

A MORPHOLOGICAL STUDY OF SWITCHGRASS,
PANICUM VIRGATUM

by

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INTRODUCTION

Switchgrass is considered by many agronomists to be one of the more desirable native forage species of the Great Plains. It is used for grazing, for hay, and for soil conservation purposes. It is a vigorous productive warm season grass with wide adaptation and good seeding characteristics.

A wide range of morphological variation has generally been recognized in switchgrass. The present study was designed to investigate this variation and the interrelationship of various morphological characters. It was felt that the results of such a study would contribute to a better overall understanding of the species.

LITERATURE REVIEW

Hoover (1939) described switchgrass as a perennial occurring widely throughout the United States but being most useful in the Great Plains. Hoover (1939), Weaver and Fitzpatrick (1932), Wheeler (1950) and Hitchcock (1950) all described switchgrass as producing an abundance of leafy forage which can be grazed or made into hay. It spreads by both rhizomes and seed, the later usually being produced in abundance. Weaver and Fitzpatrick (1932) found that although abundant seed is produced, the germination rate is low. They stated, however, that those seedlings which do emerge develop rapidly and begin tillering within five to seven weeks.

Cornelius and Johnston (1941) studied biotypes of switch-

grass from Oklahoma, Kansas, Nebraska, and North Dakota for differences in plant type as related to rust resistance. They found that of the material studied a selection from Blackwell, Oklahoma possessed not only the best resistance to the rust Uromyces graminicola but was leafy, fine-stemmed, and of good forage quality. Ross (1939) found that the only characters associated with rust resistance were erect type of growth and the presence of a waxy bloom.

Nielsen (1944) studied morphological variation in switchgrass, and found positive and highly significant regressions between plant height and the magnitude of other aerial vegetative characters. He studied plant height, leaf length and width, diameter of various nodes, and panicle length. In addition he made chromosome number determinations for the isolates studied. He found significant variation within groups of plants having the same chromosome number and between groups of plants having the same chromosome number and between groups of plants having different chromosome number.

Weaver and Fitzpatrick (1932) found that fully developed switchgrass plants in close stands usually have one to three dead basal leaves and six to seven living ones on a coarse woody stem, two to five mm. in thickness. They found that the leaves average fourteen to twenty-four mm. in width, and that they roll in dry weather. They also reported the panicle as being twelve to twenty inches long and sixteen to twenty inches wide.

METHODS AND MATERIALS

Seed for this study was obtained from a plant introduction nursery and from switchgrass breeding nurseries at Kansas State University. The introduction nursery had been grown from seed collected throughout Kansas, Oklahoma, and Arkansas. The breeding nurseries consisted of selections from the variety Blackwell and of seed progenies of earlier breeding nurseries (table 1).

During the summer of 1954, seed was collected from plants which had been selected on the basis of morphological appearance. This seed was germinated in vermiculite in greenhouse pots during February, and the seedlings were transplanted into flats in mid-March. To facilitate comparison of greenhouse and field results the same planting plan was used for both greenhouse and field plantings. The selections were grouped as follows into five classes according to the physical appearance of the seed parent: tall and non-leafy, tall and leafy, medium tall and leafy, medium tall and non-leafy, and short and leafy. Selections were randomized within groups, and the groups were randomized in each of three replications.

Actual measurements were made of the following characters: leaf length, leaf width, internode diameter, panicle length, number of tillers per plant and two aspects of plant height. Two measurements of the average height of the top collar were made in the greenhouse at different dates. A measurement of the average height of the vertically-extended tips of leaves was made in the field. Visual ratings were made for greenhouse vigor, field

vigor, extent of heading and leafiness.

The following measurement procedures were used. Many of the leaf tips were damaged, necessitating a modified leaf length measurement. It was found that all leaf tips were undamaged to a point having a width one-half that of the leaf width at the ligule. Therefore that point was used to determine a relative leaf length. The leaf arising from the third node above ground was used for leaf length and width determinations. Notes on leaf length and width, internode diameter, and panicle length consisted of five random measurements per plant of the first five plants of a row. The remaining measurements were an average of one random measurement on each of the first five plants of a row. Leaf width was taken in mm. one cm. from the ligule. Internode diameter was measured with a micrometer calibrated in hundredths of inches, the third internode above the ground being used for all determinations. Panicle length was taken as the distance in cm. from the lowest panicle branch to the tip of the mature panicle. The number of tillers per plant was determined by actual count, the small initial shoots being ignored. Average height of leaf tips in the field was measured in cm. as the distance from the ground to the vertically-extended tips of the top leaves. Height of collars in the greenhouse was taken in cm. as the average height to the top collars for each selection. For field vigor, greenhouse vigor and leafiness, plants were rated one to five with one representing the maximum and five the minimum condition with respect to each plant character. The following ratings were used to denote the various stages of

heading: fully headed, most heads out of the boot leaf, all heads remaining partially enclosed in the boot leaf, and no heads emerging from the boot leaf. The visual ratings were an average for each selection.

A germination study was conducted in the following manner. Fifty seeds of each selection were placed on moist filter paper in a petri dish. They were treated for mold, shaded by dark heavy blotter paper, and maintained at 65 to 70 degrees F. Germination counts were made on the first, second, fourth, sixth, eighth, eleventh and thirteenth days.

The study was originally designed to include comparisons of the parent clones with their respective progenies. Accordingly, an additional field planting, in which each of the parent clones was replicated nine times, was established adjacent to the progeny planting. Because of drought conditions, however, mortality among the parent clones was so high that this phase of the study had to be abandoned.

An analysis of variance was conducted for each measurement and L.S.D.'s were determined wherever the "F" test showed significance. Simple and partial correlation coefficients were determined for all comparisons that were considered valid.

Photographs of the greenhouse seedlings were taken with a graflex camera, 4" X 5", on tri-X daylight black and white film.

EXPERIMENTAL RESULTS

Mean leaf length for selections varied from 27.0 to 45.9 cm.

(table 2) with differences among selections being highly significant (table 17). Simple correlation coefficients between leaf length and leaf width, panicle length, number of tillers per plant, and height of leaf tips were highly significant, but the partial correlation coefficients were low (table 34). In some cases class names were misleading as they pertained to the seed parent and the open-pollination progeny did not always reflect the parent characters. Many of the means for "shorter" classes were greater than the means for "taller" classes (table 32).

Mean leaf width varied from 9.2 to 14.4 mm. with all classes having approximately the same range (table 3). Significant differences were found in all sources of variation (table 18). Many class mean differences were significant but in disagreement with the relationships suggested by the class names (table 32). Simple correlation coefficients were high for all characters except internode diameter (table 33). Partial correlation coefficients were low (table 34).

Mean panicle length ranged from 28.1 to 47.8 cm. (table 4). Significant differences were found in all sources of variation except replications (table 19). Simple correlation coefficients between panicle length and all other characters except internode diameter were highly significant (table 33). The only significant partial correlation coefficient was that of panicle length with height of leaf tips.

Mean internode diameter varied from 0.0918 to 0.1632 inches (table 5), and differences were highly significant for all sources of variation (table 20). Simple correlation coefficients

showed that internode diameter was not correlated with the other vegetative characters (table 33). Class mean differences were small with four being significant at the 5 per cent level (table 32).

