The Management of Buffalograss
Buchloe dactyloides (Nutt.) Engelm.
for Seed Production in Oklahoma

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Buffalograss, a major range plant adapted to the wide range of climatic conditions existing in the semi-arid plains region, received much attention from the standpoint of evaluation and improvement during the 1930's and 1940's. The demand for seed has been such that various means have been used to encourage wild seed harvests and the storage of reserve seed. Although the demand is not as great today, a considerable amount of seed is still utilized in reseeding programs. The seed used is generally harvested from wild native stands, lacking the productivity and quality of improved varieties.

The commercial production of seed of improved native grass varieties by growers is often discouraged 1) by the competition from low cost wild harvest seed. 2) by the lack of accurate methods for determining seed quality which influences the value and movement of such seed in commercial channels, and 3) by insufficient information regarding the best cultural and management practices for producing maximum seed yields. The general trend of agriculture in the Southern Plains region has been toward a reduction of cultivated acres and an increase in grass seedings. It is expected that this trend will continue for some time and that there will be a demand for high quality seeds of known varieties. Grass seed growers who follow good cultural and management practices should find a profitable market for grass seeds despite the occasional strong competition from periodic large wild harvests.

Literature Review

Buffalograss is a low-growing, dioecious, stoloniferous plant that will produce a dense sod when grown in pure stands. Its nutritive value, ability to spread under over-grazed conditions and ability to withstand dry climatic conditions have created some interest in its potential as a range grass for arid conditions in Argentina (2).

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The amount of published literature dealing with buffalograss and its wide use is evidence of its value and importance as a range plant. Literature during the period of 1930 to 1950 covered variation, morphology, distribution, origin, chemical composition, seed production, seed processing, germination, and establishment. Rather extensive literature surveys up to 1950 were made by Beetle (1), Wenger (13, 14) and Webb (11).

The major problems in the production of buffalograss seed have been 1) low yields, 2) weed control, 3) disease, and 4) harvesting. Buffalograss produces seed only on the female plant, therefore the ratio of male to female plants in an established area has a direct bearing on subsequent yield. Seed yields from native stands have been reported as low as 10 pounds and as high as 100 pounds of burs per acre. Under irrigation, however, yields have been quite high in both forage and seed. Yields of more than 1,000 pounds of seed burs per acre were produced from selected strains at Hays, Kansas, (13) each year over a 4-year period of study. Fertilization of irrigated seed production blocks gave no response in seed or forage produced. Wenger (14) states that forcing buffalograss by irrigation speeds up the natural tendency for the grass to reach the state of unresponsiveness and that after 3 to 5 years of irrigation plant vigor and weed competition are such that it is no longer profitable to irrigate.

When irrigation is practiced, weed control is a serious problem. Most literature only lightly touches the weed problem and suggests mowing as the best means of control. Meenen and Timmons (8) effectively controlled broadleaved weeds by timed applications of 2,4-D (2,4-dichlorophenoxy acetic acid). However, the infestation of weedy annual grasses following the applications of 2,4-D obscured the effect. Similarly, annual applications of fertilizer seemed to stimulate the growth of weeds.

The number of seed burs per pound of buffalograss is directly related to seed-set or quality and yield. The number of burs containing caryopses required to equal a pound of seed is much smaller than those which are empty. Seeding rates suggested by Harlan et al. (6) were based on an average of 50,000 burs per pound of pure-seed. Wenger (14) lists the average number of burs to a pound of seed as 36,500, the best quality having 30,240 and the poorest 46,286 burs per pound. The number of burs, both filled and empty, from a particular seed lot was calculated by Brown (3) as 73,532 per pound; whereas the number per pound of burs containing one or more caryopses per bur was calculated as 55,116.

The caryopses content of seed burs has never been reported to average more than three. Since there are from 2 to 5 spikelets in each bur, an average of 3 or even 2 caryopses per bur would appear to indicate a very good seed-set. The majority of the burs examined by Pladeck (9) contained from 1 to 2 caryopses, with a few containing 3 or 4. Webb (11) obtained an everage of 3 caryopses from 198 burs containing 594 caryopses. Although a few burs examined by Hensel (7) contained 4 caryopses, he was unable to obtain an average of more than 1.1 caryopses per bur.

