Orchardgrass Seed Production In Western Oregon

Influence of Fertilizers, Lime, and Cultural Methods on the Yield and Quality of Orchardgrass Seed

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H. H. RAMPTON and T. L. JACKSON

SUMMARY

Experiment 1

Experiment 1 was conducted on Woodburn silt loam, a valley floor soil with moderately good drainage that is used extensively for grass seed production. It is generally recognized as a productive soil with a minimum of soil fertility problems.

The influence of nitrogen. Nitrogen at 80 pounds per acre was most beneficial to seed production when it was applied in March. Splitting the application between October and March was more effective than applying all of the nitrogen in October.

Five-year average seed yields were increased with nitrogen applications up to 80 pounds per acre in 3-foot rows and up to 120 pounds per acre in 1-foot rows. Nitrogen at 160 pounds per acre in March usually resulted in yield reductions.

The weight of 1,000 seeds was significantly higher when nitrogen was applied in March and all rates of added nitrogen caused increased weight of 1,000 seeds. The highest rates did not result in decreased weight of individual seeds.

Germination was not influenced by either time or rate of nitrogen application.

Between 3 and 4 tons per acre of straw and chaff were produced with nitrogen at 80 to 160 pounds per acre. Such large amounts of straw, if not well distributed, can cause severe localized heat injury during post-harvest field burning.

The influence of lime. Lime had little or no effect on seed yield, weight of 1,000 seeds, germination, or mature plant yield.

The influence of row spacing. Maximum yields were produced in the 3-foot rows during the first three years, but the 1-foot rows were most productive in the fourth and fifth years. This change in order of yields could have been caused by sod webworm damage to the 3-foot rows.

The 1-foot rows required 120 pounds per acre of nitrogen for maximum yield; the best yields from 3-foot rows were obtained with 80 pounds per acre of nitrogen after the first year. In all cases, 1-foot rows required more nitrogen per pound of seed produced.

Row spacing had no consistent influence on the weight of 1,000 seeds; the five-year averages for the 3-foot and 1-foot row spacings were similar.

Germination was not significantly influenced by row spacing.

One-foot spaced rows usually produced the greatest mature plant yields.

Experiment 2

Experiment 2 was established in 2½-foot rows on Willakenzie clay loam. This soil was known to be very low in available phosphorus and nitrogen for the production of grass seeds and cereals.

The influence of nitrogen. Applications of both nitrogen and phosphorus were necessary for efficient increases in yields on this soil. Seed yields were higher with 160 pounds per acre than with 80 pounds per acre of nitrogen (40 pounds per acre in October and the remainder in March) if soil phosphorus was adequate.

The effects of nitrogen rates on the weight of 1,000 seeds were different each year and were significant only in 1963, when the 160-pound rate caused substantial increases. It was concluded that high nitrogen rates did not cause a reduction in weight per seed.

Germination was not influenced by rate of nitrogen application; the high rate of nitrogen did not decrease germination.

Mature plant yields were significantly higher with 160 pounds per acre of nitrogen than with 80 pounds per acre in 1961 and 1963.

The influence of phosphorus. Application of phosphorus was necessary to increase seed yields. In the first two years 160 pounds per acre of P_2O_5 were required for maximum yields, but after three years of application the 80-pound rate of P_2O_5 was adequate.

A nonsignificant increase in the weight of 1,000 seeds after application of phosphorus occurred in 1960. Conversely, small, but significant decreases in the weight of 1,000 seeds occurred in 1961 and 1963. There were no significant differences between rates of added phosphorus.

The weight of 1,000 seeds for the untreated check declined substantially each year. Weight per seed did not respond to phosphorus in the same manner as seed yields.

Germination was not influenced by the application of phosphorus.

Applications of both nitrogen and phosphorus were necessary to increase mature plant yields. Responses to added phosphorus were significant each year. Maximum yields were produced with the 160-

pound rate of P_2O_5 in 1960 and 1961. However, after three years of phosphorus application, the 80-pound rate of P_2O_5 gave maximum yields.

The influence of boron. Boron did not influence seed yield, weight of 1,000 seeds, germination, or mature plant yield.

Miscellaneous experiments

The effects of post-harvest burning. Burning as compared with mechanical removal of the crop residue did not result in significant seed yield differences. But the general effect of burning was to increase seed production in 3-foot rows and decrease it in 1-foot rows. A significant burning x row spacing interaction indicated that burning injury and yield reduction occurred in the 1-foot rows where the heavier straw cover caused the hottest fire.

The effect of desiccant sprays on seed quality. Dinitro general in diesel oil reduced germination; dinitro general in water had no effect on seed quality. Diquat in water and endothal in diesel oil did not reduce germination but retarded the early development of the seedlings. The desiccants were of doubtful value.

Effects of irrigation on seed yields. The effects of irrigation treatments on seed yields were not significant. Yields without irrigation were practically identical to those with fall plus spring irrigation.

Effect of rethreshing doubles and clusters. Approximately 2.5 percent was added to the cleaned weight of a lot of combine-threshed orchardgrass seed when the doubles and clusters were scalped off, rethreshed, and cleaned.

INTRODUCTION

Orchardgrass seed growing is relatively new in Oregon. Acreage devoted to the production of orchardgrass seed in the state has increased from about 120 acres in 1957 to approximately 8,000 acres in 1966. Stability and growth of this new enterprise in competition with other seed-producing areas is dependent upon economical production of good yields and high quality seed. For information on growing orchardgrass for seed, growers have relied mainly on methods used for other grass seed crops, research results from other areas, and their own experiences.

The experiments described in this bulletin were conducted to provide information on the influence of fertilizers, lime, cultural methods, and management practices on yields and quality of orchardgress seed in western Oregon. All work was conducted near Corvallis, Oregon, on Oregon State University Agricultural Experiment Station land.

Nitrogen is required in moderate to heavy amounts for the economical production of grass seeds in all areas and responses from phosphorus and potash have been measured in some locations (*7*).[1]

Nitrogen applied at 80 to 100 pounds per acre was the optimum rate for grass seed production in Pennsylvania (*2*) and Canada (*11*). In Oregon, Kentucky bluegrass required 60 to 120 pounds per acre of nitrogen annually; older stands and irrigated fields needed the higher rates (*13*). Fine fescues required 30 to 90 pounds per acre of nitrogen, depending on age of stand, moisture, and cultural practices (*13*). In Washington, increasing the rate of nitrogen did not maintain seed yields of intermediate wheatgrass as the stands became older; four-year average seed yields were as high with 80 pounds per acre of nitrogen as with 100 pounds and 120 pounds tended to reduce yields (*3*). Likewise, orchardgrass seed yields were higher when fertilized with nitrogen at 80 or 100 pounds per acre (*4*). Results from England showed that as orchardgrass stands aged, higher rates of nitrogen were required for the greatest yields of seed (*6*). Both early fall and spring applications of nitrogen were equally beneficial in their effect on seed yield in England (*5*). Spring applications of nitrogen were preferable in Ontario, Canada (*11*), and Kentucky (*17*). Split fall and spring nitrogen application was most productive in New Zealand (*16*).

Fall application of nitrogen to Kentucky bluegrass was optimum in Oregon, except that high rates were better when split between fall and early spring; fine fescue responded similarly to either fall or early spring application (*13*). Responses in grass seed yields to time of nitrogen application varied with different row spacings in western Washington (*1*); with 7-inch drill spacing, fall fertilization was better than spring or split fall and spring treatments, but the highest seed yields occurred on 42-inch rows that received the split fall and spring nitrogen treatment.

In eastern Washington, orchardgrass produced the most seed in 36-inch rows (*4*). Rows spaced 24 and 42 inches apart usually gave higher average seed yields than close-drilled or broadcast plantings, but solid stands frequently were the highest yielders in the first seed crop (*1*), (*2*), (*7*), (*10*), (*17*). Advantages cited for wide rows over solid stands for seed production were: (a) smaller amounts of stock seed are required for planting; (b) weed control and rogueing are simplified; and (c) some species maintain high yields of seed for a longer time (*7*).

In western Oregon, the addition of phosphorus to nitrogen produced higher seed yields of tall fescue than nitrogen alone (*15*). In northeastern Oregon, nitrogen and phosphorus stimulated higher seed

[1] Italic numbers in parentheses refer to Literature Cited, pages 39 and 40.

yields of Kentucky bluegrass than nitrogen alone, but neither phosphorus nor potash were consistently beneficial with fine fescue (*13*). In Pennsylvania, phosphorus and potash plus nitrogen gave higher seed yields of red fescue than nitrogen alone (*12*).

Pre-harvest treatment of orchardgrass seed crops with desiccant sprays speeds up curing and permits direct combining (*7*).

Field burning is important in the control of several serious diseases of perennial grass seed crops (*8*). Post-harvest burning of straw and stubble in grass seed fields is a common practice in Oregon. In northeastern Oregon, removal of residue before resumption of fall growth was essential for high seed yields; field burning and mechanical removal were equally effective if residue removal was equal (*14*). Residue removal was most effective if complete, but late removal which injured fall regrowth reduced yields. Residue removal increased the effectiveness of nitrogen fertilizer (*14*). Post-harvest burning and removal of every other foot of vegetation in the row were equally beneficial to seed yields of intermediate wheatgrass. The effects of these treatments appeared to be additive (*3*).

Some research indicated that nitrogen fertilization influenced seed quality. Age of stand, row spacing, and rate of nitrogen influenced the weight of 100 seeds in smooth bromegrass, crested wheatgrass, and red fescue, but the all-species response was the same to row spacing only, where 36-inch rows produced the heaviest seeds (*3*). The weight of 1,000 seeds was increased but germination was not affected by nitrogen fertilization (*5*). Rates of 40, 80, 160, and 320 pounds per acre of nitrogen resulted in significantly higher weight of 1,000 seeds than 0- and 20-pound rates (*11*). In England, nitrogen treatment increased weight per seed, germination, and the proportion of heavy to light seed but superphosphate did not (*18*).

