EFFECT OF PROCESSING ON SEEDLING PERFORMANCE OF SOME NATIVE GRASSES

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INTRODUCTION

The value and importance of native grasses, in the Great Plains, is shown by their versatile qualities. Many of them are palatable, nutritious, and have excellent beef producing qualities. They are climatically adapted and suited to a wide variety of soil types. Performance under adverse conditions of the past has proven that these grasses are now important and will continue to be important in the future.

Benefits of native grass are shown in beef production, soil conservation, and reservoirs of lucid water. Many livestock enterprises are built upon native grass resources. Preventing soil erosion has been a major problem; native grass cover is irreplaceable for holding the soil in some areas. A direct influence of clear water is shown in the growth and reproduction of fish, and many forms of wild life are dependent upon native grass for food and protection.

The soil Conservation Service and other government service agencies have been actively engaged in supplying information to those interested in regrassing programs. Native grasses have been used on a large scale by those attempting to bring submarginal and eroded land back into productivity.

The florets and spikelets of native grasses have hairs, awns, and other appendages which make planting through an ordinary drill impossible; therefore, processing or the use of specially constructed drills is necessary. Processing involves forces which separate, trim, and abrade the florets. Various degrees of processing can be obtained, from material that is slightly trimmed to clean caryopses.

Two methods of processing were used in this study, the standard (somewhat modified) hammermill with free swinging hammers, and a device used with the Waring Blendor for the purpose of simulating the hammermill.

A suitable method, for testing the degrees of processing for seedling performance, was difficult to develop. The use of forceps in picking samples for testing would bias the experiment and be too laborious. Therefore, three testing methods were used in which the testing samples of the various grades were placed on an equal weight basis of seed units. Environments used, for testing the grades, were the field, greenhouse, and germinator.

REVIEW OF LITERATURE

Considerable information is available concerning the processing of various grasses. Little is known concerning the effect that processing has on germination and seedling performance.

According to McWilliams (4), the hammermill processed seed of Little Bluestem, Andropogon scoparius Michx., Big Bluestem, Andropogon gerardi Vitman, and Side-oats Grama, Bouteloua curtipendula (Michx.) Torr., has higher germination than untreated seed. Treated seed of Blue Grama, Bouteloua gracilis (H.B.K.) Lag., had a lower germination than the check material.

Weber (10) conducted germination studies on hammermilled seed of Big Bluestem, Side-oats Grama, and Blue Grama in the greenhouse in soil; his results showed a larger number of seedlings in every species, with the two processed grades than with the untreated material.

Results of mechanical treatment on grasses not especially concerned with in this treatise may be of interest. McKinley (3), working with Buffalo Grass, Buchloe dactyloides (Nutt.) Engelm, found that seed mechanically treated had higher germination than untreated. Schwendiman and Mullen (5) studied the germination of Tall Oatgrass, Arrhenatherum elatius (L.) Presl., after processing; their results showed a marked decrease in germination in completely hulled seed and a slightly lower germination in partially processed seed.

Schewendiman et al. (7), working with Canada Wildrye, Elymus canadesis L., reported that germination tests indicated that the hammermill treatment affected viability, reducing it measurably when

cylinder speeds above the optimum for the species were used and still further with low rates of feeding into the mill.

MATERIALS AND METHODS

Seed for this experiment came from a commercial seed dealer in western Oklahoma. Sources of native grass seed were extremely rare when this study was begun. However, the seed used for this experiment was probably representative of the seeding material available for use by any consumer.

Three kinds of seeding material were used, namely, Blue Grama, Bouteloua gracilis (H.B.K.) Lag., Side-oats Grama, Bouteloua curtipendula (Michx.) Torr., and Mixed Native Grasses. Mixed Native Grasses consisted of Big Bluestem, Andropogon gerardi Vitman, Little Bluestem, Andropogon scoparious Michx., Indian grass, Sorghastrum nutans (L.) Nash, and Side-oats Grama. Side-oats Grama was the predominant species found in Mixed Native Grasses.

Every kind had been combined. All were bulky and contained considerable amounts of inert matter and weedy grass seed. Inert matter was composed of straw, broken bits of weed stalks, and other trashy material commonly found in combined grasses from native meadows. A few caryopses were threshed out in every species.

Seed of Blue Grama and Side-oats were highly viable while Mixed Native Grasses had a fair germination.

This experiment was designed to test four degrees of processing for each kind of grass seed. A randomized block design was used in every instance for testing differences among the grades[1] within a

[1]The grades are described as follows: "A", highly processed; "B", moderately processed; "C", partially processed; "D", check.

species. The null hypothesis was tested by using the "F" test as given by Snedecor (8).

Processing

The hammermill (Figure 1) and the Waring Blendor were the machines used for processing Blue Grama, Side-oats, and Mixed Native Grasses.

The hammermill was originally a standard machine used for grinding feedstuffs, but it was modified somewhat by Kneebone and Brown (2); their modifications and descriptions of the mill are as follows:

"The mill, as received, was a standard swinging hammer type with bagger. Ground material was drawn by air from the milling chamber, carried through a metal tube to the fan assembly, and from there to collecting bags. In modifying the mill, the bottom was cut out and straight ends were welded to form a chute below the screen. One welded end is shown at "A" in Figure 1. All joints, previously held together by bolts, were welded to make the interior easy to clean. The mill was on a sturdy table with an opening below the chute.

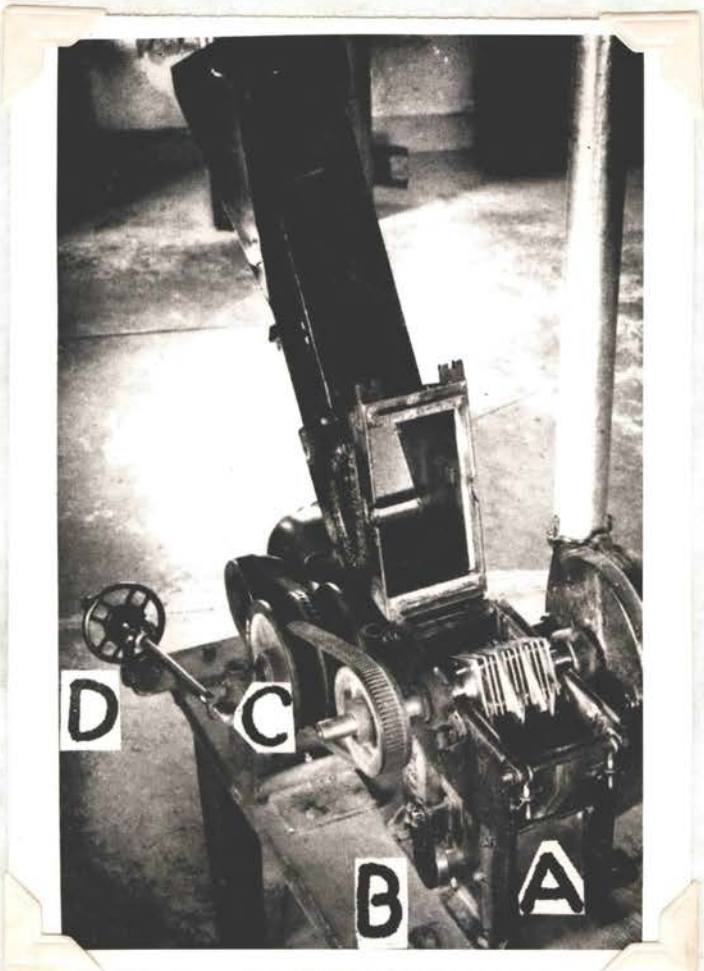

Fig. 1--Hammermill

"The bagging mechanism was modified to collect dust. The original machine had an opening at the side through which the ground material was carried and another opening was on the opposite side to let in air. The air stream was controlled by a shutter. To modify the bagger, a dust collector was made which fitted through the two openings. (See air inlet and control to the right of "B" in Figure 1). This consisted of a sleeve of 2 3/8 inch tubing with a piece of 2-inch pipe cut in it. Size of the slotted opening may be changed by turning the sleeve, thus reducing or increasing the amount of air. The adjustment is held by a set screw. In operation, the dust collector is set in place with the opening on the under side. This modification, when properly adjusted, enables dust removal without seed loss.