Mean number of tillers varied from 27.5 to 58.9 per plant (table 6). Analysis of variance showed significant differences among selections (table 29), but only one class mean difference was significant (table 32). Simple correlation coefficients were all high except that with internode diameter (table 33). The partial correlation coefficient involving number of tillers and the height of tips of leaves was significant at the 1 per cent level (table 34).

In height of the tips of leaves (which could be considered a plant height measurement) selection means ranged from 25.8 to 56.0 cm. (table 7), and there was significant variation among selections (table 28). Class mean differences varied considerably (table 32). All correlation coefficients were high except that involving internode diameter (table 33). Height of the leaf tips exhibited high partial correlations with panicle length, leaf width, and number of tillers per plant, (table 34).

Average height of the top collar (in the greenhouse) ranged from 5.3 to 18.3 cm. on April 25 (table 8). However, differences proves to be non-significant for all sources of variation (table 25).

The average height of the top collar on May 7 varied from 9.3 to 33.0 cm. with the range of the tall leafy class being great enough to include the ranges of the other classes (table 9).

All sources of variation exhibited differences which were significant at the 1 per cent level (table 24). All calculated simple correlation coefficients were high (table 33).

Greenhouse vigor ratings (plate I) were generally low (tables 10 and 11), but ratings for both dates exhibited significant differences as shown in tables 22 and 23. The May 7 data agreed very closely with those of April 25. Consequently only the May 7 note was used in correlation studies. Greenhouse vigor was highly correlated with field vigor and with the height of the top collar (table 33). The correlation coefficient with the latter was negative, since high vigor was indicated by a low number.

Ratings for field vigor were generally higher than those in the greenhouse (table 12), but showed approximately the same variation (table 26). There were many significant differences between class means (table 32).

Selections varied significantly in degree of heading (table 27). Degree of heading was highly correlated with field vigor (table 33).

Selections differed significantly in type of growth (table 30), but the differences between class means were very small (table 32). In leafiness, selections exhibited a small range of variation (table 15) and failed to differ significantly (table 31).

Germination counts indicated considerable differences among selections (table 16), and the analysis on total germination showed significant variation among progenies (table 21). Three class mean differences were significant at the 5 per cent level.

Table 1. Source of plants studied

Code No.	Kansas State No. of seed parent	Source of parent material
<u>tall leafy</u>		
*6281	2161-14	Blackwell selection 151-32
*6282	2167-2	" " 151-38
*6287	2181-19	" " 169-1
6292	2211-7	" " 183-1
*6297	2252-1	" " 211-3
*6304	3141-1	breeding nursery 1416-3
6308	3148-1	" " 1426-5
6318	3213-4	" " 1473-6
*6331	51049-7	Treece, Kansas
*6336	51054-16	" "
*6341	51208-4	Cleo Springs, Okla.
*6345	51257-6	Arkansas
<u>tall non leafy</u>		
6275	2124-3	Blackwell selection 138-19
*6277	2146-1	" " 151-16
6280	2159-3	" " 151-30
6285	2180-1	" " 168-2
6288	2197-7	" " 173-24
*6321	3231-1	breeding nursery 2173-15
*6329	3238-15	" " 2238-11
<u>medium leafy</u>		
*6283	2169-2	Blackwell selection 160-3
*6291	2210-15	" " 182-6
*6293	2212-1	" " 183-16
*6294	2220-1	" " 186-1
6296	2228-11	" " 191-7
6298	3098-1	isolation block 16-18
*6299	3102-1	" " 43-10
6301	3127-1	" " 134-10
6319	3230-1	breeding nursery 2148-18
<u>medium non-leafy</u>		
6300	3103-1	isolation block 47-3
6320	3230-2	breeding nursery 2148-18
6323	3232-1	" " 2175-17
<u>short leafy</u>		
*6289	2201-20	Blackwell selection 176-2
6324	3232-2	breeding nursery 2175-17
6327	3236-1	" " 2235-14
6328	3237-1	" " 2237-18
6339	51080-19	Ponca City, Okla.
6347	51259-3	Arkansas
6349	51260-3	Arkansas

*Plants used in germination test

Table 2. Leaf length

Selection :		Replication means :		Ranked means		Class
Selection :	Replication means	Replication means	Replication means	selection :	mean	mean
<u>tall leafy</u>						
6281	25.96	31.68	27.80	6331	45.88	
6282	30.80	32.56	30.08	6336	44.20	
6287	30.80	28.92	31.08	6345	42.56	
6292	35.52	34.60	32.88	6341	40.99	
6297	28.44	31.18	28.48	6318	40.01	
6304	29.40	31.84	44.08	6304	35.11	
6308	32.16	30.76	33.32	6292	34.33	
6318	37.04	41.96	41.04	6308	32.08	
6331	44.44	44.60	48.60	6282	31.15	
6336	45.36	44.24	43.00	6287	30.27	
6341	46.56	43.80	32.60	6297	29.37	
6345	46.64	40.28	40.76	6281	28.48	36.20
<u>tall non-leafy</u>						
6275	29.12	28.72	27.80	6277	30.97	
6277	30.48	31.32	31.12	6321	28.56	
6280	30.08	29.12	25.88	6275	28.55	
6288	27.60	25.80	28.56	6280	28.36	
6321	29.60	28.04	28.04	6329	28.28	
6329	27.96	29.28	27.60	6288	27.32	28.67
<u>medium leafy</u>						
6283	26.60	31.44	29.40	6301	34.25	
6291	29.52	32.92	31.72	6319	33.68	
6293	32.56	35.52	30.92	6299	33.13	
6294	27.92	30.08	30.36	6293	33.00	
6296	25.40	29.12	26.52	6298	32.44	
6298	32.80	34.24	30.28	6291	31.39	
6299	31.68	33.68	34.04	6294	29.45	
6301	34.80	33.92	34.04	6283	29.15	
6319	32.16	39.00	29.88	6296	27.01	31.50
<u>medium non-leafy</u>						
6300	33.16	31.88	28.30	6323	35.28	
6320	31.84	31.48	33.84	6320	32.39	
6323	36.80	33.92	35.12	6300	31.11	31.93
<u>short leafy</u>						
6289	28.36	30.52	28.12	6349	40.41	
6324	33.88	34.08	31.32	6347	38.87	
6327	37.64	35.24	30.88	6339	37.81	
6328	35.56	35.28	33.80	6328	34.88	
6339	34.52	43.95	34.96	6327	34.59	
6347	39.20	43.40	34.00	6324	33.09	
6349	42.96	40.68	37.60	6289	29.00	35.52