EXPERIMENT 1

Materials and methods

Experiment 1 was located on the Hyslop Agronomy Farm on Woodburn silt loam, a valley floor soil that is moderately well drained. This soil is used extensively for grass seed production and is generally recognized to be a productive soil with a minimum of soil fertility problems.

The following soil analyses were found with the procedures used by the Oregon State University Soil Testing Laboratory:

Phosphorus (sodium bicarbonate extractable) 50 to 59 p.p.m.

Potassium (ammonium acetate extractable) 0.6 meq/100 grams of soil.

Magnesium (ammonium acetate extractable) 2.5 meq/100 grams of soil.

Calcium (ammonium acetate extractable) 5.1 meq/100 grams of soil.

pH (1:2:: soil:water ratio) 5.3 to 5.7 in the surface 12 inches.

The land was spring plowed and fallowed. Seed of Danish commercial orchardgrass,[2] a type similar to the Potomac variety, was planted on August 25, 1956. The 3-foot rows were seeded at 1½ pounds per acre and the 1-foot rows at 4½ pounds per acre. All plots received 100 pounds per acre of 16-20-0-14 (N-P_2O_5-K-S) fertilizer banded below the seed at planting. Sprinkler irrigation aided in obtaining excellent stands.

Broadleafed weeds were controlled with 2,4-D sprays applied in the spring before head emergence. Winter-growing weeds were controlled by spraying with diuron at 3 pounds per acre in late October. The 3-foot rows received shallow cultivation once in the spring in 1957, 1958, 1959, and 1960 for additional weed control.

A modified factorial arrangement of treatments with five replications was used to test the effects of rate and time of nitrogen application, lime, sulfur, and row spacing on seed yields, weight of 1,000 seeds, and germination percent.[3] Lack of response from S and possible S contamination from an industrial plant nearby limited the validity of S comparisons. These comparisons, therefore, have been eliminated from the data. Table 1 lists the treatments reported in this experiment.

Plots were 12 feet wide by 25 feet long. An area 3 by 25 feet was harvested from each plot for seed yields, using a small garden tractor mower. Seed was harvested in early July when the stems below the panicles were changing from green to straw colored, the seeds were pale green to straw colored, in soft to hard dough, and approximately 43 to 45 percent moisture with a few beginning to shatter. Harvested plot material was cured in 45-by 60-inch burlap bags and artificially dried before threshing when necessary during unfavorable threshing weather. In 1961 and 1962, mature plant yields were measured by weighing the harvested samples before threshing.

Samples were threshed with an experimental plot thresher (*9*). Seed was cleaned with a two-screen seed cleaner under uniform procedures. The seed lots were then dried to approximately 9 percent moisture, reduced to about 150 cc volume through a Boerner Sampler, and stored in moisture-proof containers at 38 to 40 degrees F until germination tests were made. To further test seed quality, the weight of

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[2] Seed was provided through the courtesy of Northrup King and Company, Albany, Oregon.

[3] The following symbols for plant nutrients will be used in discussing Experiment No. 1: N (nitrogen), and S (sulfur).

Table 1. TREATMENT COMBINATIONS REPORTED IN EXPERIMENT 1

No.	N applied Oct. 20	N applied Mar. 15	Lime applied	Row spacing
	lb./A	*lb./A*	*T/A*	*ft.*
1	0	0	3	3
2	0	40	3	3
3	0	80	3	3
4	0	120	3	3
5	0	160	3	3
6	0	0	0	3
7	0	40	0	3
8	0	80	0	3
9	40	40	3	3
10	80	0	3	3
11	0	0	3	1
12	0	40	3	1
13	0	80	3	1
14	0	120	3	1
15	0	160	3	1
16	0	0	0	1
17	0	40	0	1
18	0	80	0	1
19	40	40	3	1
20	80	0	3	1

Lime treatments were disced into the seedbed before planting. All fertilizers were applied broadcast. N was supplied as ammonium nitrate (33.5% N).

1,000 whole single seeds from each plot was determined. To prepare the seeds for counting, 150 cc lots were blown for 15 seconds in a South Dakota Model D seed blower with the air intake set at one inch. This removed any remaining unfilled seeds.

Plots were burned in early August each year for field sanitation and to remove crop residues.

An infestation of sod webworm (*Crambus* sp.) occurred in the summer of 1960, but plant survival appeared to be adequate for the continuation of the experiment.

The first (1957) seed crop was uneven and not suitable for experimental data. Seed yields were obtained in five consecutive years from 1958 through 1962. The experiment was maintained until 1962, when plant populations became extremely variable. Variations in stand resulting in a coefficient of variability of 41.3 percent for seed yields in 1962 (Table 2) indicated that the experiment should be terminated.

Analyses of data on seed yield, germination percent, and the weight of 1,000 seeds were completed by the Statistical Service, Oregon State University. Only those treatment effects that are statistically

Table 2. Influence of Time of N Application and of Row Spacing on Seed Yields of Orchardgrass, Experiment 1

No.	Treatments		Mean seed yields per acre					
			1958	1959	1960	1961	1962	5-yr. avg.
			lb.	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*
3	N 80 spring	3-ft. rows	616	571	646	573	585	598
9	N 40 fall + 40 spring	3-ft. rows	552	527	548	516	625	554
10	N 80 fall	3-ft. rows	528	462	491	399	421	460
		3-ft. rows, avg.	565	520	562	496	544	537
13	N 80 spring	1-ft. rows	605	497	546	558	457	533
19	N 40 fall + 40 spring	1-ft. rows	536	446	505	498	468	491
20	N 80 fall	1-ft. rows	489	436	415	375	406	424
		1-ft. rows, avg.	543	460	489	477	444	483
LSD spring vs. fall N		0.05	54	68	80	72	ns	
		0.01	71	89	106	95	ns	
LSD spring vs. split N		0.05	54	ns	ns	ns	ns	
		0.01	ns	ns	ns	ns	ns	
LSD fall vs. split N		0.05	ns	ns	ns	72	ns	
		0.01	ns	ns	ns	95	ns	
LSD row spacing		0.05	ns	55	65	ns	ns	
		0.01	ns	ns	ns	ns	ns	
CV (coefficient of variability)			11.8%	17.4%	19.7%	17.3%	41.3%	

significant at the 5 percent or higher probability level will be emphasized in the following discussion.

Results and discussion (*Experiment 1*)

Seed yields

Time of N application—effect on seed yield. Seed yield data for treatments 3, 9, 10, 13, 19, and 20 comparing different times of N application at 80 pounds per acre are shown in Table 2.

Yearly and five-year average seed yields were consistently higher when the N was spring-applied than when it was applied in the fall. Differences were significant for both row spacings in 1958, 1960, and 1961 and for the 3-foot row spacings in 1959. Average seed yields from split (fall plus spring) N applications were consistently higher than from fall-applied N, but the differences were significant only in 1961. Average seed yields were higher for all spring N than for split applications, except in 1962, but differences were significant only in 1958.

These results, while not conclusive, indicate that 80 pounds per acre of N was most effectively utilized in orchardgrass seed production when the N was applied in March.

Rate of N—effect on seed yields. The effects of N applied at different rates in the spring (treatments 1 to 5 and 11 to 15) are shown in Table 3. Generally, yields of seed were highest in 1958, the first year of the experiment. Damage by sod webworm (*Crambus* sp.) in 1960 seemed to reduce yields from 1-foot row plots receiving N at 120 and 160 pounds per acre. The greatest damage occurred in plots where the plant cover was heaviest. This reduction in stand could have helped to increase seed yields on these treatments in 1961 and 1962.

Seed yields were increased with N applications up to 80 pounds per acre in 3-foot rows each year and up to 120 pounds per acre in 1-foot rows. The increase in yield from the application of 120 pounds per acre of N on the 3-foot rows was significant in 1958; the differences between these two rates of N were not significant in any other year. Yields were reduced when the N rate was increased to 160 pounds per acre for the five-year average and for each individual year comparison except for the 3-foot row spacing in 1960 and the 1-foot row spacing in 1959. While these reductions in yield were not statistically significant, this data indicated that the 120-pound rate of N was the maximum rate that should be applied for either row spacing.

In 1959 and 1960, yields from 3-foot rows were higher than those from 1-foot rows at the optimum rate of N for each spacing. The yields from the two row spacings were essentially equal in 1958. The higher yields on the 1-foot rows in 1961 and 1962 may have resulted

Table 3. INFLUENCE OF N AT DIFFERENT RATES IN SPRING AND OF ROW SPACING ON SEED YIELDS OF ORCHARDGRASS, EXPERIMENT 1

No.	Treatments		Mean seed yields per acre					
			1958	1959	1960	1961	1962	5-yr. avg.
			lb.	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*
1	N 0	3-ft. rows	423	287	262	250	215	287
2	N 40	3-ft. rows	518	481	504	488	370	472
3	N 80	3-ft. rows	616	571	646	573	585	598
4	N 120	3-ft. rows	693	576	591	531	540	586
5	N 160	3-ft. rows	664	534	591	492	529	562
		3-ft. rows, avg.	583	490	519	467	448	501
11	N 0	1-ft. rows	239	130	129	195	94	157
12	N 40	1-ft. rows	390	277	369	378	297	342
13	N 80	1-ft. rows	605	497	546	558	457	533
14	N 120	1-ft. rows	680	503	454	675	869	636
15	N 160	1-ft. rows	670	556	398	589	575	558
		1-ft. rows, avg.	517	393	379	479	458	445
LSD N rates		0.05	54	67	80	72	166	
		0.01	71	89	116	95	220	
LSD row spacing		0.05	34	43	51	ns	ns	
		0.01	45	57	67	ns	ns	
LSD N x row spacing		0.05	76	95	ns	102	235	
		0.01	101	ns	ns	135	ns	
CV			11.8%	17.4%	19.7%	17.3%	41.3%	

from stand thinning by the sod webworms. In the five-year averages, and in 1960, 1961, and 1962 the highest yields in 3-foot rows were produced with 80 pounds per acre of N. In the five-year averages and in 1958, 1961, and 1962, the highest yields in 1-foot rows were produced with 120 pounds per acre of N. This difference resulted in a significant N x row spacing interaction in all years except 1960. The highest five-year average yield occurred where 1-foot rows received 120 pounds per acre of N in the spring (treatment 14). However, this average yield was heavily weighted by the high yield of 869 pounds per acre of seed in 1962 after the sod webworm injury had had a marked effect on the uniformity of the data.