"The original metal channel from the mill to the fan housing of the bagger was replaced by a piece of flexible tubing. This may be removed along with the dust collector when an unobstructed passage with no air is desired as in coarse grinding or threshing. The bagger was replaced by 3-inch vent pipe which was run to an outside dust bin.

"The most important modification was made to the power system. The mill is powered, as recommended by the manufacturer, by an electric motor of a 2 horsepower capacity. The motor speed is 1,720 r.p.m. An adjustable pulley and two V belts were assembled to transmit power to the hammers as shown at "C" in Figure 1. The adjustable pulley was mounted between arms which may be moved through several degrees of arc by turning a threaded rod through a nut welded to the outside arm. This rod was mounted so that it would pivot with the arms holding the adjustable pulley. By moving the adjustable pulley back or forth the mill may be set at any speed from 640 to 3,880 r.p.m. A set screw, in front of the adjustment wheel holds the setting desired. This wide speed range and adjustability is essential when many types of seed and degrees of processing are involved."

A needle, pointing to a graduated r.p.m. scale, was attached to the end of the shaft which made an arc as the threaded rod was run up or down. This scale was checked for accuracy and used in adjusting the mill speed for each lot.

The Waring Blendor has been used by plant breeders for hulling various types of seed. The solid processing cup, which is a normal part of the Blendor, was modified so as to allow seed to flow from it as they are treated, and thus, improve the chances of the seed remaining undamaged.

The Blendor, with the modified cup and drain, along with the powerstat are illustrated in Figure 2. Four openings were made in the bottom of the cup for passage of the processed seed. A drain, was

Fig. 2--Blendor, modified cup and drain, powerstat

installed for ease in handling of processed seed. The powerstat controlled the voltage and thereby the processing speed.

The modified cup (Figure 3) was adaptable to different abrasives and screens. A star shaped agitator was the driving force which whirled the seed within the processing chamber. The agitator was rubber tipped because experimentation revealed that steel blades injure the seed. The agitator was bent downward to produce wind action on the bottom screen; this kept the screen from being clogged from seed blowing into it. Also, wind was directed upward and outward from the agitator. The various wind directions kept the seed moving, and therefore, more abrading action was produced.

Fig. 3--Modified cup

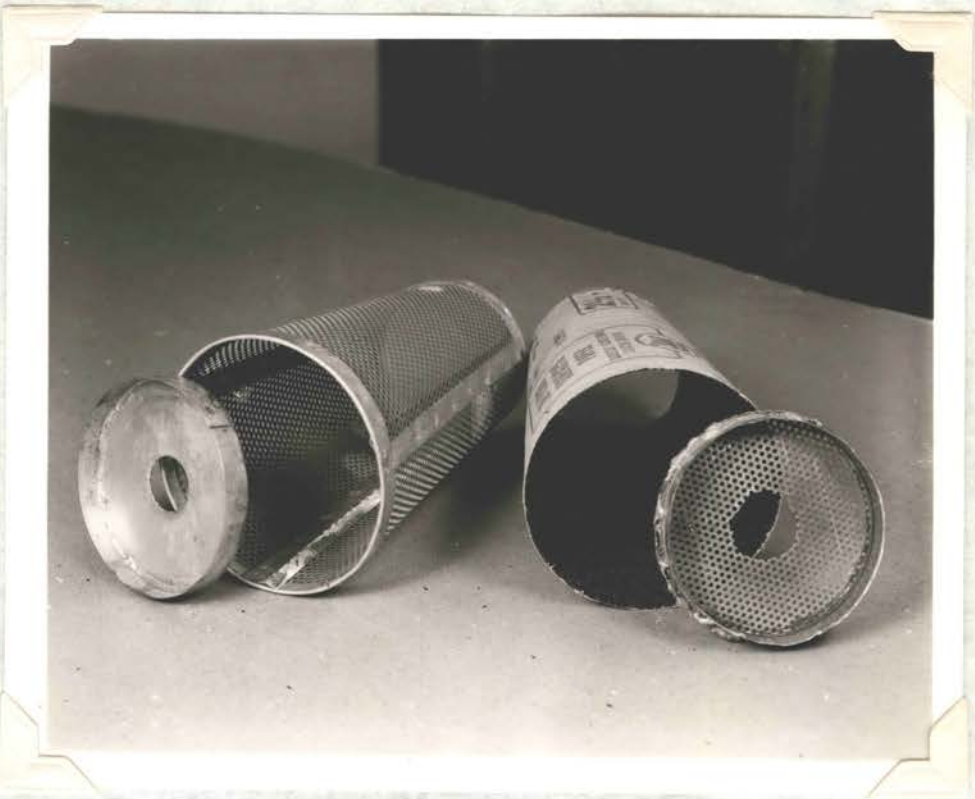

Fig. 4--Processing chambers

The two types of processing chambers for obtaining various grades are shown in Figure 4. When a high degree of processing was desired, a screen was placed in the bottom of the cup and a solid sandpaper cone, minus the end, was inserted within the rim of the screen; this formed a processing chamber with the seed outlet being the bottom screen. (This chamber was used with "A" and "B" grades). A solid bottom with a cone shaped screen formed the processing chamber for slightly processed grades. The cone shaped screens readily allowed florets to pass through, but the florets were polished somewhat by the agitator and the abrasive strips within the screens.

Hammermill and Blendor processings were similar in some respects. Both machines were capable of turning out different grades. A more even transition could be obtained with the grades from the milled material; this was due to a greater grinding effect which removed more appendages than the blender, and consequently, the material could be separated into different grades easily. The dust collector on the hammermill helped to produce various grades with hammermilled material.

The hammermill was fed at a full rate to hold down injury to the seed. More cracking of the caryopses is received when the mill chamber is but partly full while processing.

A small, laboratory model, gravity table and the South Dakota seed blower were used to give different grades within hammermilled material. The McGill aspirator was used for different amounts of cleaning on Blendor processed material to vary the grades.

