



Ecotype variation in seedling and mature plant characteristics of basin wildrye (*Elymus cinereus* Scribn. and Merr.)
by Roger Lavern Wilson

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of
MASTER OF SCIENCE in Agronomy
Montana State University
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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 tolerance.

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.

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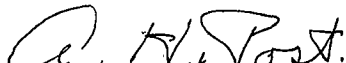
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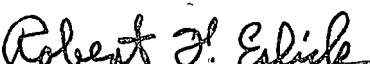
in

Agronomy

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MONTANA STATE COLLEGE
Bozeman, Montana

June, 1963

ACKNOWLEDGEMENT

The author wishes to express sincere thanks to Professor R. F. Eslick for advice and constructive criticism during the course of this study.

Special thanks to the Soil Conservation Service and to H. W. Cooper in initiating this study and to A. Thornberg, Soil Conservation Service, for assistance and suggestions in harvesting materials at the Plant Materials Center at Bridger, Montana.

Thanks also to Dr. A. H. Post, Head of the Plant and Soil Science Department and to D. Niffenegger for making possible the use of equipment for completion of this work.

The author is also indebted to Dr. L. Carter, A. Ferguson, E. Sharp, and C. Cooper for suggestions and amendments of the manuscript.

TABLE OF CONTENTS

	Page
LISTING OF TABLES.	5
LISTING OF APPENDIX TABLES	7
ABSTRACT.	8
INTRODUCTION	9
LITERATURE REVIEW.	11
MATERIALS AND METHODS.	19
RESULTS.	23
Yield Adjustments	23
Forage Yield.	25
Seed Yield.	25
Seed Weights.	30
Germination	34
Rate of Germination	37
Seedling Weight	41
Seedling Clipping Tolerance	44
Ecotype Origin.	46
Ecotype Differences	46
DISCUSSION	49
SUMMARY.	54
LITERATURE CITED	56
APPENDIX	60

LIST OF TABLES

	Page
Table I. Mean values, regression and correlation coefficients for stand percentage of basin wildrye with a number of factors.	24
Table II. Seed yield correlation and regression coefficients with various factors for ecotypes.	27
Table III. Seed yield correlation and regression coefficients with various factors within the ecotype M-27.	28
Table IV. Simple correlation coefficients for weight of seed heads per unit area with various factors.	29
Table V. Mean values, regression and correlation coefficients for mean weight of 100 seeds with ability to emerge..	31
Table VI. Analysis of variance for weight per 100 seeds of basin wildrye for ecotypes and within the ecotype M-27.	32
Table VII. Mean values, regression and correlation coefficients for mean weight of 100 seeds with germination.	33
Table VIII. Regression and correlation coefficients for 21 day germination in boxes with various factors.	35
Table IX. Mean values and simple correlation coefficients for greenhouse germination with various factors.	36
Table X. Partial and multiple correlation coefficients for rate of germination with various factors for ecotypes.	39
Table XI. Partial and multiple correlation coefficients for rate of germination with various factors within the ecotype M-27.	40
Table XII. Seedling weight correlation and regression coefficients with various factors for ecotypes.	42
Table XIII. Seedling weight correlation and regression coefficients with various factors within the ecotype M-27..	43
Table XIV. Correlation and regression coefficients for clipping response of basin wildrye seedlings with various factors.	45

	Page
Table XV. Effect of origin of ecotype on certain variables measured on basin wildrye.	47
Table XVI. Summary table of superior ecotypes according to rank for each measure listed. Only those ecotypes ranking in the upper 10% for two measures or ranking 1 or 2 for a single variable are listed. . .	48

LIST OF APPENDIX TABLES

	Page
Table I. Origin basin wildrye ecotypes with forage yield.	61
Table II. Mean values for individual ecotypes.	63
Table III. Superior ecotypes for forage yield with check included for comparison.	66
Table IV. Ecotypes with the highest seed yield shown for predicted and actual yield.	67
Table V. Superior ecotypes for mean of seed weights with checks included for comparison.	68
Table VI. Superior ecotypes for ability to emerge with checks included for comparison.	69
Table VII. Superior ecotypes for rate of germination with checks included for comparison.	70
Table VIII. Superior ecotypes for germination with check included for comparison.	71
Table IX. Superior ecotypes for seedling weight at six weeks with checks included for comparison.	72
Table X. Superior ecotypes for clipping tolerance with checks included for comparison.	73
Table XI. Superior ecotypes for seed dormancy with check included for comparison.	74

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 tolerance.

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. Hitchcock'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 $\frac{1}{2}$ 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-rhizomatous, 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 subterranean 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 $\frac{1}{2}$ inch intervals from $\frac{1}{2}$ to 3 inches in depth. Increased depth of planting showed a reduced emergence percentage. Comparing the $\frac{1}{2}$ 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. Lawrence (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 Army (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 heritable 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. Raebber (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 effect. Because of the negative correlation between plant size and fertility, selection could 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, Erysiphe graminis, was prevalent 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 $\frac{1}{2}$ " and $2\frac{1}{2}$ " 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 $2\frac{1}{2}$ " depth by the number emerged from the $\frac{1}{2}$ " depth of seeding. After the 28-day count was made, the emerged seedlings from the $2\frac{1}{2}$ " depth were destroyed and the seedlings of the $\frac{1}{2}$ " 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 tolerance.

Germination trials were conducted using two methods. In one method $1\frac{1}{2}$ " by $4\frac{1}{2}$ " by 5" plastic boxes were used; in the other $4\frac{1}{2}$ " 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 computer laboratory, 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

Y₁ = forage yield, lbs./acre

Y₂ = seed yield, lbs./acre

Y₃ = seed heads per sq. yard, number

Y₄ = 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
- X₁ = foliage color, rating
- X₂ = foliar disease, rating
- X₃ = forage yield, lbs./acre
- X₄ = seed heads per square yard, number
- X₅ = seeds per head, number
- X₆ = weight per seed, grams
- X₇ = 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 = -646.4) (.989**)						
X ₁	-.45**	-.17		-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) (.988**)						
X ₄	.79**	.98**		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) (.988**)						
X ₄	.79**	.98**		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
- X₁ = foliage color, rating
- X₂ = foliar disease, rating
- X₃ = forage yield, lbs./acre
- X₄ = seed heads per square yard, number
- X₅ = seeds per head, number
- X₆ = weight per seed, grams
- X₇ = 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) (.997***)						
X ₁	-.41*	.22		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) (.996**)						
X ₄	.95***	.99***		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) (.995***)						
X ₄	.95***	.99***		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

Seed Weights. Seedling ability to emerge was calculated by dividing the number of seedlings emerging from a $2\frac{1}{2}$ " depth of seeding by the number emerging from a $\frac{1}{2}$ " depth. Data was recorded for each of two plots at both 21 and 28 days after planting. The plots were greenhouse benches one in each of two separate houses.

