SEED GERMINATION STUDIES WITH PLANT SELECTIONS OF SWITCHGRASS, PANICUM VIRGATUM (L.)

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Bachelor of Science

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Nanking, China

1947

Submitted to the Faculty of the Graduate School of

the Oklahoma Agricultural and Mechanical College

in Partial Fulfillment of the Requirements

for the Degree of

MASTER OF SCIENCE

1951

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ACKNOWLEDGMENT

The writer wishes to express his sincere appreciation to his major advisers, Mr. Roy A. Chessmore, Mr. Hi W. Staten and Dr. Melvin D. Jones for their advice and constructive criticism; Mr. C. E. Denman of the Agronomy Department for his assistance in writing the thesis.

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INTRODUCTION

It is almost universally true that seed will go into a rest period at some stage of their development. This rest period may vary from a few days or weeks as in the seed of cottonwood and willow to several years in certain legumes. This phenomenon is usually more evident in seed produced in late summer or autumn and is much more common among native than cultivated plants.

Often the dormant period is only transient or temporary and can easily be overcome by the application of moisture, proper alternation of temperature, or oxygen supply. In other seed, a few weeks of drying in the atmosphere is sufficient to end dormancy. This is especially true in the grains which are of great value and interest to the agronomists. On the other hand, seed may remain dormant for years, in some cases 40 to 50 years or more. This is rather common in the seed of wild plants, especially in many weed and horticultural species. Dormancy is one of the most serious problems encountered by nurserymen.

When seed of a crop is sown, it is usually desirable to have all of them germinate at approximately the same time. This not only lessens the rate of seeding and cost of labor, but also greatly reduces the competition from weeds and, thus, enables the crop to ripen more evenly.

It is of great economical importance that seed has a certain period of dormancy. This is especially true in plants that ripen in the late fall in the temperate zone and in which the seed is the most valuable product. Such behavior carries the seed over the winter until the following spring and the seedlings are not exposed to freezing temperatures. At the same time, the cold temperatures of winter often produce changes in the seed which enable them to germinate in the spring.

Switchgrass, Panicum virgatum (L.), is a native, perennial, deep rooted, semi-bunch grass, that occurs throughout the tall-grass and coastal prairies. This valuable hay and pasture grass species produces an abundance of plump seed which are easily harvested and planted.

Dormancy in seed is commonly found in many selections of switchgrass. Not much work has been done on the behavior of this dormancy; although it is known that mechanical, chemical, or water treatment of seed will generally increase germination.

The primary objective of this investigation was to determine if dormancy in switchgrass varies among plant selections.

REVIEW OF LITERATURE

In studying the use of alternating temperatures in the germination of seed, Harrington (8)[1] found the favorable effects of alternation of temperatures upon the germination of seed to be caused by the changes in temperature and not by the mean or extreme temperature reached. In the use of alternating temperatures the upper temperature should be maintained only a small part of the day, never more than eight hours and usually not more than six hours. Then the change to the lower temperature should be fairly rapid. The changes to which the seed are subjected in any given alternation vary with their position within the germinator. The temperature changes giving best germination results with many kinds of seeds correspond rather closely with soil temperature in the field under conditions which induce the most prompt and vigorous production of seedlings. Harrington concluded that the results of field test suggest the use of an alternation between 18°C and 32°C for the germination of a large number of species.

In germinating seed of twelve range grasses, Plummer (10) found that alternating temperatures of 30°C for six hours and 20°C for 18 hours was at least as satisfactory as at a constant 30°C temperature.

Toole (13) prechilled Panicum obtusum seed for 14, 28, and 56 days at 3, 5 and 10°C, then germinated the treated seed at alternating temperatures. The results indicated that prechilling seed at 3°C for 28 days gave the best germination.

Cullinan (4) used alternating temperatures of 15°C (in light) to 35°C (in dark) to germinate seed of Panicum maximum.

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[1] Figures in parenthesis refer to, "Literature Cited", page 22.

