Kentucky Bluegrass Seed Production In Western Oregon

Effect of Cultural and Management Practices on the Yield and Quality of Kentucky Bluegrass Seed

Agricultural Experiment Station
Oregon State University
Corvallis

TECHNICAL BULLETIN 114
JANUARY 1971

CONTENTS

AUTHORS: H. H. Rampton is Research Agronomist, Forage and Range Research Branch, Crops Research Division, Agricultural Research Service, United States Department of Agriculture; T. L. Jackson is Professor of Soils, Oregon State University; W. O. Lee is Research Agronomist, Crops Protection Research Branch, Crops Research Division, Agricultural Research Service, United States Department of Agriculture.

Seed production investigations at the Oregon Agricultural Experiment Station are cooperative with the Crops Research Division, Agricultural Research Service, United States Department of Agriculture.

Kentucky Bluegrass Seed Production In Western Oregon

Effect of Cultural and Management Practices on the Yield and Quality of Kentucky Bluegrass Seed

H. H. RAMPTON, T. L. JACKSON, and W. O. LEE

SUMMARY

The influence of nitrogen

Kentucky bluegrass seed fields should receive substantial amounts of nitrogen in the fall. Seed yields usually responded best to nitrogen applied in the fall or in split fall and spring treatments. Spring application of nitrogen was effective when prolonged spring drouth with low temperatures suppressed plant growth.

Four-year average seed yields were highest with nitrogen at 100 pounds per acre. Increases in yield from more than 50 pounds per acre of nitrogen were not significant in the first two years, but as the stands aged the 100 pound per acre rate caused significantly higher yields of seed. Decreased yields resulted from nitrogen at 150 and 200 pounds per acre except when spring growth was retarded by prolonged dry, cold weather.

Germination of Kentucky bluegrass seeds was not influenced significantly by the time of nitrogen application.

The rate of nitrogen treatment influenced seed germination. When high rates of nitrogen caused rank growth and early lodging, seeds developing in the matted material were of low quality. When lodging did not occur, the higher rates of nitrogen increased germination.

The weight of 1,000 seeds was consistently higher with spring-applied nitrogen than with fall nitrogen. Because seed yields were usually higher and the weight of 1,000 seeds was always lower with fall-applied nitrogen, the increased yields must have resulted from greater numbers of seeds.

High rates of nitrogen did not directly reduce the weight of 1,000 seeds. Rather, the reduction was probably the result of early lodging which usually followed high rates of nitrogen. Abundant soil nutrients increased the proportion of caryopsis (kernel) in relation to the total weight of the seed. This, presumably, increased seed quality.

Total plant yield was usually lower with spring-applied nitrogen than with fall or split fall and spring applications. Total plant yields varied little with 100, 150, or 200 pounds per acre of nitrogen, but all yields were substantially higher than at the 50 pound per acre rate.

The influence of lime

In this experiment lime had little or no effect on seed yields, seed quality (germination, weight of 1,000 seeds), or mature plant yields.

The influence of sulfur

Sulfur applications did not influence seed yields in the first two years of the experiment. However, in the last two years, sulfur gave significant increases in yields, which indicated that the sulfur in the soil had become depleted.

Sulfur treatment did not influence germination, but it caused a significant increase in the weight of 1,000 seeds in 1964, a year when seed yield response also indicated a sulfur deficiency.

Sulfur caused a significant increase in mature plant yields in 1963; no response was seen in the first two years of the experiment, when sulfur supplies appeared to be adequate.

The influence of row spacing

Culture in 12-inch rows resulted in seed yields that were consistently and substantially higher than seed yields in the 30-inch rows. More efficient use of applied nitrogen was obtained in 12-inch rows.

Row spacing influenced germination in 1961, when low germination values for some 30-inch row treatments probably resulted from lodging and consequent matted masses of seedheads which became moist and moldy through prolonged contact with the soil between the rows.

Row spacing influenced the weight of 1,000 seeds in 1963. Low weight per seed occurred in some 30-inch row plots where early lodging appeared to hinder seed development.

Mature plant yields were greatest in 12-inch rows during the first two years, but in the third year the 30-inch row plantings were most productive.

The influence of herbicides

The influence of diuron on seed yields was minor. The principal benefit to the seed crop was in the control of *Poa annua*. Chlorpropham (CIPC) appeared to depress seed yields.

Herbicides had no effect on germination, and their influence on the weight of 1,000 seeds was small.

No effects of herbicides on mature plant yield were indicated.

INTRODUCTION

Seed production of Kentucky bluegrass in Oregon began about 1926. The earliest known production was on irrigated land in Klamath County. The expansion was slow until the Merion variety was introduced into Klamath County as B-27 bluegrass in 1940. Seed harvests began in Union County in 1942, in Jefferson County and the Willamette Valley in 1953, and in Jackson County in 1954. Since that time several improved varieties have been released for seed production and the acreage has expanded rapidly in Oregon.

Stability and growth of this enterprise will continue in competition with other crops and other seed-producing areas if growers can produce high quality seeds economically.

To gain information about the effects of fertilizers, lime, herbicides, and row spacing on yields and quality of Kentucky bluegrass seed in Oregon, the research reported in this bulletin was conducted at the Oregon Agricultural Experiment Station, Corvallis, Oregon.

LITERATURE REVIEW

Comparatively little research has been reported until recently on stands of Kentucky bluegrass established and managed for seed production.

In Ohio, nitrogen treatment increased the number of tillers and rhizomes on common Kentucky bluegrass. In ordinary bluegrass sod, only the most vigorous tillers produced seed heads (*5*).[1] Results of work in Kentucky showed nitrogen to be the key nutrient in stimulating seed yields of Kentucky bluegrass; nitrogen was more effective if applied in the spring. Nevertheless, fall-applied nitrogen increased the number of heads per unit area. Increasing nitrogen applications from 0 to 50 pounds per acre resulted in substantial increases in seed yield and in heads per unit area. Rates of 100, 150, and 200 pounds per acre resulted in reduced seed yields and fewer heads per unit area. Burning was the most effective farm practice for controlling insects (*12*). Later research in Kentucky showed that with postharvest clipping to December 1, nitrogen applied at 33 pounds per acre on December 1 and again on March 1 resulted in the greatest seed yields. Nonclipped pods yielded the least seed (*2*).

Research reports from northern Europe and England showed that higher rates of applied nitrogen gave increased seedheads and higher seed yields with Kentucky bluegrass. As stands aged, increased

[1] Numbers in parentheses refer to Literature Cited, page 27.

nitrogen applications were required for high yields; two to three seed crops were usually harvested from a field. Row spacings of 8, 12, and 18 inches were progressively higher in seed yields, and broadcast stands of Kentucky bluegrass were lower in seed yield than 20-inch rows (*11*).

