Ecotype variation in seedling and mature plant characteristics of basin wildrye (Elymus cinereus Scribn. and Merr.)

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Abstract:
Basin wildrye (Elymus cinereus Scribn. and Merr.) seed was collected from 94 locations throughout Montana, Wyoming, and Canada. This seed was planted at the Bridger Plant Materials Center, Bridger, Montana in 1960. In the summer of 1962 field data was recorded and all material was harvested and transported to Bozeman, Montana for further experimentation.

Ecotypes were compared for several characteristics including forage-yield, seed yield, seedling weight, seed weight, germination percentage, rate of germination, ability of seedlings to emerge, seed dormancy, and clipping tolerence.

Forage yields and seed yields were correlated, with an increase in forage yield associated with an increase in seed yield.

Larger seed weights were directly related to increased seedling emergence from a 2 1.2" depth of seeding and to reduced germination percentage.

Germination percentage was higher in boxes that were exposed to light than germination on blotters left in a dark germinator.

Rate of germination, as measured by germination on blotters at eight days divided by germination at 21 days was the most useful of six measures.

Seedling weight at six weeks was related to seed weight, rate of germination, ability of the seedling to emerge, and original forage yield. Rate of germination was probably the most important of the four factors.

Seedling response to clipping was directly correlated with seedling weight. Those seedlings with greater seedling weights were shown to have the least resistance to clipping.

Those ecotypes best suited for further research or for agronomic use were selected by ranking the 94 ecotypes for superior characteristics, Ecotypes Wy 107 and M 48 were superior and would be suited for further investigation.

ECOTYPE VARIATION IN SEEDLING AND MATURE PLANT CHARACTERISTICS

OF BASIN WILDRYE (ELYMUS CINEREUS SCRIBN. AND MERR.)

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDIX TABLES

ABSTRACT

Basin wildrye (Elymus cinereus Scribn. and Merr.) seed was collected from 94 locations throughout Montana, Wyoming, and Canada. This seed was planted at the Bridger Plant Materials Center, Bridger, Montana in 1960. In the summer of 1962 field data was recorded and all material was harvested and transported to Bozeman, Montana for further experimentation.

Ecotypes were compared for several characteristics including forage yield, seed yield, seedling weight, seed weight, germination percentage, rate of germination, ability of seedlings to emerge, seed dormancy, and clipping tolerence.

Forage yields and seed yields were correlated, with an increase in forage yield associated with an increase in seed yield.

Larger seed weights were directly related to increased seedling emergence from a 2½" depth of seeding and to reduced germination percentage.

Germination percentage was higher in boxes that were exposed to light than germination on blotters left in a dark germinator.

Rate of germination, as measured by germination on blotters at eight days divided by germination at 21 days was the most useful of six measures.

Seedling weight at six weeks was related to seed weight, rate of germination, ability of the seedling to emerge, and original forage yield. Rate of germination was probably the most important of the four factors.

Seedling response to clipping was directly correlated with seedling weight. Those seedlings with greater seedling weights were shown to have the least resistance to clipping.

Those ecotypes best suited for further research or for agronomic use were selected by ranking the 94 ecotypes for superior characteristics. Ecotypes Wy 107 and M.48 were superior and would be suited for further investigation.

INTRODUCTION

Basin wildrye (Elymus cinereus Scribn. and Merr.) (17) is a tall perennial bunchgrass. Basin wildrye is grazed in the spring but becomes coarse and tough later in the growing season. This plant produces a large amount of forage and provides good winter feed if left standing (18). Stands of basin wildrye are found in small isolated areas and are usually absent from heavily grazed areas. Stands of basin wildrye may be difficult to establish. Overgrazing, especially when the plants are young and succulent, is very damaging to the plant (2). Lack of information on basin wildrye and its forage potential resulted in the selection of this grass for detailed study.

The Soil Conservation Service collected seed from 94 different locations and planted this seed at the Bridger Plant Materials Center at Bridger, Montana for seed increase. This seed was planted in 18 foot rows spaced 3 feet apart with a common seed source, ecotype M-27, used as a check every fifth row resulting in a total of 122 rows. Field plantings were made in the fall of 1960 on irrigated land.