(Blue Grama)

Hammermill treatment was accomplished by using a 1/16 inch, round, screen and a mill speed of 1500 r.p.m. The fluffy nature of the seeding material, along with its small size, demanded a high speed and relatively

small screen for proper treatment. Screen size and speed were adjusted to get as many caryopses as possible without grinding the seed. Grades of Blue Grama are illustrated in Figure 5. Grade "A" was obtained by running process material over the gravity table and then through

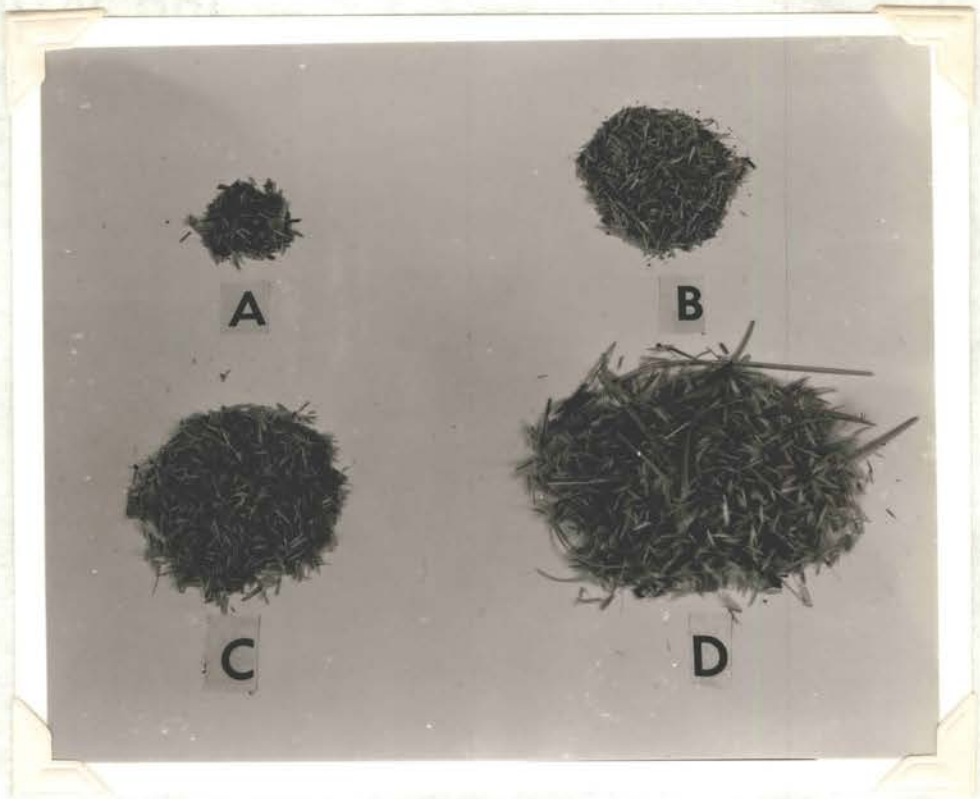

Fig. 5--Hammermilled grades of Blue Grama

the seed blower. A few florets were still present in this grade, but most of the seed units were caryopses. Grade "B" was procured by separating the light chaff from seed units by using the gravity table. Material that was straight-run from the hammermill was designated as grade "C".

Blendor processing was made at a 40 volt speed. Grade "A" was obtained by using a 1/25 inch screen[2] in the processing chamber with further cleaning being done by the aspirator. (The four grades are

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[2]All screens in the Blendor cup had round perforations with the exception of "C" in Side-oats.

shown in Figure 6.). Grade "A" posessed some inert matter, but it was

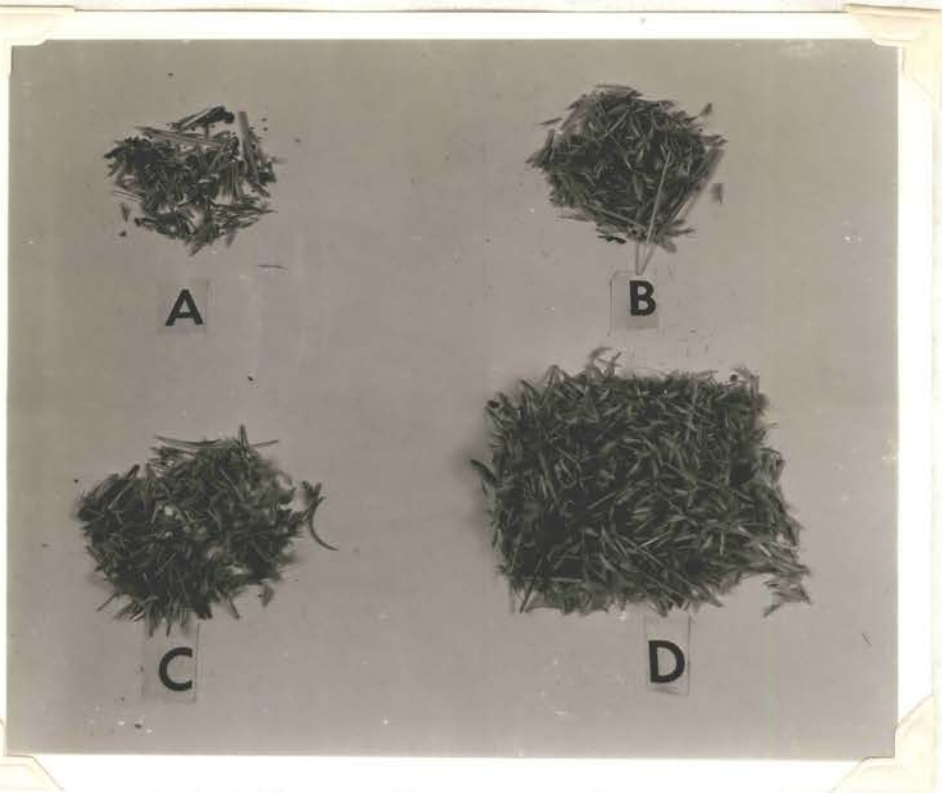

Fig. 6--Blendor processed grades of Blue Grama

in a form that could be planted easily. Very few empty florets were present with the seed units in this grade. A 1/16 inch screen was used for obtaining grade "B"; this grade was moderately cleaned by using the aspirator. Grade "C" was obtained by using a 1/12 inch screen, and further cleaning was omitted; apparently some chaffy materials were lost in the processing through grinding and blowing out of the holes in the modified cup.

(Mixed Native Grasses)

A speed of 1000 r.p.m. was used with the hammermill. An oblong screen was used whose dimensions were 1/8 x 1/16 inches. A 57 mesh screen was used on every grade, including the check, to remove immense amounts of weedy grass seeds. A good many weed seeds remained in grade "A". Grade "A" (Figure 7) was highly processed by cleaning with the

Fig. 7--Hammermilled grades of Mixed Native Grasses

gravity table and seedblower; the seed were in a very usable state. Most of the seed units were caryopses. Grade "B" contained some empty florets and a small amount of trashy material; it was obtained by cleaning milled material on the gravity table. Grade "C" was a direct product of the hammermill.