In California, irrigated Merion Kentucky bluegrass in 28- to 30-inch rows gave the highest seed yields and sustained production. Yields declined quickly in broadcast stands. The first seed crops required 80 to 125 pounds per acre of nitrogen for high yields, but older stands needed up to 200 pounds; about two-thirds of the nitrogen should be applied in the fall and the remainder in early spring (*13*). Two years' results with Merion bluegrass in western Oregon indicated that all rates of nitrogen resulted in significantly higher seed yields than no nitrogen; that the 160 pound per acre rate of nitrogen applied in late winter was the most effective rate; that there was little difference in productivity between 36-inch rows and 12-inch rows; and that there was no consistent response to application of lime when the original soil pH was 5.3 to 5.7 in the surface 12 inches.[2]

Growers of Kentucky bluegrass in northern Minnesota use improved production techniques, including low seeding rates of one pound per acre or less and liberal applications of fertilizers and herbicides (*14*). In northeastern Oregon, applications of nitrogen consistently increased the seed yields of Kentucky bluegrass and fine fescues. Bluegrass should receive 60 to 120 pounds per acre annually; older stands and irrigated stands required more nitrogen for high yields than younger or nonirrigated fields. The optimum time for applying nitrogen to bluegrass was about October 1. Where more than 100 pounds per acre of nitrogen was used, split fall and spring application was advantageous, but nitrogen was not efficiently used if all of it was applied in the spring (*9*). In northeastern Oregon, straw and stubble remaining on fields after seed harvest varied from 2,100 to 3,840 pounds per acre (*10*).

In a three-year experiment in western Washington, orchardgrass and timothy produced the most seed in 42-inch rows, colonial bentgrass yielded best in 7-inch rows, and red fescue yields were unaffected by row spacing. Spring application of fertilizers resulted in the highest seed yields in red fescue and colonial bentgrass; timothy seed yields were not influenced by the time of the fertilizer application. Orchardgrass in 42-inch rows responded best to split fall and spring treat-

[2] Harry A. Schoth and H. H. Rampton, 1956 and 1957. Annual Reports, Forage Crop Investigations, Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture and Oregon Agricultural Experiment Station, cooperating. Unpublished data: 1956, pp. 129-131; 1957, pp. 104-109.

ments; in 7-inch rows, fall fertilizing was best. Germination was not influenced by any of the treatments (*1*). In a five-year experiment with Cougar Kentucky bluegrass, seed yields were greatest with 80 or 100 pounds per acre as compared with 60 pounds per acre of applied nitrogen. Rows 12 or 24 inches apart produced more seed than 36-inch rows (*4*).

A summary of grass seed production research showed that nitrogen was required for economical production of grass seeds in all areas. Under humid or irrigated conditions the nitrogen requirement was greatest. Wide row plantings were usually most productive of seed, especially as stands aged or where soil moisture was limiting. Broadcast or close-drilled stands were frequently high yielding in the first crop year (*7*).

Diuron (3-(3, 4-dichlorophenyl)-1, 1-dimethylurea) and chlorpropham (isopropyl m-chlorocarbanilate) (CIPC) were effective for selective removal of annual grasses and broadleaf weeds from Kentucky bluegrass (*6, 15*). Several varieties of Kentucky bluegrass showed high tolerance to repeated annual applications of diuron with resulting substantial increases in seed yields (*8*). Dicamba (3, 6-dichloro-o-anisic acid), when correctly used, selectively removed red sorrel (*Rumex acetosella* L.) from bluegrass seed stands without injury to the seed crop (*3*).

MATERIALS AND METHODS

We conducted this experiment on the Hyslop Agronomy Farm on Woodburn silt loam soil, a moderately well drained valley floor soil. Soil tests indicated that neither phosphorus nor potassium were likely to limit grass seed production in any of the planned treatments; consequently, these nutrients were not applied to the soil.

Chemical analyses on soil samples taken from the upper 6 inches of soil were performed by the Oregon State University Soil Testing Laboratory using the following procedures:

pH 5.5 in a soil paste

Phosphorus (sodium bicarbonate extractable) 50 ppm

Potassium (ammonium acetate extractable) 200 ppm with a 1:10 soil to solution ratio

Calcium (ammonium acetate extractable) 7.8 meq/100 grams of soil with a 1:10 soil to solution ratio

Magnesium (ammonium acetate extractable) 2.4 meq/100 grams of soil with a 1:10 soil to solution ratio.

The land was spring plowed, pulverized, and packed to a fine firm condition. Before the final discing, agricultural lime was applied at 2½ tons per acre to the plots where lime was tested.

Foundation seed of Newport Kentucky bluegrass was planted on June 9, 1958, at 1/2 pound per acre in 30-inch rows and at 1 1/2 pounds per acre in 12-inch rows. Seedling establishment was promoted by banding ammonium sulfate below the seed and by sprinkler irrigation.

We used a factorial arrangement of treatments to evaluate the effects and interactions of rate and time of applied nitrogen, and effects of sulfur, lime,[3] row width, and herbicides on seed yields, seed quality, and total plant yields. Treatments were replicated three times in a randomized block design. The various treatments are listed in Table 1.

The plots were 10 feet x 25 feet. The wide row plots consisted of four 30-inch rows; the two middle rows were harvested for seed yields. The narrow row plots had 11 rows spaced one foot apart. These plots were completely filled in before the second seed crop. Two 30-inch strips were harvested from each plot for seed yields. The wide rows were maintained by cultivating in the fall with a 22-inch-wide rotary tiller. Spring-growing broadleaf weeds were controlled with 2,4-D (2,4-dichlorophenoxy acetic acid) and dicamba sprays. The herbicides being tested were applied in October. Fertilizers were applied about October 15 and March 15. Where S was needed, the first 25 pounds of N was applied as ammonium sulfate. All other N was applied as ammonium nitrate. Nickel sulfate-maneb sprays were used for rust control.

Seed was harvested with a shop-built mechanical plot harvester during the last week in June. The crop was cured outside in large burlap bags and threshed with an experimental plot thresher equipped with broad rubber cylinder and concave bars.[4] The plot materials were weighed before threshing to obtain mature plant yields. Seed was scoured with a bluegrass delinter and cleaned with a two-screen fanning mill.

Postharvest burning of the plots was done in August to remove crop residue, to enhance the effectiveness of the fall-applied herbicides, and to aid in pest control.

Yield data were analyzed with analysis of variance in the Department of Statistics, Oregon State University. Data from herbicide treatments were not obtained in 1962 because an overall application of chlorpropham (CIPC) and MCPA (2-methyl-4-chlorophenoxyacetic acid) was made to control red sorrel.

[3] The folowing symbols for plant nutrients will be used: N (nitrogen), L (lime), and S (sulfur).

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

Table 1. TREATMENT COMBINATIONS

No.	N applied[1] Fall	N applied[1] Spring	Lime applied	S applied	Row spacing	Herbicides applied Chlor-propham[2]	Herbicides applied Diuron[3]
	lbs./A	*lbs./A*	*T/A*	*lbs./A*	*inches*	*lbs./A*	*lbs./A*
1	0	0	0	0	30	0	0
2	25	25	0	29	30	0	0
3	50	50	0	29	30	0	0
4	75	75	0	29	30	0	0
5	100	100	0	29	30	0	0
6	25	25	2½	29	30	0	0
7	50	50	2½	29	30	0	0
8	75	75	2½	29	30	0	0
9	100	0	0	29	30	0	0
10	0	100	0	29	30	0	0
11	50	50	2½	29	30	3	0
12	50	50	2½	0	30	0	0
13	25	25	0	29	30	0	3
14	50	50	0	29	30	0	3
15	25	25	2½	29	30	0	3
16	50	50	2½	29	30	0	3
17	0	0	0	0	12	0	0
18	25	25	0	29	12	0	0
19	50	50	0	29	12	0	0
20	75	75	0	29	12	0	0
21	100	100	0	29	12	0	0
22	25	25	2½	29	12	0	0
23	50	50	2½	29	12	0	0
24	75	75	2½	29	12	0	0
25	100	0	0	29	12	0	0
26	0	100	0	29	12	0	0
27	50	50	2½	29	12	3	0
28	50	50	2½	0	12	0	0
29	25	25	0	29	12	0	3
30	50	50	0	29	12	0	3
31	25	25	2½	29	12	0	3
32	50	50	2½	29	12	0	3

[1] Where S was needed, the first 25 pounds of N was applied as ammonium sulphate. All other N was applied as ammonium nitrate. Chlorpropham and diuron were applied in mid-October.

