VARIATION IN SEED WEIGHT AND SEEDLING GROWTH IN PERENNIAL SPECIES OF THE GENUS PHALARIS

by

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Ing. Agr., University of La Plata, Argentina, 1946

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Agronomy

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1962

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INTRODUCTION

Breeding and improvement work on the perennial species of *Phalaris* has not been extensive. It has been observed in plantings in Argentina that seedlings of *Phalaris tuberosa* often exhibit a very slow initial growth. During the first year after seeding thin stands may be obtained and crop failures frequently occur. Some of the failures may be attributed to an excessive depth of planting or to the low quality of the seed, but at the same time, it is considered that the seedlings of this species are too small and too weak to become established promptly. From local ecotypes two improved selections of *Phalaris tuberosa* have been developed recently. One of them has a higher yield of forage and greater uniformity, the other has extremely low seed shattering at maturity. It would be of interest to obtain through selection a variety with more vigorous seedlings and more rapid initial growth.

Reed canarygrass, *Phalaris arundinacea*, appears to be a promising forage species, but until now it has not achieved great success. This might be due to the lack of biological adaptation, because imported seed has been used in most of the trials.

According to Schoth (15) and Trumble (18) the greatest problem in growing canarygrasses, both *Phalaris tuberosa* and *Phalaris arundinacea*, is to establish a good stand, because these species tend to germinate slowly and irregularly.

Trumble (17) stated that selection in *Phalaris tuberosa* must aim at increased density, leafiness, and vigor, with greater adaptability to sward conditions. He found that in general, lines from different sources show greater variation within lines than among lines. In his work he employed single plant selection exclusively.

The main objective of this work was to determine a) mean differences among varieties and species and b) relative variability within each of the accessions studied in relation to seed weight and such characteristics of the plants in early and late seedling stages as root and shoot elongation and dry weights, number of tillers, and vigor.

Several correlation coefficients obtained from the data showing the relationships existent among some of the traits are presented.

REVIEW OF LITERATURE

Baltensperger and Kalton (1) studied the agronomic performance of three clones of *Phalaris arundinacea* and a number of seed accessions of diverse origin. The objectives were to measure phenotypic and genotypic variability for certain characteristics and to determine interrelationships among certain characters. They obtained high estimates of genotypic variation for leafiness, bloom date, and leaf width. These were 73, 66, and 48% respectively, indicating that it is possible to obtain good results through phenotypic selection for those characteristics. The low estimate of 24% for the genotypic variation for hay vigor indicates that its variability is due mainly to environmental effects.

Several authors working with different species have found a significant positive correlation between the seed size and the initial vigor of the seedlings. Rogler (14) working with crested wheatgrass, *Agropyron desertorum* (Fisch.) Schult. and *Agropyron cristatum* (L.) Gaertn., obtained a highly significant positive correlation for the relationship of seed weight to emergence of the seedlings from deep plantings. There were much lower and nonsignificant correlation coefficients in plantings shallower than 2½ inches.

Murphy and Arny (9) showed that the seed weight of 18 species of grasses and legumes had a significant positive correlation with the total emergence from the 2 and 3 inch depths of planting. Kneebone and Cremer (6) studied several native grasses by separating their seeds into several seed size classes; they noted differences in average seedling vigor among species and among strains within species. In general, the larger the seed within a lot, the faster were the emergence and rate of growth of the seedlings. Kneebone (7) working with several grasses observed that in sand bluestem, Andropogon hallii Hack., the progenies from large-seeded plants tended to be more vigorous than those from small-seeded ones in early seedling stages and throughout the first season of growth. He stated that sand bluestem is the most promising of the grasses he studied for breeding for larger seed size and greater seedling vigor. Besides that, he observed that one cycle of selection for more vigorous seedlings in sideoats grama gave increases in seedling vigor, and that selected plants gave larger than average caryopses.

Rather extensive work has been done with smooth brome, Bromus inermis Leyss. in relation to the breeding of strains with higher seedling vigor and the association of this vigor with seed size (2, 3, 4, 10, 12, 13, 16). Raeber (13) studied the variation and inheritance of seed fertility and seedling vigor and its relationship in twenty S_0 clones of smooth brome and their S_1 segregates. He found that clones differed in general combining ability for seedling vigor but that the heritability for this character in terms of the regression of progeny means on parents was only 25.65 percent which indicated a high degree of environmental influence. The associations found between fertility and certain other agronomic characters such as yield, seedling vigor, and panicles per unit area were negligible.

Peace (12) obtained high positive values when seed weight was correlated with seedling vigor, indicating that there is some advantage in evaluating seedling vigor by seed weight. Not all variation in vigor was due to seed size because he found that when seed weights for all strains were adjusted to a uniform weight by the analysis of covariance and use of errors of estimate, highly significant strain differences in seedling vigor still existed.