Eighty-six percent of the buffalograss caryopses examined by Gernert (4) were found to be infested with fungi such as *Cercospora, Helminthosporium* and *Ustilago.* A later publication by Preston (10) lists buffalograss as a host for six organisms: 1) *Anguillulina agrostis* (Steinburg) Goodey; 2) *Cercospora seminalis* Ell. & Ev.; 3) *Erysiphe graminis* DC.; 4) *Helminthosporium turcicum* Pass.; 5) *Phyllachora bouteloua*e Rehm, and 6) *Puccinia kansensis* Ell. & Barth. Of these probably the most economically important disease in the production of seed in Oklahoma is false smut caused by the fungus *C. seminalis.*

False smut is a disease that destroys the unfertilized ovary. A detailed description of the disease and characteristics of the casual organism in culture is given by Weihing (12). In addition, he was able to effectively control the organism in greenhouse studies with 2,4-D. Time of application and concentration were shown to be critical.

Since buffalograss is a short grass bearing seedburs a few inches above the soil surface, ordinary harvesting methods have not been successful. Under field conditions various kinds of equipment, reportedly used with varying success, have included combines modified so that the sickle bar floats on a hinged extension right on the ground, flailing machines, reel and whirlwind lawn mowers, air blast and suction machines, and street sweepers. No studies were found on comparing methods of measuring yield samples in experimental plots.

Materials and Methods

Cultural and management studies were started in 1954 on an established sod of the buffalograss Cv. 'Mesa' (5) under irrigation at the livestock research station, El Reno. The study utilizing five fertility levels 1) check, 2) 60 lbs. per acre N, 3) 180 lbs. per acre N, 4) 60 lbs. per acre N + 180 lbs. per acre P_2O_5 and 5) 180 lbs. per acre N + 180 lbs. per acre P_2O_5) replicated three times in a completely randomized block design was discontinued in 1957 due to errors in management. It was evident from results of this initial study that information was needed not only on means of effective weedy annual grass control but on methods of measuring seed yields as well.

Subsequent studies, 1958 to 1960, were conducted on an F_1 generation of an experimental strain referred to as W-2 buffalograss. The W-2 strain is a group of crosses which produces 90 percent female plants in the F_1 and, except for readily shattering upon maturity, is similar to the Cv. 'Mesa.' The blocks were established several years prior to study on a Brewer clay loam soil, high in available phosphorus and potassium, medium to high in nitrogen and with a pH of 7.5.

Measuring Yield

The methods selected for trial in harvest yield data were:

1) A sample area 3 by 10 feet was mowed with a Jari mower, allowing the mowed material to dry before threshing with a Vogel nursery thresher. After threshing, the seed was carefully cleaned and weighed.

2) Entire tops of plants were harvested with a slightly modified Gehl forage cutter, shown in Figure 1, from a 5 by 10 foot plot. The chopped material was sacked and allowed to dry. The seed content was separated by scalping and cleaning on a small clipper cleaner and weighed.

3) A 1 by 1 foot sample was hand clipped, samples were processed by hand and seed weighed.

Twenty replications of each method of measuring seed yield were taken each year for a 2-year period. The inert content of each sample, regardless of the method of harvesting, was determined by hand picking several 5-gram samples. In this manner all yields reported were converted to pounds pure-burs or seed produced per acre.

Disease Control

Additional studies were conducted from 1960 to 1963 on the possible use of 2,4-D for controlling false smut. Rates of .000, .078, .104, .157, and .314 pounds acid equivalent per acre were initially applied to both seed crops in a randomized block design consisting of two replicates of each level. Treatments were later increased to include rates of .628, .932, and 1.256 pounds 2,4-D per acre and applied only to the second seed crop, during the time when most of the seed crop was in bloom.