[2] Isopropyl m-chlorocarbanilate.

[3] 3-(3,4-dichlorophenyl)-1, 1-dimethylurea.

RESULTS AND DISCUSSION

Data for the check plots and the chlorpropham (CIPC) plots were not included in the data analyses but are shown for comparisons in the tables. The check plot data were not analyzed because (1) we needed to compare responses from different amounts of applied N rather than to compare no N with the different N rates, and (2) the data would be meaningless to seed growers because they must use N fertilizers for profitable seed yields.

Seed Yields

Time of N application—effect on seed yield. Seed yield data for comparing different times of applying 100 pounds per acre of N are shown in Table 2. Applying all of the N in the fall or in split fall and spring applications produced seed yields that were higher than when all N was applied in the spring, except in 1964. These differences were highly significant (0.01) in 1961, significant (0.05) in 1963, and non-significant in 1962. The four-year average yields were slightly higher with fall N. Part of this difference was contributed by the unusually high yield of treatment 25 in 1961. Conversely, applying all N in the spring resulted in the highest seed yields in 1964. Differences in yield between all spring N and all fall N were highly significant (0.01), but

Table 2. INFLUENCE OF TIME OF N TREATMENT AND OF ROW SPACING ON SEED YIELDS OF NEWPORT KENTUCKY BLUEGRASS

Treat-ment no.	Treatments	Row spacing	Mean seed yields/acre				4-year average
			1961	1962	1963	1964	
		inches	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
1	Check (no fertilizer)	30	253	325	287	352	304
17	Check (no fertilizer)	12	315	657	302	356	407
3	N 50 fall + 50 spring	30	342	593	517	767	555
19	N 50 fall + 50 spring	12	467	1,219	743	1,005	858
	AVERAGE		404	906	630	886	706
9	N 100 fall + 0 spring	30	339	716	505	674	558
25	N 100 fall + 0 spring	12	765	1,100	779	934	894
	AVERAGE		552	908	642	804	726
10	N 0 fall + 100 spring	30	302	534	464	834	533
26	N 0 fall + 100 spring	12	428	1,112	629	1,109	819
	AVERAGE		365	823	546	971	676
30-inch rows, average			328	614	495	758	549
12-inch rows, average			553	1,144	717	1,016	857
LSD for time of N		0.05	120	ns	82	124	
		0.01	159	ns	ns	164	
LSD for row spacing		0.05	120	201	82	124	
		0.01	159	268	109	164	
LSD for TN x RS		0.05	169	ns	ns	ns	
		0.01	ns	ns	ns	ns	
CV (%)			29.5	21.9	12.3	13.2	

differences between all spring N and split fall and spring N were nonsignificant. This reversal in yield response to fall versus spring N in 1964 was probably caused by a dry, cold spring in which liberal N treatment was needed to stimulate spring growth. Little lodging occurred in the high N treatments in 1964, whereas in other years early and complete lodging followed applications of 150 and 200 pounds N per acre.

The interaction of time of N x row spacing was significant (0.05) only in 1961; the effects of fall versus spring N applied to 30-inch rows were similar, but in 12-inch rows fall-applied N resulted in 79% more seed. This difference could have been caused by variation of stands in the first year of production before the soil was uniformly occupied by the grass.

These results indicate that fall applications of N on Newport Kentucky bluegrass had about the same effect on seed yields as did split fall and spring N, and that bluegrass fields should receive substantial amounts of N in the fall.

Rate of N—effect on seed yield. The effects of N applied at different rates are shown in Table 3. Applications of N increased seed yields each year. Increases in yields with N rates above 50 pounds per acre were not significant in 1961 and 1962. However, as the stands aged, the yields from 100 pounds of N per acre were significantly higher than from the 50-pound rate. Four-year average yields were highest at the 100 pound per acre rate of N. Decreases in seed yields resulted from applications of N at 150 and 200 pounds per acre in 1961, 1962, and 1963. This adverse effect appeared to result from early, practically complete lodging which hindered subsequent pollination. Yields were not depressed by these high rates of N in 1964, when spring growth was retarded by prolonged cold, dry weather and little lodging occurred.

Higher seed yields were produced consistently with 12-inch rows, and yield increases from N were greater at this row spacing. Significant N x row spacing interactions occurred in 1962 and 1964.

Lime—effect on seed yield. Seed production was not significantly influenced by liming. Variation in yearly and four-year average yields was small (Table 3). A small but significant (0.05) interaction of L x row spacing occurred in 1963 when liming showed increased yield in 12-inch rows but not in 30-inch rows. Similar but nonsignificant effects of L x row spacing occurred in the other years and in the four-year averages. A significant (0.05) L x N interaction occurred in 1964. At the 50 pound per acre N rate, the no L treatment gave the highest yield: conversely, at the 150 pound per acre N rate, the L treatment was most productive. We concluded that liming had only minor influence on seed yields on this soil at this level of soil acidity.

Table 3. INFLUENCE OF N RATES, LIME, AND ROW SPACING ON SEED YIELDS OF NEWPORT KENTUCKY BLUEGRASS

Treat-ment no.	Treatments	Row spacing	Mean seed yields/acre 1961	1962	1963	1964	4-year average
		inches	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
1	Check (no fertilizer)	30	253	325	287	352	304
17	Check (no fertilizer)	12	315	657	302	356	407
	AVERAGE		284	491	294	354	355
2	N 50 without lime	30	350	561	550	644	526
18	N 50 without lime	12	449	1,007	594	678	682
	AVERAGE		399	784	572	661	604
6	N 50 with lime	30	350	551	533	701	534
22	N 50 with lime	12	585	1,075	757	805	805
	AVERAGE		467	813	645	753	669
	N 50, average		433	798	608	707	637
3	N 100 without lime	30	342	593	517	767	555
19	N 100 without lime	12	467	1,219	743	1,005	858
	AVERAGE		404	906	630	886	706
7	N 100 with lime	30	288	556	510	744	524
23	N 100 with lime	12	609	1,220	781	1,089	925
	AVERAGE		448	888	645	916	724
	N 100, average		426	897	638	901	715
4	N 150 without lime	30	256	535	491	839	530
20	N 150 without lime	12	508	848	615	1,161	783
	AVERAGE		382	691	553	1,000	656
8	N 150 with lime	30	326	748	468	677	555
24	N 150 with lime	12	414	984	652	1,056	776
	AVERAGE		370	866	560	866	665
	N 150, average		376	779	556	933	661
5*	N 200 without lime	30	233	394	449	603	420
21*	N 200 without lime	12	316	779	514	1,089	674
	AVERAGE		274	586	481	846	547
LSD for N rates		0.05	ns	ns	58	87	
		0.01	ns	ns	ns	116	
LSD for row spacing		0.05	69	116	47	71	
		0.01	92	155	63	95	
LSD for lime		0.05	ns	ns	ns	ns	
		0.01	ns	ns	ns	ns	
LSD for N x RS		0.05	ns	201	ns	124	
		0.01	ns	ns	ns	164	
LSD for L x RS		0.05	ns	ns	67	ns	
		0.01	ns	ns	ns	ns	
LSD for L x N		0.05	ns	ns	ns	124	
		0.01	ns	ns	ns	ns	
CV (%)			29.5	21.9	12.3	13.2	

* LSD's not applicable to these treatments.

