Germination Characteristics of Some Accessions of *Bothriochloa ischaemum* (L.) Keng

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CONTENTS

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A number of species and varieties of the Old World bluestems have found their way to the United States and are being used on a limited scale. Some have been given names, such as 'King Ranch bluestem' (*Bothriochloa ischaemum* var. songarica (Rupr.) Celarier) ; 'El Kan bluestem' (*B. ischaemum* var. *ischaemum*) ; 'Kleberg bluestem' (*Dicanthium annulatum* (Forsk.) Stapf) ; 'Medio bluestem' (*D. papillosum* (Hochst.) Stapf) ; 'Gordobluestem' (*D. aristatum* (Pior.) C. E. Hubb.) ; and 'Comagueyana' (*B. pertusa* (L.) Camus) . None of these grasses have been used very extensively to date, but as they appear on the market, seed companies will find it impractical to set their equipment differently for each of the kinds of seeds, and problems of testing and labeling will arise.

Very little research has been conducted on the germination requirements of these grasses. Preliminary studies, reported so far only in annual progress reports, indicate that the different species have different requirements for germination, and that different accessions of one species may behave differently one from the other. Studies were therefore initiated to investigate the germination characteristics of *B. ischaemum,* including both the *songarica* and *ischaemum* varieties and 3 ploidy levels.

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REVIEW OF LITERATURE

Numerous species respond in germination to dilute salt solutions. 'Reed canarygrass' (*Phalaris arundinacea*) was found by Colberg (*5*) * to respond in germination if KNO_3 was used in combination with light. According to Colborn (*6*), 'sand lovegrass' (*Eragrostis trichodes*) will give maximum germination when KNO_3 is used in combination with pre-chilling and light. Dunn (*8*) observed an increase in abnormalities within some environments when KNO_3 was used as a dormancy-breaking treatment for sand lovegrass. After further tests, he concluded the nitrate radical was responsible for the increased germination, and suggested that $Ca(NO_2)$ in combination with a pre-chill treatment would probably be a better treatment. Working with 'Bermudagrass' (*Cynodon dactylon*), Burton (*4*) found a concentrated HCl treatment significantly increased its germination capacity. The use of an H_2SO_4 treatment as reported by Laude (*14*) gave a good response in germination of 'California oatgrass' (*Dantopia californica*). Koller and Negbi (*13*) also showed a beneficial response in germination of *Oryzopsis miliacea* to a treatment of H_2SO_4 under laboratory and field conditions. As early as 1916, Demowsay (7) found a significant response in germination of garden cress using a solution of H_2O_2. He believed the effect of H_2O_2 was due to the added supply of O_2.

According to the MANUAL FOR TESTING AGRICULTURAL AND VEGETABLE SEEDS (*15*), 'Bahiagrass' (*Paspalum notatum*) may be dehulled in the process of testing. Dehulled seed will germinate readily, while the hulled seed remains dormant. Anderson (*2*) reported that dehulling had a stimulating effect on germination of *Poa compressa*. Alkamine (*1*) pointed out that the germination of *Urachloa pullulans* could be increased from 0 to 90 percent by the removal of the lemma and palea. Similar reports can be found on many other grasses.

The conditions that must be met for germination are listed by Toole *et al.* (*20*) as: (1) Moisture for rehydration; (2) temperature within a suitable regime; and (3) oxygen for respiration. They also state that germination of many grass seeds can be improved by cutting, breaking, acid treating, or removing certain seed coverings.

The RULES AND REGULATIONS UNDER THE FEDERAL SEED ACT (*21*) and the RULES FOR TESTING SEED adopted by the Association of Official Seed Analysts (*18*) recommend a dilute (KNO_3) salt solution as a part

*Italic numerals in parenthesis refer to items in "Literature Cited," page 17.

of the laboratory test on a large number of species. Fresh and dormant seed of *Andropogon ischaemum* (referred to in this bulletin as *B. ischaemum*) is listed as requiring a pre-chill treatment of 5° C for a 14-day period and germination in a 20-30° C alternate environment. No literature could be found as a basis for recommending this method other than the list compiled by Haferkamp and McSwain (*10*). The literature cited here deals primarily with seed dormancy investigations with other grass species.