The Blendor setting was 40 volts. The 57 mesh screen was again used to eliminate some weedy grass seed from the samples. This

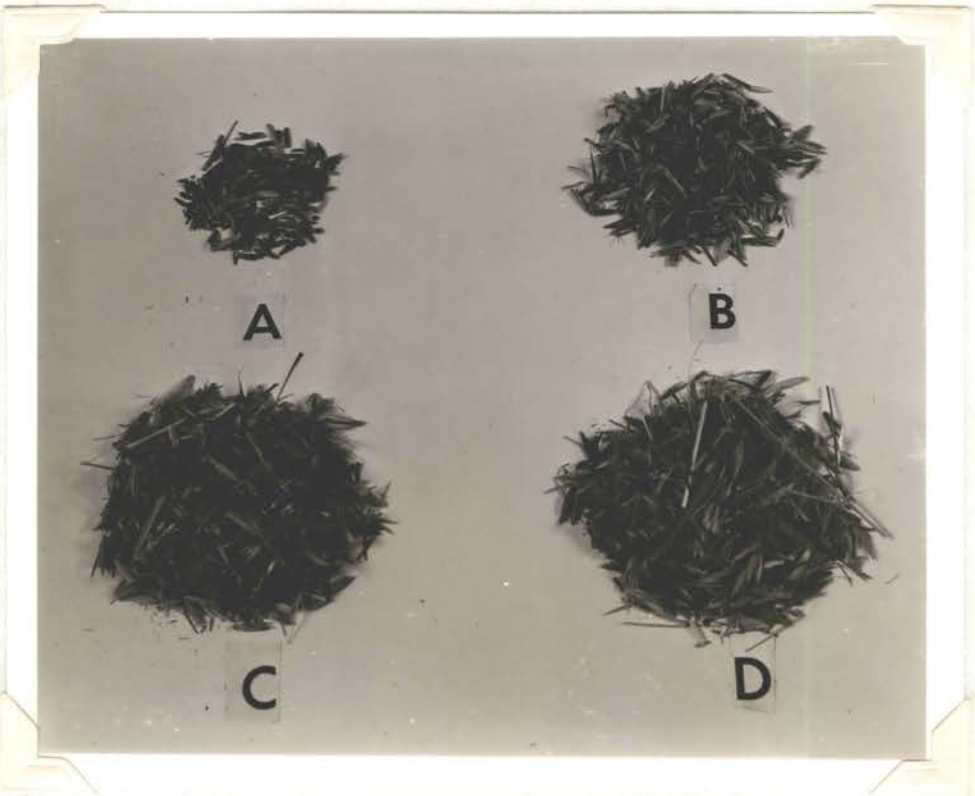

Fig. 8--Blendor processed grades of Mixed Native Grasses

preliminary screening was used for all of the grades. Grade "A" was obtained by processing material through a 1/16 inch screen; the aspirator was used to clean the seed to nearly naked caryopses. a 1/12 inch screen was used for obtaining grade "B"; further cleaning was accomplished by using the aspirator. A 1/11 inch screen was used to process seeding material to grade "C". Figure 8 illustrates the four grades.

(Side-oats Grama)

A 1/8 x 1/16 inch, oblong, screen was used in the hammermill. The mill was run at 1500 r.p.m. Grade "A" was a fairly clean sample

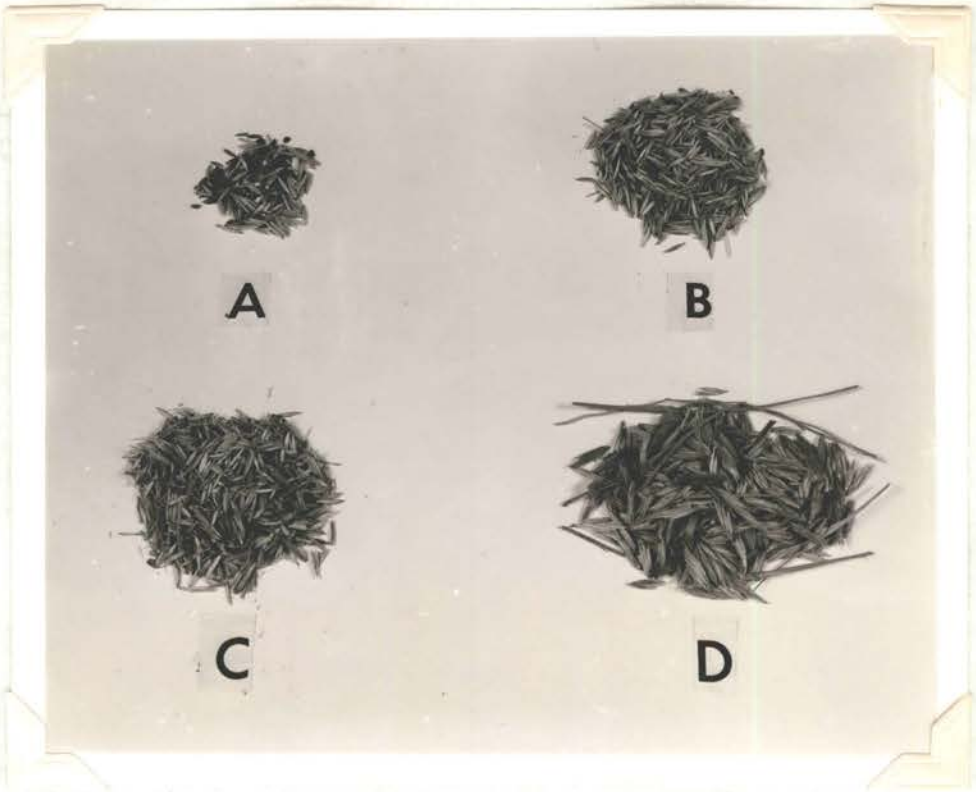

Fig. 9--Hammermilled grades of Side-oats Grama

of caryopses, and obtained by cleaning with the gravity table and seed blower. Grade "B" was made by running processed material over the gravity table, and grade "C" was straight-run hammermill material. The four grades are shown in Figure 9.

Blendor speed was adjusted to 47 volts. A 1/16 inch screen was used to process material for grade "A"; which was cleaned by using the aspirator. Grade "B" was obtained by using a 1/12 inch screen and cleaning with the aspirator. Grade "C" was slightly processed;