Sulfur—effect on seed yield. Application of S did not influence seed production in 1961 and 1962. In 1963 and 1964, however, yield increases from application of S were significant (0.05) and highly significant (0.01), respectively (Table 4). These responses to S indicated that the reserves of S in the soil plus the S applied at planting were adequate for the first two years but not for continued high yields.

Table 4. INFLUENCE OF S AND OF ROW SPACING ON SEED YIELDS OF NEWPORT KENTUCKY BLUEGRASS

Treatment no.	Treatments[1]	Row spacing	Mean seed yields/acre 1961	1962	1963	1964	4-year average
		inches	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
1	Check (no fertilizer)	30	253	325	287	352	304
17	Check (no fertilizer)	12	315	657	302	356	407
7	S 29	30	288	556	510	744	524
23	S 29	12	609	1,220	781	1,089	925
	AVERAGE		449	888	645	916	724
12	S 0	30	288	492	385	614	445
28	S 0	12	637	1,262	701	861	865
	AVERAGE		462	877	543	737	655
LSD for S		0.05	ns	ns	82	124	
		0.01	ns	ns	ns	164	
LSD for row spacing		0.05	120	201	82	124	
		0.01	159	268	109	164	
LSD for S x RS		0.05	ns	ns	ns	ns	
		0.01	ns	ns	ns	ns	
CV (%)			25.9	21.9	12.3	13.2	

[1] All treatments except checks include N at 100 pounds per acre.

Row spacing—effect on seed yield. Culture in 12-inch rows resulted in consistently higher seed yields than in 30-inch rows. Differences were highly significant (0.01) each year (Tables 2, 3, 4, and 5). Although Newport Kentucky bluegrass is a vigorous variety, in this experiment it did not appear to utilize fully the moisture and nutrient resources of the soil when grown in 30-inch rows. When grown in 12-inch rows, however, full soil cover occurred and stands utilized the available moisture and nutrients more fully and gave substantial increases in seed yields.

Herbicides—effect on seed yield. Because the influence of diuron on seed yields was minor, yields were averaged across the various combinations with N and are summarized in Table 5.

The effect of diuron on seed yields was significant (0.05) and consistent only in 1964 when small increases occurred (Table 5). The chlorpropham treatments were not included in the analyses, but comparisons of treatment 11 with treatments 6 and 7, and treatment 27 with treatments 22 and 23 show that yield reductions usually followed application of chlorpropham (CIPC). A significant (0.05) herbicide x L interaction occurred in 1961 only, when without diuron the effect of lime was to increase seed yield (compare treatments 18 and 19 with treatments 22 and 23), but with diuron, liming decreased seed yield (compare treatments 29 and 30 with treatments 31 and 32). Because this effect was not consistent, its significance is questionable.

Table 5. Influence of Herbicide, Lime, and Row Spacing on Seed Yields of Newport Kentucky Bluegrass

Treat-ment no.	Treatments	Row spacing	Mean seed yields/acre 1961	1962	1963	1964	3-year average
		inches	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
11	Lime + chlorpropham	30	277	......	477	647	467
2, 3	No lime, no herbicide	30	346	......	533	705	528
6, 7	Lime, no herbicide	30	319	......	521	722	521
13, 14	No lime, diuron	30	256	......	494	811	520
15, 16	Lime + diuron	30	281	......	496	729	502
27	Lime + chlorpropham	12	376	......	743	880	666
18, 19	No lime, no herbicide	12	458	......	668	841	655
22, 23	Lime, no herbicide	12	597	......	769	947	771
29, 30	No lime, diuron	12	646	......	778	930	785
31, 32	Lime + diuron	12	478	......	732	997	735
LSD for diuron		0.05	ns	ns	ns	62	
		0.01	ns	ns	ns	ns	
LSD for row spacing		0.05	60	ns	29	62	
		0.01	80	ns	39	82	
LSD for lime		0.05	ns	ns	ns	ns	
		0.01	ns	ns	ns	ns	
LSD for diuron x RS		0.05	ns	ns	ns	ns	
		0.01	ns	ns	ns	ns	
LSD for diuron x L		0.05	85	ns	ns	ns	
		0.01	ns	ns	ns	ns	

Although seed yields in 12-inch rows probably benefited from reduced competition where herbicides were applied, the principal benefit was in the reduction of contamination from seeds of annual bluegrass (*Poa annua* L.). Weed competition in 30-inch rows was reduced by mechanical cultivation, and this may have reduced the influence of herbicides.

Seed Quality

Germination

Time of N application—effect on germination. Time of N treatment did not significantly influence germination of Kentucky bluegrass seeds. Neither was there a significant interaction of time of N x row spacing (Table 6).

Table 6. INFLUENCE OF TIME OF N APPLICATION AND OF ROW SPACING ON GERMINATION OF NEWPORT KENTUCKY BLUEGRASS SEEDS

Treat-ment no.	Treatments	Row spacing	Germination means 1961	1962	1963	1964	4-year average
		inches	%	%	%	%	%
1	Check (no fertilizer)	30	81.16	91.50	82.17	82.08	84.23
17	Check (no fertilizer)	12	82.83	93.00	75.17	80.25	82.81
3	N 50 fall + 50 spring	30	78.49	93.00	81.83	84.83	84.54
19	N 50 fall + 50 spring	12	82.66	92.83	77.33	87.08	84.97
	AVERAGE		80.57	92.91	79.58	85.95	84.75
9	N 100 fall + 0 spring	30	82.16	91.17	77.67	86.50	84.37
25	N 100 fall + 0 spring	12	84.82	94.00	78.50	86.58	85.97
	AVERAGE		83.49	92.58	78.08	86.54	85.17
10	N 0 fall + 100 spring	30	84.66	92.00	80.67	87.00	86.08
26	N 0 fall + 100 spring	12	85.32	93.67	75.50	86.42	85.23
	AVERAGE		84.99	92.83	78.08	86.71	85.65
30-inch rows, average			81.77	92.06	80.05	86.11	85.00
12-inch rows, average			84.27	93.50	77.11	86.69	85.39
LSD for time of N		0.05	ns	ns	ns	ns	
		0.01	ns	ns	ns	ns	
LSD for row spacing		0.05	ns	ns	ns	ns	
		0.01	ns	ns	ns	ns	
LSD for TN x RS		0.05	ns	ns	ns	ns	
		0.01	ns	ns	ns	ns	
			4.7	2.4	6.8	2.9	

Rate of N—effect on germination. Germination of Kentucky bluegrass seed was influenced by rate of N (Table 7). Usually the heavier N treatments stimulated early rank growth and resulted in early lodging. Seeds developing in the matted material were of low quality. Considerable seed injury occurred in 1961 because lodging resulted in matting and molding of the developing seedheads on the moist soil. Conditions for seed development were better in 1962, but some lodging and reduction of germination occurred with the high rates of N. Seed