Tossell (16) found that seed weight is closely associated with early seedling vigor, at least during the first 4-week period of development that is the most critical one. It seems that there are other factors than seed size in the determination of seedling vigor, because he also found differences in seedling vigor within classes of similar seed weight. He obtained similar results in greenhouse and field trials, which indicates the feasibility of doing selection in greenhouse plantings. Christie and Kalton (2) made a study to determine the optimum sample size for obtaining seed weight, and by using coefficients of variation they found that two samples of 50 or 100 seeds per clone resulted in maximum efficiency. In a second paper the same authors (3) reported a correlation of 0.25 between seed weight and open pollinated seed set for several S_0 and S_2 clones. They observed substantial inbreeding depression for seed weight, fertility index, and seed yield. The correlation for these traits showed that it is possible to select simultaneously for the three characteristics despite the fact that the coefficients were variable from family to family. The authors considered that inbreeding does not appear to be a suitable method for improving seed or fertility attributes because of the lack of vigor in inbred plants. They concluded that recurrent selection seems to be a better procedure. Christie and Kalton (4), evaluating the polycross progenies of two groups of clones selected on the basis of high and low seed weight, found that the mean difference between the two progeny groups was significant at the 1% level. They concluded that it is possible to obtain greater progress by means of recurrent selection for the above mentioned characteristics than by other methods.

Neilson and Kalton (1) studying the extent of variation and segregation of combining ability in smooth brome for seed yield, panicle number and seed weight found significant differences and wide ranges for each character indicating extensive variation for combining ability. Heritability of combining ability for fertility and seed weight was relatively high, but only moderate for seed yield and panicle number.

Lawrence (8) made a study to determine if heavy-seeded types of intermediate wheatgrass Agropyron intermedium (Host.) Beauv., would have a greater ability to emerge from deep plantings than the light-seeded ones. He found significant statistical differences between clonal lines for the seed weight characteristic, but his results suggested that in intermediate wheatgrass, there is no consistent relationship between seed size and ability to emerge, and that this last characteristic was the more valuable for use in selection.

MATERIALS AND METHODS

Seeds of the several varieties and populations of reed canarygrass used in this experiment were obtained from several accessions received in the Agronomy Department of Kansas State University. The seed of Phalaris tuberosa was from a strain phenotypically selected for higher seedling vigor, and the hybrid seed was derived from the allopolyploid artificially obtained by Covas and Cialzeta (5) through chromosomal duplication by treatments with colchicine; both seed samples were brought by the author from Argentina.

The determination of seed weight was made on the basis of weighing ten random 100-seed samples of each accession on a precision balance to the one ten-thousandth part of a gram.

Table 1. Average weight of 100 seeds of varieties and accessions of *Phalaris arundinacea*, *Phalaris tuberosa*, and the hybrid *Phalaris arundinacea* x *Phalaris tuberosa*, Duncan's multiple range test, standard deviation and coefficient of variation.

Species or hybrid	Variety or accession	Average 100-seed weight (grams)*	Standard deviation (grams)	Coefficient of variation (%)
Phalaris arundinacea	San Joaquin	0.12876	0.00195	1.51
Phalaris arundinacea	Ioreed	0.12886	0.00249	1.93
Phalaris arundinacea	Frontier	0.13119	0.00038	0.29
Phalaris tuberosa	Argentina	0.13463	0.00037	0.27
Phalaris arundinacea	Arkansas	0.13500	0.00034	0.25
Phalaris arundinacea	Alabama	0.13508	0.00014	0.11
P. arundinacea x P. tuberosa	Argentina (smaller seeds)	0.13596	0.00035	0.26
P. arundinacea x P. tuberosa	Argentina (larger seeds)	0.13822	0.00037	0.26

* Duncan's multiple range test; any two means opposite the same line are not significantly different at the .05 level. Least significant difference is 0.00182.

Table 2. Average shoot length in 3-day-old seedlings of varieties and accessions of Phalaris arundinacea, Phalaris tuberosa, and the hybrid Phalaris arundinacea x Phalaris tuberosa. Duncan's multiple range, standard deviation, and coefficient of variation.

Species or hybrid	Variety or accession	Average shoot length (mm)*	Standard deviation (mm)	Coefficient of variation (%)
Phalaris arundinacea	Arkansas	16.6	2.92	17.59
Phalaris arundinacea	Ioreed	19.7	2.12	10.76
P. arundinacea x P. tuberosa	Argentina (larger seeds)	28.3	3.47	12.26
Phalaris tuberosa	Argentina	30.3	2.91	9.60
P. arundinacea x P. tuberosa	Argentina (smaller seeds)	32.5	2.50	7.69
Phalaris arundinacea	Frontier	35.9	4.91	13.67

* Duncan's multiple range test; any two means opposite the same line are not significantly different at the .05 level. Least significant difference is 2.37.