Papers by Plummer (*17*), Harrington (*11*), and Kearns and Toole (*12*), have shown the advantage of using alternate temperatures in germinating a large number of different kinds of grass seeds. Pre-chilling dormant grass seeds has aided laboratory tests of *Oryzopsis hymenoides* (Toole (*19*)), and *Panicum anceps* (Mathews (*16*); Gorman and Barton (*9*). Anderson (*3*) also found the germination of 'Merion Kentucky bluegrass' *(Poa pratensis)* would respond to pre-chilling. These papers represent only a small portion of the work which has shown beneficial effects on seed germination by pre-chilling various kinds of seed at temperatures ranging from 0-10° C for varying periods of time.

METHODS AND MATERIALS

Studies were conducted in 1957 on 8 accessions, and in 1958 on 16 accessions. In 1959, further studies were conducted on 9 of the accessions used in 1958. Most of the data reported herein were obtained from the 9 accessions listed in Table 1, which were studied in both 1958 and 1959.

Table 1. Accessions of *Bothriochloa ischaemum* studied, 1958 and 1959.

Number used in Figures	Accession Number	Source	Botanical Variety	2N Chromosome Number
1	5110	Arizona U.S.A. (Exact origin unknown)	ischaemum	40
2	7044	Hungary	ischaemum	40
3	6982	Kenya	ischaemum	40
4	726	China	songarica	50
5	7041	Hungary	ischaemum	40
6	6582	Belgium	ischaemum	40
7	562-b	Turkey	ischaemum	40
8	3457	Ethiopia	ischaemum	40
9	6985	Iran	ischaemum	40

Naked caryopses were used in most of the tests in order to be certain that a pure seed unit was present. Ergotized grains are very common in these grasses and not usually recognizable unless the glumes are removed. Apparently perfect and unbroken caryopses were used, and great care was taken in selecting seed units for the rough seed check to be sure that sound caryopses were really present.

Fifty seeds or seed units were placed in each $2\frac{1}{2} \times 2\frac{1}{2} \times \frac{3}{4}''$ plastic box on six thicknesses of kimpac tissue, moistened with 6 milliters of distilled water or salt solution and covered with a lid. Four replications were used, each on a separate tray in a randomized block design. Pre-germination treatments were started before the tests began, so that all treatments went into the germinators on the same day. Samples were counted at near 7-day intervals for a period of 21 days.

Stults Da-lite germinations were used. One was a senior model with two chambers, and two were junior models. Chambers were set for the following environments.

Constant 20° C.

Constant 30° C.

Alternating	16 hours	(dark)	at	20° C.	and	8 hours	(light)	at	30° C.
"	"	"	"	20° C.	"	"	"	"	35° C.
"	"	"	"	15° C.	"	"	"	"	30° C.
"	"	"	"	26° C.	"	"	"	"	38° C.

Seed treatments were as follows:

1) Caryopses—0.2 percent KNO_3 as a moistening agent
2) Caryopses—prechilled 5 days at 5-10° C. — 0.2 percent KNO_3
3) Caryopses—prechilled 14 days — distilled water
4) Caryopses—prechilled 5 days — distilled water
5) Caryopses—distilled water
6) Rough seed units—distilled water
7) Caryopses—glume tea extract
8) Caryopses—glumes added to substratum

The glume tea was prepared by placing 5 grams of empty glumes of each accession in hot water and steeping for 24 hours at room temperature.