LSD for selection means = 4.40

Replication means involve 25 measurements

Table 3. Leaf width

Selection	Replication means			Ranked means		Class
	mean	mean	mean	selection	mean	mean
<u>tall leafy</u>						
6281	9.70	9.60	9.48	6331	14.37	
6282	10.88	10.64	9.56	6336	13.99	
6287	10.36	9.68	9.76	6345	13.68	
6292	10.76	10.32	10.16	6341	13.39	
6297	10.00	9.08	9.60	6318	11.95	
6304	9.84	9.52	14.12	6304	11.16	
6308	10.00	10.16	9.68	6292	10.41	
6318	12.32	12.28	11.24	6282	10.36	
6331	15.40	13.72	14.00	6308	9.95	
6336	15.56	13.32	13.08	6287	9.93	
6341	15.96	14.24	9.96	6281	9.59	
6345	15.56	12.96	12.52	6297	9.56	11.45
<u>tall non-leafy</u>						
6275	9.68	9.32	9.00	6280	10.44	
6277	10.80	10.36	9.88	6277	10.35	
6280	11.04	10.24	10.04	6321	9.93	
6288	9.60	10.39	9.72	6288	9.90	
6321	10.24	9.68	9.88	6329	9.51	
6329	10.40	9.12	9.04	6275	9.33	9.91
<u>medium leafy</u>						
6283	10.48	10.08	10.00	6301	10.99	
6291	10.60	10.72	10.04	6294	10.91	
6293	10.02	9.60	9.12	6298	10.77	
6294	10.92	10.72	11.08	6291	10.45	
6296	10.00	10.32	9.68	6319	10.28	
6298	11.28	10.76	10.28	6299	10.21	
6299	10.44	10.28	9.92	6283	10.15	
6301	10.26	11.00	11.72	6296	10.00	
6319	10.84	10.04	9.96	6293	9.58	10.37
<u>medium non-leafy</u>						
6300	11.36	10.44	9.76	6320	10.87	
6320	11.24	10.36	11.00	6300	10.52	
6323	11.20	10.20	10.08	6323	10.49	10.63
<u>short leafy</u>						
6289	9.32	9.28	8.92	6349	12.95	
6324	10.24	9.84	9.92	6347	12.68	
6327	10.16	9.48	9.08	6339	10.72	
6328	10.08	9.92	10.28	6328	10.09	
6339	9.84	11.88	10.44	6324	10.00	
6347	12.80	13.68	11.56	6327	9.57	
6349	13.00	13.04	12.80	6289	9.17	10.73

LSD for selection means = 1.37

Replication means involve 25 measurements

Table 4. Panicle length

Selection	Replication means	Ranked means selection	mean	Class mean	
<u>tall leafy</u>					
6281	22.52	35.32	6336	41.83	
6282	33.76	34.84	6345	40.52	
6287	27.12	29.16	6331	39.52	
6292	35.00	35.36	6341	39.30	
6297	29.04	36.04	6292	35.18	
6304	31.48	32.96	6318	34.40	
6308	34.56	31.12	6282	34.30	
6318	32.52	36.28	6308	32.84	
6331	34.20	44.84	6297	32.54	
6336	44.02	39.64	6304	32.22	
6341	38.76	39.84	6281	28.92	
6345	44.76	36.28	6287	28.14	34.98
<u>tall non-leafy</u>					
6275	37.76	34.84	6275	36.30	
6277	33.60	33.16	6288	35.62	
6280	34.00	30.80	6277	33.38	
6288	37.76	33.48	6280	32.40	
6321	30.96	32.32	6329	31.68	
6329	32.68	30.68	6321	31.64	33.50
<u>medium leafy</u>					
6283	28.76	33.92	6298	34.90	
6291	31.28	30.96	6299	34.68	
6293	33.36	34.04	6293	33.70	
6294	26.96	30.72	6283	31.34	
6296	31.16	28.24	6291	31.12	
6298	36.04	33.76	6301	30.60	
6299	31.76	37.60	6296	29.70	
6301	29.48	31.72	6294	28.84	
6319	29.44	27.92	6319	28.68	31.51
<u>medium non-leafy</u>					
6300	33.28	31.36	6323	32.97	
6320	31.08	28.84	6300	32.32	
6323	34.95	31.00	6320	29.97	31.75
<u>short leafy</u>					
6289	30.64	30.72	6349	47.81	
6324	34.04	30.84	6347	41.20	
6327	34.16	34.24	6339	40.44	
6328	31.04	31.36	6327	34.20	
6339	38.68	42.20	6324	32.44	
6347	41.36	41.04	6328	31.20	
6349	53.58	42.04	6289	30.68	36.85

LSD for selection means = 18.59

Replication means involve 25 measurements

Table 5. Internode diameter

Selection	Replication means	:	Ranked means		Class
			selection	mean	
<u>tall leafy</u>					
6281	.1000	.1104	6341	.1632	
6282	.0948	.1064	6345	.1584	
6287	.1028	.1020	6336	.1564	
6292	.1052	.1096	6331	.1518	
6297	.0992	.1052	6318	.1406	
6304	.1012	.1000	6292	.1074	
6308	.1008	.1072	6281	.1052	
6318	.1212	.1600	6308	.1040	
6331	.1412	.1624	6287	.1024	
6336	.1404	.1724	6297	.1022	
6341	.1408	.1856	6282	.1006	
6345	.1512	.1656	6304	.1006	.1244
<u>tall non-leafy</u>					
6275	.1064	.1128	6288	.1150	
6277	.1104	.1056	6275	.1096	
6280	.1048	.1136	6280	.1092	
6288	.1056	.1244	6277	.1080	
6321	.0952	.1040	6321	.1078	
6329	.1036	.1032	6329	.1034	.1088
<u>medium leafy</u>					
6283	.0924	.1064	6291	.1066	
6291	.1012	.1120	6293	.1066	
6293	.1036	.1096	6298	.1058	
6294	.1004	.1092	6294	.1048	
6296	.0908	.1036	6301	.1048	
6298	.1012	.1104	6319	.1004	
6299	.0904	.1044	6283	.0994	
6301	.1024	.1072	6299	.0974	
6319	.0976	.1032	6296	.0972	.1026
<u>medium non-leafy</u>					
6300	.1020	.1116	6300	.1068	
6320	.1012	.1076	6320	.1044	
6323	.0912	.1044	6323	.0978	.1030
<u>short leafy</u>					
6289	.0848	.1096	6349	.1532	
6324	.0844	.0992	6347	.1470	
6327	.0936	.0964	6339	.1196	
6328	.0816	.1028	6289	.0972	
6339	.1016	.1376	6327	.0950	
6347	.1384	.1556	6328	.0922	
6349	.1452	.1612	6324	.0918	.1137