Table 7. INFLUENCE OF N RATES, LIME, AND ROW SPACING ON GERMINATION OF NEWPORT KENTUCKY BLUEGRASS SEEDS

Treatment no.	Treatments	Row spacing	Germination means 1961	1962	1963	1964	4-year average
		inches	*%*	*%*	*%*	*%*	*%*
1	Check (no fertilizer)	30	81.16	91.50	82.17	82.08	84.23
17	Check (no fertilizer)	12	82.83	93.00	75.17	80.25	82.81
	AVERAGE		81.99	92.25	78.67	81.16	83.52
2	N 50 without lime	30	82.82	93.00	69.00	85.92	82.68
18	N 50 without lime	12	81.99	90.30	72.50	80.08	81.22
	AVERAGE		82.40	91.65	70.75	83.00	81.95
6	N 50 with lime	30	80.83	91.50	79.00	86.00	84.33
22	N 50 with lime	12	81.99	93.30	77.83	83.33	84.11
	AVERAGE		81.41	92.40	78.41	84.66	84.22
	N 50, average		81.91	92.02	74.58	83.83	83.08
3	N 100 without lime	30	78.49	93.00	81.83	84.83	84.54
19	N 100 without lime	12	82.66	92.83	77.33	87.08	84.97
	AVERAGE		80.57	92.91	79.58	85.95	84.75
7	N 100 with lime	30	82.16	92.17	79.17	85.08	84.64
23	N 100 with lime	12	83.16	93.67	83.67	86.33	86.71
	AVERAGE		82.66	92.92	81.42	85.70	85.67
	N 100, average		81.62	92.92	80.50	85.83	85.21
4	N 150 without lime	30	72.33	90.83	76.00	86.67	81.46
20	N 150 without lime	12	82.66	91.00	79.33	85.75	84.68
	AVERAGE		77.49	90.91	77.66	86.21	83.07
8	N 150 with lime	30	78.83	89.83	74.83	84.83	82.08
24	N 150 with lime	12	78.83	92.33	83.50	88.75	85.85
	AVERAGE		78.83	91.08	79.16	86.79	83.96
	N 150, average		78.16	91.00	78.41	86.50	83.52
5*	N 200 without lime	30	75.99	89.50	79.17	86.42	82.77
21*	N 200 without lime	12	75.33	91.67	80.17	89.17	84.08
	AVERAGE		75.66	90.58	79.67	87.79	83.42
LSD for N rates		0.05	3.09	ns	4.37	2.00	
		0.01	ns	ns	ns	ns	
LSD for row spacing		0.05	2.52	ns	ns	ns	
		0.01	ns	ns	ns	ns	
LSD for lime		0.05	ns	ns	3.57	ns	
		0.01	ns	ns	ns	ns	
LSD for N x RS		0.05	ns	ns	ns	2.83	
		0.01	ns	ns	ns	3.76	
LSD for L x RS		0.05	ns	ns	ns	ns	
		0.01	ns	ns	ns	ns	
LSD for L x N		0.05	ns	ns	ns	ns	
		0.01	ns	ns	ns	ns	
CV (%)			4.7	2.4	6.8	2.9	

* LSD's not applicable to these treatments.

injury occurred indiscriminately in 1963 because of moist weather. The significant (0.05) effect of N in that year probably means nothing in relation to the rates of N. The 1964 spring season was dry and cool; little lodging occurred and injury to the developing seeds was minimized. As the N rate increased from 0 to 200 pounds per acre in 1964, the average germination values increased significantly (0.05) (Table 7). Perhaps the drouth resulted in nutritional deficiency at the lower N rates during seed maturation.

Table 7 shows a highly significant (0.01) N x row spacing interaction in 1964. Germination was higher in 30-inch rows with 50 pounds per acre of N, but at the higher N rates, germination was higher in 12-inch rows. The relationship of N rate to row spacing was not consistent from year to year.

These data indicate that high N is not a direct cause of low germination, but rather that low seed quality results when early lodging follows large quantities of applied N.

Lime—effect on germination. Lime had little influence on germination (Table 7). Although average germination showed a small increase with L, a significant (0.05) effect of L was indicated in 1963 only. This was the year in which weather-damaged seeds showed erratic germination which reduced the chances of a real effect of L. There was no interaction of L x row spacing or L x nitrogen.

Sulfur—effect on germination. Although analyses of seed yield data indicated a S deficiency in 1963 and 1964, S did not influence germination (Table 8). No interactions with other treatments were indicated.

Row spacing—effect on germination. Row spacing influenced germination significantly (0.05) in 1961 only (Tables 7 and 8). Seed from some treatments in 30-inch rows was low in germination; this may have resulted from lodging and consequent matted masses of seedheads which became moist and moldy with prolonged contact with the soil between the rows.

Herbicides—effect on germination. Herbicides had no significant effect on germination. Neither were there significant interactions of herbicide x L or herbicide x row spacing. To present tabular data for diuron in a condensed form, germination percentages were averaged across rates of N (Table 9). The chlorpropham (CIPC) treatments were not included in the analysis of the data, but the results are shown for comparison.

Weight of 1,000 seeds

Time of N application—effect on weight of 1,000 seeds. Nitrogen applied in the spring at 100 pounds per acre resulted in consistently greater weight of 1,000 seeds (Table 10) than when applied in the

Table 8. INFLUENCE OF S AND ROW SPACING ON GERMINATION OF NEWPORT KENTUCKY BLUEGRASS SEEDS

Treat-ment no.	Treatments	Row spacing	Germination means 1961	1962	1963	1964	4-year average
		inches	%	%	%	%	%
1	Check (no fertilizer)	30	81.16	91.50	82.17	82.08	84.23
17	Check (no fertilizer)	12	82.83	93.00	75.17	80.25	82.81
7	S 29	30	82.16	92.17	79.17	85.08	84.64
23	S 29	12	83.16	93.67	83.67	86.33	86.71
	AVERAGE		82.66	92.92	81.42	85.70	85.67
12	S 0	30	75.66	92.17	84.17	84.33	84.08
28	S 0	12	84.66	91.33	83.50	85.67	86.29
	AVERAGE		80.16	91.75	83.83	85.00	85.18
30-inch rows, average			78.91	92.17	81.67	84.70	84.36
12-inch rows, average			83.91	92.50	83.58	86.00	86.50
LSD for S		0.05	ns	ns	ns	ns	
		0.01	ns	ns	ns	ns	
LSD for row spacing		0.05	4.37	ns	ns	ns	
		0.01	ns	ns	ns	ns	
LSD for S x RS		0.05	ns	ns	ns	ns	
		0.01	ns	ns	ns	ns	
CV (%)			4.7	2.4	6.8	2.9	

Table 9. INFLUENCE OF HERBICIDES, LIME, AND ROW SPACING ON GERMINATION OF NEWPORT KENTUCKY BLUEGRASS SEEDS

Treat-ment no.	Treatments	Row spacing	Germination means 1961	1962	1963	1964	3-year average
		inches	%	%	%	%	%
1	Check	30	81.16	....	82.17	82.83	82.05
17	Check	12	82.83	....	75.17	80.25	79.42
11	Chlorpropham + lime	30	77.99	....	75.33	82.67	78.66
2, 3	Herbicide 0 + lime 0	30	80.65	....	75.41	85.37	80.48
6, 7	Herbicide 0 + lime	30	81.49	....	79.08	85.54	82.04
13, 14	Diuron + lime 0	30	81.16	....	79.91	85.29	82.12
15, 16	Diuron + lime	30	81.91	....	80.83	84.37	82.37
30-inch rows, average			80.64	....	78.11	84.65	81.13
27	Chlorpropham + lime	12	78.99	....	78.67	83.58	80.41
18, 19	Herbicide 0 + lime 0	12	82.32	....	74.91	83.58	80.27
22, 23	Herbicide 0 + lime	12	82.57	....	80.75	84.83	82.72
29, 30	Diuron + lime 0	12	82.82	....	79.83	84.20	82.28
31, 32	Diuron + lime	12	78.74	....	80.50	84.75	81.33
12-inch rows, average			81.09	....	78.93	84.19	81.40
Lime 0, average			81.74	....	77.51	84.61	81.29
Lime, average			81.18	....	80.29	84.87	82.11
Herbicide 0, average			81.76	....	77.54	84.83	81.38
Diuron, average			81.16	....	80.27	84.65	82.02