RESULTS AND DISCUSSION

Preliminary Studies in 1957

Preliminary germination tests on freshly harvested seed of *B. ischaemum* accessions were conducted in 1957. In these tests, no pre-germination treatments were used other than different germination environments, with the caryopses placed on a water-moistened substrate. Using the basis of no remaining firm or hard seeds as a criterion for ending the test on each accession within the different environments, a Turkish hexaploid accession, A-1359, required 87 days to reach maximum germination in a 20° C. environment, whereas 40 and 28 days were required to reach the same germination level in the 30° constant and 20-30° alternating environments, respectively.

Similarly, a hexaploid selection from Formosa, A-2582, required 60 to 68 days to reach maximum germination in the 20°, 30°, and 20-30° C. environments, but required only 25 days in a 26-38° environment. An accession from China, A-1347, consistently required 68 days to reach maximum germination in all environments tested. These tests suggested that on an average, 65 days is required for freshly-harvested seed of this species to reach maximum germination and that there is a definite variety and germinator environmental interaction. It was apparent from the ability of some accessions to germinate readily in one environment, whereas they required months to germinate in other environments, that the different accessions are very exacting in their temperature and/or temperature regime requirements.

Studies in 1958 and 1959

Results from 9 accessions studied in 1958 and 1959 showed significant differences between germination environments, varieties, and treatments within environments. The interactions varieties × treatment, environment × treatment, environment × varieties, and environments × varieties × treatments, were also highly significant.

Effect of Environment

Figure 1 shows the average percent germination of each accession by environment regardless of treatment. The responses seem to vary between years, but in general, favor an alternating temperature. In the three environments common to both years of study, 4 accessions in the 30° C., 4 in the 20-30° and 8 in the 20-35° had an average germination of 70 percent or above in 1959. The average total germination of 4 accessions (A-5110, A-6982, A-7041, and A-6985) was about as high in the 30° constant environment as in the alternating in 1958. Only A-6985 was consistent in its performance in both years, there being little difference between alternating and constant temperatures. Accessions A-5110, A-7044, A-726, A-7041, A-6582, and A-3457 had a total average germination by environment higher in the 15-30° and 20-35° than in the 20-30° alternate or 30° constant in 1958, indicating an environment having an alternate temperature of 15° differential was more optimum than a 10° or a ±2° constant temperature. This trend, however, was not evident in 1959, when the average total germination was in favor of the 20-30° temperature. In 1959, 7 of the 9 accessions averaged 70 percent germina-