The present research was initiated to study seed size, seedling emergence, germination, seedling vigor, seed yield, and forage yield. Research relating to the above factors has not been reported for basin wildrye. The major objective of this study was to determine the relationship of various factors to seedling vigor and yields and to select those ecotypes best suited for agronomic use. By analyzing two separate sets of data, one for the 94 different ecotypes and one for the 28 check rows, it was possible, in some cases, to comment on environmental and genetic influences and relationships. By comparing various methods and techniques, it was hoped that information could be obtained which would be useful in future studies of this type.

LITERATURE REVIEW

In 1899 basin wildrye, (_Elymus cinereus_ Scribn. Merr.), was recognized by Piper and Erythea as a variety within giant wildrye, _Elymus condensatus_. The name _Elymus cinereus_ proposed by Scribn. and Merr. in 1902 was adopted in 1950 when Agnes Chase revised A. Hitchock's Manual of the Grasses of the United States (17). _Elymus cinereus_ is a very tall bunchgrass. The plant attains a height of eight feet, with leaves two to three feet in length and ½ to 3 inches in width. Normally this grass grows in ravines, along river banks, and at the base of mountain slopes. It is differentiated from giant wildrye by being less robust, typically non-rhizomotous, pubescent especially around nodes, and because it grows at slightly higher elevations.

Natural hybrids of _Elymus cinereus_ and _Sitanion hystrix_ were found in 1960, and according to Dewey (9) both plant species were tetraploids with a chromosome number of 2N = 28. This cross was also attained experimentally.

Miller and Pammel (29) in 1901 related seed size to seedling vigor of alfalfa. Larger seed within a species produced seedlings with larger roots and leaves. Kittock and Patterson (22) reported that increased seed weight was correlated with both emergence and stand of ten dryland range grasses. There was no correlation between seed weight and survival of seedlings. Increased forage yield was associated with increased seed weights but not with increased seed yields. Henson and Trayman (15) found seed size significantly influenced all measured characters of birdsfoot trefoil. Kneebone and Cremer (24) working with native grass species found that with increasing seed weights, emergence percentage increased and emergence time decreased. The largest seed produced the greatest height and weight of seedlings. Kneebone and Cremer stated: "The larger the seed within a lot the more vigorous were the seedlings, they emerged faster and grew at a faster rate." The effects of larger seed leveled off at 13 weeks, but weight and height measurements were still greater for the larger seed. Kittock and Patterson (22) also noted the less pronounced effect of larger seeds in late summer with dryland grasses. Research by Black (4) showed the increased initial growth of three strains of subterraneum clover was due to seed weight rather than increased growth rate. By contrast, Oexemann (35) working with soybean, cucumber, and tomato indicated the seedlings from the lighter weight seeds had an increased growth rate at six weeks. Plants from the heavier seeds were more vigorous; and as stated by Oexemann (35), "the vigor was probably due to stronger tissue." Vaughan (47) noted increased vigor of clover seedlings from heavier seed. He found specific gravity to be a seed weight factor influencing germination percentage. The small seeds having a greater specific gravity and a greater number of hard seeds, lowered the total germination. Schmidt (43) found heavier seed produced seedlings with greater quantitative measurements. Niffenegger, et. al. (33) found by germinating alfalfa seed that blowing and screening increased germination percentage. They concluded that the increase was due to removal of light shriveled seed.

Seed maturity has a direct influence upon the seed weight as reported by McAllister (29), Hermann and Hermann (16), and Willson (48). McAllister (29) working with range and pasture grasses selected four stages of seed maturity; premilk, milk, dough, and mature; and harvested seed lots from each stage. Seed weight was determined, and a direct correlation between seed weight and percentage germination resulted. McAllister (29) found that a difference in plant size grown from mature and immature seed could not be detected at the end of the seedling year. Hermann and Hermann (16) working with crested wheatgrass, selected eight stages of seed maturity and found seed weight, emergence, and seedling height increased with more mature seed. Willson (48) found that red clover seed which matured earlier in the season was heavier than that which matured later, although the number of days from the end of blooming until harvest were the same. Niffeneger and Thies (34) found that heavier seed was produced with irrigated conditions than with dryland.