In tests involving ecotypes, significant correlation coefficients at the 1% level were obtained for seed weights and ability to emerge after 21 and after 28 days for Plot 2. In Plot 1, emergence and seed weight were correlated at the 5% level for 21-day emergence but not significantly correlated with ability to emerge (Table V). Seed weights were different between ecotypes and between rows of ecotype M-27 (Table VI). A mean seed weight difference of over .03 grams per 100 seeds was significant at the 5% level (27). Superior ecotypes for seed weights are presented in Appendix Table V. Seed weights were positively correlated at the 1% level with seedling weights at six weeks for ecotypes but not within the ecotype M-27 (Table XII). All correlations between seed weights and total germination percentage were negative, indicating the heaviest seed tended to have a low germination percentage (Tables VII and VIII).

Table V. Mean values, regression and correlation coefficients for mean weight of 100 seeds with ability to emerge.

X = mean weight 100 seeds, grams

Y₁ = ability to emerge 21 days Plot 1, percent

Y₂ = ability to emerge 21 days Plot 2, percent

Y₃ = ability to emerge 28 days Plot 1, percent

Y₄ = ability to emerge 28 days Plot 2, percent

Variable	Mean	Y axis intercept (a)	Regression coefficient (byx)	Correlation coefficient (r)
VALUES FOR ECOTYPES				
X	.317			
Y ₁	.533	.033	1.576	.22*
Y ₂	.397	-.600	3.145	.43**
Y ₃	.623	.211	1.298	.18
Y ₄	.465	-.304	2.425	.36**
VALUES FOR WITHIN THE ECOTYPE M-27				
X	.326			
Y ₁	.603	-.607	3.709	.31
Y ₂	.339	-.845	3.632	.29
Y ₃	.689	-.495	3.628	.36
Y ₄	.442	-.047	1.501	.12

** significant at 1% level

* significant at 5% level

Table VI. Analysis of variance for weight per 100 seeds of basin wildrye for ecotypes and within the ecotype M-27.

Source of variation	Degrees of freedom	Mean square	F ratio
Among ecotypes	93	.00186	10.735**
Within ecotypes	188	.00017	
Total	281		
Among the source rows of ecotype M-27	27	.00064	3.690**
Within the source rows of ecotype M-27	56	.00017	
Total	83		

** significant at 1% level

Table VII. Mean values, regression and correlation coefficients for mean weight of 100 seeds with germination.

X = mean weight of 100 seeds, grams

Y₁ = germination, blotters 14 days, percent

Y₂ = germination, blotters 21 days, percent

Y₃ = germination, boxes 14 days, percent

Y₄ = germination, boxes 21 days, percent

Variable	Mean	Y axis intercept (a)	Regression coefficient (byx)	Correlation coefficient (r)
VALUES FOR ECOTYPES				
X	.32			
Y ₁	57.38	57.64	-.82	-.00
Y ₂	67.68	72.52	-15.27	-.04
Y ₃	66.93	91.25	-76.69	-.18
Y ₄	83.45	101.11	-55.70	-.20
VALUES FOR WITHIN THE ECOTYPE M-27				
X	.33			
Y ₁	49.39	73.17	-72.68	-.13
Y ₂	59.32	95.59	-110.88	-.22
Y ₃	59.46	75.52	-49.07	-.07
Y ₄	85.18	102.97	-54.40	-.16

Germination. The multiple regression of 21-day germination in boxes with seed dormancy, seed weight, and fertility index was non-significant. Seed weight was negatively correlated with 21-day germination in boxes at the 5% level (Table VIII).

Germination percentage after 21 days from a $\frac{1}{2}$ " seeding depth in the greenhouse for Plots 1 and 2 was correlated at the 1% level with germination in boxes and blotters for ecotypes but was not correlated within the ecotype M-27 (Table IX). Within the ecotype M-27, 21-day germination from a $\frac{1}{2}$ " seeding depth in the greenhouse was significantly correlated with 21-day germination on blotters. Superior ecotypes for germination percentage are shown in Appendix Table VIII.

Germination in boxes exposed to light was different from that on blotters kept in darkness for 21 days. Germination in boxes was 84% for all tests. Germination on blotters was 64% for all tests (Table IX). The mean germination percentage of ecotype M-27 and for all ecotypes was relatively the same in boxes; while on blotters it was 9% higher for all ecotypes.

Table VIII. Regression and correlation coefficients for 21 day germination in boxes with various factors.

Y = 21-day germination in boxes

X₁ = seed dormancy, $\frac{21\text{-day germination boxes Aug. } 62/}{21\text{-day germination boxes Jan. } 63}$

X₂ = mean weight 100 seeds, grams

X₃ = fertility index, $\frac{\text{seed yield/}}{\text{Wt. seed heads}}$

Variable	Simple correlation r			Partial correlation r'	Multiple correlation (R)	Multiple regression coefficient b
	X ₂	X ₃	Y			
VALUES FOR ECOTYPES						
Y with X ₁ thru X ₃ , (b ₀ = 94.1)						
X ₁	.10	-.08	.08	.11	(.23)	6.64
X ₂		.07	-.20	-.21*		-60.20
X ₃			.05	.08		.006
VALUES FOR WITHIN THE ECOTYPE M-27						
Y with X ₁ thru X ₃ , (b ₀ = 106.4)						
X ₁	.03	-.10	-.21	-.20	(.27)	-10.00
X ₂		.15	-.16	-.16		-55.20
X ₃			.05	.05		.005

* significant at 5% level

Table IX. Mean values and simple correlation coefficients for greenhouse germination with various factors.

Y = germination $\frac{1}{2}$ " depth greenhouse 21 days Plot 1

X₁ = germination $\frac{1}{2}$ " depth greenhouse 21 days Plot 2

X₂ = germination 21 days, blotters

X₃ = germination 21 days, boxes

	Values for ecotypes			Values for within the ecotype M-27		
	Mean	Correlation coefficient (r)		Mean	Correlation coefficient (r)	
	X ₂	X ₃	Y	X ₂	X ₃	Y
Y	72%			60%		
X ₁	70%	.57**	.55**	60%	.39	.64**
X ₂	68%		.60**	59%	.10	.14
X ₃	83%		.41**	84%		.18

** significant at 1% level

* significant at 5% level

Rate of Germination. Six measures of germination rate were calculated as follows (1) germination from a $\frac{1}{2}$ " depth of seeding after 21 days as a percentage of germination from a $\frac{1}{2}$ " depth after 28 days Plot 1 (2) germination from a $\frac{1}{2}$ " depth of seeding after 21 days as a percentage of germination from a $\frac{1}{2}$ " depth after 28 days Plot 2 (3) 10-day germination in boxes as a percentage of 21-day germination in boxes (4) 14-day germination in boxes as a percentage of 21-day germination in boxes (5) 8-day germination on blotters as a percentage of 21-day germination on blotters, and (6) 14-day germination on blotters as a percentage of 21-day germination on blotters.

In order to determine the best estimate of rate of germination, multiple and simple correlations (Tables X and XI) were obtained for the six determinations and seedling weight at six weeks, mean weight per 100 seeds, ability to emerge, seed dormancy, and fertility index.