According to Coffman's (2) work on minimum temperature, it was found that within a given species, starchy seed was unable to resist low temperature to the same degree as the more oily seed without injury and reduction of germination. All of the small grains will germinate at the temperature of melting ice.

As a result of experiments conducted on the effect of high temperatures on seed germination, Wright (14) found that the ability of seed to endure high temperatures cannot be satisfactorily explained on the basis of varying degrees of desiccation. Endurance to high temperatures may possibly be related to seed coat thickness. Heat may increase seed coat permeability and thus aid in breaking dormancy.

It has been pointed out that in some cases the seed coats entirely inhibit water absorption or restrict the oxygen supply below the minimum necessary for germination. Alkamine (1) reported that low germination of seed of Panicum protulum is determined by the character of the seed coat which normally is not permeable to gas. Germination of this species can be improved by presoaking old seed in water or fresh seed by H_2SO_4 scarification before planting.

In England, Edward (6) found that rubbing the seed of Panicum coloratum Stapf. in a mortar with a pestle covered with sand-paper increased the germination from 0 to 40%. He concluded that the lemma and palea were impermeable and therefore prevented germination.

Piacco (9) found that the removal of seed coats of a Panicum sp. gave 91% germination. Soaking seed for eight days in water also gave good results.

It is found that some seed, when given the ordinary germination conditions, fail to germinate because the embryos must go through a series of chemical changes before growth will start. Davies (5) explained how

embryos are thrown into and out of the dormant condition. Dormancy that is produced by high temperatures under restricted oxygen supply can be overcome by keeping the seed in a germinator at 5°C for a few months.

Reports show that low germination of seed may be caused by improper storage conditions or unfavorable conditions in the germinator or seed bed. Toole (12) found that cotton seed were subject to molds if dried below 10% moisture and became hard if dried down to 5 or 6%.

Gloyer (7), in testing two types of hardness of the bean, found that beans became hard coated if stored in too dry an atmosphere.

The seed dormancy and germination of Andropogon furcatus, Andropogon scoparius, Sorghastrum nutans and Bouteloua curtipendula were studied by Coukos (3) under different storage conditions. Seed with prolonged dormancy, such as A. furcatus and S. nutans, gave low germination the first spring in the laboratory room and a poor stand of seedlings in the plots. Seeds with brief dormancy may be used the first spring in the field. Normal germination of these grasses started 14 to 18 months after harvesting. After the break of dormancy, seed stored in bags under barn loft or room temperature storage conditions retained good viability only for about 10 months. Seed stored in jar will be viable for at least 20 months. It was also found that, after a break in dormancy, cold storage in bags shortened the life span of seed, whereas cold storage in jars extended the life span at least 38 months.

MATERIAL AND METHODS

Seed of Oklahoma #1 switchgrass used in this study were obtained from the Oklahoma Agricultural and Mechanical College Agronomy Farms at Perkins and Stillwater, Oklahoma.

The seed used were:

(1) Bulk seed of Oklahoma #1 switchgrass produced in 1946, 1947, 1948, 1949, and 1950.

(2) Seed produced in 1948, 1949, and 1950 on progeny rows planted in 1948 at the Stillwater Farm from seed of individual plant selection #173, #174, #176, #178, #180 and #195.

(3) Seed of individual plant selections of plant #1, #13, #15, #17, #20, #21, and #30 from Perkins Farm:

(a) Seed produced in 1949 from the mother plant.

(b) Seed produced in 1950 from the mother plant.

(c) Seed produced in 1950 from progeny rows that were space planted with 1949 seed from the mother plant.

Germinator Tests

No treatment other than normal germinating procedures were used as the study was to determine if dormancy in switchgrass varied among different selections.

In January of 1951, one hundred seed of each sample were tested in a Manglesdorf Germinator at alternate temperatures of approximately 15°C at night and 30°C during the day. The seed were germinated on indented paper blotters 3 by 3 inches in size. Each sample was replicated 4 times and each replication was observed over a 14 day period. The treatments were randomized

in the germinator on 4 trays which were changed end for end and rotated daily with the top tray being moved to the bottom, and the other trays moved up.