From the yield samples harvested from each crop, 200 seed burs were examined at random. The number diseased and the caryopses content of each bur were determined by visual means and by hand extracting the caryopses.

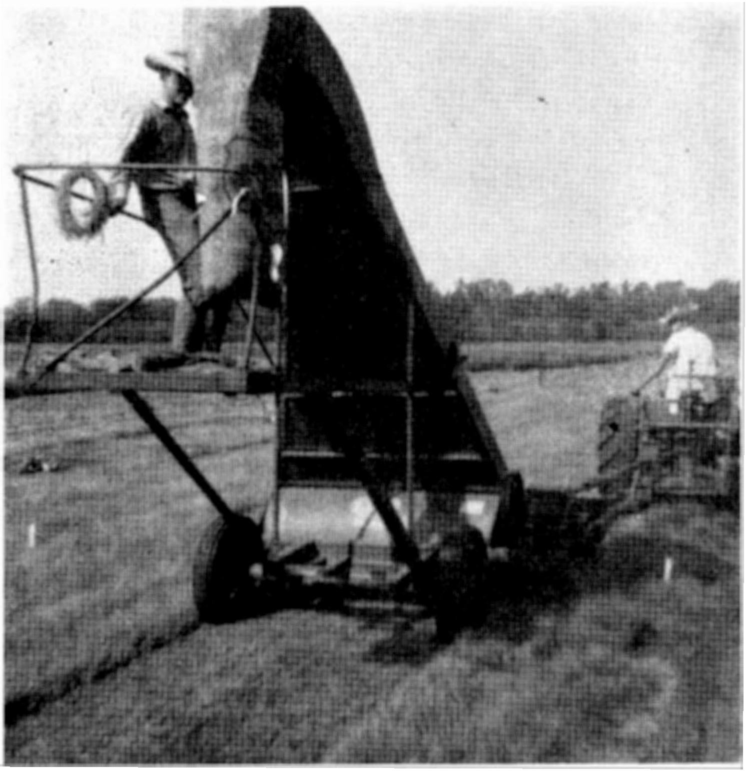

Figure 1. Method of harvesting buffalograss yield samples with a Gehl cutter.

Weed Control

A pilot study was conducted to test the ability of buffalograss to tolerate several herbicides used to control the germination and growth of annual grasses. Pre-emergence spray applications of simazine (2-chloro-4,6-bis(ethylamino)-s-triazine) and diuron (3(3,4-dichlorophenyl) 1,1-dimethyl urea) were applied during the first week of April at rates of 2 and 4 pounds active ingredient per acre. The study was not replicated. The tolerance, effectiveness, and persistence of control were determined by visual means and rough counts.

Fertility Treatments

Simazine, at 2 pounds active ingredient per acre, was applied starting in 1960 as a blanket treatment prior to the application of fertilizer in

April. Four fertility treatments, each replicated twice, were studied in a randomized block design. Treatments consisted of 1) check, 2) 30 pounds N, 3) 60 pounds N, and 4) 60 pounds N plus 60 pounds P_2O_5 per acre. The commercial fertilizers used to obtain these rates were ammonium nitrate (33% N) and treble superphosphate (46% P_2O_5). The fertilizer treatments were broadcast by hand each year of study.

Fertilizer was usually applied during the last week in April, but the dates varied 1 to 2 weeks from year to year. No additional fertilizer was applied after the first seed harvest in July. The residual effect was measured in the second crop. Size of each fertilized replicated plot was 12 by 50 feet. A Gehl forage chopper was used as the means of harvesting and gathering yield data.

Results and Discussion

Harvest Comparisons

The method used in harvesting grass seed crops can definitely affect the results and possibly lead to erroneous conclusions. Grasses differ in growth habits and seed characteristics; thus the method of harvest varies according to kind.