Grass seed growers in Oregon have generally concluded that more N is required for maximum yields from close-drilled stands than from cultivated rows.

Lime—effect on seed yields. The effects of lime treatments on seed yields are shown in Appendix Table 1. A significant increase (5% level) occurred from lime with 80 pounds per acre of N on 1-foot rows in 1958, but this same treatment was lowest in other years. Five-year average yields for limed and unlimed treatments were almost identical. There were no significant interactions involving lime. It was concluded that lime had little or no effect on seed yield.

Row spacing—effect on seed yields. Yields from 3-foot rows were consistently higher than yields from 1-foot rows for the 0- and 40-pound N treatments. Differences were significant to highly significant (Table 3 and Appendix Table 1). But these differences diminished or disappeared when N applications reached 80 pounds per acre or more. A significant row spacing x N interaction occurred in each year except 1960, when sod webworms injured the stands. The five-year averages show that 3-foot rows were most productive when N treatments did not exceed 80 pounds per acre, but maximum yields from 1-foot rows resulted when they received 120 pounds per acre. These results confirm the general conclusion that close-drilled stands require more N per pound of seed produced than do wider rows.

Seed quality

Time of N application—effect on the weight of 1,000 seeds. The effects of fall, split (fall plus spring), and spring applications of 80 pounds per acre of N on the weight of 1,000 seeds were compared. Results from treatments 3, 9, 10, 13, 19, and 20 are shown in Table 4. Each year, all spring-applied N resulted in weight differences that were significantly higher (1% level) than those from fall-applied N, even though some of the differences were small. The weight of 1,000 seeds resulting from split (fall plus spring) N was usually less than when all N was spring-applied, but was more than when all N was

Table 4. Influence of Time of N Application and of Row Spacing on 1,000-seed Weight of Orchardgrass, Experiment 1

No.	Treatments		Mean 1,000-seed weight					
			1958	1959	1960	1961	1962	5-yr. avg.
			mg	*mg*	*mg*	*mg*	*mg*	*mg.*
3	N 80 spring	3-ft. rows	1,215	1,133	1,351	1,201	1,222	1,224
9	N 40 fall + 40 spring	3-ft. rows	1,097	1,109	1,275	1,166	1,197	1,169
10	N 80 fall	3-ft. rows	1,147	1,089	1,234	1,134	1,174	1,156
		3-ft. rows, avg.	1,153	1,111	1,287	1,167	1,198	1,183
13	N 80 spring	1-ft. rows	1,120	1,124	1,342	1,182	1,270	1,208
19	N 40 fall + 40 spring	1-ft. rows	1,121	1,124	1,259	1,179	1,192	1,175
20	N 80 fall	1-ft. rows	1,077	1,077	1,210	1,111	1,133	1,121
		1-ft. rows, avg.	1,106	1,108	1,270	1,157	1,198	1,168
LSD spring vs. fall		0.05	35	26	19	28	43	
		0.01	47	34	26	37	56	
LSD split vs. single		0.05	ns	ns	ns	ns	ns	
		0.01	ns	ns	ns	ns	ns	
LSD row spacing		0.05	29	21	16	23	35	
		0.01	38	28	21	31	46	
CV			6.9%	5.2%	3.3%	2.7%	4.0%	

fall-applied. The same relationships existed in the five-year averages. These results showed a small but definite response in increased weight of 1,000 seeds to spring-applied N. However, this increased seed weight did not explain the increased seed yields resulting from spring application of N. A calculation of differences between five-year averages of treatments 3 and 10 in Table 2 showed seed yields with all spring-applied N to be 30% more than those for all fall-applied N. A similar calculation and comparison of five-year averages of treatments 3 and 10 in Table 4 showed that all spring-applied N resulted in a weight of 1,000 seeds that was only 6 percent more than that for all fall-applied N. The 24-point difference between the two must have resulted from greater numbers of seeds and better development of seeds harvested from the plots that received all N in the spring.

Rates of N—effect on the weight of 1,000 seeds. Data from treatments 1 to 5 and 11 to 15 are shown in Table 5. The weight of 1,000 seeds varied considerably from year to year; the lowest was in 1959 and the highest in 1960. Differences between rates of N were significant each year. In most cases, and in the five-year averages, the no-N plots were lowest in weight of 1,000 seeds. The optimum rates of N for seed yields (Table 3, treatments 3 and 14) resulted in weights of 1,000 seeds that were at or near the maximum and significantly greater at the 1 percent level than the no-N treatments. These results indicate that 40 pounds per acre of N was almost as effective as the higher rates in stimulating increased weight of 1,000 seeds and that high rates of N did not cause weight reduction of individual seeds.

Lime—effect on the weight of 1,000 seeds. The effects of lime were not consistent. (Data are shown in Appendix Table 2.) Although differences were significant, they were generally small and five-year averages did not show treatment effects. Lime had little or no effect on the weight of 1,000 seeds.

Row spacing—effect on the weight of 1,000 seeds. Row spacing did not have a consistent effect on the weight of 1,000 seeds. There was a slight but nonsignificant trend to higher weight in 3-foot rows, but five-year averages for 3-foot rows and for 1-foot rows were similar (Tables 4 and 5).

Time of N application—effect on seed germination. Approximate dates of germination tests for the various years were: 1958 crop—October 1960; 1959 crop—June 1960; 1960 crop—January 1961; 1961 crop—June 1963; and 1962 crop—June 1963.

The effects of 80 pounds per acre of N applied in the fall, spring, and split (fall plus spring) on germination were compared in treatments 3, 9, 10, 13, 19, and 20. The results are shown in Table 6. Germination percentages were good to excellent, with five-year averages

Table 5. Influence of N at Different Rates in Spring and of Row Spacing on 1,000-seed Weight of Orchardgrass, Experiment 1

No.	Treatments		Mean 1,000-seed weight 1958	1959	1960	1961	1962	5-yr. avg.
			mg	*mg*	*mg*	*mg*	*mg*	*mg*
1	N 0 spring	3-ft. rows	1,189	1,122	1,253	1,139	1,153	1,171
2	N 40 spring	3-ft. rows	1,129	1,186	1,337	1,187	1,158	1,199
3	N 80 spring	3-ft. rows	1,215	1,133	1,351	1,201	1,222	1,224
4	N 120 spring	3-ft. rows	1,167	1,137	1,328	1,197	1,269	1,220
5	N 160 spring	3-ft. rows	1,154	1,107	1,305	1,166	1,272	1,201
		3-ft. rows, avg.	1,171	1,137	1,315	1,178	1,215	1,203
11	N 0 spring	1-ft. rows	1,089	1,079	1,249	1,143	1,190	1,150
12	N 40 spring	1-ft. rows	1,124	1,127	1,340	1,178	1,200	1,194
13	N 80 spring	1-ft. rows	1,120	1,124	1,342	1,182	1,270	1,208
14	N 120 spring	1-ft. rows	1,139	1,158	1,359	1,212	1,162	1,206
15	N 160 spring	1-ft. rows	1,191	1,143	1,349	1,182	1,217	1,216
		1-ft. rows, avg.	1,133	1,126	1,328	1,179	1,208	1,195
LSD N rate		0.05	35	26	19	28	43	
		0.01	47	34	26	37	56	
LSD row spacing		0.05	22	16	12	18	27	
		0.01	29	22	16	24	36	
LSD N x row spacing		0.05	47	37	27	40	60	
		0.01	66	49	36	53	80	
CV			6.9%	5.2%	3.3%	2.7%	4.0%	

Table 6. INFLUENCE OF TIME OF N APPLICATION AND OF ROW SPACING ON GERMINATION OF ORCHARDGRASS SEED, EXPERIMENT 1

No.	Treatments		Germination means 1958	1959	1960	1961	1962	5-yr. avg.
			%	%	%	%	%	%
3	N 80 spring	3-ft. rows	91.6	95.4	95.3	95.9	96.4	94.9
9	N 40 fall + 40 spring	3-ft. rows	90.6	95.4	94.1	96.9	97.5	94.9
10	N 80 fall	3-ft. rows	94.4	92.2	94.9	95.5	95.8	94.6
		3-ft. rows, avg.	92.2	94.3	94.8	96.1	96.6	94.8
13	N 80 spring	1-ft. rows	92.8	95.0	95.2	96.4	96.9	95.3
19	N 40 fall + 40 spring	1-ft. rows	91.2	95.0	94.0	96.2	97.7	94.8
20	N 80 fall	1-ft. rows	92.0	93.0	95.6	95.9	96.4	94.6
		1-ft. rows, avg.	92.0	94.3	94.9	96.2	97.0	94.9
LSD spring vs. fall N		0.05	ns	2.4	ns	ns	ns	
		0.01	ns	ns	ns	ns	ns	
LSD split vs. single N		0.05	ns	ns	ns	ns	ns	
		0.01	ns	ns	ns	ns	ns	
LSD row spacing		0.05	ns	ns	ns	ns	ns	
		0.01	ns	ns	ns	ns	ns	
CV			4.2%	3.6%	2.6%	1.5%	1.5%	

approaching 95 percent in all treatments. Treatments effects were generally small; one significant (5% level) effect was observed in 1959 when spring-applied N resulted in better germination than all fall-applied N. It was concluded that time of N application had little or no effect on germination.