LSD for selection means = .0515

Replication means involve 25 measurements

Table 6. No. of tillers per plant

Selection	Replication means			Ranked means		Class mean
	selection	mean	selection	mean		
<u>tall leafy</u>						
6281	31.1	35.1	39.2	6336	58.90	
6282	39.1	27.4	51.0	6331	55.33	
6287	34.0	35.9	50.1	6341	51.43	
6292	31.6	38.9	23.3	6345	47.70	
6297	40.9	32.4	45.8	6308	47.60	
6304	48.1	48.1	39.5	6318	45.86	
6308	39.3	42.3	61.2	6304	45.23	
6318	42.4	50.3	44.9	6287	40.00	
6331	45.5	56.3	64.2	6297	39.70	
6336	56.7	59.6	60.4	6282	39.16	
6341	47.8	35.9	70.6	6281	35.13	
6345	58.4	50.4	34.3	6292	31.26	44.78
<u>tall non-leafy</u>						
6275	28.4	35.0	39.6	6285	52.16	
6277	33.1	36.6	47.1	6321	47.83	
6280	44.7	31.7	48.6	6280	41.66	
6285	52.2	54.0	50.3	6329	39.70	
6288	30.7	29.7	39.9	6277	38.93	
6321	34.2	55.6	53.7	6275	34.33	
6329	35.3	30.2	53.6	6388	33.43	41.15
<u>medium leafy</u>						
6283	33.8	44.0	51.5	6293	45.76	
6291	29.7	50.1	46.6	6319	44.90	
6293	34.6	50.3	52.4	6299	43.70	
6294	23.8	43.5	43.6	6283	43.10	
6296	35.1	34.1	36.8	6291	42.13	
6298	35.2	49.9	36.5	6298	40.53	
6299	46.8	42.1	42.2	6294	36.96	
6301	37.8	38.0	24.5	6296	35.33	
6319	39.1	53.3	42.3	6301	33.43	40.65
<u>medium non-leafy</u>						
6300	42.0	34.5	40.1	6323	42.93	
6320	38.8	45.4	35.1	6320	39.76	
6323	46.3	36.1	46.4	6300	35.53	39.41
<u>short leafy</u>						
6289	23.1	25.1	34.4	6328	51.33	
6324	38.8	51.2	47.8	6349	49.76	
6327	36.3	54.8	49.7	6327	46.93	
6328	50.6	53.5	50.0	6324	45.93	
6339	41.8	46.9	33.9	6339	40.86	
6347	39.2	38.5	34.0	6347	37.23	
6349	52.3	48.3	48.7	6289	27.53	42.80

LSD for selection means = 12.46

Replication means involve 5 measurements

Table 7. Average height to tips of leaves

Selection	Replication means			Ranked means		Class mean
	1	2	3	selection	mean	
<u>tall leafy</u>						
6281	23.5	30.8	21.7	6345	52.87	
6282	28.3	27.5	28.0	6331	52.47	
6287	25.7	28.7	30.2	6336	50.30	
6292	29.8	36.1	24.0	6318	46.17	
6297	26.5	30.3	27.8	6341	45.07	
6304	32.1	36.0	50.5	6304	39.53	
6308	26.7	37.3	33.7	6308	32.57	
6318	41.7	50.8	46.0	6292	29.97	
6331	47.7	57.9	51.8	6287	28.20	
6336	53.4	50.7	46.8	6297	28.20	
6341	49.0	56.5	29.7	6282	27.93	
6345	53.6	55.7	49.3	6281	25.33	38.22
<u>tall non-leafy</u>						
6275	31.0	27.7	29.5	6288	32.17	
6277	26.2	31.5	29.1	6285	31.47	
6280	24.8	29.6	26.3	6275	29.40	
6285	32.3	31.5	31.6	6329	29.20	
6288	32.4	33.3	30.8	6277	28.93	
6321	25.4	28.3	26.5	6280	26.90	
6329	28.3	29.3	30.0	6321	26.73	29.26
<u>medium leafy</u>						
6283	25.2	26.7	30.2	6293	36.13	
6291	23.3	30.5	27.5	6298	29.20	
6293	31.7	41.2	35.5	6299	28.80	
6294	25.6	27.1	30.2	6296	28.30	
6296	26.1	29.2	29.6	6301	28.03	
6298	30.2	32.4	25.0	6294	27.63	
6299	26.6	30.8	29.0	6283	27.36	
6301	28.3	27.9	27.9	6291	27.10	
6319	26.3	28.7	25.1	6319	26.70	28.81
<u>medium non-leafy</u>						
6300	28.5	29.0	32.3	6320	33.83	
6320	32.8	35.3	33.4	6300	29.93	
6323	27.0	29.3	30.4	6323	28.90	30.89
<u>short leafy</u>						
6289	22.3	28.3	26.9	6349	56.00	
6324	26.5	33.4	27.7	6347	40.33	
6327	29.4	35.3	32.7	6328	35.56	
6328	32.8	42.1	31.8	6327	32.46	
6339	33.2	35.6	27.6	6339	32.13	
6347	43.7	43.8	33.5	6324	29.20	
6349	62.4	56.8	48.8	6289	25.83	35.93

LSD for selection means = 6.39

Replication means involve 5 measurements

Table 8. Height top collar April 25

Selection	Replications	Ranked	means	Class mean
<u>tall leafy</u>				
6281	7	6	5 6331	18.33
6282	5	5	8 6318	17.00
6287	6	5	5 6345	15.66
6292	9	5	3 6336	15.33
6297	10	7	4 6341	11.33
6304	11	7	8 6304	8.66
6308	10	7	6 6308	7.66
6318	23	14	14 6297	7.00
6331	24	18	13 6281	6.00
6336	14	18	14 6282	6.00
6341	15	15	4 6292	5.66
6345	16	18	13 6287	5.33
				10.33
<u>tall non-leafy</u>				
6275	8	5	4 6321	7.66
6277	8	7	4 6329	7.66
6280	9	7	5 6280	7.00
6285	8	4	5 6277	6.33
6288	8	4	6 6288	6.00
6321	10	7	6 6275	5.66
6329	9	8	6 6285	5.66
				6.57
<u>medium leafy</u>				
6283	8	6	8 6283	7.33
6291	7	6	6 6298	7.33
6293	6	5	5 6299	7.00
6294	8	5	4 6291	6.33
6296	7	5	4 6319	6.00
6298	10	7	5 6294	5.66
6299	8	7	6 6293	5.33
6301	10	3	3 6296	5.33
6319	8	6	4 6301	5.33
				6.18
<u>medium non-leafy</u>				
6300	7	8	6 6300	7.00
6320	8	8	5 6320	7.00
6323	8	6	6 6323	6.66
				6.89
<u>short leafy</u>				
6289	6	7	6 6349	14.66
6324	7	7	5 6339	11.33
6327	8	7	5 6347	10.33
6328	11	9	9 6328	9.66
6339	12	12	10 6327	6.66
6347	12	9	10 6289	6.33
6349	17	16	11 6324	6.33
				9.33

LSD for selection means ==6.13

Table 9. Height top collar May 7

Selection	Replication	means	Ranked means selection	mean	Class mean	
<u>tall leafy</u>						
6281	11	11	9	6331	33.00	
6282	11	8	15	6336	31.00	
6287	12	11	9	6345	28.33	
6292	15	9	4	6318	25.66	
6297	18	14	10	6341	24.33	
6304	22	15	25	6304	20.66	
6308	17	10	15	6297	14.00	
6318	27	26	26	6308	14.00	
6331	36	39	24	6282	11.33	
6336	34	34	25	6287	10.66	
6341	37	28	8	6281	10.33	
6345	34	26	25	6292	9.33	19.39
<u>tall non-leafy</u>						
6275	14	13	7	6288	17.66	
6277	12	12	8	6321	14.66	
6280	17	12	11	6329	14.00	
6285	18	7	10	6280	13.33	
6288	23	16	14	6285	11.66	
6321	18	13	13	6275	11.33	
6329	14	18	10	6277	10.66	13.33
<u>medium leafy</u>						
6283	17	12	15	6283	14.66	
6291	16	12	11	6299	14.66	
6293	18	10	10	6298	13.66	
6294	14	10	9	6291	13.00	
6296	15	12	7	6301	13.00	
6298	18	12	11	6293	12.66	
6299	16	16	12	6319	12.33	
6301	21	12	6	6296	11.33	
6319	15	13	9	6294	11.00	12.92
<u>medium non-leafy</u>						
6300	14	14	13	6320	15.00	
6320	19	15	11	6323	14.33	
6323	19	10	14	6300	13.66	14.33
<u>short leafy</u>						
6289	13	8	9	6349	27.33	
6324	14	15	9	6347	18.33	
6327	15	11	13	6339	17.66	
6328	19	15	16	6328	16.66	
6339	22	17	14	6327	13.00	
6347	22	19	14	6324	12.66	
6349	32	23	27	6289	10.00	16.52