Seeds of most strains of buffalograss, with the possible exception of the Cv. 'Mesa,' shatter readily upon maturity and during the process of harvesting. A considerable quantity of seed is lost when inadequate methods are used in the process of harvesting. When water is not limited, under field conditions a difference in stage of maturity exists at different fertility levels. Plant maturity is delayed in areas fertilized with nitrogen more than in unfertilized areas. These sources of error, if not accounted for, may obscure the beneficial effect of treatment.

In plot studies a Jari mower or similar piece of equipment has generally been used to harvest buffalograss seed burs. Most workers prefer to measure response in yield by harvesting several small areas within each field replication. Errors created during the process of drying, storage, processing, and cleaning are not as likely with small, less bulky samples.

In order to be reasonably sure that results show the effect of treatment and are not biased by the method employed, preliminary studies were conducted on three different methods of sampling seed yields.

Large differences were measured in amounts of seed produced by the three methods, as shown in Table 1. Harvesting with the Jari mower

Table 1. A comparison of three methods of harvesting seed yield in buffalograss over a 2-year period.

Method	Year	Size	No. of Plots Harvested	Pounds Seed Burs/Acre	% C.V.	Standard Deviation
Jari Mower	1	3′ × 10′	20	225.7	66.8	150.9
	2	3′ × 10′	20	354.9	71.3	253.3
Gehl Cutter	1	5′ × 10′	20	370.6	30.2	111.9
	2	5′ × 10′	20	679.8	23.9	162.7
Quadrat	1	1′ × 1′	20	613.3	64.3	394.4
(Hand Clipped)	2	1′ × 1′	20	846.4	33.1	279.8

and by hand clipping were highly variable. Sampling errors as indicated by the percent C.V. were much smaller when yield samples were harvested with the Gehl cutter. The variability in shattering before and during the process of harvesting, lack of uniform maturity, and differences in ratios of male and female plants between sample sites were contributing factors accounting in part for the large sampling errors found when the mower and hand-clipped methods were used. The results of using the 1 by 1 foot measurement suggest, in addition, that bur production was not uniform and that the area sampled was not adequate to reliably approximate actual yield.

Seed samples harvested with the Gehl cutter were by far the most efficient. The average yield, measured each year of the study, more nearly approximated the actual amount of seed produced per acre. The cylinder speed of 1500 R.P.M.'s not only was adequate for harvesting the standing forage, but created at the same time a suction force able to pick up and deliver the shattered seed burs. Only a very small portion of the total seed produced was lost in the areas harvested with this machine.

Co-variances of 20-30 percent are not uncommon in grass seed production studies. However, sampling errors within this range are larger than desired and make it extremely difficult to measure differences. It was later observed that the size of plots varied + 8 inches from the intended length at the time the Gehl cutter was used. Since this error was considered a significant cause of the C.V. percentages found, it was decided that measuring each plot after the samples were taken would reduce the sampling error to a more acceptable level.

It was felt that the above data were conclusive enough to restrict the method used in further studies to harvesting only with the Gehl cutter.

Weed Control

The early and effective control of weeds and weedy annual grasses is essential in the production of buffalograss seed. Annual grass infestation became so serious in the irrigated fertilized plots of the initial study that further study without some chemical means of weed control was not practicable. Light application of 2, 4-D effectively controlled broadleaf weeds but, at the same time, seemed to stimulate an encroachment of the annual grasses.

Pre-emergence spray applications of simazine and diuron applied in April were effective in almost completely eliminating the annual grass competition in buffalograss sod. Both herbicides effectively controlled the common weeds and weedy grasses, with the exception of a *Solanum* sp., throughout the growing season. Neither 2 nor 4 pounds active simazine per acre appeared to have any harmful or retarding effects on growth. However, there was an apparent lag in growth, indicating some antagonism to buffalograss, in the areas sprayed with diuron. The beneficial results were so obvious, as compared to untreated areas, no further study or evaluations were felt necessary. It was decided to incorporate pre-emergence spray applications of simazine at 2 to 3 pounds per acre as a blanket treatment prior to application and study of other management practices.