The lower germination values in 1958 and 1959 may have been caused by threshing injury. Reduced dehulling of seed with better and more uniform germination was obtained in other years after installing a threshing cylinder with a less violent threshing action.

Rates of N—effect on seed germination. The effects of different rates of spring-applied N on germination were compared in treatments 1 to 5 and 11 to 15. The results are shown in Table 7. The comparatively low germination values in 1958 and 1959 probably were caused by threshing injury. The low N plots were most severely affected, possibly because the low volume of straw gave less protection to the seed in the thresher cylinder.

Highly significant differences in germination occurred in 1958 and 1959 for different rates of N. Differences in other years were nonsignificant. The effects of threshing injury previously explained reduced the usefulness of the data for 1958 and 1959.

Lime—effect on seed germination. The limitations on the usefulness of germination data for 1958 and 1959 have been explained. The results for the 1960, 1961, and 1962 seed crops showed no effects on germination from liming the soil. The results of lime treatments are shown in Appendix Table 3.

Row spacing—effect on seed germination. Row spacing had no significant effect on germination (see Table 6).

Mature plant yields

Mature plant yields represented the above-ground production at seed harvest time except for about three inches of stubble which remained uncut. Data were obtained to measure the amount of crop residue remaining after harvest of an orchardgrass seed crop. Yield data shown in Table 8 were not analyzed statistically. Crop residue produced was about 1½ tons per acre with no N; approximately 3 tons per acre with 40 pounds per acre of N; and between 3 and 4 tons per acre with N at 80 to 160 pounds per acre. The 1-foot rows usually produced the highest yields.

Growers of orchardgrass seed in Oregon remove crop residue by post-harvest burning or by pasturing or mechanical removal followed by burning. The large amount of straw covering an orchardgrass seed field after harvest requires good distribution before burning to prevent excessive localized heat injury to the stand.

Table 7. Influence of N Applied at Different Rates in Spring and of Row Spacing on Germination of Orchardgrass Seed, Experiment 1

No.	Treatments		Germination means 1958	1959	1960	1961	1962	5-yr. avg.
			%	%	%	%	%	%
1	N 0	3-ft. rows	89.0	91.4	94.6	96.0	95.8	93.4
2	N 40	3-ft. rows	86.4	95.6	96.6	95.5	95.9	94.0
3	N 80	3-ft. rows	91.6	95.4	95.3	95.9	96.4	94.9
4	N 120	3-ft. rows	94.0	95.0	94.4	96.0	96.9	95.3
5	N 160	3-ft. rows	91.4	96.0	94.4	95.5	97.0	94.9
		3-ft. rows, avg.	90.5	94.7	95.1	95.8	96.6	94.5
11	N 0	1-ft. rows	86.2	85.2	92.9	94.5	95.8	90.9
12	N 40	1-ft. rows	89.4	95.4	95.5	96.9	97.4	94.9
13	N 80	1-ft. rows	92.8	95.0	95.2	96.4	96.9	95.3
14	N 120	1-ft. rows	94.0	95.2	92.7	95.6	95.4	94.6
15	N 160	1-ft. rows	90.4	94.4	92.5	94.6	97.7	93.9
		1-ft. rows, avg.	90.6	93.0	93.8	95.6	96.6	93.9
LSD N rate		0.05	4.76	3.72	ns	ns	ns	
		0.01	6.31	4.94	ns	ns	ns	
LSD row spacing		0.05	ns	ns	ns	ns	ns	
		0.01	ns	ns	ns	ns	ns	
LSD N x row spacing		0.05	ns	ns	ns	ns	ns	
		0.01	ns	ns	ns	ns	ns	
CV			4.2%	3.6%	2.6%	1.5%	1.5%	

Table 8. TOTAL PLANT YIELDS AT SEED MATURITY OF ORCHARDGRASS GROWN UNDER DIFFERENT FERTILIZER TREATMENTS AND ROW SPACING, EXPERIMENT 1

No.	Treatments			Air-dry material 2-year avg.
				lb./A
1	N	0 + lime	3-ft. rows	3,203
2	N	40 + lime	3-ft. rows	5,808
3	N	80 + lime	3-ft. rows	6,528
4	N	120 + lime	3-ft. rows	6,760
5	N	160 + lime	3-ft. rows	7,416
6	N	0 no lime	3-ft. rows	3,560
7	N	40 no lime	3-ft. rows	5,767
8	N	80 no lime	3-ft. rows	6,392
9	N	40 fall		
		40 spring + lime	3-ft. rows	6,719
10	N	80 fall + lime	3-ft. rows	5,726
11	N	0 + lime	1-ft. rows	2,017
12	N	40 + lime	1-ft. rows	5,653
13	N	80 + lime	1-ft. rows	7,268
14	N	120 + lime	1-ft. rows	7,350
15	N	160 + lime	1-ft. rows	8,107
16	N	0 no lime	1-ft. rows	2,036
17	N	40 no lime	1-ft. rows	5,873
18	N	80 no lime	1-ft. rows	7,499
19	N	40 fall		
		40 spring + lime	1-ft. rows	7,278
20	N	80 fall + lime	1-ft. rows	6,041

EXPERIMENT 2

Materials and methods

Experiment 2 was established in October 1959 to supplement information being gained from Experiment 1 and to evaluate the responses of orchardgrass to nitrogen, phosphorus, sulfur, and boron on a hill soil of low fertility. The soil was gently sloping Willakenzie clay loam that was known to be very low in available phosphorus and nitrogen.

The following soil analyses were determined with the procedures used by the Oregon State University Soil Testing Laboratory:

Phosphorus (sodium bicarbonate extractable) 1.0 to 1.5 p.p.m.

Potassium (ammonium acetate extractable) 0.67 to 1.06 meq/100 grams of soil.

Magnesium (ammonium acetate extractable) 3.15 to 5.55 meq/100 grams of soil.

Calcium (ammonium acetate extractable) 4.8 to 9.0 meq/100 grams of soil.

pH (1:2::soil:water ratio) 5.5 to 5.8 in the surface 12 inches.

A greenhouse experiment was conducted using this soil before the field experiment was started. The responses of orchardgrass to fertilizers in the greenhouse were used as a basis for selecting treatments used in the field (Table 9).

Table 9. Treatment Combinations*, Experiment 2

No.	N	P (P_2O_5)	B
	lb./A	*lb./A*	*lb./A*
1	0	0	0
2	80	40	0
3	80	80	0
4	80	160	0
5	80	0	4
6	80	40	4
7	80	80	4
8	80	160	4
9	160	40	4
10	160	80	4
11	160	160	4

Treatment 1 was not included in the analyses of data.
N applied as ammonium nitrate (33.5% N).
P_2O_5 applied as concentrated superphosphate (45% P_2O_5).
B applied as agricultural borax (14% B).
* Sulfur comparisons eliminated.

Plant material for the yield plots was obtained from three high seed yielding types designated as clones A, B, and C. Vigorous tillers of these clones were started in individual pots in the summer; they were ready to transplant in October. This planting method was used to eliminate one year from normal establishment practices and to try to reduce plant variation within the experimental plots.

Each plot consisted of six plants—two of each clone—planted at random. Each plot was surrounded by border rows established by taking plugs from a stand of Danish commercial orchardgrass. All plants were spaced 2½ feet each way.

The limited size of the experimental area made it necessary to use a modified factorial design with four replications.

Treatments were applied to evaluate responses to nitrogen, phosphorus, sulfur, and boron,[4] and to obtain a measure of their interactions (Table 9).

[4] The following symbols for plant nutrients will be used in discussing Experiment 2: N (nitrogen), P (phosphorus), S (sulfur), and B (boron).

P, S, and 40 pounds per acre of N were applied 2 inches deep in subsurface bands with a tractor-mounted, belt-type applicator in late October each year. B and the additional N required were surface-applied in March. N was split into fall and spring applications because it was thought that response to fall-applied P might be enhanced by fall-applied N on the Willakenzie clay loam soil.

After the fall of 1959, weed control, harvesting, and seed processing procedures were similar to those described for Experiment 1. Crop residues were removed mechanically. Post-harvest burning was not done because of fire danger to an adjacent forest.

Seed and total plant yields were obtained in 1960, 1961, and 1963. Fertilizers were not applied in the fall of 1961; therefore, yields were not measured in 1962.

Data on seed yields, plant yields, and seed quality were analyzed in the Oregon State University Department of Statistics. Discussion will be limited mostly to those treatment effects that were statisically significant, and LSD's will be presented for significant treatment effects. Treatment 1 was not included in the analyses of data, but data appear in the tables for general comparisons.

As in Experiment 1, a lack of consistent response to S and possible contamination from a nearby industrial plant limited the validity of S comparisons. Response to S on this soil was expected because the area is generally deficient in this element, and S deficiency was observed in a greenhouse experiment with soil from the experimental tract. Because of the question about interpretation of S effects, the data on S have been eliminated. Treatment effects of N, P, and B were obtained by averaging yield data across S treatments.

Results and discussion (Experiment 2)

SEED YIELDS

Seed yields increased each succeeding year. This increase may have been caused by gradual penetration of the orchardgrass roots to a greater depth each year, by continued increase in size of the spaced plants, and by an increasing supply of available P in the soil.

Rates of N—effects on seed yields. Seed yield data from different N rates are shown in Table 10. Differences in seed yield between the 80 and 160 pounds per acre N treatments were small in 1960, greater but nonsignificant in 1961, and highly significant in 1963. Response to N increased with higher rates of P (Table 10) and was dependent upon adequate P on this soil (compare treatments 5, 6, 7, and 8 in Tab'e 11). Interactions of N x P did not significantly affect seed yields.