LSD for selection means = 5.62

Table 10. Greenhouse vigor April 25

Selection		Replication means		Ranked means		Class
				selection	mean	mean
<u>tall leafy</u>						
6281	3	4	4	6287	4.00	
6282	4	4	3	6292	4.00	
6287	4	4	4	6281	3.66	
6292	3	4	5	6282	3.66	
6297	3	4	3	6297	3.33	
6304	2	3	2	6308	3.00	
6308	2	4	3	6304	2.33	
6318	1	2	2	6341	2.33	
6331	1	1	2	6318	1.66	
6336	1	1	1	6331	1.33	
6341	1	2	4	6345	1.33	
6345	1	2	1	6336	1.00	2.64
<u>tall non-leafy</u>						
6275	3	4	5	6275	4.00	
6277	3	4	5	6277	4.00	
6280	3	4	4	6285	4.00	
6285	3	4	5	6280	3.66	
6288	2	4	3	6288	3.00	
6321	2	3	3	6329	3.00	
6329	2	3	4	6321	2.66	3.47
<u>medium leafy</u>						
6283	3	3	3	6293	4.00	
6291	3	4	3	6294	4.00	
6293	3	5	4	6296	4.00	
6294	3	4	5	6299	3.66	
6296	3	4	5	6291	3.33	
6298	3	3	3	6301	3.33	
6299	3	4	4	6319	3.33	
6301	2	4	4	6283	3.00	
6319	3	4	3	6298	3.00	3.52
<u>medium non-leafy</u>						
6300	3	3	3	6300	3.00	
6320	3	3	3	6320	3.00	
6323	3	3	3	6323	3.00	3.00
<u>short leafy</u>						
6289	3	3	5	6324	4.00	
6324	4	3	5	6289	3.66	
6327	3	3	4	6327	3.33	
6328	2	3	2	6328	2.33	
6339	2	2	2	6339	2.00	
6347	2	2	2	6347	2.00	
6349	1	1	2	6349	1.33	2.66

LSD for selection means = 0.94

Table 11. Greenhouse vigor May 7

Selection		Replication means		Ranked means selection		Class mean
<u>tall leafy</u>						
6281	4	5	4	6281	4.33	
6282	4	5	3	6282	4.00	
6287	4	4	4	6287	4.00	
6292	3	4	5	6292	4.00	
6297	2	3	3	6308	3.33	
6304	2	3	2	6297	2.66	
6308	3	4	3	6304	2.33	
6318	2	1	1	6341	2.33	
6331	1	1	2	6318	1.33	
6336	1	1	1	6331	1.33	
6341	1	2	4	6345	1.33	
6345	1	2	1	6336	1.00	2.66
<u>tall non-leafy</u>						
6275	3	3	5	6285	4.33	
6277	3	4	5	6277	4.00	
6280	3	4	3	6275	3.66	
6285	3	5	5	6280	3.33	
6288	2	3	3	6288	2.66	
6321	2	3	3	6321	2.66	
6329	2	3	3	6329	2.66	3.33
<u>medium leafy</u>						
6283	3	3	3	6296	4.00	
6291	4	3	4	6291	3.66	
6293	2	4	4	6294	3.66	
6294	3	4	4	6293	3.33	
6296	4	4	4	6298	3.33	
6298	3	3	4	6299	3.33	
6299	4	3	3	6301	3.33	
6301	2	4	4	6319	3.33	
6319	3	3	4	6283	3.00	3.44
<u>medium non-leafy</u>						
6300	3	3	3	6323	3.33	
6320	3	3	3	6300	3.00	
6323	3	4	3	6320	3.00	3.11
<u>short leafy</u>						
6289	4	5	5	6289	4.66	
6324	3	3	4	6324	3.33	
6327	3	3	3	6327	3.00	
6328	2	3	2	6328	2.33	
6339	2	2	3	6339	2.33	
6347	1	2	2	6347	1.66	
6349	1	1	2	6349	1.33	2.66

LSD for selection means = 1.32

Table 12. Field vigor

Selection		Replication means		Ranked means		Class
				selection	mean	mean
<u>tall leafy</u>						
6281	3.5	3.1	3.2	6281	3.22	
6282	3.2	3.1	3.1	6287	3.22	
6287	3.6	3.1	3.1	6292	3.16	
6292	3.4	2.9	3.2	6282	3.13	
6297	3.2	3.0	3.1	6297	3.10	
6304	2.8	2.7	1.4	6308	2.93	
6308	3.2	2.8	2.8	6304	2.30	
6318	1.9	1.3	1.7	6341	1.93	
6331	1.9	1.0	1.0	6345	1.66	
6336	1.7	1.2	1.1	6318	1.63	
6341	1.9	1.1	2.8	6336	1.33	
6345	1.5	1.4	2.1	6331	1.30	2.41
<u>tall non-leafy</u>						
6275	3.0	3.1	2.8	6329	3.06	
6277	3.1	3.1	2.6	6288	3.00	
6280	3.0	3.0	2.8	6275	2.96	
6285	2.7	2.5	2.9	6277	2.93	
6288	3.0	3.0	3.0	6280	2.93	
6321	3.0	2.9	2.8	6321	2.90	
6329	3.2	3.2	2.8	6285	2.70	2.93
<u>medium leafy</u>						
6283	3.1	2.9	3.0	6296	3.13	
6291	3.3	2.7	2.9	6283	3.00	
6293	3.0	2.3	2.8	6291	2.96	
6294	3.0	2.8	2.7	6298	2.90	
6296	3.2	3.1	3.1	6299	2.90	
6298	3.0	2.7	3.0	6319	2.86	
6299	2.8	2.9	3.0	6294	2.83	
6301	2.6	2.4	3.0	6293	2.70	
6319	3.0	2.7	2.9	6301	2.66	2.88
<u>medium non-leafy</u>						
6300	3.0	2.8	3.0	6300	2.93	
6320	2.7	2.8	2.8	6323	2.93	
6323	2.9	2.9	3.0	6320	2.43	2.76
<u>short leafy</u>						
6289	3.5	3.1	3.2	6289	3.26	
6324	2.8	2.8	2.9	6327	2.93	
6327	3.0	2.9	2.9	6324	2.83	
6328	2.6	2.4	2.8	6328	2.60	
6339	2.5	2.3	2.7	6339	2.50	
6347	1.9	1.9	2.3	6347	2.03	
6349	1.1	1.4	1.4	6349	1.30	2.49