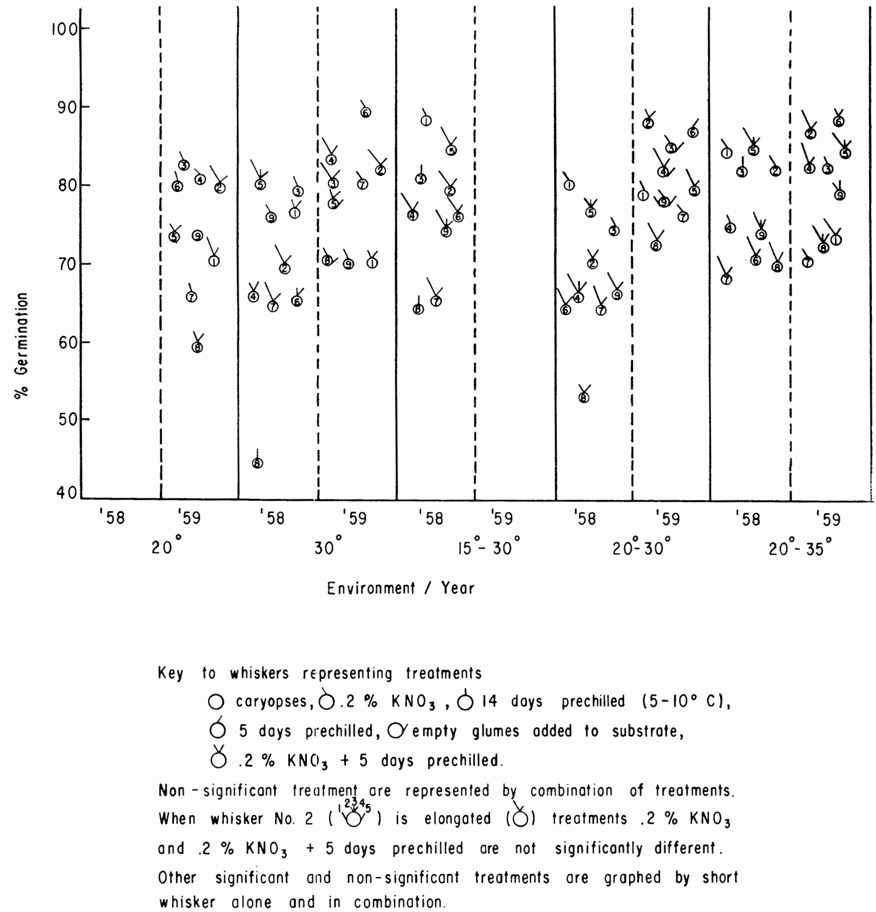

Figure 1.—Scatter diagram showing the average germination and the significant pre-germination treatments for each of 9 accessions within 5 environments, 1958 and 1959. These data are shown in numerical form in Appendix A.

tion or better in the 20° constant environment, although this environment usually gives poor results. Apparently, the nature of the environment × variety interaction can vary between years of harvest.

Effect of Treatment

The response in germination to a given treatment varies slightly between environment and variety, but in general is consistently better where 0.2 percent KNO_3 solution is used as a moistening agent alone or in combination with a 5-day pre-chill treatment. Out of a possible 72 chances—9 accessions and 4 environments in each of 2 years of study—the use of a 0.2 percent KNO_3 solution as a moistening agent appears 66 times alone or in combination as either the best treatment or as not significantly different from the best treatment. The 14-day pre-chill treatment was significantly effective in increasing germination in 2 accessions (A-3457 and A-6982) in two of the four environments in 1958. In 1959, the rough seed units of accession A-6985 germinated as well as the samples receiving pre-germination treatments.

Using the average percent germination of the untreated rough pure seed units as an index of the amount of seed dormancy, the seed harvested in 1958 was much more dormant than in 1959 (Figure 2). The average percent germination of each accession varied with the environment and the year of study. In 1958, a slight to a striking increase in germination is noted by comparing the response in the 30° C. to the alternating environments. The rough seed units of only one accession,

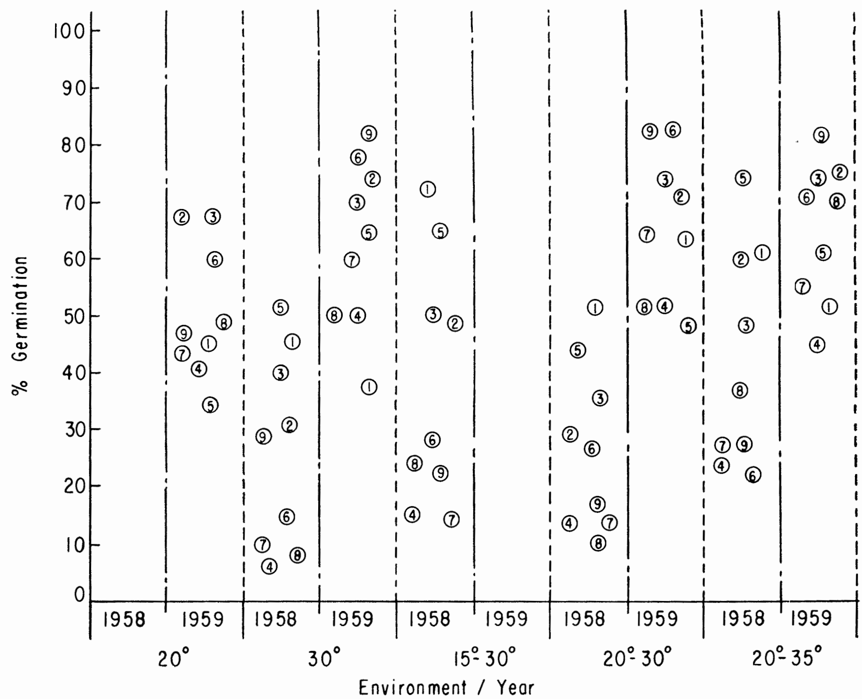

Figure 2.—Difference in seed dormancy based on the average germination capacity of the rough seed unit, between years and environment tested; 9 *B. ischaemum* accessions. See Table 1 for identity of accessions corresponding to numerical value.