Table 10. INFLUENCE OF TIME OF N TREATMENT AND OF ROW SPACING ON WEIGHT OF 1,000 SEEDS OF NEWPORT KENTUCKY BLUEGRASS

Treat-ment no.	Treatments	Row spacing	Wt. of 1,000 seeds (means) 1961	1962	1963	1964	4-year average
		inches	*mg*	*mg*	*mg*	*mg*	*mg*
1	Check (no fertilizer)	30	279	376	340	341	334
17	Check (no fertilizer)	12	289	364	330	347	332
3	N 50 fall + 50 spring	30	256	373	319	353	325
19	N 50 fall + 50 spring	12	282	371	321	357	333
	AVERAGE		269	372	320	355	329
9	N 100 fall + 0 spring	30	275	363	314	342	323
25	N 100 fall + 0 spring	12	268	348	333	343	323
	AVERAGE		271	355	323	342	323
10	N 0 fall + 100 spring	30	278	382	323	366	337
26	N 0 fall + 100 spring	12	278	391	348	376	348
	AVERAGE		278	386	335	371	342
30-inch rows, average			270	373	319	354	328
12-inch rows, average			276	370	334	359	335
LSD for time of N		0.05	ns	14	ns	11	
		0.01	ns	19	ns	15	
LSD for row spacing		0.05	ns	ns	14	ns	
		0.01	ns	ns	18	ns	
LSD for TN x RS		0.05	ns	ns	ns	ns	
		0.01	ns	ns	ns	ns	
CV (%)			5.1	3.2	3.7		

fall. Differences were highly significant in 1962 and 1964. Split fall and spring applications of N usually resulted in seeds that were heavier than those from fall applications. However, differences in weight were significant (0.05) in 1964 only. There were no interactions with row spacing.

Because seed yields were usually higher (Table 2) and weight of 1,000 seeds was always lower with fall-applied N, the increased seed yields must have resulted from greater numbers of seeds.

Rate of N—effect on weight of 1,000 seeds. Reduction in weight of 1,000 seeds was associated with high rates of N in 1961 and 1963 when early lodging was most prevalent (Table 11). However, differences were significant (0.05) only in 1963. Lodging, especially when it occurs early, is detrimental to pollination and to good development of seeds. Conversely, average weights of 1,000 seeds varied little under the different rates of N in 1962; again in 1964, with cool temperatures and low rainfall, lodging was minimal. This indicated that when high

Table 11. INFLUENCE OF N RATES, LIME, AND ROW SPACING ON WEIGHT OF 1,000 SEEDS OF NEWPORT KENTUCKY BLUEGRASS

Treat-ment no.	Treatments	Row spacing	Wt. of 1,000 seeds (means) 1961	1962	1963	1964	4-year average
		inches	*mg*	*mg*	*mg*	*mg*	*mg*
1	Check (no fertilizer)	30	279	376	340	341	334
17	Check (no fertilizer)	12	289	364	330	347	332
	AVERAGE		284	370	335	344	333
2	N 50 without lime	30	278	376	317	352	331
18	N 50 without lime	12	273	373	337	350	333
	AVERAGE		275	374	327	351	332
6	N 50 with lime	30	265	374	321	352	328
22	N 50 with lime	12	257	374	326	352	327
	AVERAGE		261	374	323	352	327
	N 50, average		268	374	325	351	330
3	N 100 without lime	30	262	373	319	353	327
19	N 100 without lime	12	282	371	321	357	333
	AVERAGE		272	372	320	355	330
7	N 100 with lime	30	257	365	318	357	324
23	N 100 with lime	12	257	370	339	352	329
	AVERAGE		257	367	328	354	326
	N 100, average		264	370	324	355	328
4	N 150 without lime	30	256	375	302	359	323
20	N 150 without lime	12	267	376	321	355	330
	AVERAGE		261	375	311	357	326
8	N 150 with lime	30	260	368	304	353	321
24	N 150 with lime	12	245	363	323	348	320
	AVERAGE		252	365	313	350	320
	N 150, average		257	370	312	354	323
5*	N 200 without lime	30	252	387	318	356	328
21*	N 200 without lime	12	247	373	295	362	319
	AVERAGE		249	380	306	359	323
LSD for N rate		0.05	ns	ns	10	ns	
		0.01	ns	ns	ns	ns	
LSD for row spacing		0.05	ns	ns	8	ns	
		0.01	ns	ns	11	ns	
LSD for lime		0.05	9	ns	ns	ns	
		0.01	ns	ns	ns	ns	
LSD for N x RS		0.05	ns	ns	ns	ns	
		0.01	ns	ns	ns	ns	
LSD for L x RS		0.05	ns	ns	ns	ns	
		0.01	ns	ns	ns	ns	
LSD for L x N		0.05	ns	ns	ns	ns	
		0.01	ns	ns	ns	ns	
CV (%)			5.1	3.2	3.7		

* LSD's not applicable to these treatments.

Table 12. EFFECT OF FERTILIZER ON WEIGHT OF 1,000 SEEDS AND PERCENT CARYOPSES AND HULLS IN NEWPORT KENTUCKY BLUEGRASS (1964)

Treat-ment no.	Treatments	Weight of 1,000 seeds					Cary-opses and hulls
		Rep. I	Rep. II	Rep. III	Totals	Means	
		mg	*mg*	*mg*	*mg*	*mg*	%
17	Check (no fertilizer)						
	Whole seeds	350	357	360	1,067	356	
	Caryopses	–220	–228	–235	683	–228	64
	Lemma and palea	130	129	125		128	36
21	N 200 + S 29						
	Whole seeds	358	381	351	1,090	363	
	Caryopses	–245	–275	–243	763	–254	70
	Lemma and palea	113	106	108		109	30

N rates were accompanied by reduced seed quality the reduction was not the direct result of abundant N.

A highly significant (0.01) N x row spacing interaction occurred in 1963 when 50 and 150 pounds N per acre had the highest weight of 1,000 seeds in 12-inch rows, and 200 pounds N per acre had the highest value in 30-inch rows. Because this interaction was present only once in four years, it may have occurred by chance.

To determine the influence of a high soil fertility level on percent caryopsis (kernel) in Kentucky bluegrass, we compared 1964 crop seeds from all replications of treatments 17 and 21 (Table 1). Seeds from the 1964 crop were chosen because seed development was not hindered by lodging that year. One 1,000-seed sample was counted from each lot and weighed (compare treatments 17 and 21 in Table 12 with the same treatments for 1964 in Table 11), then rubbed gently between canvas surfaces to remove the lemma and palea. After blowing to separate the chaff, the caryopses were weighed and the percent of loss was calculated (Table 12). High nutrient level did not result in increased or decreased weight of the individual seeds in 1964 when no lodging occurred. This observation agrees generally with the results from 1964 shown in Table 11. However, the data in Table 12 indicate that high fertility increased the proportion of caryopsis in relation to total weight of the seed. This, presumably, increased seed quality.