Table 10. Influence of N and of P at Different Rates on Seed Yields of Orchardgrass, Experiment 2

No.	Treatments		Mean seed yields per acre 1960	1961	1963	3-yr. avg.
			lb.	*lb.*	*lb.*	*lb.*
1	No fertilizer		86	236	636	319
6	N_{80} P_{40}		137	535	935	536
7	N_{80} P_{80}		139	472	1,207	606
8	N_{80} P_{160}		211	780	1,145	712
		N_{80}, avg.	162	596	1,096	618
9	N_{160} P_{40}		146	630	1,109	629
10	N_{160} P_{80}		173	715	1,229	706
11	N_{160} P_{160}		208	816	1,270	765
		N_{160}, avg.	176	720	1,203	700
LSD for N		0.05	ns	ns	97	
		0.01	ns	ns	129	
LSD for P		0.05	30	111	97	
		0.01	40	147	129	
LSD for N x P		0.05	ns	ns	ns	
		0.01	ns	ns	ns	
CV			26.3%	24.8%	13.1%	

Rates of P—effect on seed yields. Application of P was essential to obtain increases in seed yield from other nutrients on this low-P soil. This is shown by comparing treatments 1 and 5 with other treatments in Table 11. The beneficial effect on seed yield was significant each year when P was increased from 40 to 160 pounds per acre of P_2O_5 (Table 10). Also, the effect on seed yield was significant when P was increased from 80 to 160 pounds per acre of P_2O_5 in 1960 and 1961 (Table 11). The N x P interactions were not significant.

B—effect on seed yields. A comparison of treatments 2, 3, and 4 with treatments 6, 7, and 8 in Table 12 shows that B did not influence seed yield, directly or indirectly.

Seed quality

Rate of N—effect on the weight of 1,000 seeds. The weight of 1,000 seeds (Table 13) was appreciably higher in 1960 than in the other two years; however, treatment effects were small for any one year. The weight of 1,000 seeds for treatment 1 was intermediate in

Table 11. INFLUENCE OF N AND OF P AT DIFFERENT RATES ON SEED YIELDS OF ORCHARDGRASS, EXPERIMENT 2

No.	Treatments		Mean seed yields per acre 1960	1961	1963	3-yr. avg.
			lb.	*lb.*	*lb.*	*lb.*
1	No fertilizer		86	236	636	319
5	N_{80} P_0		87	306	656	350
6	N_{80} P_{40}		137	535	935	536
9	N_{160} P_{40}		146	630	1,109	629
		P_{40}, avg.	141	582	1,022	582
7	N_{80} P_{80}		139	472	1,207	606
10	N_{160} P_{80}		173	715	1,229	706
		P_{80}, avg.	156	593	1,218	656
8	N_{80} P_{160}		211	780	1,147	713
11	N_{160} P_{160}		208	816	1,270	765
		P_{160}, avg.	209	798	1,208	739
LSD for N		0.05	ns	ns	97	
		0.01	ns	ns	129	
LSD for P		0.05	30	111	97	
		0.01	40	147	129	
LSD for N x P		0.05	ns	ns	ns	
		0.01	ns	ns	ns	
CV			26.3%	24.8%	13.1%	

1960, highest of all treatments in 1961, and lowest of all treatments in 1963. Low seed yields from treatment 1 (Table 10) indicate a severe shortage of nutrients in the soil.

Effects of added N on the weight of 1,000 seeds (Table 13) were not significant in 1960 and 1961, but they were highly significant in 1963. The comparatively heavy set of developing seeds in 1963 (Table 10) may have placed the plants under N stress at the 80-pound per acre N rate, resulting in lower weight of 1,000 seeds than at the 160-pound per acre rate (Table 13). The validity of this reasoning is open to question, considering the 1,000-seed weights for the no-fertilizer plots in 1960 and 1961. However, during the first two years, the comparatively few developing seeds of the no-fertilizer plots may have been able to draw sufficient reserves from the leaves and stems to give good seed development at maturity.

Table 12. INFLUENCE OF B ON SEED YIELDS OF ORCHARDGRASS, EXPERIMENT 2

No.	Treatments		Mean seed yields per acre 1960	1961	1963	3-yr. avg.
			lb.	*lb.*	*lb.*	*lb.*
1	No fertilizer		86	236	636	319
2	N_{80} P_{40} B_0		134	639	966	580
3	N_{80} P_{80} B_0		177	703	1,177	686
4	N_{80} P_{160} B_0		178	661	1,084	641
		B_0, avg.	163	668	1,076	636
6	N_{80} P_{40} B_4		137	535	935	536
7	N_{80} P_{80} B_4		139	472	1,207	606
8	N_{80} P_{160} B_4		211	780	1,147	713
		B_4, avg.	162	596	1,096	618
LSD for B		0.05	ns	ns	ns	
		0.01	ns	ns	ns	
LSD for B x N; B x P		0.05	ns	ns	ns	
		0.01	ns	ns	ns	
CV			26.3%	24.8%	13.1%	

Table 13. INFLUENCE OF N AND OF P AT DIFFERENT RATES ON WEIGHT OF 1,000 SEEDS OF ORCHARDGRASS, EXPERIMENT 2

No.	Treatments		Mean weight of 1,000 seeds 1960	1961	1963	3-yr. avg.
			mg	*mg*	*mg*	*mg*
1	No fertilizer		1,324	1,218	1,142	1,228
6	N_{80} P_{40}		1,301	1,169	1,163	1,211
7	N_{80} P_{80}		1,312	1,178	1,170	1,220
8	N_{80} P_{160}		1,335	1,171	1,153	1,219
		N_{80}, avg.	1,316	1,173	1,162	1,217
9	N_{160} P_{40}		1,328	1,179	1,204	1,237
10	N_{160} P_{80}		1,297	1,183	1,207	1,229
11	N_{160} P_{160}		1,303	1,162	1,202	1,222
		N_{160}, avg.	1,309	1,175	1,204	1,229
LSD for N		0.05	ns	ns	17	
		0.01	ns	ns	22	
LSD for P		0.05	ns	ns	ns	
		0.01	ns	ns	ns	
LSD for N x P		0.05	ns	ns	ns	
		0.01	ns	ns	ns	
CV			3.4%	2.7%	2.0%	

The effect of N on the weight of 1,000 seeds was generally less pronounced in this experiment than in Experiment 1, except in 1963. However, the conclusion can be made, as in Experiment 1, that high rates of nitrogen did not cause a reduction in weight per seed.

Rates of P—effect on the weight of 1,000 seeds. A nonsignificant increase in weight of 1,000 seeds followed the P treatment in 1960. Highly significant (1% level) decreases in weight of 1,000 seeds followed the application of P in 1961 and 1963 (Table 14). The decrease in the weight of 1,000 seeds in 1961 and 1963 may have been associated with a "dilution" effect because the decreases were accompanied by increases in both seed and vegetative yield from the application of P. The no-fertilizer plots declined substantially in the weight of 1,000 seeds each year.

Table 14. INFLUENCE OF P AT DIFFERENT RATES ON WEIGHT OF 1,000 SEEDS OF ORCHARDGRASS, EXPERIMENT 2

No.	Treatments		Mean weight of 1,000 seeds			
			1960	1961	1963	3-yr. avg.
			mg	*mg*	*mg*	*mg*
1	No fertilizer		1,324	1,218	1,142	1,228
5	N_{80} P_0		1,306	1,213	1,235	1,251
6	N_{80} P_{40}		1,301	1,169	1,163	1,211
7	N_{80} P_{80}		1,312	1,178	1,170	1,220
8	N_{80} P_{160}		1,335	1,171	1,153	1,219
LSD for P		0.05	ns	32	24	
		0.01	ns	43	31	
CV			3.4%	2.7%	2.0%	

B—effect on weight of 1,000 seeds. B had no effect on the weight of 1,000 seeds (Table 15).

Effects of fertilizers on seed caryopsis development. To compare the effects of fertilizer treatments on the development of the caryopsis (kernel) in orchardgrass seeds, 1,000 seed samples were taken from replications I, II, and III of treatments 1 and 11. After weighing, these samples were rubbed gently between canvas surfaces to remove the lemma and palea (chaff). The chaff was removed by blowing and the remaining caryopses were weighed. Amounts and percentages lost and remaining are shown in Table 16. A slight increase in the weight of 1,000 seeds was indicated as a result of abundant nutrients in the soil (compare data for 1963 in Table 13). Moreover, the data in Table 16 indicate that high fertility caused increased caryopsis development

Table 15. INFLUENCE OF P AND OF B ON WEIGHT OF 1,000 SEEDS OF ORCHARDGRASS, EXPERIMENT 2

No.	Treatments		Mean weight of 1,000 seeds 1960	1961	1963	3-yr. avg.
			mg	*mg*	*mg*	*mg*
1	No fertilizer		1,324	1,218	1,142	1,228
2	N_{80} P_{40} B_0		1,329	1,172	1,169	1,223
3	N_{80} P_{80} B_0		1,288	1,168	1,126	1,194
4	N_{80} P_{160} B_0		1,318	1,165	1,130	1,204
		B_0, avg.	1,312	1,168	1,142	1,207
6	N_{80} P_{40} B_4		1,301	1,169	1,163	1,211
7	N_{80} P_{80} B_4		1,312	1,178	1,170	1,220
8	N_{80} P_{160} B_4		1,335	1,171	1,153	1,219
		B_4, avg.	1,316	1,173	1,162	1,217
LSD for B		0.05	ns	ns	ns	
		0.01	ns	ns	ns	
LSD for P		0.05	ns	ns	17	
		0.01	ns	ns	ns	
LSD for B x P		0.05	ns	ns	24	
		0.01	ns	ns	ns	
CV			3.4%	2.7%	2.0%	

in relation to the amount of lemma and palea. Seeds from treatment 1 were 55 percent caryopsis. Treatment 11 produced seeds that were 63 percent caryopsis, which indicates higher quality.