Normal seedlings were counted and removed from the blotters on alternate days beginning with the fifth day. At the end of the fourteenth day, all normal seedlings and diseased seed were removed; the remaining seeds were considered as hard seed.

Analysis of variance was made and the "F" test applied as given by Snedecor(11).

RESULTS AND DISCUSSION

Bulk Seed Selections

The results of this test are given in Table 1 which shows clearly that age affected the viability of switchgrass seed and it needs a certain rest period before it will germinate readily. Ages of seed were significantly different both in the percentage of germination and in percentage of disease.

There is general tendency for the percentage of germinated seed to vary inversely with the percentage of diseased seed. Seed harvested in 1949, which was about 16 months old when this test was conducted, produced the highest germination and the lowest number of diseased seed, 84.75% and 14.50% respectively. Seed from 1947, 1948 and 1950 showed a tendency to somewhat weakened and reduced in germination while percentage of diseased seed increased greatly in 1947 and 1948 and less in 1950. The 1946 results indicate a definite loss of viability with a germination of only 18.25% and a greater increase in diseased seed with 79.75%.

The percentage of hard seed was highest in 1950 and was consistently low after 1949. This probably accounts for the low germination in the 1950 seed as compared to the seed produced in 1949.

Table 1.--Effect of age on the viability of bulk switchgrass seed germinated in January 1951 at Stillwater, Oklahoma.

Year harvested	Seed		
	Germinated	Diseased	Hard
1946	18.25	79.75	2.00
1947	53.50	43.25	3.25
1948	48.50	47.00	4.50
1949	84.75	14.50	0.75
1950	53.75	28.50	18.75
F-value	43.63**	38.28**	

**Indicates that the F-value exceeds the value required for significance at the 1% level.

Row Selections

Results of the effect of age on the viability of row selections of switchgrass is recorded in Table 2 and the analysis of variance in Tables 3 and 4.

Seed from 6 selections differ significantly in their germination response. For an average of 3 years, selections #180 and #195 produced the best germination percentages, 87.83% and 90.33% respectively, while the other selections germinated from 78.08% to 81.50%. Significant differences were also obtained between years of harvest (Table 3). It is obvious that mean percentage of germination of seed harvested in 1949 was the highest while the 1948 seed were considerably better than 1950 ones (Table 2). However, there are two instances that may be worth noticing. Selection #176 has approximately the same germination percentage both in 1948 and 1949 while selection #178 germinated 98% in 1948 and 68% in 1949. Interaction occurred between selections and years of harvest. This indicates that selections failed to perform in the same manner during the three years and that no selection consistently exceeded others every year. Selection #195 which had the highest mean germination was the best in 1949 but was second both in 1948 and 1950. Selection #178 which had a mean germination of 79.25% was the best in 1948 but was the lowest in 1949 and fifth in 1950.

The percentage of diseased seed is recorded in Table 2. There was less fluctuation between ages of seed than between selections. Seed harvested in three different years produced diseased seed with variations ranging from 7.87% to 9.42% or less than 2% difference. Seed from different selections varied from 2.58% to 14.17% or more than 11% difference which is considered significantly important in this instance. This indicates that the age of seed did not affect the number of diseased seed as much as did selection.

Table 2.--Effect of age on the viability of row selections of switchgrass seed germinated in January, 1951, at Stillwater, Oklahoma.