Considerable work has been done on the relationship between seedling vigor and the ability of a seedling to emerge from a depth. By using an air blower, Rogler (41) obtained eight seed weight classes of crested wheatgrass which were planted at ½ inch intervals from ½ to 3 inches in depth. Increased depth of planting showed a reduced emergence percentage. Comparing the ½ with the 3 inch depth of planting, the emergence percentage was higher with the heavier seed weight classes than the lighter; being 30 to 45% and 1 to 6%, respectively. In another study Rogler (38) found a positive correlation between seed weight and seedling emergence. In deep plantings the heavier seeded strains were superior. He concluded that, with crested wheatgrass, the heavier seeded strains developed faster and produced sturdier seedlings at all depths of seeding. Rogler (41) recorded delayed development of the second leaf with increased depth of planting with crested wheatgrass and, in comparing the $\frac{1}{2}$ with the $2\frac{1}{2}$ inch depth of seeding, the lighter seeded strains were six days later than the heavier. Lawerence (25) working with intermediate wheatgrass with various planting depths and several seed weight classes found seed weights and seedling emergence were correlated between clones but not within a clone. He suggested emergence from $2\frac{1}{2}$ to 3 inch depth of planting as a selection criteria for intermediate wheatgrass. Kolar (25) found the heavier seeds of bromegrass can send up shoots from greater depths and establish more vigorous seedlings. Erickson (12) reported both germination and vigor were directly associated with seed size. Increased depth of planting decreased seedling vigor, but a higher percentage of vigorous seedlings resulted from larger seed than small. Kinsinger's (21) work with Indian ricegrass shows a direct correlation between the seeding depth and the total height of the seedling. He found this correlation significant up to a three inch depth of planting on sandy, well-drained soils. Murphy and Arny (32) and Moore (31) compared the seedling emergence from several depths of seeding on various soil types. The optimum seeding depth for most grasses was $\frac{1}{2}$ inch, but good results were obtained with deeper planting depths in lighter textured soils. Beveridge and Wilsie (3) did not find correlation between seed size and emergence ability with alfalfa up to a $1\frac{1}{2}$ inch depth of planting. Other reports indicate differences in emergence ability was hard to detect at shallow planting depths. As stated by Plummer (36): "Within wide limits weight of seed is probably a factor in emergence at deeper seeding depths, but does not appear to be within narrow ranges." In field tests with twelve range grasses he reported success or failure depends upon root development prior to summer drought. Kalton, et. al. (19) noted environmental differences in forage species when seeded at various depths. They noted that optimum depth of planting in the greenhouse was $\frac{1}{2}$ inch, whereas in the field, 1 inch depth was optimum. Correlations between field and greenhouse germination corresponded more closely at deeper depths of seeding, indicating the plantings in the greenhouse one inch or deeper would be best for predicting field germination. Wide variation in genotypes for ability to emerge was found. Kalton, et. al. (19) suggested that less conflicting data would result if seed lots were produced the same year under similar conditions.

Natural and artificial selection are important in forage crop improvement. Christie and Kalton (7) showed, with 20 strains of bromegrass, that seed size was a highly heritible character and progress in breeding could be made by recurrent selection. Kneebone (23) reported that selection for seedling vigor was effective in side-oats grama grass, and that seed weight and seedling vigor were correlated. Raeber (37) and Tossell (46) found that there was a difference between clonal lines of bromegrass when compared for seedling vigor and that selection among and within strains would be effective. According to