Rate of germination determined from 8-day germination on blotters as a percentage of 21-day germination on blotters was correlated with more variables than any other determination. On the basis of the partial correlation coefficients for ecotypes, this determination of rate of germination was chosen for further tests. Rate of germination as determined by germination from a $\frac{1}{2}$ " depth of seeding after 21 days as a percentage of germination from $\frac{1}{2}$ " depth after 28 days was positively correlated with ability of seedlings to emerge for ecotypes. The only significant multiple correlation coefficient was for seedling weight with germination from a $\frac{1}{2}$ " depth of seeding in 21 days as a percentage of germination from $\frac{1}{2}$ " depth after 28 days.

Rate of germination on blotters and greenhouse germination after 21 days as a percentage of germination after 28 days was significantly correlated within the ecotype M-27. Correlations between greenhouse germination after 21 days as a percentage of germination after 28 days and rate of germination in boxes and blotters were significant for ecotypes. Rate of germination in boxes and rate of germination on blotters were positively correlated for ecotypes but not within the ecotype M-27.

Seedling weight at six weeks in either Plot 1 or Plot 2 was correlated with each measure of rate of germination. Mean seed weights were not related to rate of germination. Ability to emerge after 21 and 28 days was correlated with rate of germination on blotters for Plot 2 but not for Plot 1. Seedling emergence after 21 days on Plot 2 and after 28 days on Plots 1 and 2 was correlated with rate of germination in boxes. Seedling emergence after 21 days on Plot 1 was not correlated with rate of germination in boxes.

Seed dormancy and rate of germination in boxes and blotters each for 14-day as a percentage of 21-day germination were correlated. Seed dormancy was correlated with rate of germination Plot 2 of $\frac{1}{2}$ " depth of seeding 21 days as a percentage of $\frac{1}{2}$ " after 28 days. This rate of germination was also significantly correlated with fertility index for ecotypes.

Table X. Partial and multiple correlation coefficients for rate of germination with various factors for ecotypes.

Rate of germination		Y ₁ = seedling wt. 6 weeks Plot 1
X ₁ = $\frac{1}{2}$ " depth of seeding 21 days/ $\frac{1}{2}$ " depth of seeding 28 days	Plot 1	Y ₂ = seedling wt. 6 weeks Plot 2
X ₂ = $\frac{1}{4}$ " depth of seeding 21 days/ $\frac{1}{2}$ " depth of seeding 28 days	Plot 2	Y ₃ = mean wt. 100 seeds
X ₃ = 10-day germination in boxes/ 21-day germination in boxes		Y ₄ = ability to emerge 21 days Plot 1
X ₄ = 14-day germination in boxes/ 21-day germination in boxes		Y ₅ = ability to emerge 21 days Plot 2
X ₅ = 8-day germination on blotters/ 21-day germination on blotters		Y ₆ = ability to emerge 28 days Plot 1
X ₆ = 14-day germination on blotters/ 21-day germination on blotters		Y ₇ = ability to emerge 28 days Plot 2
		Y ₈ = seed dormancy
		Y ₉ = fertility index, calculated

	Each Y with X ₁ thru X ₆						Each Y with each X							
	Multiple correlation coefficient (R)						Partial correlation coefficient (r')							
		X ₁	X ₂	X ₃	X ₄	X ₅	X ₆		X ₁	X ₂	X ₃	X ₄	X ₅	X ₆
Y ₁	.52**	.07	-.02	-.05	-.06	.33**	.08							
Y ₂	.52**	.02	.11	.09	-.14	.32**	.09							
Y ₃	.24	.10	-.09	-.03	-.05	.10	.04							
Y ₄	.32	.07	.16	.13	-.08	-.17	-.12							
Y ₅	.50**	.04	-.28**	.07	-.05	.30**	.12							
Y ₆	.35*	.06	.22*	.10	.01	-.13	-.07							
Y ₇	.47**	.06	-.24*	.08	-.04	.27*	.09							
Y ₈	.38*	.01	.15	-.05	.09	-.13	.23							
Y ₉	.34*	.01	-.29	.20	-.19	-.02	.09							

Simple correlation coefficient between Y and among X variables

	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆
Y ₁	.26*	.20	.25*	.23*	.51**	.40**
Y ₂	.21*	.27**	.18	.14	.48**	.38**
Y ₃	.13	-.07	-.11	-.11	.09	.06
Y ₄	-.02	.09	.04	-.01	-.19	-.18
Y ₅	.19	-.05	.21*	.20	.42**	.33**
Y ₆	.04	.25*	.24*	.22*	-.00	.03
Y ₇	.20	-.02	.24*	.23*	.41**	.33**
Y ₈	.11	.25*	.20	.24*	.15	.32**
Y ₉	-.00	-.27**	-.01	-.08	-.05	-.02
X ₁		.17	.15	.15	.35**	.39**
X ₂			.38**	.37**	.38**	.40**
X ₃				.92**	.47**	.46**
X ₄					.47**	.50**
X ₅						.68**

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

Table XI. Partial and multiple correlation coefficients for rate of germination with various factors within the ecotype M-27.

Speed of germination		Y ₁ = seedling wt. 6 weeks Plot 1
X ₁ = $\frac{1}{2}$ " depth of seeding 21 days/	Plot 1	Y ₂ = seedling wt. 6 weeks Plot 2
$\frac{1}{2}$ " depth of seeding 28 days		Y ₃ = mean wt. 100 seeds
X ₂ = $\frac{1}{2}$ " depth of seeding 21 days/	Plot 2	Y ₄ = ability to emerge 21 days
$\frac{1}{2}$ " depth of seeding 28 days		Plot 1
X ₃ = 10-day germination in boxes/		Y ₅ = ability to emerge 21 days
21-day germination in boxes		Plot 2
X ₄ = 14-day germination in boxes/		Y ₆ = ability to emerge 28 days
21-day germination in boxes		Plot 1
X ₅ = 8-day germination on blotters/		Y ₇ = ability to emerge 28 days
21-day germination on blotters		Plot 2
X ₆ = 14-day germination on blotters/		Y ₈ = seed dormancy
21-day germination on blotters		Y ₉ = fertility index, calculated

	Each Y with X ₁ thru X ₆						Each Y with each X					
	Multiple correlation coefficient (R)						Partial correlation coefficient (r ⁱ)					
	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆
Y ₁	.91*	.83*	.10	-.41	.39	.33	.83*	.10	-.41	.39	.33	-.42
Y ₂	.64	.01	-.56	.44	-.46	.14	.01	-.56	.44	-.46	.14	.36
Y ₃	.68	.42	.28	-.41	.37	-.13	.42	.28	-.41	.37	-.13	-.57
Y ₄	.83	-.53	.61	.45	-.53	-.45	-.53	.61	.45	-.53	-.45	-.09
Y ₅	.73	-.07	.18	.14	-.22	.39	-.07	.18	.14	-.22	.39	-.64
Y ₆	.57	.36	-.08	.18	-.22	-.39	.36	-.08	.18	-.22	-.39	.09
Y ₇	.64	-.19	.20	.31	-.37	.32	-.19	.20	.31	-.37	.32	-.40
Y ₈	.69	-.40	-.49	.21	-.23	.14	-.40	-.49	.21	-.23	.14	.38
Y ₉	.69	.03	.55	-.52	.47	-.29	.03	.55	-.52	.47	-.29	-.27