Selection	Date Harvested	Seed		
		Germinated	Diseased	Hard
#173	1948	76.25	16.75	7.00
	1949	94.75	3.25	2.00
	1950	73.50	9.00	17.50
	av.	81.50	9.67	8.83
#174	1948	84.50	11.25	4.25
	1949	97.25	1.50	1.25
	1950	60.00	5.75	34.25
	av.	80.58	6.17	13.25
#176	1948	80.75	8.50	10.75
	1949	80.50	17.00	2.50
	1950	73.00	4.75	22.25
	av.	78.08	10.08	11.84
#178	1948	98.00	1.00	1.00
	1949	68.00	24.00	8.00
	1950	71.75	17.50	10.75
	av.	79.25	14.17	6.58
#180	1948	86.75	13.25	0.00
	1949	93.75	5.50	0.75
	1950	83.00	9.25	7.75
	av.	87.83	9.33	2.83
#195	1948	93.25	5.75	1.00
	1949	98.75	1.00	0.25
	1950	80.25	1.00	18.75
	av.	90.33	2.58	6.67
Average	1948	86.58	9.42	4.00
	1949	88.83	8.01	2.46
	1950	73.58	7.87	18.54
L.S.D. for years		7.06	3.23	
L.S.D. for selections		4.40	3.22	

Table 3.--Analysis of variance for seed germinated in row selections of switchgrass.

Source of variation	D.F.	S.S.	M.S.	F.
Years	2	3,253.00	1,626.50	16.31**
Replications	3	275.89	91.96	
Error (a)	6	598.44	99.74	
Selections	5	1,557.00	311.40	10.74**
Selections x years	10	3,935.50	393.55	13.50**
Error (b)	45	1,304.17	28.98	
Total	71	10,924.00		

**Indicates that F-value exceeds the value required for significance at the 1% level.

Table 4.--Analysis of variance for diseased seeds in row selections of switchgrass.

Source of variation	D.F.	S.S.	M.S.	F.
Years	2	28.58	14.29	
Replications	3	272.22	90.74	4.33**
Error (a)	6	125.87	20.98	
Selections	5	923.50	184.60	12.00**
Selections x years	10	2,149.92	214.99	13.98**
Error (b)	45	691.91	15.38	
Total	71	4,192.00		

**Indicates that F-value exceeds the value required for significance at the 1% level.

Highly significant interactions occurred between selections and years of harvest. This indicates that the 6 selections did not respond consistently the same in the production of diseased seed for the 3 years. In general, the older seed was more diseased. For instance, selections #173, #174, #180 and #195, seed from the 1948 crop produced a much higher percentage of diseased seed than those harvested in 1949 and 1950. However, this is not always true. For example, selections #176 and #178 had the highest number of diseased seed in 1949, 17% and 24% respectively. This indicates that the number of diseased seed present was influenced not only by environment but also by selection. It may be interesting to note that selection #195 gave the lowest percentage of diseased seed and seemed to be more resistant to disease than the others.

It is obvious that hard seed was present in all the selections. Dormancy was prominent in seed harvested in 1950 which were about 4 months old when these tests were conducted. In selections, #178, #180 and #195, dormancy had almost disappeared after 14 months of storage, while in the other three, hard seed increased rather significantly in the 1948 seed. The average percentage of hard seed produced among selections varied from 2.83% in selection #180 to 13.25% in selection #174. Such a difference is considered important. The foregoing results indicate that the production of hard seed is affected by age and varied among row selections.

Individual Plant Selections

The effects of age and selection upon the dormancy of individual plant selections of switchgrass are given in Table 5 and the analysis of variance in Table 6 and 7.

The percentage of germinated seed varied significantly, both between selections and between years of harvest, with the former fluctuating less

Table 5.--Effect of age on the viability of individual plant selections of switchgrass seed germinated in January, 1951 at Stillwater, Oklahoma.