In applying the simazine one should consider the soil type on which the stand is established. In these studies the soil was a Brewer clay loam with a high buffering capacity. One early spring application of 2 to 3 pounds active ingredient per acre was sufficient to maintain a stand almost entirely free of weeds and weedy grasses throughout growth and reproduction of both crops. In soils having a low buffering capacity the action of the chemical at rates used above may not be as effective. Continuous use of simazine may build up a toxic residual effect that could result in loss of stand. The first sign of this, according to information obtained from other grass studies, is a loss in the percent seed-set or fill. It may be practicable to apply simazine for weed control for a period of two years, omit applications in the third year, and use again in the fourth.

Fertility Treatments

Early studies on the fertility requirements of buffalograss were discontinued due to heavy infestations of weedy annual grasses in the fertilized plots. The high nitrogen plots were heavily infested, whereas competition was not serious in check plots. It was felt that buffalograss was not able to utilize all the nitrogen made available, creating an excess which made conditions favorable for the invasion of weedy grasses. The application of simazine completely eliminated this problem even when large amounts of nitrogen were applied. The residual action of the herbicide was sufficient to control the weed problem throughout the growing season.

Buffalograss will produce two seed crops per year. The first, harvested in July, usually yields the major portion of the total seed produced, as shown in Table 2. The second crop, generally harvested in October, is usually light and of very poor quality. The first crops produced, under irrigation, an average of 500 to more than 1,000 pounds of seed per acre per year. Response to fertilizer was more pronounced in the first than in the second crop. Seed yields were increased an average of 33, 109, and 337 pounds per acre over the check by the application

Table 2. Effect of various treatments on seed production of buffalograss.

Year	Crop	Treatments Applied in March			
		0	N_{30}	N_{60}	$N_{60}P_{60}$
		— Lbs. seed burs per acre —			
1960	1	1308	1289	1112	1317
	2	309	246	287	340
	Total	1617	1535	1399	1657
1961	1	686	668	696	905*
	2	190	305	295	370
	Total	876	973	991	1275
1962	1	445	332	454	394
	2	87	64	55	107
	Total	532	396	509	501
1963	1	502	783	1113*	1616*
	2	61	105	105	111
	Total	563	888	1218	1727
Average yearly production					
	1	735	768	844	1072
	2	162	180	185	232
	Total	897	948	1029	1304

* Significant within any one year at the 5% level.

of 30 pounds N, 60 pounds N, and 60 pounds N plus 60 pounds P_2O_5 per acre respectively. However, response due to fertilizer under irrigation was statistically significant only in 2 of the 4 years of study. It appears that the application of phosphorus in combination with nitrogen is essential for the production of high seed yields under irrigation.

Leaching and other losses of the broadcast nitrogen fertilizer may have been substantial enough to significantly reduce the amount of nitrogen available for the second crop. The residual effect of the spring treatments as measured by amount of seed produced by the second crop was disappointing. Although yields were generally higher in the fertilized areas, other factors not encountered in the first crop were responsible for the lack of response in the second.

In 1962, samples were drawn from check plots of each seed crop for comparison. It is known that macro-climatic and micro-climatic factors during growth and reproduction of the July and October crops are quite different. However, this does not explain the reasons for the reduction in seed yields, when potentially production is as great in the second as in the first crop. Upon examination, the bur or seed-unit of the second crop was found to contain an average of 3 spikelets as compared to an average of 4 to 5 per bur for the first crop (Table 3). Seed-set or percent fill, as measured by the average number of caryopses per bur, was found to be much lower in the latter crop. The average number of caryopses per bur ranged from 1.62 to 2.08 in the first crop, compared to .66 to .92 in the second crop. Considering the differential in number of spikelets per bur between crops, the seed-set of the second could be considered better than the first. The number of pure seed burs required to equal a pound was calculated at approximately 32,000 for the first as compared to 47,000 for the second. This suggests that the size or number of spikelets per bur influenced the yield to a greater extent than did seed-set. Disease, particularly false smut, was observed to be more prevalent in the second than in the first harvest and was most obvious in plots fertilized with nitrogen.