Tossell (46) breeding material could be improved by screening for seed weight. Dewey (10) working on components of seed yield in crested wheatgrass showed fertility of the seed heads and plant size affected seed yield, whereas seed size and spiklets per spike had little affect. Because of the negative correlation between plant size and fertility, selection sould be based on a compromise between the two traits for maximum seed yields. Schaaf, et. al. (42) after 11 years of studying the effects of forage yield, seed yield, and seed weights on breeding, obtained data on over 100 strains of crested wheatgrass. They found that there was a greater variation in seed yields than in forage yields or seed weights. Seed weights were higher the first than the second and third years. The correlation coefficients of forage yield with seed yield and of seed yield with seed weight were non-significant, but a correlation significant at the 1% level occurred for seed weight with forage yield. Estimates of genetic constants were calculated and heritability was relatively the same for culm height, seed yield, and seed weight. The genetic coefficient of variability was from two to four times greater for seed yield, indicating that seed yield variation was heritable to a greater extent than was seed weight and culm height. Fulkerson's and Tossell's (18) research with timothy showed spike length and seed weight were significantly correlated with seed yield, whereas spike number per unit area was not.

The ability of a plant or seedling to withstand frequent clipping appears to be a factor in evaluating seedling vigor. Grass species do not respond the same under different clipping programs as shown by

Heinrichs and Clark (14). Four clipping frequencies were used on each of five grass species. Results showed that crested wheatgrass and Russian wildrye tolerated frequent clipping and produced better root systems than did intermediate wheatgrass, streambank wheatgrass, and green speargrass after five years. Work by Dewey (8) with 30 clones of orchardgrass on response to clipping revealed that there were differences between clones as well as differences due to clipping practices. Generally, clones that were high yielding in one clipping practice were high yielding for all. Thaine (45) studied the effects of 1, 2, 3, and 5 clippings a year upon Russian wildrye. Increased clipping frequency decreased total vegetative yield. Root yield declined with frequent clipping, but leaf and stem yield increased. Branson (5) (6) found the height of the growing point to be an influencing factor on clipping and grazing with several grasses. He reported that with Kentucky bluegrass the growing point was below ground level most of the year and it was least affected by clipping and grazing. In contrast, the growing point of western wheatgrass was above the ground early in the season and that clipping and grazing were more detrimental to this grass. Other grasses studied showed the same relationship but not to the same extent as the two species above.

Dormancy is a factor to be considered in studying germination. Rogler (39) (40), studying seed dormancy in Indian ricegrass and green needlegrass, found peak germination was obtained five to six years after seed harvest. Some ecotypes of Indian ricegrass reached peak germination in three years, but germination percentage was not as high as for those ecotypes that reached peak germination in five to six years. After the fifth and sixth year, germination gradually declined for twenty years.

MATERIALS AND METHODS

Seed lots of basin wildrye ecotypes were collected from 94 locations throughout Montana, Wyoming, and Canada (Appendix Table I). Seeds were planted in October, 1960 at the Bridger Plant Materials Center, Bridger, Montana. All material was planted in 18 foot rows, three foot apart, under irrigated conditions. Every fifth row planted was from the same seed source, ecotype M-27, which was used as a check throughout the experiment. A total of 28 check rows were planted. The perennial grass did not produce seed the first year. The following year, seed was produced and harvested in August. Seed heads per row were counted, weighed, and recorded. Seed heads were then run through a small hammer mill. The seed was cleaned, and the weight recorded.

The fertility index was calculated by dividing the clean seed weight by the weight of the seed heads and multiplying by 100. The number of seeds per head was calculated by dividing the seed weight per head by the mean weight per seed.

Foliage color was estimated by visual observation; using 1, 3, 5, 7, 9 code; with 1 = blue green, 3 = dark green, 5 = mixed colors, 7 = light green, and 9 = diseased yellow.

Powdery mildew, <u>Erysiphe graminis</u>, was prevelant on most ecotypes. Disease was also rated by visual observation; using 1, 3, 5, 7, 9 code; 1= 0 to 25%, 3 = 25 to 65%, 7 = 65 to 85%, and 9 = 85 to 100%. (Rating shown as percentage of chlorotic and brown-colored foliage). In this report powdery mildew will be referred to as foliar disease.

August 6, 1962, the forage of each row was harvested and weighed green in the field. Due to the unequal establishment of some ecotypes a measure of stand was needed. The total space occupied by plants in each 18 foot row was determined and recorded as percentage of row based on 18 feet as 100% row. This will be referred to as stand percentage.