Simple correlation coefficients between Y and among X variables						
	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆
Y ₁	.87**	.58*	-.01	.01	.59*	.47
Y ₂	-.15	-.37	-.17	-.21	-.11	-.01
Y ₃	-.07	-.09	-.17	-.15	-.27	-.35
Y ₄	-.38	.01	-.37	-.43	-.34	-.22
Y ₅	-.23	-.13	-.09	-.15	-.11	-.50
Y ₆	.09	-.16	-.29	-.32	-.32	-.07
Y ₇	-.12	.09	-.12	-.19	.08	-.22
Y ₈	-.47	-.49	-.20	-.20	-.24	-.09
Y ₉	.11	.25	-.37	-.32	-.05	.12
X ₁		.65*	.02	.03	.61*	.59*
X ₂			.05	.04	.74**	.66*
X ₃				.99**	.09	-.24
X ₄					.09	-.20
X ₅						.69**

** significant at 1% level

* significant at 5% level

Seedling Weight. Multiple regression analysis of seedling weight with forage yield, fertility index, seedling emergence from a $2\frac{1}{2}$ " depth, seed weight, and rate of germination (8-day germination on blotters as a percentage of 21-day germination on blotters) gave a significant correlation for ecotypes. Separate analyses were run by deleting one variable at a time, and with only two variables (seed weights and rate of germination) the multiple correlation coefficient remained significant at the 1% level (Table XII). This could indicate that seed weight and rate of germination were more important than fertility index, forage yield, and seedling emergence from a depth as determiners of seedling weights.

Seedling Clipping Tolerance. A multiple regression problem was analyzed to compare clipping results of basin wildrye with forage yield, fertility index, seedling emergence, seed weight, rate of germination, and weight of seedlings. Seedling weight and number of seedlings killed by clipping was related for ecotypes. With increased seedling weight more seedlings were killed by clipping (Table XIV).

Table XIV. Correlation and regression coefficients for clipping response of basin wildrye seedlings with various factors.

- Y = seedlings killed by clipping, number
 X₁ = forage yield, lbs./acre
 X₂ = fertility index, calculated
 X₃ = ability to emerge 21 days mean 2 plots, percent
 X₄ = mean weight 100 seeds, grams
 X₅ = rate of germination $\frac{8\text{-day blotters}}{21\text{-day blotters}}$
 X₆ = weight of 25 seedlings 6 weeks, grams

Variable	Simple correlation r	Partial correlation r'	Multiple correlation (R)	Multiple regression coefficient b
VALUES FOR ECOTYPES N=94 Y with X ₁ thru X ₆ , (b ₀ = 13.64).				
X ₁	.15	-.00	(.48**)	-.000003
X ₂	.20	.17		.0359
X ₃	.13	-.08		-1.3870
X ₄	.17	.04		3.1916
X ₅	.32	.11		1.8695
X ₆	.45**	.29**		7.2299

All simple correlation coefficients among X variables on Table XII

VALUES FOR WITHIN THE ECOTYPE M-27 N=13
Y with X₁ thru X₆, (b₀ = 8.94)

X ₁	.05	.06	(.28)	.000044
X ₂	.11	.09		.0287
X ₃	.02	.04		.5796
X ₄	.21	.15		19.3153
X ₅	.06	.00		.0933
X ₆	.15	.13		3.7006

All simple correlation coefficients among X variables on Table XIII

** significant at 1% level

Ecotype Origin. The analysis of variance values for origin of ecotypes, Montana-Canada versus Wyoming for seedling weight, forage yield, seed yield, fertility index, ability to emerge, seed weight, and rate of germination, are presented in Table XV. Wyoming ecotypes had significantly higher seedling weight at the end of six weeks than Montana-Canada ecotypes. Rate of germination using 8-day germination on blotters as a percentage of 21-day germination on blotters was significantly higher at the 1% level for the Wyoming lines. Forage yields were significantly higher at the 25% level for Montana-Canada ecotypes. Seed yield, fertility index, ability to emerge, and mean seed weights were relatively the same for the origins.

Ecotype Differences. Ecotype differences for ability to emerge from a depth, clipping tolerance, seedling weight, and germination percentage germination in boxes and on blotters after 21 days were significantly different at the 25% level. Detailed data is presented in Appendix Tables VI, VIII, IX, and X. Superior ecotypes for ability to emerge from a depth, mean germination after 21 days determined in boxes and on blotters, seedling weight at six weeks, and clipping tolerance are listed in Table XVI.

Table XV. Effect of origin of ecotype on certain variables measured on basin wildrye.

Variables	Origin means	
	Montana-Canada N=52	Wyoming N=42
Seedling weight 6 weeks mean 2 plots, grams	.58*	.63*
Forage yield, lbs./acre	11,241.00***	10,639.00***
Seed yield, lbs./acre	289.30	287.70
Fertility index, calculated	57.30	56.30
Ability to emerge 21 days mean 2 plots, percent	.47	.46
Mean weight 100 seeds, grams	.316	.319
Rate of germination 8-day blotters/ 21-day blotters	.46**	.53**

*** significant at 25% level from the corresponding Wyoming mean

** significant at 1% level from the corresponding Wyoming mean

* significant at 5% level from the corresponding Wyoming mean

Table XVI. Summary table of superior ecotypes according to rank for each measure listed. Only those ecotypes ranking in the upper 10% for two measures or ranking 1 or 2 for a single variable are listed.

- | | |
|-----------------------|-------------------------|
| 1 = forage yield | 6 = rate of germination |
| 2 = seed yield | 7 = germination |
| 3 = seedling weight | 8 = clipping tolerance |
| 4 = seed weight | 9 = dormancy |
| 5 = ability to emerge | |

Ecotype No.	Measures								
	1	2	3	4	5	6	7	8	9
Wy 107	4	1	4	10	1	2	4		8
M 48	1	2	2						
M 262	5	3					9	7	6
Wy 50	6	9	8						
M 190	2	8							
M 298	3					5			
M 226	8				2				
Wy 118	10				3				
M 718		6	5			4			
M 102				3			7		
Wy 78				4	6				
Wy 18				5	5				
Wy 57				7					10
Wy 90			10	9					
Wy 127			7				10		3
M 67					7	6			
M 201			1		8	9			
M 199					10			10	
Wy 126			9			8			
Wy 48							6	10	
M 116							8	9	
Wy 77				1					
M 43				2					
Wy 23						1			
M 91							1		
M 220							2		
M 172								1	
M 115								2	
M 63									1
Wy 130									2
M 27*	7	13	49	21	46	36	66	25	79

* mean of checks

DISCUSSION

To make meaningful comparisons between 94 different ecotypes grown under field conditions, some adjustment for differences in stand establishment was needed. Covariance adjustment was used to eliminate the unequal adjustment obtained by the proportional method. Percentage stand influenced seed yield, forage yield, and number of seed heads per unit area. The overall regression coefficient and mean value for the adjusted variable are used in each single covariance adjustment. It was found that the mean percentage stand for ecotype M-27 was 90, while the mean for all other ecotypes was 73%. The relationship of stand to forage yield, seed yield, and number of seed heads per unit area was more evident for ecotypes due to the greater fluctuations in stand.