Lime—effect on weight of 1,000 seeds. Liming had little effect on the weight of 1,000 seeds. Four-year averages for effects of lime versus no lime on the weight of 1,000 seeds were about equal (Table 11). However, in 1961, seeds from limed plots were significantly (0.05) lower in the weight of 1,000 seeds. This lone significant effect of lime may not have been real.

Sulfur—effect on weight of 1,000 seeds. Sulfur treatment influenced the weight of 1,000 seeds in 1964 only (Table 13), when the S treatment resulted in an increase that was highly significant (0.01). No interaction with row spacing was evident. The increase of seed weight may have been real because it occurred in both 30-inch and 12-inch row means. Perhaps the S supply was adequate during the first three years but became deficient in the final year. Responses of legumes to added S are readily measured on this soil; responses in grass seed crops have not been so consistent or so definite.

Table 13. INFLUENCE OF SULFUR AND ROW SPACING ON WEIGHT OF 1,000 SEEDS OF NEWPORT KENTUCKY BLUEGRASS

Treatment no.	Treatments	Row spacing	Wt. of 1,000 seeds (means) 1961	1962	1963	1964	4-year average
		inches	*mg*	*mg*	*mg*	*mg*	*mg*
1	Check	30	279	376	340	341	334
17	Check	12	289	364	330	347	332
7	S 29	30	257	365	318	357	324
23	S 29	12	257	370	339	352	329
	AVERAGE		257	367	328	354	326
12	S 0	30	253	370	330	335	322
28	S 0	12	251	370	328	337	321
	AVERAGE		252	370	329	336	321
30-inch rows, average			255	367	324	346	323
12-inch rows, average			254	370	333	344	325
LSD for S		0.05	ns	ns	ns	11.3	
		0.01	ns	ns	ns	15.0	
LSD for row spacing		0.05	ns	ns	ns	ns	
		0.01	ns	ns	ns	ns	
LSD for S x RS		0.05	ns	ns	ns	ns	
		0.01	ns	ns	ns	ns	
CV (%)			5.1	3.2	3.7		

Row spacing—effect on weight of 1,000 seeds. Row spacing influenced the weight of 1,000 seeds in 1963 only. Differences were highly significant (0.01) (Tables 10 and 11). Early and almost complete lodging occurred in 1963, especially in the 30-inch rows. This probably reduced seed weight and caused the highly significant difference between row spacings. Even though these differences were significant in only one year, they seem to be real.

Herbicides—effect on weight of 1,000 seeds. Because the significant differences between herbicide treatments were few, treatments involving herbicides were averaged across two rates of N for presentation in Table 14.

The general effect of herbicides in 1961 was to decrease the weight of 1,000 seeds; differences were highly significant. The difference in 1961 seemed to be the result of (a) low values for treatments 31 and 32, which received both herbicide and lime; and (b) high values for treatments 2, 3, 18, and 19, which received neither herbicide nor lime. Differences in other years were usually small. There were no herbicide x row spacing interactions. These isolated instances of the influence of herbicides on the weight of 1,000 seeds indicated that the effects of diuron and chlorpropham (CIPC) were minor. There were no herbicide x lime interactions.

Table 14. Effect of Herbicides, Lime, and Row Spacing on Weight of 1,000 Seeds of Newport Kentucky Bluegrass

Treat-ment no.	Treatments	Row spacing	Wt. of 1,000 seeds (means) 1961	1962	1963	1964	3-year average
		inches	*mg*	*mg*	*mg*	*mg*	*mg*
1	Check	30	279	......	340	341	320
17	Check	12	289	......	330	347	322
11	Lime + chlorpropham	30	265	......	319	361	315
2, 3	No lime, no herbicide	30	270	......	318	352	313
6, 7	Lime, no herbicide	30	261	......	319	354	312
13, 14	No lime, diuron	30	250	......	331	364	315
15, 16	Lime + diuron	30	359	......	329	361	316
27	Lime + chlorpropham	12	256	......	333	350	313
18, 19	No lime, no herbicide	12	277	......	329	353	320
22, 23	Lime, no herbicide	12	257	......	332	352	314
29, 30	No lime, diuron	12	254	......	336	355	315
31, 32	Lime + diuron	12	244	......	327	352	307

Mature Plant Yield

Data on this phase of the experiment were not obtained in 1964.

Time of N application—effect on mature plant yield. Contrary to expectations, spring-applied N usually resulted in less total plant yield than fall, or split fall and spring applications of N (Table 15). Differences were significant (0.05) in 1963 only. Yield reductions may have resulted from suppression of late spring growth by the heavy mat of lodged plant material that followed application of all N in the spring.

Table 15. INFUENCE OF TIME OF N APPLICATION AND ROW SPACING ON MATURE PLANT YIELDS OF NEWPORT KENTUCKY BLUEGRASS

Treat-ment no.	Treatments	Row spacing	Mean yields per acre 1961	1962	1963	3-year average
		inches	*lbs.*	*lbs.*	*lbs.*	*lbs.*
1	Check (no fertilizer)	30	1,360	1,250	1,650	1,420
17	Check (no fertilizer)	12	1,260	2,410	1,090	1,587
3	N 50 fall + 50 spring	30	3,130	4,680	5,690	4,500
19	N 50 fall + 50 spring	12	4,030	7,060	4,890	5,327
	AVERAGE		3,580	5,870	5,290	4,913
9	N 100 fall + 0 spring	30	2,910	4,380	5,490	4,260
25	N 100 fall + 0 spring	12	4,550	6,180	4,910	5,213
	AVERAGE		3,730	5,280	5,200	4,736
10	N 0 fall + 100 spring	30	2,710	4,170	4,610	3,830
26	N 0 fall + 100 spring	12	4,170	6,760	4,360	5,097
	AVERAGE		3,440	5,465	4,485	4,463
30-inch rows, average			2,917	4,410	5,263	4,197
12-inch rows, average			4,250	6,667	4,720	5,212
LSD for time of N		0.05	ns	ns	629	
		0.01	ns	ns	ns	
LSD for row spacing		0.05	685	946	ns	
		0.01	911	1,265	ns	
LSD for TN x RS		0.05	ns	ns	ns	
		0.01	ns	ns	ns	
CV (%)			18.0	15.7	12.1	

Rate of N—effect on mature plant yield. The effects of N in stimulating plant production caused differences that were highly significant (0.01) in 1962 and 1963 (Table 16), and nonsignificant in 1961 when the stand had not fully occupied the soil. Over three years there was little difference in average yield between the 100, 150, and 200 pounds per acre N treatments. All were substantially higher in total plant yield than the 50 pound per acre treatment.

Lime—effect on mature plant yield. Lime had little effect on plant production; differences were not significant (Table 16). A significant (0.05) L x N interaction occurred in 1961. This may have occurred by chance in the 12-inch rows when, without lime, the 150 pound per acre N treatment outyielded the 50 pound per acre N treatment, and with lime, the 50 pound per acre N treatment outyielded the 150 pound per acre N treatment.