Table 3. Average root length in 3-day-old seedlings of varieties and accessions of Phalaris arundinacea, Phalaris tuberosa, and the hybrid Phalaris arundinacea x Phalaris tuberosa, Duncan's multiple range test, standard deviation, and coefficient of variation.

Species or hybrid	Variety or accession	Average root length (mm)*	Standard deviation (mm)	Coefficient of variation (%)
Phalaris arundinacea	Ioreed	15.4	4.45	28.89
Phalaris arundinacea	Arkansas	18.4	3.60	19.56
Phalaris arundinacea	Frontier	28.6	5.42	18.95
Phalaris tuberosa	Argentina	29.4	6.53	22.21
P. arundinacea x P. tuberosa	Argentina (larger seeds)	35.8	10.86	30.33
P. arundinacea x P. tuberosa	Argentina (smaller seeds)	37.0	8.04	21.72

* Duncan's multiple range test; any two means opposite the same line are not significantly different at the .05 level. Least significant difference 4.97.

Table 4. Variability of root and shoot elongation in greenhouse-grown fifteen-day-old plants of varieties and accessions of Phalaris arundinacea, Phalaris tuberosa, and the hybrid Phalaris arundinacea x Phalaris tuberosa.

Species or hybrid	Variety or accession	Mean (mm)	Range	Standard deviation (mm)	Coefficient of variation (%)
	Shoot elongation				
Phalaris arundinacea	Ioreed	49	40-70	7.95	16.06
Phalaris arundinacea	Frontier	45	25-65	10.20	22.66
Phalaris arundinacea	Arkansas	51	32-70	9.77	19.04
Phalaris tuberosa	Argentina	61	45-81	8.04	13.18
P. arundinacea x P. tuberosa	Argentina (smaller seeds)	59	40-80	7.47	12.66
P. arundinacea x P. tuberosa	Argentina (larger seeds)	63	40-88	10.10	16.03
	Root elongation				
Phalaris arundinacea	Ioreed	34	16-45	7.48	22.19
Phalaris arundinacea	Frontier	23	7-36	8.14	35.39
Phalaris arundinacea	Arkansas	39	12-65	11.50	29.48
Phalaris tuberosa	Argentina	30	8-45	10.33	34.43
P. arundinacea x P. tuberosa	Argentina (smaller seeds)	30	12-46	8.34	27.80
P. arundinacea x P. tuberosa	Argentina (larger seeds)	37	22-65	10.86	29.35

Table 5. Calculated regression lines between seed weight and shoot and root elongation of 3-day- and 15-day-old plants of varieties and accessions of *Phalaris arundinacea*, *Phalaris tuberosa*, and the hybrid *Phalaris arundinacea* x *Phalaris tuberosa* on the basis of data given in tables 1, 2 and 3.

Characters analyzed	Regression lines
Seed weight - Shoot elongation in 3-day-old plants	- 1.1 + 337.5 X n.s.
Seed weight - Root elongation in 3-day-old plants	12.07 + 182.5 X n.s.
Seed weight - Shoot elongation in 15-day-old plants	39.71 + 182.1 X n.s.
Seed weight - Root elongation in 15-day-old plants	-24.90 + 678.6 X n.s.

Table 6. Variability of root and shoot elongation and number of tillers in greenhouse-grown fifty-day-old plants of varieties and accessions of *Phalaris arundinacea*, *Phalaris tuberosa*, and the hybrid *Phalaris arundinacea* x *Phalaris tuberosa*.

Species or hybrid	Variety or accession	Mean (cm)	Range	Standard deviation (cm)	Coefficient of variation (%)
	Shoot elongation				
Phalaris arundinacea	Ioreed	21	17-24	2.88	13.45
Phalaris arundinacea	Frontier	23	14-28	3.64	15.82
Phalaris arundinacea	Arkansas	15	9-25	4.64	30.12
Phalaris tuberosa	Argentina	15	11-23	3.68	24.37
P. arundinacea x P. tuberosa	Argentina (smaller seeds)	13	6-22	4.20	32.55
P. arundinaces x P. tuberosa	Argentina (larger seeds)	16	5-21	3.81	24.11
	Root elongation				
Phalaris arundinacea	Ioreed	11	8-18	3.34	30.36
Phalaris arundinacea	Frontier	13	7-25	4.13	32.51
Phalaris arundinacea	Arkansas	11	7-19	3.51	31.33
Phalaris tuberosa	Argentina	12	7-28	4.64	40.00
P. arundinacea x P. tuberosa	Argentina (smaller seeds)	12	7-16	2.90	23.20
P. arundinacea x P. tuberosa	Argentina (larger seeds	11	5-24	4.55	39.91
	Number of tillers				
Phalaris arundinacea	Ioreed	1.6	1-2	0.55	34.37
Phalaris arundinacea	Frontier	2.1	1-4	0.96	45.85
Phalaris arundinacea	Arkansas	1.2	1-2	0.40	33.33
Phalaris tuberosa	Argentina	1.1	1-2	0.31	28.63
P. arundinacea x P. tuberosa	Argentina (smaller seeds)	1.0	1-1	0	0
P. arundinacea x P. tuberosa	Argentina (larger seeds)	1.4	1-4	0.85	60.71

Table 7. Variability of shoot elongation and number of tillers in greenhouse-grown seventy-day-old plants of varieties and accessions of *Phalaris arundinacea*, *Phalaris tuberosa*, and the hybrid *Phalaris arundinacea* x *Phalaris tuberosa*.