Forage yield and seed yields were positively correlated indicating that with increased forage production there was increased seed production. This is contrary to some grass species and a useful relationship. An increase in forage yield was accompanied by an increase in the number of seed heads and their total weight.

The foliar disease, powdery mildew, influenced both seed yield and forage yield of ecotypes but had no influence within the ecotype M-27, indicating that powdery mildew is probably a genetically controlled factor in basin wildrye. Foliage color and foliar disease were correlated. It appears that where powdery mildew was a factor, color was closely related and probably a second measure of powdery mildew incidence. As foliar disease increased foliage color decreased. Selection for mildew resistance could increase yields.

By multiple regression it was found that 98% of the variation of seed yield was accounted for by the components of seed yield, number of seed heads per unit area, number of seed per head, and the weight per seed as the determinations were made in this study. This is a very accurate seed yield prediction formula as can be noted by comparison of actual and predicted seed yields (Appendix Table IV). For selection purposes the number of seed heads per unit area would be the best single criteria to select superior ecotypes for seed yield.

The correlation between fertility index and seed yield within ecotype M-27 was a measure of the environmental relationship of these two variables. This may have been due to inadequate pollen or incompatibility of adjacent genotypes. Fertility index, as determined here, was related to the number of seeds per head, indicating that the number of seeds per head was a function of floret fertility. Floret fertility could have been a measure of genetic compatibility, pollen dispersal, or other factors.

Seed weight was associated with the ability of seedlings to emerge from a depth after 21 and 28 days for ecotypes but not within the ecotype M-27. This would indicate that this was a genetically controlled factor. Seed weight was also associated with seedling weights at six weeks, indicating increased seed weights may have been associated with increased seedling weights or more vigorous seedlings.

One unexpected result obtained in these experiments was that all correlations between seed weights and germination percentage were negative. As seed weights increased there was a decrease in percentage

germination. This was found with nine separate correlation coefficients although only one was significant at the 5% level.

Germination was greater in plastic boxes than on blotters. The increased germination percentage in boxes may have been due to the influence of light or temperature. The plastic boxes were removed from the germinators for seven or eight hours each day while the blotters, were kept in the germinators. Room temperature was not greatly different from the germinator temperature of 68° F. Light probably contributed to the greater germination percentage in boxes.

Six measures of rate of germination were analyzed to obtain the best measure for further tests. Of the six determinations 8-day germination on blotters as a percentage of 21-day germination on blotters gave the best estimate of rate of germination. Only one other determination, germination from a $\frac{1}{2}$ " depth of seeding for 21 days as a percentage of germination from a $\frac{1}{2}$ " depth for 28 days, was significantly correlated with ability to emerge. This could mean that seeds slow in germinating would be less likely to emerge from greater depths. Seedling emergence after 21 days Plot 2 and after 28 days Plots 1 and 2 was related to rate of germination in boxes for ecotypes. Rate of germination on blotters was not related to ability to emerge for Plot 1 for either 21 or 28 days. Evidently the higher mean temperature to which Plot 1 was exposed increased seedling emergence or rate of emergence to the point that it was no longer measured or correlated with rate of germination as measured by boxes and blotters.

Seed dormancy for ecotypes was positively correlated with rate of germination while all simple correlation coefficients within the ecotype M-27 were negative. Positive correlation could indicate that rate of germination increased with decreased dormancy. The negative correlations may have been due to environmental influence. In ranking ecotypes for seed dormancy, it was found that ecotype M-27 had a greater seed dormancy than most ecotypes. Germination percentage for M-27 was greater in boxes exposed to light than on blotters kept in darkness, indicating that light may increase germination of seeds with dormancy.

The very low or negative correlation obtained for rate of germination within the ecotype M-27 relative to the significant correlation for ecotypes could mean that rate of germination is genetically controlled.

In clipping studies, seedling weight at six weeks was correlated at the 1% level with number of seedlings killed. This could have been due to the procedure used in clipping. Those seedlings with high seedling weights may have exhausted their carbohydrate reserve and by clipping at ground level every week for three weeks they were unable to survive. Branson (5) (6) working with other grasses found the height of the growing point important in clipping studies. The seedling with the larger seedling weights may have had a higher growing point which was removed by the clipping method used.

Forage yield, seed weight, ability to emerge, and rate of germination were all significantly correlated with seedling weight at six weeks. The multiple correlation coefficient for the above variables

plus fertility index was .73. With only the two variables, seed weight and rate of germination, the multiple correlation coefficient was .66 which indicates that these two variables were important in seedling weight prediction. The fact that correlations were not significant within the ecotype M-27 suggests that seedling weight as measured in this study was genetically controlled.

Differences due to origin of ecotypes were found when Montana-Canada ecotypes were compared with Wyoming ecotypes. Forage yields of Montana-Canada ecotypes were significantly higher at the 25% level. Wyoming ecotypes had a faster rate of germination and greater seedling weights at six weeks. Significance was at the 1 and 5% levels, respectively. It is thought that relative distances north and south may have been a factor, but undoubtedly elevation, soil properties, test sight, etc. influenced the results.

To select those ecotypes best suited for agronomic use and for further testing, superior ecotypes were selected for forage yield, seed yield, seedling weight, seed weight, ability to emerge, rate of germination, total germination, clipping tolerance, and dormancy. One ecotype Wy 107 was ranked in the top ten for eight of the nine factors studied and appears to be one of the best for all around performance. Several other ecotypes, M 48, M 262, Wy 50, and M 190 were ranked in the top ten for at least forage yield and seed yield.

SUMMARY

Ninety four ecotypes of basin wildrye, Elymus cinereus Scribn. and Merr. were selected from Montana, Wyoming, and Canada to study seedling and mature plant variation. To make useful comparisons of these 94 ecotypes, a covariance adjustment for stand establishment was made.

Unlike many grass species, increased forage yields were accompanied by increased seed yields. Powdery mildew decreased both seed and forage yield for ecotypes but did not affect the ecotype M-27. In all tests disease had little influence upon ecotype M-27.

Seed yields were accurately predicted by using a regression formula with seed heads per unit ares, number of seed per head, and weight per seed. These three factors were shown to account for 98% of the variation in seed yield.

In greenhouse tests, emergence from a $2\frac{1}{2}$ " depth of seeding increased with increased seed weights. Germination percentage decreased with increasing seed weights.

Germination percentage in plastic boxes exposed to light and room temperatures for seven to eight hours each day was higher than germination on blotters kept in germinators at a constant temperature of 68° F. The difference of 20% after 21 days was mainly attributed to the influence of light on germination.