LSD for selection means = 0.43

Table 13. Heading

Selection		Replication means		Ranked means		Class
Selection	mean	selection	mean	selection	mean	mean
<u>tall leafy</u>						
6281	2.3	2.1	2.8	6345	2.93	
6282	2.0	2.1	2.3	6318	2.76	
6287	2.2	2.1	2.2	6336	2.76	
6292	2.3	2.1	2.7	6331	2.73	
6297	2.0	2.1	2.2	6341	2.60	
6304	2.1	2.1	2.9	6281	2.40	
6308	2.0	2.0	2.3	6292	2.37	
6318	3.5	3.3	3.5	6304	2.37	
6331	2.6	2.6	3.0	6287	2.16	
6336	2.8	2.5	3.0	6282	2.13	
6341	2.7	2.6	2.5	6297	2.10	
6345	2.7	2.8	3.3	6308	2.10	2.45
<u>tall non-leafy</u>						
6275	2.1	2.2	2.1	6321	2.66	
6277	2.1	2.1	2.4	6280	2.36	
6280	2.5	2.2	2.4	6277	2.20	
6285	2.0	2.0	2.0	6329	2.20	
6288	2.0	2.0	2.0	6275	2.13	
6321	2.7	2.6	2.7	6285	2.00	
6329	2.0	2.1	2.5	6288	2.00	2.22
<u>medium leafy</u>						
6283	2.1	2.1	2.3	6319	2.53	
6291	2.1	1.9	2.3	6301	2.43	
6293	2.1	1.8	2.0	6299	2.26	
6294	2.3	2.2	2.2	6294	2.23	
6296	2.1	2.0	2.1	6283	2.16	
6298	2.0	1.9	2.2	6291	2.10	
6299	2.2	1.9	2.7	6296	2.06	
6301	2.1	2.3	2.9	6298	2.03	
6319	2.4	2.4	2.8	6293	1.96	2.20
<u>medium non-leafy</u>						
6300	2.0	2.1	2.1	6323	2.60	
6320	2.0	2.0	2.5	6320	2.16	
6323	2.7	2.4	2.7	6300	2.06	2.27
<u>short leafy</u>						
6289	2.2	2.0	2.1	6347	2.80	
6324	2.2	2.3	2.6	6349	2.46	
6327	2.1	2.1	2.1	6339	2.40	
6328	2.4	2.0	2.5	6324	2.36	
6339	2.3	2.1	2.8	6328	2.30	
6347	2.6	2.6	3.2	6289	2.10	
6349	2.4	2.2	2.8	6327	2.10	2.36

LSD for selection means = 0.03

Table 14. Type of growth

Selection	Replication	means	Ranked means selection	mean	Class mean
<u>tall leafy</u>					
6281	3.0	3.0	6297	3.43	
6282	3.4	3.1	6331	3.20	
6287	2.4	3.3	6282	3.16	
6292	3.0	3.1	6336	3.13	
6297	3.5	3.2	6281	3.06	
6304	2.7	2.9	6318	3.03	
6308	3.1	3.0	6345	3.00	
6318	2.9	3.0	6287	2.96	
6331	3.0	3.1	6341	2.93	
6336	3.0	3.0	6308	2.86	
6341	3.0	2.8	6304	2.83	
6345	3.0	2.9	6292	2.16	2.98
<u>tall non-leafy</u>					
6275	3.5	3.3	6275	3.40	
6277	2.7	3.1	6321	3.33	
6280	2.9	3.0	6285	3.10	
6285	2.8	3.5	6388	3.03	
6288	3.0	3.0	6280	2.90	
6321	3.3	3.3	6277	2.83	
6329	3.0	2.6	6329	2.83	3.06
<u>medium leafy</u>					
6283	3.2	2.9	6301	3.33	
6291	3.3	2.9	6294	3.13	
6293	2.6	2.9	6298	3.10	
6294	3.3	3.1	6291	3.06	
6296	3.0	3.0	6283	3.03	
6298	3.2	3.0	6296	3.03	
6299	2.8	3.1	6299	2.96	
6301	3.6	3.3	6293	2.80	
6319	3.0	2.7	6319	2.80	3.03
<u>medium non-leafy</u>					
6300	3.8	3.4	6300	3.46	
6320	3.0	2.8	6323	3.06	
6323	3.0	3.0	6320	2.80	3.11
<u>short leafy</u>					
6289	4.0	4.0	6289	3.86	
6324	3.0	2.9	6339	3.33	
6327	3.2	3.2	6327	3.20	
6328	3.0	3.0	6349	3.03	
6339	3.6	3.0	6328	2.96	
6347	2.9	2.7	6324	2.86	
6349	3.1	3.0	6347	2.86	3.16

LSD for selection means = 3.24

Table 15. Leafiness

Selection	Replication means			Ranked means		Class mean
	:	:	:	selection	mean	
<u>tall leafy</u>						
6281	2.0	2.8	2.3	6287	2.96	
6282	2.7	2.6	2.0	6292	2.76	
6287	2.5	2.7	2.7	6297	2.73	
6292	2.8	2.6	2.9	6308	2.50	
6297	2.8	2.8	2.6	6336	2.46	
6304	2.0	2.0	2.3	6282	2.43	
6308	2.5	2.4	2.6	6281	2.36	
6318	2.1	1.5	2.2	6341	2.36	
6331	2.4	2.0	2.3	6345	2.36	
6336	2.9	2.1	2.4	6331	2.23	
6341	2.7	2.4	2.0	6304	2.10	
6345	2.5	2.0	2.6	6318	1.93	2.43
<u>tall non-leafy</u>						
6275	3.4	3.0	3.2	6275	3.20	
6277	2.7	2.6	2.3	6288	2.86	
6280	2.8	2.7	2.3	6285	2.83	
6285	3.0	2.5	3.0	6280	2.60	
6288	2.7	2.9	3.0	6277	2.53	
6321	2.7	2.2	1.3	6329	2.53	
6329	2.5	2.8	2.3	6321	2.06	2.66
<u>medium leafy</u>						
6283	2.2	1.7	2.3	6294	2.96	
6291	2.6	2.1	2.3	6296	2.83	
6293	3.0	2.5	2.8	6293	2.76	
6294	2.9	2.3	2.7	6298	2.76	
6296	2.6	2.8	3.1	6291	2.33	
6298	2.7	2.7	2.9	6301	2.33	
6299	1.7	2.1	2.9	6299	2.23	
6301	2.4	2.3	2.3	6283	2.06	
6319	1.9	1.5	1.6	6319	1.66	2.44
<u>medium non-leafy</u>						
6300	3.2	3.0	2.7	6300	2.96	
6320	2.3	1.8	1.6	6323	2.23	
6323	2.4	2.4	1.9	6320	1.90	2.36
<u>short leafy</u>						
6289	3.3	3.3	3.3	6289	3.30	
6324	1.7	1.9	1.4	6327	2.56	
6327	2.4	2.7	2.6	6349	2.40	
6328	1.3	1.7	1.4	6347	2.06	
6339	2.0	2.0	2.1	6339	2.03	
6347	2.3	1.9	2.0	6324	1.66	
6349	2.5	2.2	2.5	6328	1.46	2.21