Species or hybrid	Variety or accession	Mean (cm)	Range	Standard deviation (cm)	Coefficient of variation (%)
Shoot elongation					
Phalaris arundinacea	Ioreed	30	9-54	11.13	36.85
Phalaris arundinacea	Frontier	41	26-51	7.17	17.48
Phalaris arundinacea	Arkansas	30	12-47	10.54	35.13
Phalaris tuberosa	Argentina	38	17-50	10.14	26.68
P. arundinacea x P. tuberosa	Argentina (smaller seeds)	34	7-52	9.63	28.32
P. arundinacea x P. tuberosa	Argentina (larger seeds)	38	14-62	10.36	27.26
Number of tillers					
Phalaris arundinacea	Ioreed	2.7	1-6	1.74	64.44
Phalaris arundinacea	Frontier	3.9	1-8	1.36	34.87
Phalaris arundinacea	Arkansas	1.6	1-4	0.97	61.12
Phalaris tuberosa	Argentina	2.1	1-4	1.05	50.00
P. arundinacea x P. tuberosa	Argentina (smaller seeds)	2.0	1-5	1.16	58.00
P. arundinacea x P. tuberosa	Argentina (larger seeds)	1.5	1-4	0.91	60.66

Table 8. Variability in height and number of tillers in greenhouse-grown 105-day-old plants of varieties and accessions of Phalaris arundinacea, Phalaris tuberosa, and the hybrid Phalaris arundinacea x Phalaris tuberosa.

Species or hybrid	Variety or accession	Mean (cm)	Range	Standard deviation (cm)	Coefficient of variation (%)
	Height				
Phalaris arundinacea	Ioreed	55	41-70	9.34	17.07
Phalaris arundinacea	Frontier	53	31-82	11.59	22.00
Phalaris arundinacea	Arkansas	52	32-71	10.90	20.80
Phalaris tuberosa	Argentina	34	23-54	8.07	23.80
P. arundinacea x P. tuberosa	Argentina (smaller seeds)	31	22-44	6.97	22.70
P. arundinacea x P. tuberosa	Argentina (larger seeds)	39	14-55	10.55	27.05
	Number of tillers				
Phalaris arundinacea	Ioreed	6.8	4-14	3.36	49.41
Phalaris arundinacea	Frontier	6.1	2-13	2.82	46.15
Phalaris arundinacea	Arkansas	4.0	1-6	1.59	39.75
Phalaris tuberosa	Argentina	4.1	1-7	1.46	35.09
P. arundinacea x P. tuberosa	Argentina (smaller seeds)	4.1	1-7	1.94	46.41
P. arundinacea x P. tuberosa	Argentina (larger seeds)	3.4	1-9	2.23	65.73

Table 9. Simple correlation coefficients for relationships among several vegetative characteristics in greenhouse-grown 105-day-old plants of varieties and accessions of <u>Phalaris</u> <u>arundinacea</u>, <u>Phalaris</u> <u>tuberosa</u>, and the hybrid <u>Phalaris</u> <u>arundinacea</u> x <u>Phalaris</u> <u>tuberosa</u>.

Species or hybrid	Variety or Accession	Characters correlated: Height-Tillers	Height-dry weight	Tillers-dry weight
Phalaris arundinacea	Ioreed	0.56 n.s.	0.79**	0.85**
Phalaris arundinacea	Frontier	0.59*	0.64**	0.71**
Phalaris arundinacea	Arkansas	0.77*	0.89**	0.65**
Phalaris tuberosa	Argentina	0.03 n.s.	0.45 n.s.	0.71**
P. arundinacea x P. tuberosa	Argentina (smaller seeds)	-0.26 n.s.	0.11 n.s.	0.79**
P. arundinacea x P. tuberosa	Argentina (larger seeds)	0.08 n.s.	0.72**	0.29**

	Variety or Accession	Characters correlated: Top dry weight-Root dry weight	Vigor-Top dry weight	Root/Top ratios
Phalaris arundinacea	Ioreed	0.88**	0.94**	0.68
Phalaris arundinacea	Frontier	0.69**	0.82**	0.59
Phalaris arundinacea	Arkansas	0.96**	0.93**	0.41
Phalaris tuberosa	Argentina	0.91**	0.93**	0.71
P. arundinacea x P. tuberosa	Argentina (smaller seeds)	0.82**	0.86**	0.71
P. arundinacea x P. tuberosa	Argentina (larger seeds)	0.86**	0.92**	0.62