Rate of germination was best measured by the ratio of germination after 8 and 21 days on blotters. This measure of rate of germination, seed weight, ability to emerge from a depth, and forage yield were

directly related to seedling weight at six weeks. Rate of germination appeared to be the factor influencing seedling weight most.

Seed dormancy appeared to influence germination percentage of ecotype M-27 more than the other ecotypes.

Seedling survival after three clippings was directly related to seedling weight. Low seedling weight ecotypes had the greatest survival.

Origin of ecotypes showed some difference in yield factors, rate of germination, and seedling weights. There was no general trend for one origin being superior to the other. It is believed that the relative distance between north and south was not great enough to greatly influence all factors.

In selecting those ecotypes best suited for further research or for agronomic use, the 94 ecotypes were ranked for superior characteristics. Ecotype Wy 107 appears to be the best adapted for overall performance. Ecotype M 48 was also superior in that it was number one for forage yield, and number two for seed yield and seedling weight. Other ecotypes with good ratings were M 262, Wy 50, and M 190.

The results of this thesis should be further verified by research on basin wildrye. It is suggested that those ecotypes with superior characteristics as indicated by this research be used and those tests that were found to be of most value repeated.

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APPENDIX

Table I. Origin basin wildrye ecotypes with forage yield.

Row No.	Ecotype No.	Origin	Forage Yield lbs./acre
F 2	Wy 22	Baggs, Wyoming	9,206
3	Wy 807	Cody, Wyoming	9,976
4	M 298	Alberta, Canada	16,214
5	Wy 831	Lander, Wyoming	9,287
7	M 718	Livingston, Montana	12,236
8	M 43	Laurel, Montana	10,477
9	Wy 18	Riverdale, Wyoming	14,026
10	Wy 813	Tipton, Wyoming	10,139
12	M 48	Choteau Co., Montana	16,864
13	Wy 23	Carbon Co., Wyoming	8,455
14	M 60	Lewistown, Montana	11,576
15	M 61	Lewistown, Montana	11,878
17	M 62	Lewistown, Montana	10,799
18	M 63	Carbon Co., Montana	12,398
19	M 67	Choteau Co., Montana	12,024
20	Wy 24	Dubois, Wyoming	6,494
22	Wy 25	Dubois, Wyoming	6,050
23	M 74	Dillon, Montana	8,354
24	M 78	Dillon, Montana	8,294
25	M 79	Big Timber, Montana	9,942
27	M 80	Big Timber, Montana	9,453
29	M 85	Cut Bank, Montana	12,342
30	M 86	Cut Bank, Montana	12,070
32	Wy 33	Goshen Co., Wyoming	10,940
33	M 89	Polson, Montana	11,218
34	M 90	Polson, Montana	12,060
35	M 91	Polson, Montana	10,179
37	M 95	Livingston, Montana	10,774
38	M 102	Ekalaka, Montana	9,010
39	M 113	Wheatland Co., Montana	10,487
40	M 114	Wheatland Co., Montana	10,830
42	M 115	Gallatin Co., Montana	7,754
43	M 116	Gallatin Co., Montana	10,552
44	Wy 38	Uinta Co., Wyoming	10,562
45	M 122	Toole Co., Montana	11,132
47	M 130	Whitehall, Montana	7,406
48	M ^v 131	Whitehall, Montana	8,026
49	M 135	Townsend, Montana	12,503
G 2	M 136	Townsend, Montana	9,761
3	M 154	Missoula Co., Montana	12,917
4	M 155	Missoula Co., Montana	11,808
5	M 158	Eureka, Montana	12,529
7	M 159	Eureka, Montana	10,729
8	M 171	Granite Co., Montana	11,087
9	M 172	Granite Co., Montana	10,199
10	Wy 48	Park Co., Wyoming	9,060
12	Wy 49	Big Horn Co., Wyoming	11,203

Table I. Continued

Row No.	Ecotype No.	Origin	Forage Yield lbs./acre
G 13	Wy 50	Big Horn Co., Wyoming	14,268
14	Wy 52	Hot Springs Co., Wyoming	9,166
15	Wy 53	Park Co., Wyoming	10,623
17	Wy 57	Freemont Co., Wyoming	11,092
18	Wy 58	Freemont Co., Wyoming	11,001
20	M 173	Lewis & Clark Co., Montana	9,438
22	M 174	Lewis & Clark Co., Montana	8,430
23	M 175	Stillwater Co., Montana	9,630
24	M 181	Big Horn Co., Montana	9,226
25	M 190	Blaine Co., Montana	16,441
27	M 191	Blaine Co., Montana	11,198
28	M 194	Madison Co., Montana	11,500
29	M 196	Deer Lodge Co., Montana	11,712
30	M 199	Liberty Co., Montana	12,090
32	M 201	Liberty Co., Montana	12,014
33	Wy 62	Johnson Co., Wyoming	13,260
34	Wy 63	Johnson Co., Wyoming	10,678
35	Wy 70	Big Horn Co., Wyoming	11,546
37	Wy 71	Big Horn Co., Wyoming	10,542
38	Wy 72	Big Horn Co., Wyoming	10,487
39	Wy 73	Converse Co., Wyoming	8,561
40	Wy 76	Lander, Wyoming	8,142
42	Wy 77	Lander, Wyoming	10,759
43	Wy 78	Meeteetsee, Wyoming	9,579
44	Wy 79	Meeteetsee, Wyoming	9,120
45	Wy 81	Wheatland, Wyoming	10,537
47	Wy 82	Wheatland, Wyoming	11,959
48	Wy 83	Wheatland, Wyoming	9,236
49	Wy 89	Powell, Wyoming	9,887
H 2	Wy 90	Powell, Wyoming	10,462
3	Wy 103	Laramie, Wyoming	12,685
4	Wy 107	Sheridan, Wyoming	15,710
8	Wy 118	Natrona Co., Wyoming	13,219
9	Wy 122	Buffalo, Wyoming	11,445
10	Wy 125	Buffalo, Wyoming	10,951
12	Wy 104	Laramie, Wyoming	12,680
13	Wy 126	Tensleep, Wyoming	11,752
14	Wy 127	Tensleep, Wyoming	11,364
15	Wy 130	Douglas, Wyoming	11,798
18	Wy 136	Cokeville, Wyoming	11,510
19	Wy 137	Cokeville, Wyoming	10,376
20	M 220	Powder River Co., Montana	9,478
22	Wy 142	Medicine Bow, Wyoming	10,119
25	M 226	Phillips Co., Montana	13,416
27	M 244	Alberta, Canada	12,105
28	M 262	Whitehall, Montana	15,024
Checks	M 27	Roundup, Montana	13,860

Table II. Mean values for individual ecotypes.

