestation on these plots (see Table 4). This aphid population and the resulting heavy infection with yellow dwarf virus caused a crop failure on the second planting date—the maximum yield was 520 pounds per acre.

Responses from N, P, K, and S on both planting dates were very marked in early vegetative growth. This was in contrast to the 1960 experiment where a vegetative response from N was evident with little or no vegetative response from P or K. The 1960 experiment was adjacent to the 1961 experiment and had comparable soil test values for P and K (Table 1).

The best yield on the April 4, 1961, planting was 1,790 pounds of barley per acre. In contrast, three treatments each produced more than 3,000 pounds per acre in 1960. Test weights averaged 48.5 pounds per bushel and thin kernels averaged 26% on the first planting dates in 1961. This is in contrast to a test weight of 53.3 pounds per bushel and 4% of thin kernels on the first planting date in 1960. Increases in yield, test weight, and reduction in thin kernels from application of P and K were significant in 1961.

It is important to recognize that differences between seasons could be expected. However, the marked difference in response from P and K on the two years was undoubtedly due to the heavier yellow dwarf virus disease infection in 1961. It is very improbable that differences between yields of barley on 1960 and 1961 plantings could be attributed entirely to seasonal effects when weather conditions were fairly similar.

Marion County, 1961. The response pattern at the Marion County location was very similar to the response observed at the 1961 Hyslop farm location. Yellow dwarf did not develop as early on the late planting, and consequently the late planting yielded more than the late planting at the Hyslop farm. Aphids were observed to build up during the same period that populations developed at the Hyslop farm (Table 2, 1961 data). Yield and test weights were greater and the percent of thin kernels was less on comparable treatments on the March 31 planting.

Response from N, P, and K was evident on both planting dates through the season. Again, there was a response from both P and K on a soil that would normally be considered adequately supplied with both of these nutrients. Both P and K increased yield, increased test weight, and decreased the percent of thin kernels.

Polk County, 1961. The Polk County location was the only soil among the six experiments where a response from P would have been predicted on the basis of the soil test using previous soil test response calibration curves. This was the basis for selecting this location to compare broadcast versus banded applications of P. The average response from broadcasting 40 pounds of phosphate (P_2O_5) per acre was 170 pounds of barley per acre versus a yield increase of 1,170 pounds of barley per acre where the P was banded within one inch of the seed at planting time.

Again, the plots planted early (March 31) yielded more than the plots planted April 28. The response from P was consistent on both planting dates and resulted in increased test weight and fewer thin kernels. The yield increase from K was significant on the second planting date where yellow dwarf was evident by May 30. Application of K also decreased the percent of thin kernels. Virus infection was not severe on this location; it had a lower aphid infestation than the other locations in 1961 (see Table 4).

Effects of fertilizer treatments and planting dates on protein content during 1961

Protein was determined on samples of grain from the check plots. Grain samples also were saved from the plots receiving the complete NPKS fertilizer treatment. The importance and possibility of fertilizer treatments reducing protein content was not anticipated at harvest time.

Protein content was consistently lower for the early planting dates than for the late planting dates—this was expected with the higher yields on the early plantings. The first 40-pound increment of nitrogen in the complete NPKS treatment resulted in a protein content equal to or lower than the check plot on both planting dates on all locations except for the early planting date on the East farm. Protein content for the early planting date on the East farm was undoubtedly affected by the weather conditions discussed earlier.

The higher protein content of the check plots indicates that N was not a factor limiting yield on the check plots in 1961. The N content of the grain from the check plots was comparable to the N content of grain from the plots that approached maximum yield. The magnitude of response and the protein content of the grain from N alone or N plus S indicates adequate supplies of these nutrients during early seedling stages of growth. P and K deficiencies apparently limited growth and/or metabolic processes more than did N.

The higher N content of grain from check plots when compared with plots receiving a complete NPKS fertilizer at a 40 pound rate of N per acre was observed on three additional Willamette Valley locations planted on April 18, 1961. These data were not included in this report, since the experiments were limited to a single planting date.

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