Disease Control

During the blooming phase of reproduction in 1955 the production block of buffalograss was accidentally sprayed with 0.628 pounds of 2,4-D acid per acre. A cured or die-back appearance of the foliage resulted. Seed burs harvested were relatively free of disease, well filled, and of very high quality. This suggested that 2,4-D cound effectively control false smut. A year later Weihing (12) published his finding on the

Table 3. Comparison of seed quality as to seed-set and disease in first and second groups, 1962.

	First Crop Replications						Second Crop Replications					
	1	2	3	4	5	Av.	1	2	3	4	5	Av.
Total Number Burs Examined	548	486	505	749	571	571	546	536	579	496	561	543
% Visibly Diseased	11.13	8.64	16.83	8.14	15.06	11.96	24.9	24.6	25.7	30.2	32.9	28.3
Ave. Wt./Bur (Gms.)												
Healthy	.0153	.0138	.0147	.0160	.0133	.0146	.0093	.0114	.0082	.0088	.0108	.0097
Diseased	.0117	.0125	.0111	.0102	.0109	.0113	.0076	.0091	.0080	.0087	.0085	.0083
% Loss in Wt. Due to Disease	23.52	9.42	24.48	36.25	18.04	22.34	18.28	15.97	2.40	1.13	23.14	12.18
Av. Number of Caryopses/Bur												
Healthy	1.67	1.62	1.86	1.92	2.08	1.83	2.05	2.02	2.20	1.72	1.85	1.93
Diseased	.50	.24	.31	.54	.46	.41	.78	.66	.69	.75	.92	.75
Difference	1.17	1.38	1.55	1.38	1.62	1.42	1.27	1.36	1.15	.95	.88	1.17
% Seed-set Loss Due to Disease	70.5	85.2	83.3	71.8	77.8	77.7	61.9	67.3	68.7	55.8	48.8	60.5

control of false smut with 2,4-D under greenhouse and field conditions. He described the action of 2,4-D as a chemotherapeutant rather than a protective fungicide. He indicated that it may alter the host's tissues, making them incompatible with the pathogen. Rather extensive studies were carried on for several years on the effect of 2,4-D on quality and yield of buffalograss. It was found that effective control with only one application was dependent on the almost impossible task of applying the 2,4-D when the major portion of the crop was in bloom.

As shown in Table 4, seed-set of the first crop averaged 60 percent greater than that of the second crop. An average of 2.11 caryopses per bur was found in the first crop, as compared to an average of 1.46 in the second. The application of 2,4-D during the bloom stage of the first crop did not have any effect on seed-set in the first crop but appears to have stimulated seed-set in the second. By comparing, according to treatment, the number of diseased burs and the average number of caryopses per bur in the second crop, the increased yield of the plots receiving .315 pounds 2,4-D acid per acre showed it to be the most effective rate for reducing disease damage.

Although only one year's data are reported, other studies were conducted using .628, .932 and 1.256 pounds 2,4-D acid per acre. The findings all indicated some beneficial effect on quality, especially in the second crop. More conclusive data would have been likely if several light applications had been made during the reproduction phase.

Summary and Conclusions

The producer's method of harvesting buffalograss seed can make the difference between profit and loss. Seeds of most strains, with the exception of Cv. 'Mesa,' shatter readily upon maturity and during the process of harvesting. By comparing three methods of harvesting seed yields, it was found that a Gehl cutter most nearly harvests the actual amount of seed produced per acre. The Gehl cutter harvests the tops of the plants and at the same time creates a suction force capable of picking up and delivering the shattered seed burs lying on the ground. By pulling a trailer behind the cutter and scalping immediately after harvest, this machine can be used on a large scale with little seed loss.

Buffalograss will produce two seed crops per year. The first, harvested in July, usually produces the major portion of the total seed produced. Under irrigation, the first crop will produce an average of 500 to more than 1,000 pounds of seed burs per acre. The second crop,

Table 4. Effect of various concentrations of 2,4-D applied during bloom on quality and yield of buffalograss seed burs, for two seed crops under field conditions.