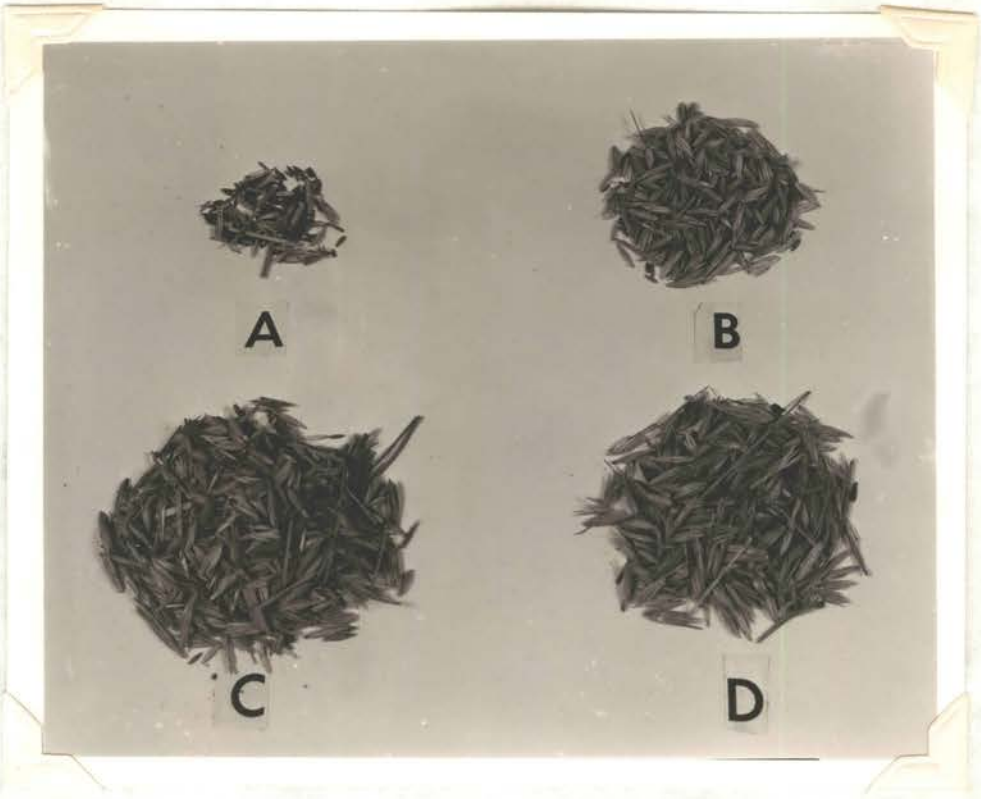

Fig. 10--Blendor processed grades of Side-oats

it was obtained by using a 1/4 x 1/14 inch, oblong, screen. The four grades are indicated in Figure 10.

Sampling

The grades of each kind of grass were tested on an equal weight basis of seed units by three methods as described below.

(Mechanical Purity)

A corrugated rubber trowel and matting were used to rub the sample grades down to such a degree that all chaff could be removed with the seed blower. The caryopses were then separated from the weed seeds and inert matter. The weight of caryopses in each grade from a given size sample was determined. Sample sizes for each grade were then calculated so that each test sample contained the same weight of caryopses.

(Estimation)

Grade "A" for each kind of grass, was the pattern for processing, i.e., the other sample grades were processed down until they appeared the same as grade "A". By determining the amount of highly processed material a grade could produce a proportion was established and sample sizes determined. Proper adjustments were made for the more bulky grades, so that each sample contained approximately the same number of seeds. The amount of highly processed material that a given grade could yield was determined by the appearance of processed subsamples and consequently subject to error of judgment.

(Entire Sample)

This method of sampling was made possible through construction of the modified cup used with the Waring Blendor.

A lot of material was thoroughly mixed and reduced in size by cutting the material in half and discarding half of it; this procedure was continued until a small lot of seed was left. The small lot of seed was divided into four or ten parts, depending on whether the lot was to be used for field, germinator, or greenhouse testing. When four replications were needed the small lot was divided into four parts. (The same procedure was used for ten replicates). Each lot contained approximately the same number of seeds. Some lots were then processed in the blendor to "A" grade, some to grade "B", some to grade "C" and some left unprocessed for grade "D". Differences in seed content of the various grades were then largely due to the effect of processing. If seed were destroyed or damaged in the processing it would be reflected in the quality of the several grades of seed.

Testing

Field plantings were made by using a V belt seeder. Rows were twenty-five feet long and one foot apart. Each grade was replicated four times. Cultivation was employed when needed to keep weeds under control. Some of the field plantings were irrigated by a sprinkler irrigation system. The irrigation was to insure or increase a seedling population. The rows were staked at each end for making the counting more convenient. Depth of seeding was from 1/4 to 1/2 inches.

Two irrigation plantings and one dry land planting were made with each kind of grass during the summer of 1953. These plantings were from hammermilled grades. The "Mechanical Purity" sampling method was used for determining seeding weights.

Dry land plantings were made with Side-oats and Blue Grama, from hammermill and Blendor processed material, during the spring of 1954. The "Estimation" method was used with the hammermilled grades to determine seeding weights.

Greenhouse plantings were made in bands two inches apart. This plan was a minature field layout. The grades were replicated ten times. The soil used in the flats was sterilized before the plantings were made.

A greenhouse planting was made with each kind of grass during the summer of 1953. This planting was from hammermill processed seed, and the "Mechanical Purity" sampling method was used for determining planting weights.

Two greenhouse plantings were made during the spring of 1954. These plantings were from hammermill and Blendor processed material. The "Estimation" sampling method was used for seeding weights from hammermilled grades.

Germination tests were carried on in a Manglesdorf germinator. The samples of the grades were placed upon paper squares which were arranged at random upon blotters. The blotters were arranged as replications, and the grades were replicated four times.

Germination tests were made of each grade from each kind of grass by the three methods of determining testing sample weights.

EXPERIMENTAL RESULTS

There appeared to be no difference in seedling vigor between degrees of processing. The highly processed grades emerged quicker, but the difference of all seven day old seedlings was hardly noticeable.

Blue Grama

Field results (Table 1) indicate that the check grade will produce more seedlings than the treated. Highly significant differences were shown in both irrigation plantings. Grade "B" was second to "D" in seedling frequency. In the 1953 dry land plot, grade "B" had a slightly greater number of seedlings than "D"; in separate count analysis, no significance was shown, but combined count analysis showed a significant difference. The 1954 dry land plot showed a highly significant difference with "D" having the most seedlings. Combined analysis of the first count of each of the 1953 field plantings showed a highly significant difference between the grades.

Greenhouse results (Table 1) were not to consistent. Two experiments showed "B" with the most seedlings, and one showed "D" with the most. The experiment in which "D" excelled had a two count analysis; each count showed a significant difference, and when the counts were combined a highly significant difference was shown. Of the two experiments in which "B" excelled, only one showed highly significant difference while the other showed no significance.

Of the three germinator experiments (Table 1), two showed "D" with the greatest seedling frequency while the other showed "B" with the most. There were highly significant difference in all three experiments.

Table 1.--Total Seedling Counts of Blue Grama from Various Experimental Methods

Experiment No. [1]	Testing Date	Enviornment	Processing Device	Sampling Method	Count [2]	Seedlings in Grades A	B	C	D	
1	Summer, 1953	Irrigation (1st Plot)	Hammermill	Mechanical Purity	First	167	222	179	231	
					Second	78	172	149	202	**
2	Summer, 1953	Irrigation (2nd Plots)	Hammermill	Mechanical Purity	First	128	134	147	371	**
					Second	111	76	89	149	
3	Summer, 1953	Dry Land	Hammermill	Mechanical Purity	First	61	92	64	84	
					Second	55	84	51	77	
4	Spring, 1954	Dry Land	Hammermill	Estimation	First	23	43	36	258	**
5	Spring, 1954	Greenhouse	Hammermill	Estimation	First	715	1319	965	884	**
6	Summer, 1953	Greenhouse	Hammermill	Mechanical Purity	First	72	49	57	97	*
					Second	77	58	73	103	*
7	Spring, 1954	Greenhouse	Blendor	Entire Sample	First	1095	1151	1005	1124	
8	Spring, 1954	Germinator	Hammermill	Estimation	First	196	417	328	356	**
9	Spring, 1954	Germinator	Hammermill	Mechanical Purity	First	409	464	441	690	**
10	Spring, 1954	Germinator	Blendor	Entire Sample	First	176	276	388	477	**
						3363	4557	3972	5103	
								Grand total		

[1]Analysis of Variance Tables are found in the Appendix listed by Experiment number.

[2]Seedling counts were made in seven days after planting while the second count was made after fourteen days; where only one count was made, the count is designated as first.

**The "F" value exceeds the value required for significance at the 1% level.

*The "F" value exceeds the value required for significance at the 5% level.