A-6985, had an average germination higher in the 30° constant than in the alternating environments. The average germination of each accession in the four environments studied in 1959 was rather high in comparison to the results in 1958. The germination capacity of the rough seed treatment for all accessions, with the exception of A-5110, was lowest in the 20° constant environment. Only accessions A-5110 and A-3457 exhibited the same germination trend by environment as was exhibited the year before. As a rule, in 1959 the rough seed unit of the species germinated as well in a 30° constant environment as in alternating. This suggests that when seed dormancy is not a problem, the seeds will germinate well over a wide range of environmental conditions, but the seeds are more exacting in environmental requirements when seed dormancy is appreciable.

As shown in Table 2, any pre-germination treatment, except for accessions A-6985 and A-3457 in 1959, seemed to improve germination in this species. Almost without exception the untreated rough seed units

Table 2. The Average Percent Germination of Nine *Bothriochloa ischaemum* Accessions by Treatments Within all Environments, 1958 and 1959.

Accession Number	Year	Rough Check	Grain Check	0.2% KNO_3	5-day pre-chill plus 0.2% KNO_3	5-day pre-chill	14-day pre-chill	Glume Tea	Grain plus Glume
A-5110	'58	58.0	78.8	91.0	90.0	88.4	87.2		
	'59	49.4	83.5	82.4	86.5	77.6	66.1	71.2	70.9
A-7044	'58	40.0	65.5	89.4	80.6	91.5	86.1		
	'59	73.0	84.4	95.0	81.1	89.1	83.1	86.0	84.0
A-6982	'58	41.6	79.4	90.5	88.0	87.4	90.9		
	'59	71.6	84.7	89.2	82.7	85.0	73.1	86.2	87.5
A-726	'58	15.2	61.9	86.1	90.2	87.1	86.7		
	'59	47.5	90.4	91.4	92.0	83.2	76.2	91.9	82.7
A-7041	'58	58.9	80.9	89.0	89.3	84.6	88.1		
	'59	51.9	88.1	81.6	85.7	78.0	77.7	86.0	77.9
A-6582	'58	21.0	47.9	91.1	93.7	71.6	90.4		
	'59	73.5	90.4	92.0	89.7	90.2	89.2	87.5	84.5
A-562-b	'58	16.2	54.1	84.1	87.9	71.0	78.5		
	'59	58.1	64.0	88.1	86.4	74.4	80.1	82.1	55.9
A-3457	'58	20.0	36.2	68.0	83.8	54.7	83.1		
	'59	56.0	54.0	83.0	83.6	59.5	75.1	75.0	69.5
A-6985	'58	24.0	70.2	88.9	86.9	78.0	88.0		
	'59	73.7	84.9	81.5	71.2	62.6	69.5	80.4	81.6
Average for 1958 and 1959		47.2	72.2	86.8	86.1	78.5	81.6		
Average for 1958		32.7	63.8	86.5	87.8	79.3	85.5		
Average for 1959		61.6	80.5	87.1	84.3	77.7	76.6	82.9	77.2

gave the lowest average germination in all environments. The most effective germination treatments for the 2-year period of study were: (1) A 0.2 percent KNO_3 solution as a moistening agent alone and/or in combination with a 5-day pre-chill treatment; and (2) a 14-day pre-chill treatment at 5-10° C. Pre-chilling the seed for a 5-day period seemed to have little effect on the capacity to germinate in a number of accessions, but continuing the treatment to 14 days seemed to increase the germination capacity. However, pre-chilling alone was seldom as effective as KNO_3 alone or in combination with a 5-day pre-chill treatment. Where a pre-germination treatment was required to aid germination in these species, the use of KNO_3 as a moistening agent was just as effective if not more so than the 14-day pre-chill treatment.