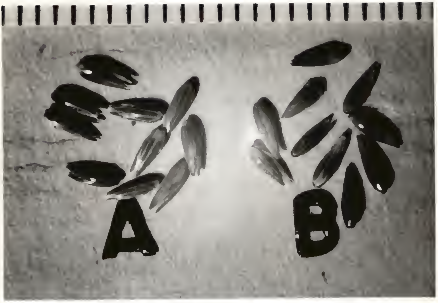

Fig. 1. Seeds of Phalaris arundinacea: (A) San Joaquin accession; (B) Ioreed variety.

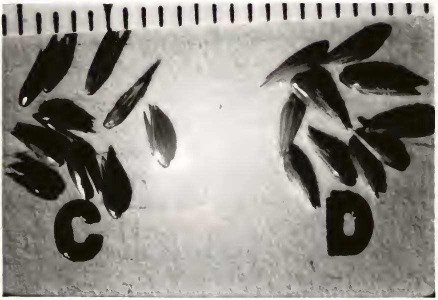

Fig. 2. Seeds of Phalaris arundinacea: (C) Frontier variety; (D) Arkansas accession.

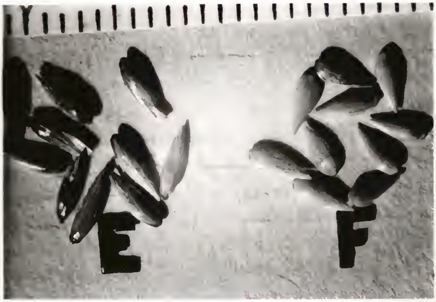

Fig. 3. (E) Alabama accession of Phalaris arundinacea: (F) Seeds of Phalaris tuberosa accession from Argentina.

Fig. 4. Seeds of the interspecific hybrid Phalaris arundinacea x Phalaris tuberosa, (G) smaller seeds; (H) larger seeds.

For the determination of shoot and root elongation in seedlings of three days of age, fifty seeds of each variety or species were put on a wet filter paper in a Petri dish. The seedlings that were measured at ages greater than three days were grown in the greenhouse at normal temperatures in Petri dishes filled with a mixture of half soil and half sand.

The measurement of the three-day-old seedlings were taken in millimeters from the caryopsis to the tip of the shoot or to the tip of the principal root. The measurements of the tops of older seedlings were taken in centimeters from the base of the plant to the tip of the longest leaf and the measurements of roots from the base of the plant to the tip of the longest root.

At the age of fifteen days the plants were transplanted to fertile loamy soil in wooden flats. At the age of fifty days they were again transplanted, this time to 4-inch clay pots with the same type of soil. Seedling vigor was scored 1-10, with 10 best.

The seed of the interspecific hybrid was separated by hand into two different portions, one with normal seeds and the other with easily distinguished larger seeds and darker lemmas. These seeds could have come from any specific plant or plants that produced that type of seeds.

RESULTS

There is no written information about significant differences in seed weight in different varieties of *Phalaris arundinacea*. Statistical analysis of the 100-seed weights showed that there were significant differences among some of the accessions analyzed for this agronomic characteristic.

According to Table 1, the accessions San Joaquin and Ioreed have the smallest seeds and there is no significant difference between them. Ioreed had the highest coefficient of variation. Frontier seeds were significantly larger. *Phalaris* tuberosa, Phalaris arundinacea accessions from Arkansas and Alabama, and the smaller seeds of the interspecific hybrid did not differ significantly in seed size. The larger seeds of the hybrid were significantly different and the heaviest of the accessions. (Fig. 1, 2, 3, and 4)

The statistical analysis of the data related to shoot elongation in seedlings of three days of age, in Table 2, also showed significant differences among species and varieties. The variety with least shoot elongation in the 3-day period appears to be the Arkansas accession of Phalaris arundinacea. It is significantly different from the Ioreed variety, and this in turn is significantly different from the hybrid accession with large seeds. There is no significant difference between this last one and Phalaris tuberosa, and at the same time there is no significant difference between Phalaris tuberosa and the portion of the hybrid with smaller seeds. However, there is a significant difference between the two portions of the hybrid. The variety Frontier appears to have the greatest shoot elongation at three days of age, with an average of 35.9 mm.

In Table 3 it can be observed that according to Duncan's multiple range test three groups, each with two seed accessions, appear to be significantly different one from the other in relation to root elongation characteristics at fifteen days of age. The group formed by the two portions of the interspecific hybrid showed the greatest root elongation, and the large-seeded hybrid had the highest standard deviation and coefficient of variation. Phalaris arundinacea, variety Frontier, and Phalaris tuberosa formed an intermediate group with respect to average root elongation. The third group, which had the slowest root elongation, was formed by Ioreed and the Arkansas accession.