Sulfur—effect on mature plant yield. Yields in 1961 and 1962 were slightly lower after the S application but not significantly so. In

Table 16. INFLUENCE OF N RATE, LIME, AND ROW SPACING ON MATURE PLANT YIELDS OF NEWPORT KENTUCKY BLUEGRASS

Treat-ment no.	Treatments	Row spacing	Mean yields per acre 1961	1962	1963	3-year average
		inches	lbs.	lbs.	lbs.	lbs.
1	Check (no fertilizer)	30	1,360	1,250	1,650	1,420
17	Check (no fertilizer)	12	1,260	2,410	1,090	1,587
2	N 50 without lime	30	2,820	3,200	4,620	3,547
18	N 50 without lime	12	2,740	4,550	2,310	3,200
	AVERAGE		2,780	3,875	3,465	3,373
6	N 50 with lime	30	2,720	3,390	4,160	3,423
22	N 50 with lime	12	4,360	6,420	3,460	4,747
	AVERAGE		3,540	4,905	3,810	4,085
	N 50, average		3,160	4,390	3,637	3,729
3	N 100 without lime	30	3,130	4,680	5,690	4,500
19	N 100 without lime	12	4,030	7,060	4,890	5,327
	AVERAGE		3,580	5,870	5,290	4,913
7	N 100 with lime	30	2,790	3,950	5,560	4,100
23	N 100 with lime	12	4,330	7,290	4,920	5,513
	AVERAGE		3,560	5,620	5,240	4,806
	N 100, average		3,570	5,745	5,265	4,860
4	N 150 without lime	30	2,830	4,530	5,220	4,193
20	N 150 without lime	12	4,660	7,770	5,170	5,867
	AVERAGE		3,745	6,150	5,195	5,030
8	N 150 with lime	30	3,360	4,630	5,310	4,433
24	N 150 with lime	12	3,820	7,220	5,270	5,437
	AVERAGE		3,590	5,925	5,290	4,935
	N 150, average		3,667	6,037	5,242	4,982
5*	N 200 without lime	30	3,060	4,040	5,300	4,133
21*	N 200 without lime	12	3,690	8,100	4,740	5,510
	AVERAGE		3,375	6,070	5,020	4,821
LSD for N		0.05	ns	669	445	
		0.01	ns	895	591	
LSD for row spacing		0.05	396	546	363	
		0,01	526	730	483	
LSD for lime		0.05	ns	ns	ns	
		0.01	ns	ns	ns	
LSD for N x RS		0.05	ns	ns	629	
		0.01	ns	ns	836	
LSD for L x RS		0.05	ns	ns	ns	
		0.01	ns	ns	ns	
LSD for L x N		0.05	685	ns	ns	
		0.01	ns	ns	ns	
CV (%)			18.0	15.7	12.1	

* LSD's not applicable to these treatments.

1963, however, highly significant (0.01) increases followed S treatments (Table 17). This occurrence was further indication that the supply of S in the soil was adequate for the 1961 and 1962 crops but became limiting in 1963 and 1964. No interactions of S x row spacing occurred.

Table 17. INFLUENCE OF S AND ROW SPACING ON MATURE PLANT YIELDS OF NEWPORT KENTUCKY BLUEGRASS

Treatment no.	Treatments	Row spacing	Mean yields per acre 1961	1962	1963	3-year average
		inches	*lbs.*	*lbs.*	*lbs.*	*lbs.*
1	Check (no fertilizer)	30	1,360	1,250	1,650	1,420
17	Check (no fertilizer)	12	1,260	2,410	1,090	1,587
7	S 29	30	2,790	3,950	5,560	4,100
23	S 29	12	4,330	7,290	4,920	5,513
	AVERAGE		3,560	5,620	5,240	4,806
12	S 0	30	2,990	4,240	4,220	3,817
28	S 0	12	4,710	7,350	4,150	5,403
	AVERAGE		3,850	5,795	4,185	4,610
	30-inch rows, average		2,890	4,095	4,890	3,958
	12-inch rows, average		4,520	7,320	4,535	5,458
	LSD for S	0.05	ns	ns	629	
		0.01	ns	ns	836	
	LSD for row spacing	0.05	685	946	ns	
		0.01	911	1,265	ns	
	LSD for S x RS	0.05	ns	ns	ns	
		0.01	ns	ns	ns	
	CV (%)		18.0	15.7	12.1	

Row spacing—effect on mature plant yield. Twelve-inch rows produced greater yields than 30-inch rows in 1961 and 1962; in 1963, 30-inch rows outyielded the 12-inch rows (Tables 16 and 17). Differences in each case were highly significant (0.01). Reasons for the low yields of 12-inch rows in 1963 are obscure. Heavy lodging and matting over large areas in the 12-inch row plots may have limited late spring growth, but little lodging occurred in the check plots. There were no N x row spacing interactions. A highly significant N x row spacing interaction occurred in 1964.

The mature plant yields produced indicate the amounts of crop residue that remain after a seed crop of bluegrass has been harvested. Some yields were about 4 tons per acre.

Herbicides—effect on mature plant yield. Data were available for herbicides in 1961 and 1963. No effects of herbicides on mature plant yields were indicated; tabular presentation of the data is omitted.

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. Buckner, Robert C., and Paul Burrus, Jr. 1959. The effect of certain management and fertilization practices on seed production of Kentucky bluegrass (abs.). Assoc. South. Agric. Workers Proc., *56*:66-67.
3. Canode, C. L., and W. C. Robocker. 1967. Chemical control of red sorrel in Kentucky bluegrass seed fields. Weeds, *15*:351-353.
4. Canode, C. L. 1968. Influence of row spacing and nitrogen fertilization on grass seed production. Agron. Jour., *60*:263-267.
5. Evans, Morgan W. 1949. Kentucky bluegrass. Research Bulletin 681, Ohio Agric. Expt. Sta., Wooster, Ohio.
6. Furtick, W. R., and D. O. Chilcote. 1957. Chemical weed control in grass seed crops. Oregon Agric. Expt. Sta. Cir. of Info. 551, rev.
7. Garrison, C. S. 1960. Technological advances in grass and legume seed production and testing: 1. Maintaining varietal purity and cultural and management practices. In: *Advances in Agronomy*, Vol. 12, pp. 42-71. Academic Press: New York and London.
8. Lee, William O. 1966. Effect of annual applications of diuron on seed yields of perennial grasses in Oregon. Tech. Bull. 1358, Agricultural Research Service, USDA, in cooperation with Oregon Agric. Expt. Sta. Washington, D. C.
9. Pumphrey, F. V. 1965. Fertilizing Kentucky bluegrass and fine fescue for seed production in northeastern Oregon. Oregon Agric. Expt. Sta. Bull. 601. Oregon State Univ., Corvallis.
10. 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.
11. Schwanbom, N., and K. Froier. 1949. Methods of herbage seed production. Jour. Brit. Grasslands Soc., *4*:233-255.
12. Spencer, J. T., H. H. Jewett, and E. N. Fergus. 1949. Seed production of Kentucky bluegrass as influenced by insects, fertilizers, and sod management. Kentucky Agric. Expt. Sta. Bull. 535. Univ. of Kentucky, Lexington.
13. Summer, D. C., John R. Goss, and Byron R. Houston. 1958. Merion bluegrass seed production. California Agric. Expt. Sta. Ext. Serv. Circ. 470. Univ. of Calif., Davis.
14. Thomas, H. L., 1960. Kentucky bluegrass seed production in Minnesota. Proc. 1960 Turf Conf., Midwest Regional Turf Foundation and Purdue Univ., Lafayette, Indiana. March 7-9.
15. Warren, Rex. 1968. Weed control recommendations for grass seed crops. Oregon State Univ. Coop. Ext. Serv. FS 59.