- 1 = ecotype number
- 2 = seed yield, lbs./acre
- 3 = seed weights, grams/100 seeds
- 4 = seed per head, number
- 5 = seed heads, No./sq. yard
- 6 = seedling weight, grams/25 seedlings
- 7 = seed dormancy, germination percent Aug. 1962 boxes 21 days/
germination percent Jan. 1963 boxes 21 days
- 8 = ability to emerge, seedlings emerging from 2 $\frac{1}{2}$ " depth 21 days/
number emerging from $\frac{1}{2}$ " depth 21 days
- 9 = rate of germination, 8-day germination on blotters/
21-day germination on blotters
- 10 = fertility index, seed yield/
weight of seed heads
- 11 = germination, mean of boxes and blotters 21 days, percent
- 12 = clipping tolerance, surviving seedlings of 25, number

	1	2	3	4	5	6	7	8	9	10	11	12
Wy 22		307	.31	154	60	.51	.68	.50	.43	74	76	1
Wy 807		256	.28	101	85	.59	.73	.24	.72	42	81	3
M 298		327	.34	128	71	.69	.71	.54	.70	40	78	4
Wy 831		236	.32	126	55	.66	.72	.49	.58	55	80	3
M 718		427	.32	159	78	.80	.69	.60	.72	63	83	1
M 43		224	.36	118	66	.61	.85	.56	.45	54	57	4
Wy 18		247	.35	134	50	.72	.86	.66	.51	54	76	5
Wy 813		279	.30	152	57	.56	.88	.39	.62	54	72	6
M 48		564	.33	194	83	.89	.73	.40	.56	64	68	3
Wy 23		223	.32	124	53	.69	.70	.47	.78	54	78	0
M 60		435	.33	180	69	.71	.68	.37	.43	67	67	0
M 61		249	.34	146	47	.63	.55	.48	.40	57	57	4
M 62		359	.29	160	72	.46	.53	.59	.47	61	72	7
M 63		333	.33	134	71	.63	1.09	.56	.44	60	59	4
M 67		321	.33	160	57	.65	.88	.64	.70	65	80	3
Wy 24		153	.34	111	38	.54	.81	.59	.56	58	68	4
Wy 25		139	.30	112	39	.49	.63	.37	.49	47	78	7
M 74		201	.29	137	48	.48	.76	.46	.45	49	76	3
M 78		209	.27	144	50	.48	.86	.57	.46	52	84	3
M 79		364	.32	172	62	.52	.71	.51	.29	75	62	6
M 80		374	.32	134	82	.56	.74	.57	.37	66	78	4
M 85		253	.31	155	49	.49	.87	.54	.37	54	86	5
M 86		276	.33	173	45	.45	.72	.34	.38	65	66	5
Wy 33		248	.33	82	86	.60	.55	.42	.57	45	66	4
M 89		262	.29	160	53	.48	.78	.51	.49	65	79	1
M 90		467	.28	168	93	.37	.56	.06	.37	64	71	3
M 91		292	.34	118	68	.65	.73	.41	.61	54	90	2

Table II. Continued

	1	2	3	4	5	6	7	8	9	10	11	12
M	95	299	.31	153	59	.73	.75	.52	.66	64	79	3
M	102	243	.36	125	50	.62	.74	.40	.43	52	66	4
M	113	367	.28	185	67	.64	.78	.40	.51	61	79	5
M	114	272	.35	135	54	.71	.67	.55	.41	60	72	5
M	115	148	.33	120	35	.58	.60	.48	.35	46	72	9
M	116	205	.30	130	49	.59	.85	.30	.49	55	85	6
Wy	38	336	.32	185	53	.67	.94	.38	.55	68	81	2
M	122	251	.33	135	53	.50	.61	.55	.39	59	62	8
M	130	117	.34	148	22	.62	.93	.45	.50	63	77	2
M	131	189	.30	128	46	.49	.71	.25	.49	47	80	7
M	135	210	.33	88	67	.63	.91	.48	.44	32	84	4
M	136	320	.32	143	65	.52	.89	.47	.61	63	82	2
M	154	417	.30	159	82	.43	.86	.27	.42	60	64	3
M	155	240	.26	133	65	.48	.82	.34	.38	44	79	2
M	158	362	.34	126	79	.62	.74	.67	.32	60	73	2
M	159	262	.29	124	69	.56	.59	.43	.33	55	75	3
M	171	293	.28	160	61	.58	.64	.39	.40	59	66	3
M	172	251	.28	172	49	.42	.79	.31	.27	46	55	9
Wy	48	296	.24	116	100	.54	.83	.41	.51	47	86	6
Wy	49	220	.30	85	81	.65	.84	.43	.49	32	79	1
Wy	50	408	.33	153	76	.77	.85	.57	.47	60	85	1
Wy	52	234	.31	149	48	.47	.75	.39	.27	43	81	3
Wy	53	260	.33	124	60	.56	.87	.60	.45	52	82	3
Wy	57	327	.35	113	78	.61	.89	.54	.23	53	81	2
Wy	58	283	.30	143	62	.58	.74	.35	.34	61	70	3
M	173	250	.29	166	49	.47	.75	.32	.31	66	66	5
M	174	214	.31	169	38	.50	.71	.43	.42	65	76	4
M	175	163	.34	139	32	.47	.81	.47	.29	60	78	4
M	181	164	.32	116	42	.78	.78	.54	.41	54	78	4
M	190	463	.32	157	86	.59	.81	.53	.29	60	75	2
M	191	318	.34	129	68	.58	.80	.43	.66	57	82	6
M	194	251	.34	122	57	.50	.88	.48	.51	52	77	4
M	196	290	.32	131	65	.50	.60	.41	.47	54	68	5
M	199	254	.33	139	52	.42	.73	.62	.26	52	66	6
M	201	311	.32	143	64	.90	.76	.62	.68	62	76	2
Wy	62	323	.32	160	59	.57	.73	.43	.34	64	74	6
Wy	63	209	.30	140	46	.62	.82	.39	.64	53	83	2
Wy	70	348	.28	178	66	.68	.79	.48	.60	59	76	2
Wy	71	255	.28	164	52	.57	.57	.34	.47	65	79	2
Wy	72	273	.28	154	59	.56	.66	.41	.41	62	77	4
Wy	73	275	.32	142	57	.65	.75	.63	.59	57	69	4
Wy	76	141	.33	111	36	.52	.77	.39	.46	53	64	2
Wy	77	314	.37	156	51	.62	.65	.38	.40	63	66	2
Wy	78	189	.36	119	41	.66	.72	.65	.54	44	86	2
Wy	79	355	.31	157	68	.51	.71	.32	.33	57	80	3
Wy	81	243	.33	128	54	.64	.78	.48	.51	57	83	2