Selection	Year harvested	Seed		
		Germinated	Diseased	Hard
# 1	1949	17.75	80.75	1.50
	1950	83.75	6.75	9.50
	Progeny from 1949	93.50	1.75	4.75
	av.	65.00	29.75	5.25
#13	1949	14.75	82.50	2.75
	1950	87.50	8.50	4.00
	Progeny from 1949	87.75	11.50	0.75
	av.	63.33	34.17	2.50
#15	1949	8.25	90.75	1.00
	1950	95.00	3.50	1.50
	Progeny from 1949	94.25	3.00	2.75
	av.	65.83	32.42	1.75
#17	1949	75.75	23.00	1.25
	1950	82.25	6.00	11.75
	Progeny from 1949	93.75	1.50	4.75
	av.	83.92	10.16	5.92
#20	1949	42.25	56.75	1.00
	1950	84.50	3.00	12.50
	Progeny from 1949	92.50	4.00	3.50
	av.	73.08	21.25	5.67
#21	1949	13.00	85.25	1.75
	1950	77.75	7.75	14.50
	Progeny from 1949	95.25	2.00	2.75
	av.	62.00	31.67	6.33
#30	1949	64.25	35.50	0.25
	1950	84.00	5.75	10.25
	Progeny from 1949	96.00	1.50	2.50
	av.	81.42	14.25	4.33
Total av.	1949	33.71	64.93	1.36
	1950	84.96	5.89	9.14
	Progeny from 1949	93.28	3.96	3.11
L.S.D. for years		3.17	3.60	
L.S.D. for selections		4.26	4.98	

Table 6.--Analysis of variance for seed germinated in individual plant selections of switchgrass.

Source of variation	D.F.	S.S.	M.S.	F.
Selections	6	5,775.92	962.65	39.10**
Replications	3	683.29	227.76	9.25**
Error (a)	18	443.12	24.62	
Years	2	58,282.61	29,141.31	844.43**
Years x selections	12	12,932.72	1,077.73	31.23**
Error (b)	42	1,449.34	34.51	
Total	83	79,567.00		

**Indicates that the F-value exceeds the value required for significance at the 1% level.

Table 7.--Analysis of variance for diseased seed in individual plant selections of switchgrass.

Source of variation	D.F.	S.S.	M.S.	F.
Selections	6	6,665.28	1,110.88	33.71**
Replications	3	576.66	192.22	5.83
Error (a)	18	593.01	32.95	
Years	2	67,673.74	33,836.87	759.36**
Years x selections	12	11,064.93	922.08	20.69**
Error (b)	42	1,871.33	44.56	
Total	83	88,444.95		

**Indicates that the F-value exceeds the value required for significance at the 1% level.

than the latter. Seed harvested in 1950 exceeded seed produced in 1949 in percentage germination. The average percentage of seed germinated in different years varied from 33.71% to 93.28%. In nearly every instance, progeny from 1949 seed germinated higher than 1949 and 1950 seed from the mother plant. Among the 7 selections #17 and #30 gave the best germination with 83.92% and 81.42%, while the other 5 selections ranged from 62.0% to 73.08%.

Diseased seed was significantly high in 1949 with an average of 64.93%. This apparently accounts for the low percentage of seed germinated in this particular year. Differences which occurred in the number of diseased seed between 1950 seed and progeny from 1949 were not significant. Selections #17 and #30 appear to be less susceptible to disease than the others.

Highly significant interactions occurred between selections and years of harvest. This indicates that the 7 selections performed differently during this two years. Therefore, variability in germination is probably influenced by both selection and environmental factors. In this experiment the environmental factors appear to be more important than selection.

The number of hard seed was high in 1950 mother plants but was much lower in both the 1949 seed and the progeny from 1949 seed. This may be due to the limited period of time allowed for germination in the greenhouse. Seed produced in 1949 from mother plants were planted in the greenhouse. After two weeks the seedlings were transplanted. Consequently, it was those which possessed the greatest dormancy and required a longer period to germinate that were discarded, while the seedlings transplanted were from seed of less dormancy. This has probably been a factor in the decrease in

dormancy of plant selections during the breeding procedure.

The high percentage of hard seed in the 1950 mother plants indicates that seeds from these selections have a certain period of dormancy. Selection #15 was considerably lower in dormancy than the others. The percentage of hard seed produced by the 1949 mother plants indicates that dormancy may be greatly reduced after 14 months of storage.

SUMMARY AND CONCLUSIONS

Investigations were conducted to determine if dormancy in switchgrass, Panicum virgatum (L.), seed varies among plant selections. Seed of Oklahoma #1 switchgrass were used in this study. Seed germination tests were conducted in a Manglesdorf germinator at Stillwater, Oklahoma in January of 1951.