In the Table 4, with the data of the fifteen-day-old plants, it can be noted that the large-seeded hybrid showed the greatest shoot elongation, followed by Phalaris tuberosa. It is interesting to note that if the hybrid accessions are considered as a single population they present the widest range of the whole group.

With reference to the mean values in root elongation, the accession Arkansas of *Phalaris arundinacea* appeared to have the greatest root growth in the fifteen-day period, the greatest standard deviation, and the widest range of variation of that character. It is followed in mean root elongation values by the large-seeded hybrid, and the Ioreed variety is third. Again, it can be noted that if the two hybrid accessions are considered as only one population, their range of root elongation turns out to be similar to that of the Arkansas accession, the widest of all. Coefficients of variation obtained from root elongation data in fifteen-day-old plants are considerably higher than those obtained from shoot elongation data.

Regression lines that were calculated on the basis of seed weight and root and shoot elongation in 3- and 15-day-old plants are given in Table 5. All the "b" values are nonsignificant but their positive signs seem to indicate certain degree of positive relationship between seed weight and root and shoot elongation.

Table 6 shows that Frontier had the greatest shoot elongation at fifty days of age, followed by Ioreed and the hybrid with the larger seeds. With respect to root elongation, although there is not much difference among the several accessions, Frontier again showed the greatest and was followed by *Phalaris tuberosa* and the small seeded hybrid. In number of tillers Frontier showed the highest average followed by Ioreed and the large-seeded hybrid.

At seventy days of age, in Table 7, Frontier keeps its place as the tallest of the accessions followed in this case by *Phalaris tuberosa* and the large-seeded hybrid. The same variety had the highest number of tillers in average, the second was Ioreed and the third *Phalaris tuberosa*.

At 105 days of age, in Table 8, the tallest accession was Ioreed followed by Frontier and the Arkansas accession. Ioreed also had the highest average tiller number, second was Frontier, and in the third place were Phalaris tuberosa and the small-seeded hybrid with the same number of tillers in average.

The correlation coefficients, shown in Table 9, between height and number of tillers were not consistent and this lack of consistency may be due to the variation in habit of growth and plant type in the different accessions. Only in the case of Frontier and the Arkansas accession were there significant positive correlations between height and number of tillers at the .05 level. With reference to the Frontier variety, this may be due to the particular vegetative type of that variety with its tall stature and relatively numerous tillers. The non-significant correlation coefficient values in Phalaris tuberosa and in the interspecific hybrid, approaching 0.0 or being negative, seem to indicate either that there is no relationship at all or that there is an extreme variability in type of plant that prevents any relationship from being shown.

Height gave a good estimate of yield in four of the accessions; correlations between height and dry weight, except in Phalaris tuberosa and in the population of the interspecific hybrid with smaller seeds, were positive and highly significant.

The correlations between number of tillers and dry weight are all highly significant, indicating that number of tillers would be one of the components of yield in the genus Phalaris, at least in plants up to 105 days of age.

There is also a very good relationship between top dry weight and root dry weight which indicates that the selection of plants of high forage yield would at the same time result in lines with better root system development or vice versa. The character of a well developed root system is important in the establishment period of the seedling and under abnormal growing conditions as are encountered in dry soils or under low fertility levels.

The relationship between vigor score and top dry weight is shown by the high correlation coefficients to be outstanding. It would appear that the vigor score used, 1 to 10 with 10 best, was a better estimate of yield in all the accessions than height or number of tillers. The root/top ratios given in Table 9 were relatively high and consistent in all the accessions; *Phalaris tuberosa* and the small-seeded hybrid had the highest root-top ratio and Ioreed was second. The lowest was that of the Arkansas accession.

DISCUSSION

To start selection work with plants it is first necessary to have some information on the relationships involved among the different desirable and undesirable traits. At the same time, it is important to have an idea about the relative variability of the available biological material.

Several of the most important characteristics that are desirable in improvement programs are the product of different component traits that have to be analyzed in detail in order to obtain accurate information on them. In the case of the initial vigor of the seedlings it seems that one of its principal components would be the size of the seed. Other components have not yet been disclosed.

Seed weight is one of the components of seed yield and according to the work of Christie and Kalton (3) it showed inbreeding depression that varied between 6 and 32 percent; thus they believed that inbreeding offers little opportunity to select superior genotypes. The percentage of depression appeared to be proportional to the seed weight of the parental clone.

It would appear that recurrent selection would be an appropriate method to use for selection of a higher seed weight in mainly cross-pollinated perennial forage plants.

Until now, there remain some doubts about which of the traits, either seed weight or emergence from deep plantings, are best to select for in order to obtain a high degree of seedling vigor. In future work in the genus Phalaris the comparison of the relative value of both characteristics will be considered.