Mixed Native Grasses

The two counts in the first irrigation planting (Table 2) showed highly significant differences between degrees of processing. One count in the second irrigation had significant differences, but when it was combined with the second count no significance was shown. Of the two irrigation plantings, three counts showed "C" with the largest number of seedlings while one showed "B". In the dry land planting of 1953 differences were not significant. Combined 1953 field plantings showed a highly significant difference between the grades.

Grade "B" (Table 2) was the greatest in seedling frequency in the greenhouse. Experiment four showed a highly significant difference. Experiments five and six showed no significant differences.

In the germinator (Table 2), grade "B" also gave the most seedlings. Significant and highly significant differences were found from hammermilled material.

Side-oats Grama

In the field tests (Table 3), grade "D" had the greatest number of seedlings. Significant and highly significant differences were shown from the combined 1953 field analysis.

Greenhouse results (Table 3) showed highly significant differences from the two experiments conducted from hammermilled material. No significance was shown from the Blendor treated material.

Grade "B" was the greatest in seedling frequency of all three germinator experiments while grade "A" was next. However, significance was only shown in one experiment. In the signhificant experiment, which was from hammermilled material (Table 3), grade "A" had the largest number of seedlings.

Table 2.--Total Seedling Counts of Mixed Native Grasses from Various Experimental Methods

Experiment No.[1]	Testing Date	Enviornment	Processing Device	Sampling Method	Count[2]	Seedlings in Grades A	B	C	D	
1	Summer, 1953	Irrigation (1st Plot)	Hammermill	Mechanical Purity	First	74	136	240	78	**
					Second	100	140	227	125	**
2	Summer, 1953	Irrigation (2nd Plot)	Hammermill	Mechanical Purity	First	178	181	200	126	*
					Second	144	175	158	150	
3	Summer, 1953	Dry Land	Hammermill	Mechanical Purity	First	22	25	18	20	
					Second	24	33	24	24	
4	Summer, 1953	Greenhouse	Hammermill	Mechanical Purity	First	34	64	60	31	**
					Second	43	90	76	46	**
5	Spring, 1954	Greenhouse	Hammermill	Estimation	First	137	164	147	121	
6	Spring, 1954	Greenhouse	Blendor	Entire Sample	First	160	254	194	237	
7	Spring, 1954	Germinator	Hammermill	Mechanical Purity	First	213	373	264	105	**
8	Spring, 1954	Germinator	Hammermill	Estimation	First	195	131	67	85	*
9	Spring, 1954	Germinator	Blendor	Entire Sample	First	180	254	194	237	
						1524	2020	1869	1385	
							Grand totals			

[1]Analysis of Variance Tables are found in the Appendix listed by Experiment number.

[2]Seedling counts were made in seven days after planting while the second count was made after fourteen days; where only one count was made, the count is designated as first.

**The "F" value exceeds the value required for significance at the 1% level.

*The "F" value exceeds the value required for significance at the 5% level.

Table 3.--Total Seedling Counts of Side-oats Grama from Various Experimental Methods

Experiment No. [1]	Testing Date	Enviornment	Processing Device	Sampling Method	Count [2]	Seedlings in Grades A	B	C	D	
1	Summer, 1953	Irrigation (1st Plot)	Hammermill	Mechanical Purity	First	178	230	133	263	*
					Second	201	239	168	304	**
2	Summer, 1953	Irrigation (2n Plot)	Hammermill	Mechanical Purity	First	255	242	230	430	**
					Second	174	180	166	249	**
3	Summer, 1953	Dry Land	Hammermill	Mechanical Purity	First	131	131	77	116	*
					Second	103	115	60	123	
4	Spring, 1954	Dry Land	Hammermill	Estimation	First	83	87	59	121	*
5	Spring, 1954	Dry Land	Blendor	Entire Sample	First	25	30	93	134	**
6	Summer, 1953	Greenhouse	Hammermill	Mechanical Purity	First	46	36	32	30	
					Second	70	55	26	88	**
7	Spring, 1954	Greenhouse	Hammermill	Estimation	First	1024	970	808	922	**
8	Spring, 1954	Greenhouse	Blendor	Entire Sample	First	879	1047	1029	1028	
9	Spring, 1954	Germinator	Hammermill	Mechanical Purity	First	425	390	420	311	*
10	Spring, 1954	Germinator	Hammermill	Estimation	First	348	413	386	331	
11	Spring, 1954	Germinator	Blendor	Entire Sample	First	276	301	293	294	
						4221	4491	3980	4744	
								Grand total		

[1]Analysis of Variance Tables are found in the Appendix listed by Experiment number.

[2]Seedling counts were made in seven days after planting while the second count was made after fourteen days; where only one count was made, the count is designated as first.

**The "F" value exceeds the value required for significance at the 1% level.

*The "F" value exceeds the value required for significance at the 5% level.

DISCUSSION AND CONCLUSIONS

Indications are that the results from the various kinds of grasses may not be entirely from the same cause. Further study should be made to establish or validate the results.

Blue Grama

The hulls, enclosing the caryopses, are hard to remove as experienced from Blendor processing. The unprocessed grade gave the largest number of seedlings, thus, indicating that the force required for removal of the hulls may be detrimental to the caryopses as far as the development of seedlings is concerned. Therefore, viability of seeding material is decreased by processing.

Mixed Native Grasses

Processed grades produce more seedlings despite the fact that some damage is incurred from processing. Thus, another factor may be influencing the overall results. It has been reported that Buffalo grass has a greater germination when the caryopses are freed from the hulls (3). This factor may be true for some of the other native grasses, especially with Indian, Big Bluestem, and Little Bluestem. Processing may also be responsible for bringing some seed out of dormancy.

Side-oats Grama

From observations of the different environments, little damage is suspected from processing. However, under field performance, untreated seed will give the most seedlings. This may be due to better water holding power of the trashy seed or to harmful organisms affecting the processed seed.

SUMMARY

The hammermill and Waring Blendor were used to process Blue Grama, Mixed Native Grasses, and Side-oats Grama. Three degrees of processing were made from each kind of grass. By using an unprocessed check, four grades were available for testing. The McGill aspirator, North Dakota seed blower, and gravity table were used to vary the processed material into different grades.

"Mechanical Purity", "Estimation", and Entire Sample", were the sampling methods used to place the processed grades on an equal seed unit basis for testing.

The grades of each kind of grass were tested in the field, greenhouse, and germinator. A randomized block design was used in each environment. The grades were replicated four times in the field and germinator while ten replications of each grade were made in the greenhouse.

Seedling counts were made seven days after testing, whether in the field, greenhouse, or germinator. In most field counts, a second count was made after fourteen days.

From the standpoint of field establishment, unprocessed material of Blue Grama and Side-oats will produce more seedlings while the processed grades of Mixed Native Grasses produce the most.