LSD for selection means = 0.71

Table 16. Accumulative germination counts by days
(average of 3 replications)

Selection	Days after start of study						
	1st	2nd	4th	6th	8th	11th	13th
<u>tall leafy</u>							
6281	0.0	0.0	0.0	0.6	0.6	0.6	0.6
6282	3.3	8.3	21.6	21.6	29.6	30.6	31.3
6287	0.6	2.6	9.0	12.0	13.6	14.0	14.3
6297	1.3	2.0	9.6	14.6	15.6	15.6	16.0
6304	7.6	10.0	12.6	14.3	15.3	15.3	15.3
6331	0.3	0.6	4.0	6.6	7.6	8.6	9.6
6336	0.0	0.0	0.6	3.0	4.6	6.0	6.6
6341	1.0	1.0	4.3	7.0	7.3	8.6	10.0
6345	0.0	0.6	3.6	6.3	7.6	9.6	11.3
<u>tall non-leafy</u>							
6277	1.0	3.0	7.0	11.0	11.6	11.6	11.6
6321	1.0	5.6	10.0	11.3	12.6	13.0	13.3
6329	1.6	5.3	16.6	21.0	22.6	23.6	24.6
<u>medium leafy</u>							
6283	4.3	6.3	9.6	10.6	10.6	11.6	11.6
6291	3.6	11.6	21.6	25.6	25.6	25.6	26.3
6293	1.3	3.3	6.3	11.3	13.0	13.6	13.6
6294	1.3	3.0	4.6	6.0	6.3	6.3	6.3
6299	0.0	0.3	3.3	5.3	5.3	5.6	5.6
<u>short leafy</u>							
6289	0.0	0.6	3.6	6.3	7.0	7.0	7.0

Table 17. Analysis of variance of leaf length

Source of variation	D.F.	M.S.
Selections	36	1800.36**
Replications	2	622.22*
Selections X replications	72	181.12**
Plants same sel. and rep.	444	78.87**
Leaves same plant	2220	13.95
Total	2774	

Table 18. Analysis of variance of leaf width

Source of variation	D.F.	M.S.
Selections	36	137.41**
Replications	2	109.51**
Selections X replications	72	17.50**
Plants same sel. and rep.	444	5.08**
Leaves same plant	2220	0.70
Total	2774	

Table 19. Analysis of variance of panicle length

Sources of variation	D.F.	M.S.
Selections	36	943.30**
Replications	1	7.79
Selections X replications	36	261.03**
Plants same sel. and rep.	296	116.14**
Leaves same plant	1480	24.70
Total	1849	

Table 20. Analysis of variance of internode diameter

Sources of variation	D.F.	M.S.
Selections	36	0.02111**
Replications	1	0.07000**
Selections X replications	36	0.00166**
Plants same sel. and rep.	296	0.00057**
Stems same plant	1480	0.00009
Total	1849	

Table 21. Analysis of variance of total germination count#

Sources of variation	D.F.	M.S.
Selections	17	181.48**
Replications	2	40.57*
Error	34	11.94
Total	53	

#Feb. 17 to Mar. 2

Table 22. Analysis of variance of greenhouse vigor, April 25

Sources of variation	D.F.	M.S.
Selections	37	2.37**
Replications	2	7.61**
Error	74	0.36
Total	113	

Table 23. Analysis of variance of greenhouse vigor, May 7

Sources of variation	D.F.	M.S.
Selections	37	2.07**
Replications	2	4.75**
Error	74	0.66
Total	113	

Table 24. Analysis of variance of height top collar, May 7

Sources of variation	D.F.	M.S.
Selections	37	112.15**
Replications	2	362.11**
Error	74	11.96
Total	113	

Table 25. Analysis of variance of height top collar, Apr. 25

Sources of variation	D.F.	M.S.
Selections	37	15.08
Replications	2	106.74**
Error	74	14.22
Total	113	

Table 26. Analysis of variance of field vigor, Sept. 2

Sources of variation	D.F.	M.S.
Selections	37	0.25**
Replications	2	17.85**
Error	74	0.07
Total	113	

Table 27. Analysis of variance of heading, Aug. 15

Sources of variation	D.F.	M.S.
Selections	37	0.287**
Replications	2	0.990**
Error	74	0.026
Total	113	

Table 28. Analysis of variance of average height to tips of leaves

Sources of variation	D.F.	M.S.
Selections	37	210.75**
Replications	2	145.39**
Error	74	15.48
Total	113	

Table 29. Analysis of variance of number of tillers per plant

Sources of variation	D.F.	M.S.
Selections	37	138.43
Replications	2	307.78**
Error	74	58.81
Total	113	

Table 30. Analysis of variance of type of growth

Sources of variation	D.F.	M.S.
Selections	37	0.1562**
Replications	2	0.0200
Error	74	0.0398
Total	113	

Table 31. Analysis of variance of leafiness

Sources of variation	D.F.	M.S.
Selections	37	0.27
Replications	2	0.23
Error	74	0.19
Total	113	

Table 32. Differences between class means

Class	Compared with	Leaf length	Leaf width	Panicle length	Internode diameter	Panicle length	Internode diameter	No. of tillers per plant	Date of heading	Field height of tips of leaves	Type of growth	Vigor April 25	Vigor May 7	Vigor, Field	Height top of collar, May 7	Germination
tall leafy	tall non-leafy	7.47*	1.60*	1.56	.0072*	1.56	.0072*	3.63	.2294*	8.96*	#.0808	#.83*	#.67*	#.23*	6.06*	#2.64
	medium height leafy	4.00*	1.16*	3.45*	.0113	3.45*	.0113	4.13*	.2552*	9.41*	#.0475	#.88*	#.78*	#.25*	6.47*	#0.66
	medium height non-leafy	3.35*	0.94*	3.28*	.0097	3.28*	.0097	5.37	.1775*	7.33*	#.1275	#.36	#.45	#.35*	5.06*	-----
	short leafy	0.71	0.81*	#1.87	.0023	#1.87	.0023	1.98	.0908*	2.29*	#.1779*	#.02	.00	#.08	2.87*	5.80*
tall non-leafy	medium height leafy	#3.48*	#0.44	1.91	.0041	1.91	.0041	0.50	.0258	0.45	.0333	#.05	#.11	#.02	0.41	1.98
	medium height non-leafy	#4.13*	#0.66	1.74*	.0025	1.74*	.0025	1.74	#.0519	#1.63	#.0467	.47*	.22	#.12	#1.00	-----
	short leafy	#6.77*	#0.79*	#3.43*	#.0049	#3.43*	#.0049	#1.65	#.1386*	#6.67*	#.0971	.81*	.67*	.15	#3.19*	8.44*
medium height leafy	medium height non-leafy	#0.65	#0.22	#0.17	#.0016	#0.17	#.0016	1.24	#.0777	#2.08	#.0801	.52*	.33	#.10	#1.41	-----
	short leafy	#3.29*	#0.35	#5.34*	#.0090	#5.34*	#.0090	#2.15	#.1644*	#7.12*	#.1304*	.86*	.78*	.17*	#3.60*	6.46*
medium height non-leafy	short leafy	#2.64*	#0.13	#5.17*	#.0074	#5.17*	#.0074	#3.39	#.0867*	#5.04*	#.0504	.34*	.45*	.27*	#2.19*	-----

*Differences at the 5 per cent level of significance

#Differences in which the class in the second column had the greater mean

Table 33. Simple correlation coefficients

	2	3	4	5	6	7	8	9	10	11
1	.029	.800	.720	.623	.749					-.298
2		.002	.001	.001	.001					
3			.695	.608	.861					
4				.427	.780					
5					.645	.710				
6						.929		-.948		
7							-.911			
8								.883		
9									-.712	
10										

5% Level of significance .321

1% Level of significance .413

Legend of Code No's.