The data obtained from bulk seed selections indicates that age affects the viability of seed. Decreased germination was generally accompanied by a high percentage of diseased seed. Seed harvested in 1946 had a definite loss of viability while 1947 and 1948 seed were somewhat reduced in germination. The 1949 seed had the highest germination and lowest percentage of diseased seed. The high percentage of hard seed in the 1950 seed indicates that seed of this species needs a certain period of dormancy before it will germinate readily.

Germination response differed significantly among 6 row selections and between years of harvest. The germination percentage of seed harvested in 1949 was the highest, while the 1948 seed were considerably higher than 1950. Interactions occurred between selections and years of harvest. However, no single selection consistently exceeded the others every year. The percentage of diseased seed fluctuated less between ages of seed than between selections. This apparently indicates that age of the seed did not affect the number of diseased seed as much as did selection. Hard seed was present in all 6 selections and was prominently high in seed harvested in 1950. Data obtained from this test indicates that the production of hard seed is affected by age and varies among selections.

In comparing the germination of individual plant selections it was found that the percentage of germination varied significantly between selections and years of harvest with the former fluctuating less than the

latter. In almost every instance, progeny from 1949 seed germinated higher than 1949 and 1950 seed from the mother plant. Diseased seed was consistently high in all the selections of 1949 seed from the mother plant but was rather low in both 1950 seed and progeny from the 1949 seed. The number of hard seed was high in the 1950 mother plant seed, comparatively low in the 1949 progeny seed, and very low in the 1949 mother plant seed.

Results of this investigation indicate that dormancy is common in all the selections employed in this study. It varies between years of harvest and among selections. The seed will usually recover from dormancy after 14 months storage. However, there will be an increased loss of viability and an increase in diseased seed as the seed becomes older.

The factor of seed storage and how much it might affect the germination was not taken into consideration. The investigator should have a knowledge of the seed source and previous storage before a problem of this type can be solved satisfactorily.

The data obtained is insufficient to give conclusive evidence, but the trends obtained seem worthy of consideration.

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A P P E N D I X

Table 8.--Effect of age on the viability of bulk switchgrass seed germinated in January, 1951 at Stillwater, Oklahoma.

Year Harvested	Replication	Seed		
		Germinated	Diseased	Hard
1946	1	14	85	1
	2	12	88	0
	3	17	83	0
	4	30	63	7
	av.	18.25	79.75	2.00
1947	1	43	56	1
	2	51	47	2
	3	61	37	2
	4	59	33	8
	av.	53.50	43.25	3.25
1948	1	55	42	3
	2	51	44	5
	3	47	50	3
	4	41	52	7
	av.	48.50	47.00	4.50
1949	1	81	18	1
	2	83	17	0
	3	84	14	2
	4	91	9	0
	av.	84.75	14.50	0.75
1950	1	61	34	5
	2	48	42	10
	3	54	16	30
	4	48	22	30
	av.	52.75	28.50	18.75

Table 9.---Effect of age and selection on the viability of seed from row selections of switchgrass germinated in January, 1951 at Stillwater, Oklahoma.