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APPENDIXES

Appendix A

Individual Count Analysis

Table 4.--Analysis of Variance of the Seedling Counts of Blue Grama in the field

	Source	d.f.	S.S.	M.S.
Experiment 1				
(First Count)	Total	15	4740.94	
	Grades	3	743.69	247.90
	Reps	3	1237.19	412.40
	Error	9	2760.06	306.67
(Second Count	Total	15	3733.94	
	Grades	3	2093.19	697.73**
	Reps	3	747.69	249.23
	Error	9	893.06	99.27
Experiment 2	Total	15	14055.00	
	Grades	3	10372.50	3457.50**
(First Count)	Reps	3	1706.50	568.83
	Error	9	1976.00	219.55
(Second Count)	Total	15	2075.90	
	Grades	3	765.70	255.23
	Reps	3	488.40	162.80
	Error	9	821.80	91.31
Experiment 3	Total	15	508.44	
	Grades	3	171.69	57.23
(First Count)	Reps	3	76.19	25.40
	Error	9	260.56	28.95
(Second Count)	Total	15	591.44	
	Grades	3	197.19	65.73
	Reps	3	78.69	26.23
	Error	9	315.56	35.06
Experiment 4				
(First Count)	Total	15	14966.00	
	Grades	3	9459.50	3153.16**
	Reps	3	1408.50	469.50
	Error	9	4098.00	455.33

**The "F" value exceeds the value required for significance at the 1% level.

*The "F" value exceeds the value required for significance at the 5% level.

Table 5.--Analysis of Variance of the Seedling Counts of Blue Grama in the Greenhouse and Germinator.

	Source	d.f.	S.S.	M.S.
Experiment 5	Total	39	103938.18	
	Grades	3	19424.48	6474.82**
	Reps	9	68966.53	7662.72
	Error	27	15549.17	575.90
Experiment 6	Total	39	1510.38	
	Grades	3	133.65	44.65*
(First Count)	Reps	9	1068.63	118.74
	Error	27	308.07	11.41
(Second Count)	Total	39	523.00	
	Grades	3	165.00	55.00**
	Reps	9	206.78	22.98
	Error	27	211.22	7.82
Experiment 7	Total	39	41559.38	
	Grades	3	1207.08	402.36
	Reps	9	14218.13	1579.79
	Error	27	26134.17	967.93
Experiment 8	Total	15	9790.94	
	Grades	3	6518.19	2172.73**
	Reps	3	1412.19	470.73
	Error	9	1860.56	206.73
Experiment 9	Total	15	16417.00	
	Grades	3	12288.50	4096.16**
	Reps	3	1138.50	379.50
	Error	9	2990.00	332.22
Experiment 10	Total	15	14937.44	
	Grades	3	12900.69	4200.56**
	Reps	3	906.69	302.23
	Error	9	1130.06	125.56

**The "F" value exceeds the value required for significance at the 1% level.

*The "F" value exceeds the value required for significance at the 5% level.

Table 6.--Analysis of Variance of Seedling Counts of Mixed Native Grasses in the Field

	Source	d.f.	S.S.	M.S.
Experiment 1	Total	15	5370.00	
	Grades	3	4490.00	1496.67**
(First Count)	Reps	3	441.00	147.00
	Error	9	439.00	48.78
(Second Count)	Total	15	3182.00	
	Grades	3	2284.50	761.50**
	Reps	3	297.00	99.00
	Error	9	600.50	66.72
Experiment 2	Total	15	1440.44	
	Grades	3	753.69	251.23
(First Count)	Reps	3	321.69	107.23
	Error	9	365.06	40.56
(Second Count	Total	15	1196.44	
	Grades	3	136.32	45.44
	Reps	3	64.69	21.56
	Error	9	995.43	110.60
Experiment 3	Total	15	127.44	
	Grades	3	6.69	2.23
(First Count)	Reps	3	74.69	24.90
	Error	9	46.06	5.12
(Second Count)	Total	15	151.94	
	Grade	3	15.19	5.06
	Reps	3	102.19	34.06
	Error	9	34.56	3.84

**The "F" value exceeds the value required for significance at the 1% level.

*The "F" value exceeds the value required for significance at the 5% level.

Table 7.--Analysis of Variance of Seedling Counts of Mixed Native Grasses in the Greenhouse and Germinator

	Source	d.f.	S.S.	M.S.
Experiment 4	Total	39	391.98	
	Grades	3	197.31	65.77**
(First Count)	Reps	9	129.23	14.36
	Error	27	65.44	2.42
(Second Count)	Total	39	497.38	
	Grades	3	158.48	52.83**
	Reps	9	89.63	9.96
	Error	27	249.27	9.23
Experiment 5	Total	39	3690.98	
	Grades	3	197.48	32.49
	Reps	9	2438.74	270.97
	Error	27	1164.76	43.14
Experiment 6	Total	39	2689.38	
	Grades	3	366.48	122.16
	Reps	9	1116.63	124.07
	Error	27	1206.27	44.68
Experiment 7	Total	15	13185.44	
	Grades	3	9303.19	3101.06**
	Reps	3	1963.69	654.56
	Error	9	1981.56	220.17
Experiment 8	Total	15	4483.75	
	Grades	3	2444.75	814.91**
	Reps	3	366.25	122.08
	Error	9	1625.75	183.64
Experiment 9	Total	15	1457.75	
	Grades	3	582.75	194.25
	Reps	3	144.25	48.08
	Error	9	730.75	81.19

**The "F" value exceeds the value required for significance at the 1% level.

*The "F" value exceeds the value required for significance at the 5% level.

Table 8.--Analysis of Variance of Seedling Counts of Side Oats Grama in the field.

	Source	d.f.	S.S.	M.S.
Experiment 1	Total	15	4451.00	
	Grades	3	2459.50	819.83*
(First Count)	Reps	3	901.00	300.33
	Error	9	1090.50	121.16
(Second Count)	Total	15	4159.00	
	Grades	3	2741.50	913.83
	Reps	3	656.00	218.67
	Error	9	761.50	84.61
Experiment 2	Total	15	8366.55	
	Grades	3	6681.75	2227.25**
(First Count)	Reps	3	606.75	202.25
	Error	9	1078.05	119.73
(Second Count)	Total	15	1685.00	
	Grades	3	1098.25	366.08**
	Reps	3	326.44	108.13
	Error	9	260.31	28.92
Experiment 3	Total	15	1453.94	
	Grades	3	487.69	162.56**
(First Count)	Reps	3	593.14	197.71
	Error	9	373.11	41.46
(Second Count)	Total	15	1639.00	
	Grades	3	596.50	198.83
	Reps	3	524.00	174.67
	Error	9	518.50	57.61
Experiment 4	Total	15	2399.75	
	Grades	3	2062.25	687.42**
	Reps	3	91.25	30.42
	Error	9	246.25	27.36
Experiment 5	Total	15	1353.75	
	Grades	3	488.75	162.92*
	Reps	3	500.25	166.75
	Error	9	364.75	40.53

**The "F" value exceeds the value required for significance at the 1% level.

*The "F" value exceeds the value required for significance at the 5% level.