The material collected was transported to Bozeman, Montana and stored until December, 1962. All seed samples were mechanically divided with a Garnet seed divider and five grams of each seed lot was obtained for further tests. This seed was then blown by using a South Dakota seed blower to insure uniformity of samples. All material removed by blowing was examined and separation of fertile from sterile florets was accomplished in accordance with accepted procedures.

Four hundred seeds from each ecotype were counted and the weight of one hundred seeds recorded to the nearest .01 g. Two replications of 50 seeds at each of two depths, $\frac{1}{2}$ and $2\frac{1}{2}$ inches, were planted in the greenhouse on January 4 and 5. Since the two replications were in different rooms at different mean temperatures, they will be referred to as Plot 1 and Plot 2. Plot 1 had a mean temperature of 70° F. and Plot 2 had a mean temperature of 65° F. The check, M-27, was used every tenth row to conserve space and intermediate and crested wheatgrass were included for comparative purposes. In one replication, all materials were selected and planted at random; whereas in the other, all materials were planted in numerical order as harvested in the field. Uniform depth of planting was accomplished with the aid of a metal plate pushed into the sandy loam soil to the desired depth. All rows were one foot long and two inches apart with the ½" and 2½" depths of planting adjacent. Emergence counts were made at 21 and 28 days after planting. Seedling emergence was calculated from these data by dividing the number of emerged seedlings from the 2½" depth by the number emerged from the ½" depth of seeding. After the 28-day count was made, the emerged seedlings from the 2½" depth were destroyed and the seedlings of the ½" depth of seeding were thinned to 25. The 25 seedlings for each ecotype were clipped at ground level six weeks after planting. The seedlings were oven dried and their weight recorded to the nearest .01 g.

To study the influence of clipping the seedlings were clipped at ground level at seven and again at eight weeks. At the end of ten weeks after planting, all living seedlings were counted and recorded as a measure of clipping tolerence.

Germination trials were conducted using two methods. In one method 1½" by 4½" by 5" plastic boxes were used; in the other 4½" by 8" blotters were used. All tests included 100 seeds, and the temperature in the germinators was held at 68° F. Boxes and blotters were rotated each day to eliminate any temperature gradient within the germinators (1). Tap water was used to maintain adequate moisture levels. Germination counts were made at 10, 14, and 21 days in boxes and 8, 14, and 21 days on blotters. The methods were similar except that the boxes were exposed to daylight and room temperatures for seven to eight hours each day, whereas the blotters were in darkness at all times.

Germination tests were made in boxes immediately after seed harvest in August, 1962. Similar tests were made in January, 1963 and seed dormancy was calculated by dividing the germination percentage in August, 1962 by the germination percentage in January, 1963.

By reviewing the problems and objectives, a plan was written for analyzing and comparing all data collected. The data was processed at the computor labortory, Montana State College, in order to obtain a more comprehensive examination. Two separate sets of data, one for the ecotypes and one for within the ecotype M-27, were analyzed. Environmental and genetic influenced characteristics were estimated.

For testing hypotheses of the statistical results, generally accepted methods were used (25) (42). The number of samples for between ecotypes was 94 in all tests; but within the ecotype M-27, 28 samples were used in all tests except those in the greenhouse. Only 13 samples of the M-27 were used in tests for ability to emerge, seedling weights, clipping resistance, and greenhouse germination.

RESULTS

Yield Adjustments. Stand percentage was a factor with forage yield, seed yield, and the number of seed heads for the ecotype. Weight of seeds was not a factor of stand. Stand percentage was positively correlated with forage yield but not with seed yield, number of seed heads, and seed weight within the ecotype M-27. Mean stand percentage (Table I) was higher for the ecotype M-27 than for the 94 ecotypes; being 90% and 73%, respectively. Stand establishment did affect yields when low stand percentages were encountered.