Selection	Year Harvested	Seed: Germinated Replication 1	2	3	4	av.	Diseased Replication 1	2	3	4	av.	Hard Replication 1	2	3	4	av.
#173	1948	76	78	82	69	76.25	24	18	11	14	16.75	0	4	7	17	7.00
	1949	97	94	91	97	94.75	1	4	7	1	3.25	2	2	2	2	2.00
	1950	69	75	66	84	73.50	16	11	3	6	9.00	15	14	31	10	17.50
#174	1948	80	80	91	87	84.50	20	12	5	8	11.25	0	8	4	5	4.25
	1949	98	96	97	98	97.25	2	1	2	1	1.50	0	3	1	1	1.25
	1950	57	66	46	71	60.00	4	5	8	6	5.75	39	29	46	23	34.25
#176	1948	87	66	83	87	80.75	13	5	14	2	8.50	0	29	3	11	10.75
	1949	80	73	82	87	80.50	20	23	14	11	17.00	0	4	4	2	2.50
	1950	69	71	66	86	73.00	5	3	4	7	4.75	26	26	30	7	22.25
#178	1948	97	99	98	98	98.00	3	0	1	0	1.00	0	1	1	2	1.00
	1949	70	72	62	68	68.00	30	24	32	10	24.00	0	4	6	22	8.00
	1950	71	72	72	72	71.75	25	18	14	13	17.50	4	10	14	15	10.75
#180	1948	84	86	89	88	86.75	16	14	11	12	13.25	0	0	0	0	0.00
	1949	96	91	95	93	93.75	4	9	5	4	5.50	0	0	0	3	0.75
	1950	87	80	78	87	83.00	9	16	4	8	9.25	4	4	18	5	7.75
#195	1948	91	97	91	94	93.25	9	3	8	3	5.75	0	0	1	3	1.00
	1949	99	98	99	99	98.75	1	2	0	1	1.00	0	0	1	0	0.25
	1950	91	89	60	81	80.25	1	1	2	0	1.00	8	10	38	19	18.75

Table 10.--Effect of age and selection on viability of the seed from individual plant selections of switchgrass germinated in January, 1951 at Stillwater, Oklahoma.

Selection	Year harvested	Seed													
		Germinated Replication					Diseased Replication					Hard Replication				
		1	2	3	4	av.	1	2	3	4	av.	1	2	3	4	av.
# 1	1949	31	11	12	17	17.75	64	89	88	82	80.75	5	0	0	1	1.50
	1950	84	85	75	91	83.75	15	10	1	1	6.75	1	5	24	8	9.50
	Progeny from 1949	95	96	91	92	93.50	3	1	1	2	1.75	2	3	8	6	4.75
#13	1949	24	3	13	19	14.75	65	97	87	81	82.50	11	0	0	0	2.75
	1950	93	86	85	86	87.50	5	13	8	8	8.50	2	1	7	6	4.00
	Progeny from 1949	94	85	81	91	87.75	5	15	17	9	11.50	1	0	2	0	0.75
#15	1949	16	4	3	10	8.25	80	96	97	90	90.75	4	0	0	0	1.00
	1950	94	95	93	98	95.00	4	3	5	2	3.50	2	2	2	0	1.50
	Progeny from 1949	94	94	95	94	94.25	4	3	2	3	3.00	2	3	3	3	2.75
#17	1949	74	89	70	70	75.75	26	11	29	26	23.00	0	0	1	4	1.25
	1950	86	82	75	86	82.25	8	9	0	7	6.00	6	9	25	7	11.75
	Progeny from 1949	93	91	95	96	93.75	2	2	0	2	1.50	5	7	5	2	4.75
#20	1949	61	31	41	36	42.25	35	69	59	64	56.75	4	0	0	0	1.00
	1950	84	76	83	95	84.50	5	3	1	3	3.00	11	21	16	2	12.50
	Progeny from 1949	96	89	88	97	92.50	2	9	3	2	4.00	2	2	9	1	3.50
#21	1949	19	11	19	3	13.00	75	89	80	97	85.25	6	0	1	0	1.75
	1950	81	74	73	83	77.75	5	16	4	6	7.75	14	10	23	11	14.50
	Progeny from 1949	95	95	91	100	95.25	3	3	2	0	2.00	2	2	7	0	2.75
#30	1949	77	62	61	57	64.25	22	38	39	43	35.50	1	0	0	0	0.25
	1950	85	81	84	86	84.00	5	6	3	9	5.75	10	13	13	5	10.25
	Progeny from 1949	98	98	94	94	96.00	0	2	1	3	1.50	2	0	5	3	2.50

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THESIS TITLE: SEED GERMINATION STUDIES WITH PLANT SELECTIONS OF SWITCHGRASS, PANICUM VIRGATUM (L.)

NAME OF AUTHOR: MING-YU LI

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