Table II. Continued

	1	2	3	4	5	6	7	8	9	10	11	12
Wy 82	329	.35	150	59	.64	.72	.44	.55	51	77	1	
Wy 83	218	.32	161	40	.61	.76	.33	.56	63	82	5	
Wy 89	311	.27	177	61	.55	.80	.36	.42	66	76	5	
Wy 90	358	.35	144	66	.73	.60	.53	.58	68	80	3	
Wy 103	396	.31	171	70	.71	.80	.34	.59	66	73	1	
Wy 107	601	.35	151	107	.81	.90	.83	.76	63	87	0	
Wy 118	374	.33	132	81	.72	.61	.68	.63	59	71	4	
Wy 122	300	.32	131	67	.82	.72	.59	.55	63	84	1	
Wy 125	358	.31	152	71	.55	.60	.25	.53	63	76	2	
Wy 104	305	.31	116	79	.54	.72	.49	.57	33	63	6	
Wy 126	322	.32	146	65	.74	.83	.59	.69	64	80	1	
Wy 127	281	.35	158	48	.78	1.00	.56	.64	66	85	1	
Wy 130	354	.34	149	66	.65	1.09	.59	.53	49	78	1	
Wy 136	325	.32	191	50	.67	.65	.38	.50	67	78	1	
Wy 137	257	.29	128	65	.68	.79	.29	.70	58	83	3	
M 220	153	.32	112	40	.62	.85	.49	.58	61	88	4	
Wy 142	165	.33	140	34	.68	.70	.47	.64	40	77	1	
M 226	283	.32	176	47	.65	.71	.71	.40	68	81	4	
M 244	186	.29	149	41	.64	.77	.38	.61	48	88	3	
M 262	448	.32	141	93	.61	.92	.54	.61	60	85	7	
M 27*	371	.33	178	59	.60	.65	.47	.51	65	72	4	

* mean of check rows

Table III. Superior ecotypes for forage yield with check included for comparison.

Ecotype No.	Row No.	Forage yield pounds per acre
M 48	F 12	16,864
M 190	G 25	16,441
M 298	F 4	16,214
Wy 107	H 4	15,710
M 262	H 28	15,024
Wy 50	G 13	14,268
M 27	Check rows, mean	13,860
M 226	H 25	13,416
Wy 62	G 33	13,260
Wy 118	H 8	13,219
M 154	G 3	12,917

Table IV. Ecotypes with the highest seed yield shown for predicted and actual yield.

Using formula $Y = b_0 + b_4X_4 + b_5X_5 + b_6X_6$

Y = predicted seed yield, lbs./acre

X_4 = seed heads per sq. yard, number

X_5 = seed per head, number

X_6 = weight per seed, grams

Predicted seed yield = $-643.9 + 4.756(X_4) + 2.203(X_5) + 104,644.1(X_6)$

Ecotype No.	Row No.	Seed yield pounds per acre	
		Actual	Predicted
Wy 107	H 4	601	560.4
M 48	F 12	564	522.0
M 262	H 28	448	442.7
M 60	F 14	435	425.3
M 90	F 34	467	416.9
M 718	F 7	427	415.0
M 154	G 3	417	411.4
M 190	G 25	463	404.7
Wy 50	G 13	408	400.4
Wy 103	H 3	396	389.6
M 27	Check rows, mean	371	374.8

Table V. Superior ecotypes for mean of seed weights with checks included for comparison.

Ecotype No.	Row No.	Mean seed weights, grams
Wy 77	G 42	.37
M 43	F 8	.36
M 102	F 38	.36
Wy 78	G 43	.36
Wy 18	F 9	.35
M 114	F 40	.35
Wy 57	G 17	.35
Wy 82	G 47	.35
Wy 90	H 2	.35
Wy 107	H 4	.35
Wy 127	H 14	.35
<hr/> M 27 Check row, mean		.33
Intermediate wheatgrass		.44
Crested wheatgrass		.24

Table VI. Superior ecotypes for ability to emerge with checks included for comparison.

$$\text{Ability to emerge} = \frac{\text{seedlings emerging from } 2\frac{1}{2}'' \text{ depth 21 days}}{\text{number emerging from } \frac{1}{2}'' \text{ depth 21 days}}$$

Ecotype No.	Row No.	Ability to emerge
Wy 107	H 4	.83
M 226	H 25	.71
Wy 118	H 8	.68
M 158	G 5	.67
Wy 18	F 9	.66
Wy 78	G 43	.65
M 67	F 19	.64
M 201	G 32	.63
Wy 73	G 39	.63
M 199	G 30	.62
M 27	Check rows, mean	.47
Intermediate wheatgrass		.83
Crested wheatgrass		.55

Table VII. Superior ecotypes for rate of germination with check included for comparison.

$$\text{Rate of germination} = \frac{\text{8-day germination on blotters}}{\text{21-day germination on blotters}}$$

Ecotype No.	Row No.	Rate of germination
Wy 23	F 13	.78
Wy 107	H 4	.76
Wy 807	F 3	.72
M 718	F 7	.72
M 298	F 4	.70
M 67	F 19	.70
Wy 137	H 19	.70
Wy 126	H 13	.69
M 201	G 32	.68
M 95	F 37	.66
M 191	G 27	.66
M 27	Check rows, mean	.51

Table VIII. Superior ecotypes for germination with check included for comparison.

Germination = mean of boxes and blotters 21 days

Ecotype No.	Row No.	Germination percent
M 91	F 35	90
M 220	H 20	89
M 244	H 27	88
Wy 107	H 4	87
M 85	F 29	86
Wy 48	G 10	86
Wy 78	G 43	86
M 116	F 43	85
M 262	H 28	85
Wy 127	H 14	85
Wy 50	G 13	85
M 27	Check rows, mean	72

Table IX. Superior ecotypes for seedling weight at six weeks with checks included for comparison.

Ecotype No.	Row No.	Mean seedling wt. 6 weeks, grams
M 201	G 32	.90
M 48	F 12	.89
Wy 122	H 8	.82
Wy 107	H 4	.81
M 718	F 7	.80
M 181	G 24	.78
Wy 127	H 14	.78
Wy 50	G 13	.77
Wy 126	H 13	.74
Wy 90	H 2	.73
M 95	F 37	.73
M 27	Check rows, mean	.60
Intermediate wheatgrass		1.15
Crested wheatgrass		.92

Table X. Superior ecotypes for clipping tolerance with checks included for comparison.

Clipping tolerance = number of surviving seedlings out of 25

Ecotype No.	Row No.	No. of surviving seedlings
M 172	G 9	9
M 115	F 42	9
M 122	F 45	8
M 131	F 48	7
Wy 25	F 22	7
M 62	F 17	7
M 262	H 28	7
Wy 813	F 10	6
M 116	F 43	6
Wy 48	G 10	6
M 199	G 30	6
Wy 62	G 33	6
M 27	Check rows, mean	4
	Intermediate wheatgrass	1
	Crested wheatgrass	1

Table XI. Superior ecotypes for seed dormancy with check included for comparison.

$$\text{Seed dormancy} = \frac{\text{germination percent Aug. 1962 boxes 21 days}}{\text{germination percent Jan. 1963 boxes 21 days}}$$

Ecotype No.	Row No.	Least dormant
M 63	F 18	1.09
Wy 130	H 15	1.09
Wy 127	H 14	1.00
Wy 38	F 44	.94
M 130	F 47	.93
M 262	H 28	.92
M 135	F 49	.91
Wy 107	H 4	.90
M 136	G 2	.89
Wy 57	G 17	.89
M 27	Check rows, mean	.65