Oldemeyer and Hanson (11) working with orchard grass have tried to obtain some correlation between seedling vigor and yield of forage in the field. From three correlation coefficients calculated, they obtained only one that was positive and highly significant. This is a limited but encouraging result and it suggests that more research on the subject would be desirable. Biological material of different kinds could be screened much faster if seedling vigor, emergence, or any other characteristic were correlated with forage yield, vigor, or persistence of the adult plant.

SUMMARY

Significant differences in seed weight have been found among several accessions and varieties of Phalaris arundinacea, Phalaris tuberosa, and an interspecific hybrid of both species. The large-seeded portion of the interspecific hybrid presented the greatest seed weight. The accession San Joaquin and the synthetic variety Ioreed of Phalaris arundinacea had the smallest seed weight and the highest coefficients of variation of the whole group of accessions.

There were also significant differences in shoot elongation in seedlings at three days of age. In this case, the variety Frontier had the highest growth and the Arkansas accession the smallest one with the greatest coefficient of variation.

The two portions of the interspecific hybrid had the greatest root elongation without showing significant difference between them, while Ioreed and the Arkansas accession of Phalaris arundinacea exhibited the smallest root elongation of the whole group without significant difference between them.

At fifteen days of age, the large-seeded hybrid presented the greatest shoot elongation and the accession Arkansas had the greatest root growth. Coefficients

of variation were considerably higher for root elongation than for shoot elongation data.

Despite the fact that the regression lines calculated between seed weight and shoot and root elongation at 3 and 15 days of age were all nonsignificant, the "b" values were all positive and seem to indicate that there is certain degree of positive relationship between seed weight and shoot and root elongation.

Additional information about the variability of the several accessions in shoot and root elongation and number of tillers in plants at 50, 70, and 105 days of age is given in the form of tables.

On the basis of data taken in 105-day-old plants, correlation coefficients were calculated among several vegetative characteristics in order to obtain information about the more efficient method of estimating actual yield of individual plants. It would seem that one of the best means of estimating forage yield in plants of 105 days of age would be the use of vigor score. The correlation coefficients obtained between vigor score and dry weight were highly significant and higher than those obtained in the correlation between number of tillers and dry weight. Correlation coefficients between top dry weight and root dry weight of individual plants were also highly significant in all the accession root/top ratio values were consistently high in all the accessions.

ACKNOWLEDGEMENTS

The author wishes to express his sincere appreciation to Dr. Kling L. Anderson for his cooperation and assistance in this investigation and for his suggestions in the preparation of this manuscript.

Thanks is also due to Mr. Wilfred Mac Murphy for his assistance in part of the statistical analysis of the data.

LITERATURE CITED

1. Balstensperger, A. A. and R. R. Kalton. Variability in reed canarygrass Phalaris arundinacea, L. I. Agronomic characteristics, Agron. J. 50 (11): 659-663, 1958.

2. Christie, B. R. and R. R. Kalton. Sampling for seed weight determinations in bromegrass, Bromus inermis Leyss. Can. J. Plant Sci. 39: 158-163. 1959.

3. Christie, B. R. and R. R. Kalton. Inheritance of seed weight and associated traits in bromegrass, Bromus inermis Leyss. Can. J. Plant Sci. 40 (2): 353-365. 1960.

4. Christie, B. R. and R. R. Kalton. Recurrent selection for seed weight in bromegrass, Bromus inermis Leyss. Agron. J. 52 (10): 575-578. 1960.

5. Covas, G. and C. Cialzeta. Allopoliploide sintético del género Phalaris de posible valor economico como planta forrajera. IDIA, 62: 8-10. 1953.

6. Kneebone, W. R. and C. L. Cremer. The relationship of seed size to seedling vigor in some native grass species. Agron. J. 47 (10):472-477. 1955

7. Kneebone, W. R. Breeding for seedling vigor in sand bluestem (Andropogon hallii hack.) and other native grasses. Agron. J. 48 (1): 37-40. 1956.

8. Lawrence T. Emergence of intermediate wheatgrass lines from five depths of seeding. Can. J. Plant Sci. 37: 215-219. 1957.

9. Murphy, R. P. and A. C. Arny. The emergence of grass and legume seedlings planted at d'fferent depths in five soil types. J. Amer. Soc. Agron. 31: 17-28. 1939.

10. Neilson, A. K. and R. R. Kalton. Combining ability for seed characteristics in Bromus inermis Leyss. Agron. J. 51: 178-181. 1959.

11. Oldemeyer, D. L. and A. A. Hanson. Evaluation of combining ability in orchard grass Dactylis glomerata L. Agron. J. 47 (4): 158-162. 1955.

12. Peace, R. D., Heritable and environmental relationships of seed weight and seedling vigor in smooth bromegrass, Bromus inermis. Rept. Western Grass Breeders Work Planning Conference, Mandan, N. Dak. Mimeog. pp. 36-38, 1953.