GERMINATION

Rates of N—effect on germination. Germination data were not obtained for the 1960 crop. Germination percentages were usually quite uniform. Coefficients of variation (CV) were low, especially in 1963. The higher CV and lower germination values for 1961 may have resulted from holding the seed until May 1964 (albeit in dry cold) before the germination tests.

A comparison of treatment 1 with treatment 5 (Table 17) indicates that application of N alone resulted in increased germination in 1961 but not in 1963. The low germination value for the no-fertilizer treatment in 1961 is difficult to explain. Two of the four replications showed 64.5 percent and 71 percent germination, while the others showed 80.5 percent and 82.0 percent. These two low values indicate that threshing injury may have occurred.

Table 16. Effects of Fertilizers on Weight of 1,000 Seeds and Percent Caryopses in Orchardgrass, 1963

No.	Treatment		Weight of 1,000 seeds				Components
			Rep. I	Rep. II	Rep. III	Means	
			mg	*mg*	*mg*	*mg*	%
1	No fertilizer	Whole seeds	1,173	1,173	1,155	1,167	100
		Caryopses	636	682	603	640	55
		Lemma and palea	537	491	552	527	45
11	$N_{160}P_{160}B_4$	Whole seeds	1,213	1,293	1,276	1,261	100
		Caryopses	760	844	768	791	63
		Lemma and palea	453	449	508	470	37

Table 17. INFLUENCE OF N AND OF P AT DIFFERENT RATES ON GERMINATION OF ORCHARDGRASS SEEDS, EXPERIMENT 2

No.	Treatments		Germination means 1961	1963	2-yr. avg.
			%	%	%
1	No fertilizer		74.37	94.38	84.37
5	N_{80} P_{0}		82.65	94.75	88.70
6	N_{80} P_{40}		83.19	94.68	88.93
7	N_{80} P_{80}		83.85	94.75	89.30
8	N_{80} P_{160}		84.26	94.65	89.45
		N_{80}, avg.	83.77	94.69	89.23
9	N_{160} P_{40}		84.48	94.94	89.71
10	N_{160} P_{80}		85.00	93.50	89.25
11	N_{160} P_{160}		80.55	95.87	88.21
		N_{160}, avg.	83.34	94.77	89.06
LSD for N, P, N x P		0.05	ns	ns	
		0.01	ns	ns	
CV			4.8%	2.0%	

A comparison of rates of added N (Table 17) shows no significant response in germination percent in either year. Increasing the rate of N from 80 to 160 pounds per acre did not decrease germination, a point that is frequently questioned by grass seed growers. In this experiment, however, lodging was less than that which often prevails in orchardgrass fields that are heavily fertilized with N. Interference with pollination, stem injury, and leaf deterioration in lodged seed crops may restrict seed development, causing lightweight seed with low germination.

Rates of P—effect on germination. Good yields of seed were not obtained without application of P; nevertheless, effects of P on germination were nonsignificant and inconsistent (Table 18). Interactions were not significant.

B—effect on germination. B did not affect germination and interactions with other added nutrients were not indicated (Table 19).

MATURE PLANT YIELDS

Rates of N—effect on mature plant yields. Production was low in 1960, ranging from 670 to 1,630 pounds per acre of dry material (Table 20). Yields in 1961 were much higher, ranging from 2,030 to 7,560 pounds per acre. Intermediate yields varying from 1,590 to 3,370

Table 18. INFLUENCE OF N AND OF P AT DIFFERENT RATES ON GERMINATION OF ORCHARDGRASS SEEDS, EXPERIMENT 2

No.	Treatments		Germination means 1961	1963	2-yr. avg.
			%	%	%
1	No fertilizer		74.37	94.38	84.37
6	N_{80} P_{40}		83.19	94.68	88.93
9	N_{160} P_{40}		84.48	94.94	89.71
		P_{40}, avg.	83.83	94.81	89.32
7	N_{80} P_{80}		83.85	94.75	89.30
10	N_{160} P_{80}		85.00	93.50	89.25
		P_{80}, avg.	84.42	94.12	89.27
8	N_{80} P_{160}		84.26	94.65	89.45
11	N_{160} P_{160}		80.55	95.87	88.21
		P_{160}, avg.	82.40	95.26	88.83
LSD for N, P, N x P		0.05	ns	ns	
		0.01	ns	ns	
CV			4.8%	2.0%	

Table 19. INFLUENCE OF P AND OF B ON GERMINATION OF ORCHARDGRASS SEEDS, EXPERIMENT 2

No.	Treatments		Germination means 1961	1963	2-yr. avg.
			%	%	%
1	No fertilizer		74.37	94.38	84.37
2	N_{80} P_{40} B_0		83.24	93.56	88.40
3	N_{80} P_{80} B_0		85.92	94.88	90.40
4	N_{80} P_{160} B_0		81.95	95.25	88.59
		B_0, avg.	83.70	94.56	89.13
6	N_{80} P_{40} B_4		83.19	94.68	88.93
7	N_{80} P_{80} B_4		83.85	94.75	89.30
8	N_{80} P_{160} B_4		84.26	94.65	89.45
		B_4, avg.	83.77	94.69	89.23
LSD for P, B, P x B		0.05	ns	ns	
		0.01	ns	ns	
CV			4.8%	2.0%	

Table 20. INFLUENCE OF N AND P AT DIFFERENT RATES ON MATURE PLANT YIELDS OF ORCHARDGRASS, EXPERIMENT 2

No.	Treatments		Mean plant yields per acre			
			1960	1961	1963	3-yr. avg.
			lb.	*lb.*	*lb.*	*lb.*
1	No fertilizer		670	2,030	1,590	1,430
6	N_{80} P_{40}		1,030	4,460	2,730	2,740
7	N_{80} P_{80}		1,030	4,340	2,990	2,787
8	N_{80} P_{160}		1,510	6,060	2,950	3,507
		N_{80}, avg.	1,190	4,953	2,890	3,011
9	N_{160} P_{40}		1,140	5,070	3,030	3,080
10	N_{160} P_{80}		1,380	7,560	3,340	4,093
11	N_{160} P_{160}		1,630	7,410	3,370	4,137
		N_{160}, avg.	1,383	6,680	3,247	3,770
LSD for N		0.05	261	994	369	
		0.01	ns	1,323	ns	
LSD for P		0.05	320	1,218	ns	
		0.01	426	ns	ns	
LSD for N x P		0.05	ns	ns	ns	
		0.01	ns	ns	ns	
CV			26.8%	23.7%	16.5%	

pounds per acre were produced in 1963. The high yields in 1961 probably resulted from two consecutive years of fertilizer application. Fertilizer was not applied in the fall of 1961 or in the spring of 1962, but the growth was removed in 1962.

The ineffectiveness of N applied alone on P-deficient soil is shown by comparing treatments 1, 5, and 6 (Table 21). However, N did influence mature plant yields as shown by the effect of the 160-pound per acre N treatment (Tables 20 and 21). N x P interactions were not indicated.

Rates of P—effect on mature plant yields. Application of P was necessary for N to be effective. Yields increased consistently with applications of P when the 0 rate was compared with 40, 80, and 160 pounds per acre (Table 21). Increases were significant to highly significant each year. Comparison of yield effects from the different rates of added P showed no significant differences between the 40- and 80-pound per acre rates. Differences in yield between the 40- and 160-pound per acre P treatments were highly significant (1% level) in 1960 and 1961, but not in 1963. By the third year, applications of P had increased the

Table 21. INFLUENCE OF P AT DIFFERENT RATES ON MATURE PLANT YIELDS OF ORCHARDGRASS, EXPERIMENT 2

No.	Treatments		Mean plant yields per acre 1960	1961	1963	3-yr. avg.
			lb.	lb.	lb.	lb.
1	No fertilizer		670	2,030	1,590	1,430
5	N_{80} P_0		680	2,390	1,770	1,613
6	N_{80} P_{40}		1,030	4,460	2,730	2,740
9	N_{160} P_{40}		1,140	5,070	3,030	3,080
		P_{40}, avg.	1,085	4,765	2,880	2,910
7	N_{80} P_{80}		1,030	4,340	2,990	2,787
10	N_{160} P_{80}		1,380	7,560	3,340	4,093
		P_{80}, avg.	1,205	5,950	3,165	3,440
8	N_{80} P_{160}		1,510	6,060	2,950	3,507
11	N_{160} P_{160}		1,630	7,410	3,370	4,137
		P_{160}, avg.	1,570	6,735	3,160	3,822
LSD for P		0.05	320	1,218	452	
		0.01	426	1,620	602	
CV			26.8%	23.7%	16.5%	

supply of available P sufficiently for high production with the 80-pound per acre rate of N. Interaction of P with N was not indicated.

B—effect on mature plant yields. Yield increases where B was applied were small and nonsignificant (Table 22). There were no significant interactions with P.

MISCELLANEOUS EXPERIMENTS

Effects of post-harvest burning vs. mechanical removal of crop residue. Grass seed growers depend on post-harvest burning of seed fields to dispose of large amounts of relatively worthless crop residue, to aid in pest control through field sanitation, and to maintain seed yields.