Table 9.--Analysis of Variance of Seedling Counts of Side-oats Grama in the Greenhouse and Germinator

	Source	d.f.	S.S.	M.S.
Experiment 6	Total	39	681.60	
	Grades	3	15.20	5.06
(First Count)	Reps	9	482.10	53.57
	Error	27	184.30	6.83
(Second Count)	Total	39	630.74	
	Grades	3	206.24	68.75**
	Reps	9	192.49	21.39
	Error	27	232.01	8.59
Experiment 7	Total	39	12177.60	
	Grades	3	2538.00	846.00
	Reps	9	3973.10	441.45
	Error	27	4666.50	172.83
Experiment 8	Total	39	31119.78	
	Grades	3	1840.28	613.42
	Reps	9	8003.53	889.28
	Error	27	21275.97	787.99
Experiment 9	Total	15	4363.75	
	Grades	3	2079.25	693.08*
	Reps	3	887.25	295.75
	Error	9	1397.25	155.25
Experiment 10	Total	15	3041.44	
	Grades	3	1140.69	380.23
	Reps	3	269.19	89.73
	Error	9	1631.56	181.28
Experiment 11	Total	15	4897.00	
	Grades	3	109.50	36.50
	Reps	3	1276.50	425.50
	Error	9	3511.00	390.11

**The "F" value exceeds the value required for significance at the 1% level.

*The "F" value exceeds the value required for significance at the 5% level.

Appendix B

Combined Count Analysis

Table 10.--Analysis of Variance of Combined Seedling Counts of Blue Grama

	Source	d.f.	S.S.	M.S.
Experiment 1	Total	31	11700.00	
	Counts	1	1825.12	1825.12**
	Grades	3	2541.75	847.25*
	Grades x Count	3	295.15	98.37
	Reps	3	1874.25	624.75
	Error	21	5765.75	274.46
Experiment 2	Total	31	20069.22	
	Counts	1	3938.32	3938.32**
	Grades	3	8038.84	2679.61**
	Grades x Count	3	3099.26	1033,12**
	Reps	3	1942.10	647.36
	Error	21	3050.00	145.26
Experiment 3	Total	31	1136.00	
	Counts	1	36.12	36.12
	Grades	3	365.25	121.42*
	Grades x Count	3	3.63	1.21
	Reps	3	150.50	50.17
	Error	21	580.50	27.64
Experiment 6	Total	79	2049.56	
	Counts	1	16.17	16.17
	Grades	3	235.05	78.35**
	Grades x Count	3	3.63	1.21
	Reps	9	981.05	109.00
	Error	63	813.65	12.92

**The "F" value exceeds the value required for significance at the 1% level.

*The "F" value exceeds the value required for significance at the 5% level.

Table 11.--Analysis of Variance of Combined Seedling Counts of Mixed Native Grasses

	Source	d.f.	S.S.	M.S.
Experiment 1	Total	31	8680.00	
	Counts	1	128.00	128.00
	Grades	3	4518.75	1506.25**
	Grades x Count	3	2165.75	721.92
	Reps	3	657.00	219.00
	Error	21	1210.50	57.64
Experiment 2	Total	31	2742.00	
	Counts	1	105.12	105.12
	Grades	3	533.00	177.67
	Grades x Count	3	357.01	119.00
	Reps	3	292.75	97.58
	Error	21	1454.12	69.24
Experiment 3	Total	31	291.98	
	Counts	1	12.50	12.50
	Grades	3	18.38	6.13
	Grades x Count	3	3.50	1.16
	Reps	3	170.63	56.87
	Error	21	86.97	4.14
Experiment 4	Total	79	943.80	
	Counts	1	54.44	54.44**
	Grades	3	239.30	79.76**
	Grades x Count	3	116.49	38.83**
	Reps	9	209.05	23.23
	Error	63	324.52	5.15

**The "F" value exceeds the value required for significance at the 1% level.

Table 12.--Analysis of Variance of Combined Seedling Counts of Side-oats Grama

	Source	d.f.	S.S.	M.S.
Experiment 1	Total	31	9122.00	
	Counts	1	512.00	512.00**
	Grades	3	5178.50	1729.50**
	Grades x Counts	3	22.50	7.50
	Reps	3	1530.50	510.16
	Error	21	1878.50	89.45
Experiment 2	Total	31	14692.88	
	Counts	1	4703.38	4703.38**
	Grades	3	6576.63	2192.21**
	Grades x Count	3	1203.37	401.12**
	Reps	3	887.13	98.57
	Error	21	1322.37	62.97
Experiment 3	Total	31	3174.22	
	Counts	1	81.28	81.28
	Grades	3	1013.09	337.69**
	Grades x Counts	3	71.10	23.70
	Reps	3	1099.09	366.36
	Error	21	909.66	43.31
Experiment 6	Total	79	1425.99	
	Counts	1	113.05	113.05
	Grades	3	117.64	39.21**
	Grades x Counts	3	103.80	34.60*
	Reps	9	522.26	8.94

**The "F" value exceeds the value required for significance at the 1% level.

*The "F" value exceeds the value required for significance at the 5% level.

Appendix C

Combined Field Plantings
1953

Table 13.--Analysis of Variance of Combined Field Plantings of Blue Grama, Mixed Native Grasses, and Side-oats Grama.[1/]

	Source	d.f.	S.S.	M.S.
Blue Grama	Total	47	29253.67	
	Plantings	2	9954.29	4977.14**
	Grades	3	5544.67	1848.22**
	Grades x Plantings	6	5745.21	957.20
	Reps	3	1207.50	402.50
	Error	33	6809.00	206.33
Mixed Native Grasses				
	Total	47	19039.20	
	Plantings	2	12101.32	6050.66**
	Grades	3	2564.20	854.73 **
	Grades x Plantings	6	2686.18	447.69**
	Reps	3	98.70	32.90
	Error	33	1588.80	48.15
Side-oats Grama	Total	47	29808.67	
	Plantings	2	15400.23	7700.11**
	Grades	3	5876.83	1958.94**
	Grades x Plantings	6	3752.11	625.35**
	Reps	3	1401.50	467.16
	Error	33	3178.00	96.30

[1/] The first counts of each kind were combined.

**The "F" value exceeds the value required for significance at the 1% level.

Appendix D

Supplementary Material

Table 14.--Testing Weights (in grams) from Different Sampling Methods of All Kinds of Grasses in the Field, Greenhouse, and Germinator.

	Mechanical Purity				Estimation				Entire Sample
	A	B	C	D	A	B	C	D	A,B,C,D.
Field									
Blue Grama	.187	.350	.448	.982	1.000	3.700	4.050	6.000	3.000
Side-oats Grama	.145	.292	.384	.720	.500	1.390	1.720	2.460	2.500
Mixed Native Grasses	.289	.650	2.077	1.227	1.000	1.990	5.170	6.120	4.000
Greenhouse									
Blue Grama	.017	.032	.041	.091	.150	.555	.608	.900	.900
Side-oats Grama	.013	.027	.034	.066	.150	.416	.517	.737	.737
Mixed Native Grasses	.026	.078	.192	.111	.150	.298	.776	.918	.918
Germinator									
Blue Grama	.187	.350	.448	.982	.100	.370	.405	.600	.600
Side-oats Grama	.145	.292	.384	.720	.100	.277	.345	.491	.491
Mixed Native Grasses	.289	.650	2.077	1.227	.500	.599	.917	1.012	1.000

Table 15.--Purity of the Processed Grades of Blue Grama, Mixed Native Grasses, and Side-oats Grama

Kind	Grade	Percent of Pure Seed[1]	Number of seed per gram
Blue Grama	A	26.00	576
	B	13.10	308
	C	10.90	241
	D	5.60	110
Mixed Natives	A	35.08	373
	B	12.23	127
	C	6.37	52
	D	10.25	88
Side-oats	A	55.00	747
	B	23.70	369
	C	19.13	279
	D	11.30	150

[1]Mechanical methods were used to determine purity.

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