13. Raeber, J. G. Variation and inheritance of seed fertility and seedling vigor in Bromus inermis Leyss. Iowa Sta. Coll. J. Sci. 28: 390-391. 1954.

14. Rogler, G. A. Seed size and seedling vigor in crested wheatgrass. Agron. J. 46 (5): 216-220. 1954.

15. Schoth, H. A. Reed canarygrass. Farmers Bull. 1062, U.S. Dept. Agric., pp. 11, 1929 and 1938.

16. Tossell, W. E. Early seedling vigor and seed weight in relation to breeding in smooth bromegrass, Bromus inermis Leyss.

LITERATURE CITED (continued)

17. Trumble, H. C., The improvement of *Phalaris* species by selective breeding. Imp. Bur. Pl. Gen. Herb. Pl. Bul. 7: 17-20. 1932.

18. Trumble, H. C., The agricultural features of *Phalaris tuberosa* and allied forms. J. Dept. Agric. S. Aust. 37, 400-25. 1933.

VARIATION IN SEED WEIGHT AND SEEDLING GROWTH IN PERENNIAL SPECIES OF THE GENUS PHALARIS

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AN ABSTRACT OF

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Agronomy

KANSAS STATE UNIVERSITY

Manhattan, Kansas

1962

Perennial species of the genus *Phalaris* are not very widely used as forage plants, but *Phalaris tuberosa* is rather extensively cultivated in Australia and in Argentina. *Phalaris arundinacea* is used for forage in the northern hemisphere and in soil conservation for reclaiming poorly drained land.

Breeding and improvement in these species has not been extensive, but recently the interest of the investigators has been centered in the development of a suitable interspecific hybrid of the two.

Written information and direct observation have shown that the perennial species of *Phalaris* have weak and slow-growing seedlings.

Experimental work on several perennial grasses indicates that a close relationship exists between seed weight and seedling vigor. This latter characteristic has been expressed either as emergence percent from deep plantings or as rate of growth of the seedlings. There is no information about variation in seed weight and its relation to seedling vigor in the perennial species of *Phalaris*.

The main objective of this work has been to determine a) mean differences in seed weight and rate of seedling growth among several accessions of *Phalaris arundinacea*, *Phalaris tuberosa*, and the fertile interspecific hybrid *Phalaris arundinacea* x *Phalaris tuberosa* and b) relative variability within each of the accessions with respect to the same characteristics in early and late seedling stages. The relationship among several vegetative traits of 105-day-old plants were also estimated in several accessions through the use of correlation coefficients.

The determination of seed weight was made on the basis of weighing ten random 100-seed samples of each accession on a precision balance to the one ten-thousandth part of a gram. Previously the hybrid seed had been separated by hand into large- and small-seeded portions that were then treated as if they were two different accessions.

For the determination of shoot and root elongation in three-day-old seedlings, fifty seeds of each variety were germinated on a wet filter paper in a Petri dish. The seedlings measured at greater ages than three days were grown in Petri dishes filled with half soil and half sand. The seedlings were transplanted to soil in wooden flats at fifteen days of age and from these to 4-inch clay pots at fifty days. Seedling vigor was scored 1 to 10, with 10 the best.

Significant differences were found in seed weight among some of the accessions. The accessions San Joaquin and Ioreed of Phalaris arundinacea had the smallest seeds. The hybrid with larger seeds was significantly different and the heaviest of the accessions.

The variety Frontier appeared to have the greatest shoot elongation at three days of age, with an average of 35.9 mm. It was followed by the hybrid with smaller seeds, Phalaris tuberosa, and the hybrid with larger seeds, respectively.

The group formed by the two portions of the interspecific hybrid showed the greatest root elongation. They were followed by Frontier and Phalaris tuberosa as an intermediate group.

At fifteen days of age the large-seeded hybrid showed the greatest shoot elongation, with a mean of 63 mm, followed by Phalaris tuberosa and the small-seeded hybrid. The Arkansas accession of Phalaris arundinacea appeared to have the greatest root growth, and it was followed by the large-seeded hybrid and the Ioreed variety.

Regression lines of shoot and root elongation in seed weight in 3- and 15-day-old plants were nonsignificant, but positive "b" values seem to indicate certain degree of positive relationship. Additional information about the variability of the several accessions in shoot and root elongation and number of tillers in plants at 50, 70, and 105 days of age is given in the form of tables.

Correlation coefficients among several vegetative characteristics were calculated from data obtained in 105-day-old plants. The correlation coefficients obtained between vigor score and dry weight were highly significant and higher than those obtained in the correlation between number of tillers and dry weight. It would seem that one of the best means of estimating forage yield, at least in 105-day-old plants, would be the use of vigor score.

Correlation coefficients between height and number of tillers were not consistent. Height gave a good estimate of yield in only four of the accessions. Correlations between number of tillers and dry weight were all highly significant.