In view of the above correlations, a covariance adjustment to 100% stand was made for forage yield, seed yield, and number of seed heads per unit area. Simple proportion adjustment was also made. It can be observed from the (a) values (Table I) that the true regression of stand with the adjusted factors did not go through 0. As an example: ecotype Wy 22 yielded 3,910 lbs./acre with 53% stand, the simple proportion adjustment was 7,370 lbs./acre and the covariance adjustment was 9,216 lbs./acre; while ecotype M 298 yielded 10,180 lbs./acre with 46% stand, simple proportion adjustment was 22,130 lbs./acre and the covariance adjustment was 16,214 lbs./acre. The example shows that even though forage yield was more closely correlated with stand than the other factors (Table I) low yielding ecotypes were under adjusted and high yielding ecotypes were over adjusted by the simple proportion method. Covariance adjustments were considered more realistic and were used for all subsequent calculations involving forage yield, seed yield and seed heads per square yard.

Table I. Mean values, regression and correlation coefficients for stand percentage of basin wildrye with a number of factors.

X = stand percentage

Y_1 = forage yield, lbs./acre

Y_2 = seed yield, lbs./acre

Y_3 = seed heads per sq. yard, number

Y_4 = mean weight of 100 seeds, grams

Variable	Mean	Y axis intercept (a)	Regression coefficient (byx)	Correlation coefficient (r)
		VALUES FOR ECOTYPES		
X	73.36			
Y_1	7,981.50	-255.23	112.27	.75**
Y_2	202.50	-34.43	3.23	.60**
Y_3	44.90	3.10	.57	.59**
Y_4	.32	.32	.00	-.06
		VALUES FOR WITHIN THE ECOTYPE M-27		
X	90.00			
Y_1	12,735.80	-1,588.00	158.81	.47*
Y_2	338.40	49.43	3.21	.22
Y_3	53.50	33.69	.02	.12
Y_4	.33	.32	.00	.04

** significant at 1% level
* significant at 5% level

Forage Yield. Forage yield was positively correlated with number of seed heads, weight of seed heads, and number of seeds per head for ecotypes and within ecotype M-27 (Tables II and III). Foliage color and forage yield were negatively correlated in both populations (Tables II and III). The negative correlations were a result of the coding system used, with the low values assigned to dark green foliage and high values for yellow or diseased foliage. Foliar disease significantly influenced forage yield of the ecotypes but had no influence on the forage yield within ecotype M-27. The positive correlation of foliage color and foliar disease for ecotypes and the lack of correlation within ecotype M-27 indicates that foliage color was associated with the incidence of powdery mildew. Forage yield was positively correlated at the 5% level with ability to emerge in 21 days for ecotypes but not within the ecotype M-27. About 50% of the variation in seed yield may be associated with forage yield.

Seed Yield. Multiple correlation and regression coefficients were obtained to interpret seed yield results (Tables II and III). Seed yields were tested for association with foliage color, foliar disease, forage yield, seed heads per unit area, number of seeds per head, weight per seed, and fertility index. By separate analysis of ecotypes and within the check ecotype, M-27, it was found that five variables significantly influenced seed yield. Three components of yield variables; seed heads per unit area, number of seeds per head, and weight per seed; were correlated with seed yield for ecotypes and within the ecotype M-27. Foliar disease and seed yield were negatively correlated for ecotypes; while fertility index and seed yield were positively correlated within the ecotype M-27 (Table III). The multiple regression of the three variables, seed heads per unit area, number of seeds per head, and weight per seed, upon seed yield for ecotypes and within the ecotype M-27 was highly significant (R=.99). This multiple regression formula was used for seed yield prediction. The prediction formula and the ten highest seed yielding ecotypes are reported in Appendix Table IV.

Simple correlation coefficients of variables studied are listed at the bottom of Tables II and III except for weight of seed heads which is recorded in Table IV. The weight and number of seed heads per unit area was positively correlated at the 5% level with the number of seeds per head for ecotype M-27. Number of seed heads per unit area and weight of seed heads per unit area were positively correlated for both populations. As the number of seed heads increased their total weight increased.

Foliage color was correlated at the 1% level with number and weight of seed heads per unit area for ecotypes and at the 5% level within the ecotype M-27. Foliar disease was negatively correlated with weight of seed heads per unit area at the 1% level for ecotypes.