Treat-ment	Number Burs Examined Per Rep. & Crop	Av. No. Visual Burs Infected with False Smut		Av. No. Caryopses per 200 Burs		Av. No. Caryopses Diseased/200		Av. % Visual Infection		Av. Yield lbs. Burs/A		Lbs./Acre Loss due to Disease		Adjusted Total Yield
2,4-D* lbs. acid/A		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	
.314	200	0	30	451	317	0	5	0.0	16.5**	787	868	0	135	1520
.157	200	2	29	409	297	0	4	1.0	15.8	750	650	8	103	1289
.104	200	2	45	392	284	0	13	1.0	27.0	657	724	7	195	1179
.078	200	8	37	427	287	0	6	4.0	26.0	713	819	28	213	1291
.000	200	7	43	433	273	0	26	3.5	31.0	777	704	27	218	1236

* 5.02 lbs. 2,4-D acid per gallon used.

** The number of diseased grain was divided by the average number of caryopses per bur and added to the number of visibly diseased burs for percent determination.

generally harvested in October, is usually light and of very poor quality. However, other factors not encountered in the first crop are responsible for the lack of response in the second. 1) The macro-climatic and micro-climatic factors are quite different during growth and reproduction of the two crops. 2) The seed bur of the second crop contains an average of 3 spikelets as compared to an average of 4 to 5 per bur for the first crop. 3) Seed-set as determined by the average number of caryopses per bur was found to be much lower in the latter crop. 4) The number of seed burs required to equal a pound was calculated at approximately 32,000 for the first crop as compared to 47,000 for the second crop. Evidently the number and size of the seed bur influences yield to a greater extent than does seed-set. 5) Disease, especially false smut, was observed to be more prevalent in the second than in the first crop and was most obvious in areas fertilized with nitrogen.

Significant response to fertilizer was measured in 2 of the 4 years of study. Nitrogen applied at the rate of 60 pounds per acre alone and in combination with 60 pounds actual phosphorus were the most effective treatments. The residual effect of the spring applications of fertilizer was not sufficient to meet the needs of the second crop for maximum production. Additional fertilizer applications after removal of the first crop might have increased greatly the amount of seed produced.

Without effective weed control practices, fertilization of buffalograss under irrigation is not practical. Early and effective control of weeds and weedy grasses is essential for the production of buffalograss seed. Light applications of 2,4-D effectively controlled broadleaf weeds but, at the same time, seemed to stimulate the encroachment of annual grasses. Pre-emergence spray applications of simazine and diuron in April were effective in almost completely eliminating the annual grass competitors. Neither 2 nor 4 pounds active simazine per acre appeared to have any harmful or retarding effect on growth. An apparent lag in plant growth was observed in the areas sprayed with the same amounts of diuron. The beneficial results were very obvious and led to the incorporation of pre-emergence spray applications of simazine at 2 to 3 pounds active ingredient per acre as a blanket treatment prior to application and study of other management practices.

With an effective weed control program, heavy applications of fertilizers under irrigation are practical. However, in the areas fertilized with nitrogen alone a higher percentage of disease (false smut) was observed, particularly in the second crop. Application of 2,4-D at rates of .314 and .628 pounds acid per acre appeared to reduce the amount of infection and to stimulate seed-set.

Bearing in mind the above information, the following management practices are recommended.

(1) Establish a dense stand of buffalograss in ratio of approximately 1 to 10 male to female plants.

(2) Apply one pre-emergence spray application of 2-3 pounds of simazine per acre in early spring prior to fertilizing.

(3) Fertilize both first and second crops under irrigation with 60 to 80 pounds per acre actual nitrogen either alone or in combination with 60 pounds of phosphorus.

(4) Pay close attention to disease control, especially in the second crop. During the blooming phase of reproduction apply several applications of .157 pounds 2,4-D acid per acre.

The method of harvesting will depend on available equipment but should be considered carefully. The Gehl cutter was more efficient in harvesting the seed burs produced than either of the other two methods investigated.

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