Extracting the caryopses from their appendages in 1958 was enough to stimulate seed germination as compared to the untreated rough seed units, with the exceptions of accessions A-3457 and A-562-b. This same trend occurred in 1959. Inhibition of germination was evidently due in part to the enclosing appendages. In order to measure the effect of the glumes, two additional seed germination treatments were added in 1959: (1) Empty glumes were placed upon the moist substrate in the presence of the caryopses; and (2) a tea was prepared by letting the glumes steep in water for a 24-hour period. This tea was then used as a moistening agent. These treatments indicated that germination is controlled to some extent by inhibitors in the seed appendages. More work is needed with both these treatments to determine the concentrations required to inhibit seed germination to the level of the rough seed unit.

The response in germination by each accession varied as to environment and treatment. As shown in Figure 3, the germination of the more dormant rough seed units in 1958 was better in a 15-30° and a 20-35° C. alternating environment, while in 1959 (Figure 4) the best environments were the 20-35° alternating and the 30° constant. When the grain was extracted, the most favorable environments for germination were the 15-30° and 20-30° in 1958, and the 20-30° and 20-35° in 1959. The 20-30° environment was generally the best in the remaining treatments in 1958. Germination in the 20° constant environment in 1959 was surprisingly high when KNO_3 was used alone, or in combination with a 5-day pre-chill treatment. In general, the seed-receiving pre-chilled treatments germinated best in the 20-35° environment. However, the most favorable environments of this species, regardless of seed treatment, were the 20-30° and/or 15-30° alternate temperatures. The most unfavorable environments were those which maintained a constant temperature. A few accessions seemed to have little preference as to whether the environment is alternating or constant.