1. Leaf length
2. Internode diameter
3. Leaf width
4. Panicle length
5. No. of tillers per plant
6. Average height to tips of leaves
7. Height top collar, May 7
8. Vigor in greenhouse, May 7
9. Vigor in field
10. Heading
11. Leafiness

Table 34. Partial correlation coefficients

	2	3	4	5
1	-.2536	.0247	.1539	-.0506
2		-.1778	-.0561	.4709
3			-.0651	.4379
4				.4897

5% Level of significance .339

1% Level of significance .437

Legend of Code No's.

1. Leaf length
2. Leaf width
3. Panicle length
4. No. of tillers per plant
5. Height to tips of leaves

DISCUSSION

Results of this study were in general agreement with the findings of Weaver and Fitzpatrick (1932) with respect to the size of the leaves, stems, panicle, and the overall height of a mature plant.

As mentioned earlier, switchgrass is useful for grazing, for hay production, and for soil conservation practices. Cornelius and Johnston (1941) are among the many who suggest that the best plant for these three uses would be a leafy, fine-stemmed plant of good height.

Results of the study of leaf length, leaf width, internode diameter, panicle length, height of leaf tips, and number of tillers per plant indicate that improvement of the species should not be difficult. High values for the simple correlation coefficients r_{13} , r_{15} , r_{16} , r_{35} , r_{36} , and r_{56} indicate that no adverse linkage or pleiotropic relationships exist among leaf length, leaf width, number of tillers per plant, and plant height. Indeed it is likely that improvement in any one of these characters would be accompanied by improvement in each of the others.

Panicle length also was highly correlated with the above characters. It is unlikely that panicle length would be directly involved in forage production, but it would presumably have an important bearing upon seed yield.

The lack of correlation between internode diameter and any of the other characters is encouraging. It indicates that selection for fineness of culms need not result in adverse changes in

other characters contributing to forage value.

Heterogeneity LSD values indicate significant intra-class variation in most instances, the greater differences occurring in the tall leafy and the short leafy classes. These two classes consistently exhibited the greatest ranges which often were great enough to include the ranges of other classes. The inter-class differences were generally small, significance generally occurring in comparisons involving the tall leafy and short leafy classes.

Two types of switchgrass have generally been recognized, a smaller, fine-stemmed "upland" type, and a larger, coarse-stemmed "lowland" type. In the present study no attempt was made to distinguish these two forms, although a recent investigation of materials in the source nurseries has indicated that the parents of lines 6345, 6347 and 6349 were of the lowland type. These lines occurred in the tall leafy and short leafy classes, and an examination of the tabulated results strongly suggest that their inclusion in the study resulted in an increase in the variability found for most characters.

Results of recent studies indicate that the upland and lowland types differ cytologically, and that they may exist as distinct breeding populations. If this is true the high degree of variability demonstrated in the present study might be considered as being partly due to the inclusion of measurements from two distinct populations differing in their distribution of plant height, leaf width, etc. Additional research is required to determine whether the upland and lowland types should indeed

EXPLANATION OF PLATE I

Variation among selections
while in greenhouse.

PLATE I



be considered separate populations.

High values for the correlation coefficients r_{69} , r_{78} , and r_{56} suggest that "vigor" is largely a reflection of plant height and number of tillers per plant. Vigor appears to be a rather vague and indefinite term which, in this study at least, could well have been replaced by the more meaningful term "plant size".

It is interesting to note that differences in leafiness were less significant than were those in leaf length, leaf width, and other characters directly involved in leafiness. A large part of this apparent discrepancy is no doubt explained by the fact that "leafiness" was a visual rating which would lack much of the consistency of ratings based on actual measurements.

As shown in table 16, the ranking of the various selections with respect to percentage of germination did not become stable until about the tenth day, after which there was little additional germination. The apparent variation in rate of germination implies that sufficient time must be allowed in evaluation of seed sources for percentage germination. It is interesting to note that in the main study only one selection failed to produce a good proportion of healthy vigorous seedlings.

It is unfortunate that the parent-progeny portion of this study was lost. It would have helped establish the heritabilities of the characters studied.

SUMMARY

A morphological study of switchgrass was established from

open-pollinated seed of selected clones. Progenies of the selected clones were established in the greenhouse and later transplanted to the field. Measurements were taken in the greenhouse and in the field. Fifteen sets of data, involving both actual measurements and visual ratings, were obtained and analyzed statistically.

The results showed high simple correlation among all factors contributing to plant yield except internode diameter. Only three partial correlation coefficients were significant. The inter-class variations were generally small with the greatest variation being present within the tall leafy and short leafy classes.

It was felt that improvement of the species should not be too difficult. A study of the correlation coefficients indicated that selections of tall plants with large leaves, slender culms, and many tillers was probably feasible.

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A MORPHOLOGICAL STUDY OF SWITCHGRASS,
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by

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A study of morphological variation of various characters and their interrelationship was made as an aid to a better overall understanding of switchgrass.

From nurseries on the Kansas State University Agronomy farms seed clones were selected and classified as tall leafy, tall non-leafy, medium tall leafy, medium tall non-leafy and short leafy. The open-pollinated seed was collected and germinated in the greenhouse. Seedlings of each selection were transplanted to flats and later to the field. Observations were made on leaf length, leaf width, panicle length, internode diameter, height of tips of leaves, height of collar, number of tillers per plant, type of growth, heading, greenhouse vigor, field vigor and leafiness. The results were analyzed statistically.

The characters leaf length, leaf width, panicle length, height of leaf tips, and number of tillers per plant were highly correlated with one another. Internode diameter was not correlated with any other character, and the visual ratings were correlated only with the characters of which they were an estimate. High positive correlations among most yield-contributing characters indicated that improvement of the species would be possible by careful selection.

The class names, although accurately describing the seed parents, were not completely satisfactory for the open-pollination progeny; however the larger variations found within the tall leafy and short leafy classes were believed to have been due in part to the difference in genetic background. From recent studies it is felt that there are two distinctly different

types of switchgrass present in the Great Plains. It was believed that both types were present in the study but were not analyzed separately.

A germination study of several selections used in the main study was made. The results showed considerable variation between selections in percentage germination. However, the seedlings used in the main study were generally easily established and in only one selection was there a shortage of plants caused by seedling mortality.

A parent-progeny study was begun but had to be abandoned because of high mortality of the parent clones.

It was felt that further work including a parent-progeny study would be of value.