Seeds per head was positively correlated with fertility index for ecotypes and within the ecotype M-27. Weight of seed heads per unit area was positively correlated with fertility index but only for ecotypes. The number of seeds per head was related to weight per seed, indicating that with fewer seed there was a tendency for heavier seed.

Table II. Seed yield correlation and regression coefficients with various factors for ecotypes.

Y = seed yield, lbs./acre
X_1 = foliage color, rating
X_2 = foliar disease, rating
X_3 = forage yield, lbs./acre
X_4 = seed heads per square yard, number
X_5 = seeds per head, number
X_6 = weight per seed, grams
X_7 = fertility index, calculated

Variable	Simple correlation r	Partial correlation r'	Multiple correlation (R)	Multiple regression coefficient b
		Y with X_1 thry X_7, (b_0 = -646.4)		
X_1	-.45**	-.17	(.989**)	-1.224
X_2	-.29**	.30**		2.503
X_3	.70**	.13		.001
X_4	.79**	.97**		4.625
X_5	.49**	.91**		2.091
X_6	.05	.84**		100,262.900
X_7	.43**	.14		.327
		Y with X_4 thru x_7, (b_0 = -642.8)		
X_4	.79**	.98**	(.988**)	4.750
X_5	.49**	.93**		2.164
X_6	.05	.87**		103,570.900
X_7	.43**	.07		.145
		Y with X_4 thru X_6, (b_0 = -643.9)		
X_4	.79**	.98**	(.988**)	4.756
X_5	.49**	.96**		2.203
X_6	.05	.88**		104,644.100

Simple correlation coefficients among the X variables

	X_2	X_3	X_4	X_5	X_6	X_7
X_1	.41**	-.61**	-.36**	-.16	-.09	-.05
X_2		-.45**	-.20	-.19	-.16	-.17
X_3			.56**	.27**	.19	.10
X_4				-.04	-.16	.01
X_5					-.18	.68**
X_6						.07

** significant at 1% level

Table III. Seed yield correlation and regression coefficients with various factors within the ecotype M-27.

Y = seed yield, lbs./acre
X_1 = foliage color, rating
X_2 = foliar disease, rating
X_3 = forage yield, lbs./acre
X_4 = seed heads per square yard, number
X_5 = seeds per head, number
X_6 = weight per seed, grams
X_7 = fertility index, calculated

Variable	Simple correlation r	Partial correlation r'	Multiple correlation (R)	Multiple regression coefficient b
		Y with X_1 thru X_7, (b_0 = -661.1)		
X_1	-.41*	.22	(.997**)	1.805
X_2	-.13	-.22		-2.460
X_3	.82**	.14		.001
X_4	.95**	.98**		5.326
X_5	.65**	.91**		1.651
X_6	.10	.75**		79,068.200
X_7	.21	.49*		1.403
		Y with X_4 thru X_7, (b_0 = -643.2)		
X_4	.95**	.99**	(.996*)	6.576
X_5	.65**	.91**		1.568
X_6	.10	.75**		77,658.200
X_7	.21	.52**		1.515
		Y with X_4 thru X_6, (b_0 = -612.6)		
X_4	.95**	.99**	(.995**)	6.427
X_5	.65**	.95**		1.810
X_6	.10	.74**		86,828.000

Simple correlation coefficients among the X variables

	X_2	X_3	X_4	X_5	X_6	X_7
X_1	.23	-.58**	-.39*	.39*	.13	.02
X_2		-.18	-.23	.17	.22	.11
X_3			.84**	.42*	.05	-.06
X_4				.41*	.01	-.02
X_5					-.04	.53**
X_6						.15

** significant at 1% level
* significant at 5% level

Table IV. Simple correlation coefficients for weight of seed heads per unit area with various factors.

Variable	Correlation coefficients (r)	
	Values for ecotypes	Values for within the ecotype M-27
Seed per head, number	-.19	.50**
Weight per seed, grams	-.03	.08
Fertility index, calculated	.27**	.02
Forage yield, lbs./acre	.59**	.83**
Foliage color, rating	-.43**	-.44*
Foliar disease, rating	-.27**	-.21
Seed heads, number	.71**	.96**

** significant at 1% level
* significant at 5% level