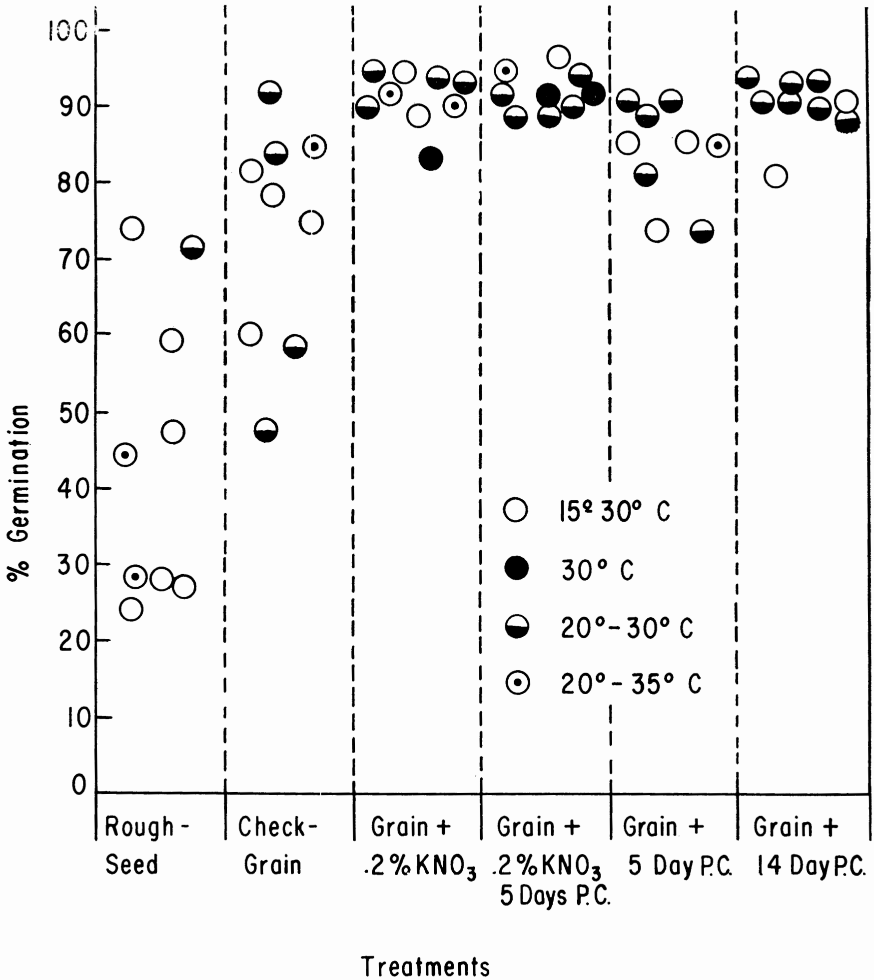

Figure 3.—Highest average percent germination of each treatment by environment, for 9 *B. ischaemum* accessions studied in 1958.

Polyembryony

The occurrence of more than one functional embryo in this species, as measured by the average occurrence of twin and triplet seedlings combined per 100 seed units (Figure 5), seem to be divided into groups having low, medium, and high frequencies of 0 to 0.99, 1.0 to 1.99, and more than 2.00 twins per 100 seed units. Less than 1 twin per 100 seed

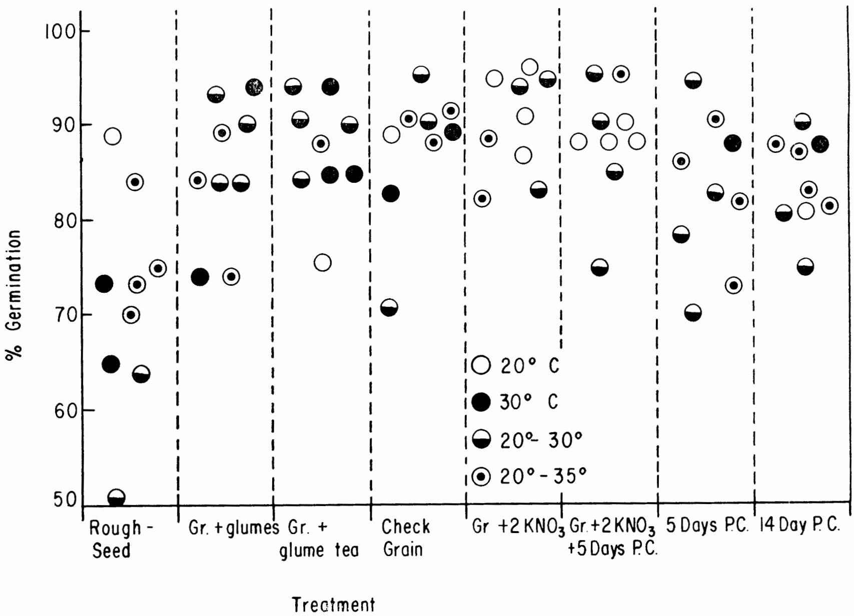

Figure 4.—Highest average percent germination of each treatment by environment, for 9 *B. ischaemum* accessions studied in 1959.

units occurred in A-3794, A-4776, A-1358-b, A-7056, and A-726. Less than 2 but more than 1 occurred in accessions A-3457, A-6985, A-6582, A-2557, and A-4008, while more than 2 occurred in accessions A-562-b, A-6982, A-7044, A-7041, A-5110, and A-7059.