This experiment was located adjacent to Experiment 1. It was conducted after the first seed crop to evaluate the effects of post-harvest burning vs. mechanical removal of seed crop residue on Danish commercial and Welsh S. 143 orchardgrass in 3-foot and 1-foot rows. N at 100 pounds per acre was applied in early March of 1958 and 1959. Weed control and other cultural practices were the same as described for Experiment 1. Burning and mechanical residue removal were im-

Table 22. INFLUENCE OF B ON MATURE PLANT YIELDS OF ORCHARDGRASS, EXPERIMENT 2

No.	Treatments		Mean plant yields per acre 1960	1961	1963	3-yr. avg.
			lb.	*lb.*	*lb.*	*lb.*
1	No fertilizer		670	2,030	1,590	1,430
2	N_{80} P_{40} B_0		1,000	5,180	2,450	2,877
3	N_{80} P_{80} B_0		1,200	5,120	2,760	3,027
4	N_{80} P_{160} B_0		1,260	5,040	2,670	2,990
		B_0, avg.	1,153	5,113	2,627	2,965
6	N_{80} P_{40} B_4		1,030	4,460	2,730	2,740
7	N_{80} P_{80} B_4		1,030	4,340	2,990	2,797
8	N_{80} P_{160} B_4		1,510	6,060	2,950	3,507
		B_4, avg.	1,190	4,953	2,890	3,015
LSD for B		0.05	ns	ns	ns	
		0.01	ns	ns	ns	
CV			26.8%	23.7%	16.5%	

posed in a split-plot design replicated three times. Varieties and row spacings were the sub-plots. A treatment in which residues remained was not included.

Preparation for the experiment began with standing harvest of the first seed crop on July 7, 1958, when the seed had begun to shatter. A field combine harvester with a straw spreader was used. Standing harvest involved only the upper portions of the plants; the principal production of each plot remained in place. On July 31, all plots were close-mowed to promote drying of the stubble. The residue was then removed as thoroughly as possible from the plots that were to remain unburned. Amounts of straw per acre ranged from 3.1 tons of S. 143 in 3-foot rows to 3.8 tons of Danish in 1-foot rows. On August 4, the plots to be burned were fired. Good clean burns were obtained. Injury and death of some plants occurred on all burned plots, especially in the 1-foot rows where the heaviest residue made the hottest fire.

Fall recovery was normal with good stands of tillers. The seed crop was harvested in early July 1959 to obtain the data on the effects of burning and of mechanical removal of residue after the previous harvest. Seed was harvested, threshed, and cleaned as described for Experiment 1.

Seed yields and results of analysis of data are shown in Table 23. Burning had the general effect of increasing seed production in the

Table 23. Effect of Post-harvest Burning vs. Mechanical Removal of Straw on Seed Yields of Two Orchardgrass Varieties in Different Row Spacings, 1959

Variety and treatment	Mean seed yields per plot					
	I	II	III	Totals	Means	*lb./A*
	g	*g*	*g*	*g*	*g*	
S. 143 in 3-ft. rows, burned	504	479	370	1,353	451	577
Straw removed, not burned	422	394	420	1,236	412	528
S. 143 in 1 ft. rows, burned	248	138	164	550	183	216
Straw removed, not burned	175	234	270	679	226	267
Danish in 3-ft. rows, burned	525	492	574	1,591	530	679
Straw removed, not burned	469	412	530	1,411	470	602
Danish in 3-ft. rows, burned	229	282	350	861	287	339
Straw removed, not burned	317	347	402	1,066	355	420
LSD for burning 0.05					ns	
0.01					ns	
LSD for row spacing and variety 0.05					46	
0.01					65	
LSD for burning x row spacing 0.05					65	
0.01					ns	
CV					14.2%	

3-foot rows and of reducing it in the 1-foot rows. However, when the effect of burning was compared with mechanical removal of the straw, the difference was not statistically significant. The important indication here is that burning did not cause significant reduction of seed yield. Differences in yield between varieties and between row spacings were highly significant (1% level), favoring Danish and 3-foot rows. A significant (5% level) burning x row spacing interaction occurred, indicating that burning injury and yield reduction occurred in the 1-foot row spacing where the heavier straw cover caused hotter fires.

Loss of a portion of this area prevented continuation of this experiment.

Effects of desiccants on seed quality.[5] Spray-applied drying agents that would bring a standing crop of grass seed to a uniform dryness and acceptable maturity without windrow curing would speed up the harvest and perhaps reduce costs. To determine the effects of desiccants applied for pre-harvest drying on the quality of orchardgrass seeds, an experiment was conducted on Danish commercial and S. 143 orchardgrass. Six replicated treatments were applied on June 29, 1960, when the seeds were in milk-to-soft-dough stage and nearing maturity. The weather was warm and calm, allowing good spray coverage with little drift. The desiccants seemed to have little effect on rate of moisture loss, but samples were not taken to determine this loss. Seed was harvested on July 5 and was cured, threshed, and cleaned as in Experiment 1. Standard laboratory germination tests were made. Data were not analyzed statistically. Treatments and results are shown in Table 24. Dinitro general in diesel oil caused reduced germination, but the dinitro general in water treatment had no effect. Diquat at one-half and one pound per acre and oil-miscible endothall caused no reduction of germination but resulted in some chemical injury to the seeds. This injury was characterized by stubby roots or lack of root hairs on the seedlings, and it was most pronounced when the germination substrata were becoming somewhat dry. However, the affected seedlings had recovered at the conclusion of the 21-day germination tests and were counted as normal. Although the injured seedlings made recovery in the germinator, the reduced growth rate probably would hinder seedling establishment in the field, especially when soil moisture is suboptimal.

As a substitute for curing in the windrow, pre-harvest conditioning of orchardgrass seed crops with the desiccants used in this experiment appeared to be of doubtful value.

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[5] Cooperative with Dr. W. O. Lee, research agronomist, Crops Protection Branch, ARS, U. S. Department of Agriculture.

Table 24. Effect of Desiccants on Germination of Orchardgrass Seeds, 1960

Treatments	Germination means			Remarks
	S. 143	Danish	Avg.	
	%	%	%	
Untreated check	90.5	90.5	90.5	
Dinitro general 3 pints + 20 gal. diesel oil/acre	85.0	81.5	83.2	
Dinitro general 3 pints + 20 gal. water/acre	91.0	91.5	91.2	
Diquat ½ lb. + 20 gal. water/acre	95.5	93.0	94.2	Chemical injury
Diquat 1 lb. + 20 gal. water/acre	94.0	91.0	92.5	Chemical injury
Endothall (oil misc.) 2 lb. + 20 gal. diesel oil/acre	94.0	88.5	91.2	Chemical injury

Table 25. Influence of Irrigation on Seed Yields of Orchardgrass at Corvallis, 1963

Treatments	Seed yields per plot					
	Rep. I	Rep. II	Rep. III	Total	Means	Pounds per acre
	g	g	g	g	g	
Check—no irrigation	1,227	949	1,131	3,307	1,102	705
Irrigated fall 1962 only	1,038	1,005	1,097	3,140	1,047	670
Irrigated fall and spring	1,003	1,214	1,146	3,363	1,121	718
Irrigated spring 1963 only	1,158	1,274	1,206	3,638	1,213	777
LSD 0.05					ns	
0.01					ns	
CV					9.7%	

Effects of irrigation on seed yields.[6] This experiment was conducted during the crop year of 1962-63 on plots of Danish commercial orchardgrass previously used in Experiment 1. The plots chosen were 3-foot row plots that had received 80 pounds per acre of N annually. For the irrigation experiment, all plots received 30 pounds per acre of N and 36 pounds of S on September 6, 1962, plus 70 pounds per acre of N on March 20, 1963. Volunteer grass and broadleafed weeds were controlled as previously described for Experiment 1.

The experimental design was a randomized block with three replications. Irrigation treatments (Table 25) began on September 7, 1962. Watering was done with plot sprinklers when needed, as indicated by gypsum block moisture-tension readings of 1.5 bars at a depth of one foot. Irrigation was discontinued when the developing seeds were in the milk stage. Rainfall by months from September 1962 through June 1963 is shown below:

1962		1963	
Month	*Inches*	*Month*	*Inches*
September	1.60	January	1.64
October	4.62	February	5.23
November	7.89	March	6.30
December	2.90	April	4.64
		May	3.94
		June	0.96

Fall precipitation was adequate for the production of numerous fall-formed tillers. Spring rainfall was plentiful excepting in June. Seed was harvested, cured, threshed, and cleaned as in Experiment 1.

Seed yields were practically identical without irrigation and with fall plus spring irrigation (Table 25). Production was highest with spring irrigation and lowest with fall irrigation. None of the effects of irrigation on seed yields were significant. It was concluded that natural rainfall was adequate for a seed crop of orchardgrass under the conditions of this experiment. Irrigation probably would benefit seed yields when: (1) prolonged drought in fall and early winter reduces the number and vigor of new tillers; and (2) when drought causes soil moisture stress during heading, pollinating, and seed development.

Rethreshing of doubles and clusters. A common characteristic of orchardgrass is that many doubles and larger groups of spikelets or clusters of seed fail to break up in threshing. Seed producers some-

[6] Cooperative with: D. D. Evans, formerly professor of soils, Oregon State University, now at the University of Arizona; Marvin N. Shearer, extension irrigation specialist, OSU; and J. W. Wolfe, professor of agricultural engineering, OSU.

times wonder if they are screening out and losing significant amounts of good seeds in these clusters during cleaning. To investigate this question, doubles and clusters were scalped off from a combine-harvested lot of orchardgrass seed in 1959. This material was re-threshed in an experimental plot thresher with a rubber-covered cylinder and concave bars. After recleaning, the good seeds recovered added approximately 2.5 percent to the cleaned weight of the lot from which they were scalped. Many clusters and doubles remained after re-threshing. Close examination showed them to be immature or empty and not developed enough to break apart readily.

LITERATURE CITED

1. Austenson, H. M., and Dwight V. Peabody, Jr., 1964.
   Effects of row spacing and time of fertilization on grass seed production. Agron. Jour., *56:*461-463.

2. Buller, Roderic E., J. S. Bubar, H. R. Fortmann, and H. L. Carnahan, 1955.
   Effects of nitrogen fertilization and rate and method of seeding on grass seed yields in Pennsylvania. Agron. Jour., *47:*559-563.

3. Canode, C. L., 1965.
   Influence of cultural treatments on seed production of intermediate wheatgrass (*Agropyron intermedium* (Host) Beauv.). Agron. Jour., *57:*207-210.

4. Canode, C. L. 1968.
   Influence of row spacing and nitrogen fertilization on grass seed production. Agron. Jour., *60:*263-267.

5. Davies, John, and D. H. A. Edwards, 1953.
   The influence of nitrogen on the seed yields of a cocksfoot seed crop. Jour. British Grasslands Soc., *8:*261-266.

6. Evans, T. A., 1953.
   Management and manuring for seed production in cocksfoot and timothy. Jour. British Grasslands Soc., *8:*245-259.

7. Garrison, C. S., 1960.
   Technological advances in grass and legume seed production and testing: I. Maintaining varietal purity and cultural and management practices. Advances in Agronomy, *12:*42-71. (Academic Press, New York and London.)

8. Hardison, J. R., 1960.
   Technological advances in grass and legume seed production and testing: IV. Disease control in forage seed production. Advances in Agronomy, *12:*96-106. (Academic Press Inc., New York, N. Y.)

9. Harmond, Jesse E., and Leonard M. Klein, 1964.
   A versatile plot thresher. U. S. Department of Agriculture, Agricultural Research Service. ARS 42-4-1 Rev.

10. Klages, K. H. W., and R. H. Stark, 1949.
    Grass and grass seed production. University of Idaho Agric. Expt. Sta. Bull. 273.

11. Mac Vicar, R. M., and D. R. Gibson, 1951.
    Effects of sources of nitrogen, rates of application, and methods of application on seed production of orchardgrass. Scientific Agriculture, *31:*399-412.

12. Musser, H. B., 1947.
    The effect of burning and various fertilizer treatments on seed production of red fescue, *Festuca rubra* L. Jour. Am. Soc. Agron., *39:*335-340.

13. Pumphrey, F. V., 1965.
    Fertilizing Kentucky bluegrass and fine fescue for seed production in northeastern Oregon. Agric. Expt. Sta. Bull. 601, Oregon State University, Corvallis.

14. Pumphrey, F. V., 1965.
Residue management in Kentucky bluegrass (*Poa pratensis* L.) and red fescue (*Festuca rubra* L.) seed fields, Agron. Jour., *57:*559-561.

15. Richardson, G. L., 1951.
Some studies on the causes of sod-binding in Alta fescue, *Festuca elatior,* var. *arundinacea* (Schreb.) Wimm. Ph.D. thesis, Oregon State College, unpublished.

16. Sears, P. D., 1950.
Cocksfoot seed production trials. N. Z. Jour. Ag., *80:*379-384.

17. Spencer, T. J., 1950.
Seed production of Kentucky 31 fescue and orchardgrass as influenced by rate of planting nitrogen fertilization, and management. Kentucky Agric. Expt. Sta. Bull. 554.

18. Stapledon, R. A., and A. R. Beddows, 1926.
The qualitative and quantitative response of orchardgrass (*Dactylis glomerata* L.) to sodium nitrate and to superphosphate. Welsh Jour. Ag., *2:*103-113.

Appendix Table 1. Influence of Lime and of Row Spacing on Seed Yields of Orchardgrass, Experiment 1

No.	Treatments		Mean seed yields per acre					
			1958	1959	1960	1961	1962	5-yr. avg.
			lb.	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*
1	N 0 + lime	3-ft. rows	423	287	262	250	215	287
2	N 40 + lime	3-ft. rows	518	481	504	488	370	472
3	N 80 + lime	3-ft. rows	616	571	646	573	585	598
		Lime, avg.	519	446	471	437	390	452
11	N 0 + lime	1-ft. rows	239	130	129	195	94	157
12	N 40 + lime	1-ft. rows	390	277	369	378	297	342
13	N 80 + lime	1-ft. rows	605	497	546	558	457	533
		Lime, avg.	411	301	348	377	283	344
6	N 0 no lime	3-ft. rows	423	290	329	261	205	302
7	N 40 no lime	3-ft. rows	517	448	545	486	470	493
8	N 80 no lime	3-ft. rows	579	569	547	539	575	562
		No lime, avg.	506	436	474	427	417	452
16	N 0 no lime	1-ft. rows	182	116	139	196	105	148
17	N 40 no lime	1-ft. rows	401	352	420	434	428	407
18	N 80 no lime	1-ft. rows	472	504	570	536	619	540
		No lime, avg.	352	324	376	389	384	365
LSD lime		0.05	31	ns	ns	ns	ns	
		0.01	ns	ns	ns	ns	ns	
LSD row spacing		0.05	31	39	46	41	ns	
		0.01	41	52	61	ns	ns	
LSD lime x row spacing		0.05	ns	ns	ns	ns	ns	
		0.01	ns	ns	ns	ns	ns	
CV			11.8%	17.4%	19.7%	17.3%	41.3%	

Appendix Table 2. INFLUENCE OF LIME AND OF ROW SPACING ON 1,000-SEED WEIGHT OF ORCHARDGRASS, EXPERIMENT 1

No.	Treatments		Mean 1,000-seed weight					
			1958	1959	1960	1961	1962	5-yr. avg.
			mg	*mg*	*mg*	*mg*	*mg*	*mg*
1	N 0 + lime	3-ft. rows	1,189	1,122	1,253	1,139	1,153	1,171
2	N 40 + lime	3-ft. rows	1,129	1,186	1,337	1,187	1,158	1,199
3	N 80 + lime	3-ft. rows	1,215	1,133	1,351	1,201	1,222	1,224
		Lime, avg.	1,178	1,147	1,314	1,176	1,178	1,198
6	N 0 no lime	3-ft. rows	1,113	1,098	1,239	1,141	1,141	1,146
7	N 40 no lime	3-ft. rows	1,144	1,142	1,298	1,186	1,219	1,198
8	N 80 no lime	3-ft. rows	1,190	1,184	1,356	1,199	1,247	1,235
		No lime, avg.	1,149	1,141	1,298	1,175	1,202	1,193
11	N 0 + lime	1-ft. rows	1,089	1,079	1,249	1,143	1,190	1,150
12	N 40 + lime	1-ft. rows	1,124	1,127	1,340	1,178	1,200	1,194
13	N 80 + lime	1-ft. rows	1,120	1,124	1,342	1,182	1,270	1,208
		Lime, avg.	1,111	1,110	1,310	1,168	1,220	1,184
16	N 0 no lime	1-ft. rows	1,141	1,098	1,262	1,146	1,158	1,161
17	N 40 no lime	1-ft. rows	1,100	1,117	1,325	1,183	1,181	1,181
18	N 80 no lime	1-ft. rows	1,167	1,160	1,358	1,206	1,195	1,217
		No lime, avg.	1,136	1,125	1,315	1,178	1,178	1,186
LSD lime		0.05	20	15	11	16	25	
		0.01	27	20	15	22	33	
LSD row spacing		0.05	20	15	11	16	25	
		0.01	27	20	15	22	33	
LSD lime x row spacing		0.05	29	21	16	23	35	
		0.01	39	28	21	31	46	
CV			6.9%	5.2%	3.3%	2.7%	4.0%	

Appendix Table 3. INFLUENCE OF LIME AND OF ROW SPACING ON GERMINATION OF ORCHARDGRASS SEED, EXPERIMENT 1

No.	Treatments		Germination means 1958	1959	1960	1961	1962	5-yr. avg.
			%	%	%	%	%	%
1	N 0 + lime	3-ft. rows	89.0	91.4	94.6	96.0	95.8	93.4
2	N 40 spring + lime	3-ft. rows	86.4	95.6	96.6	95.5	96.9	94.2
3	N 80 spring + lime	3-ft. rows	91.6	95.4	95.3	95.9	96.4	94.9
		Lime, avg.	89.0	94.1	95.5	95.8	96.4	94.2
6	N 0 no lime	3-ft. rows	89.2	92.4	93.3	94.8	95.3	93.0
7	N 40 spring no lime	3-ft. rows	90.4	91.8	95.5	95.4	96.4	93.9
8	N 80 spring no lime	3-ft. rows	89.6	93.8	94.2	95.9	97.2	94.1
		No lime, avg.	89.7	92.7	94.3	95.4	96.3	93.7
11	N 0 + lime	1-ft. rows	86.2	85.2	92.9	94.5	95.8	90.9
12	N 40 spring + lime	1-ft. rows	89.4	95.4	95.5	96.9	97.4	94.9
13	N 80 spring + lime	1-ft. rows	92.8	95.0	95.2	96.4	96.9	95.3
		Lime, avg.	89.5	91.9	94.5	95.9	96.7	93.7
16	N 0 no lime	1-ft. rows	83.8	91.0	92.2	94.9	95.4	91.5
17	N 40 spring no lime	1-ft. rows	88.6	93.8	94.7	96.2	95.7	93.8
18	N 80 spring no lime	1-ft. rows	90.6	91.8	94.8	96.0	96.7	94.0
		No lime, avg.	87.7	92.2	93.9	95.7	95.9	93.1
LSD lime		0.05	ns	ns	ns	ns	ns	
		0.01	ns	ns	ns	ns	ns	
LSD row spacing		0.05	ns	ns	ns	ns	ns	
		0.01	ns	ns	ns	ns	ns	
LSD lime x row spacing		0.05	ns	ns	ns	ns	ns	
		0.01	ns	ns	ns	ns	ns	
CV			4.2%	3.6%	2.6%	1.5%	1.5%	