The treatments producing the highest number of twin and triplet seedlings, depending on environment, were generally those having the highest germination. Accessions A-3457, A-7044, and A-726 produced the highest number of twins when 0.2 percent KNO_3 was used alone. The number of twins produced, with the exception of A-3457, varied as to treatment and environment. A 0.2 percent KNO_3 treatment alone, and a 0.2 percent KNO_3 treatment in combination with a 5-day pre-chill, were the more favorable treatments in the alternating 20-30° and 15-30° C. environments in stimulating the germination of more than one functional embryo. In the 20-35° alternate environment, the 14-day and 5-day pre-chill treatments were the most effective, respectively; while in the constant environments, the 5-day pre-chill plus 0.2 percent KNO_3 treatment produced the highest number of twins. A large number of variable twin types was observed in accession A-6985. Twins seldom oc-

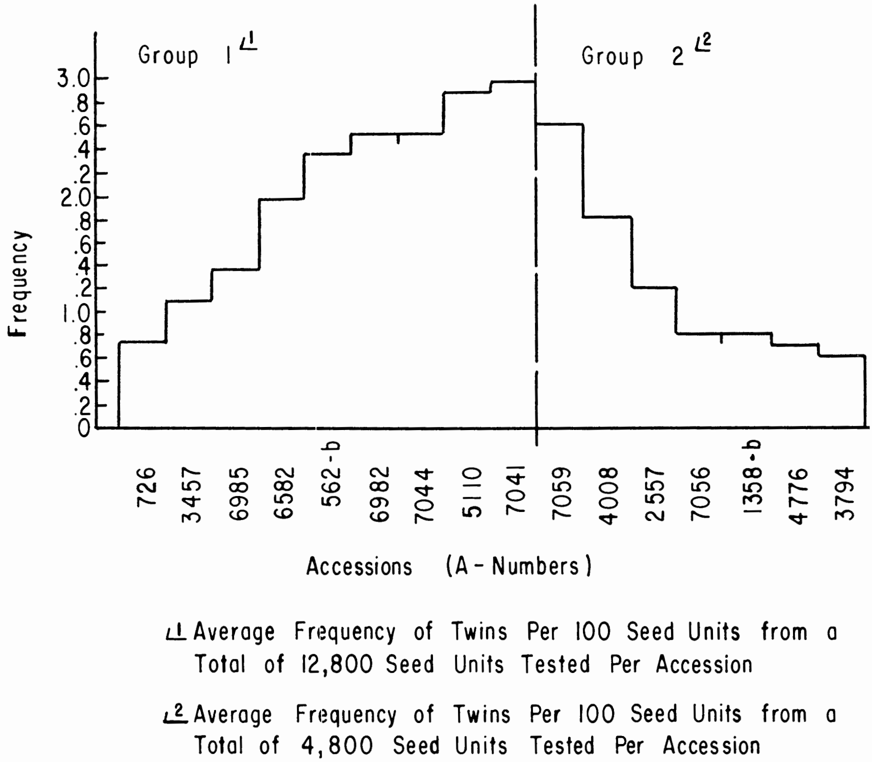

Figure 5.—Average frequency of twin seedlings occurring per 100 seed units in 9 *B. ischaemum* accessions studied during both 1958 and 1959, and 7 additional accessions studied in 1958, shown as groups 1 and 2, respectively.

curred in either check treatment. Triplets occurred in nearly all accessions, but were infrequent.

Many seedlings having shattered and/or split plumules with one or more primary root systems were considered abnormal. These were in all probability polyembryony, where competition in growth between embryos resulted in abnormal seedling development. This is probably due to the incomplete separation of the embryos. Since all these accessions of *B. ischaemum* are apomictic, one wonders why a few seeds have 2 and sometimes 3 functional embryos, while the majority seem to have only one. However, the probability of stimulating germination of all functional embryos in an artificial environment such as was used in this study is very remote. If precise control of the variables affecting germination could be maintained, an estimate of the functional embryos could be obtained where polyembryony exists.

Abnormal Seedlings

The highest number of abnormal seedlings was more commonly found in the pre-chilled treatments, but varied as to treatment and environment. With accessions A-726 and A-3457, the optimum treatment and environment frequently produced the greatest number of abnormalities. KNO_3 used as a moistening agent produced a large number of abnormal seedlings having no roots. This was observed in the alternating environments during both years of study, but was not evident in the constant 20° or 30° C. With these two accessions, $Ca(NO_3)_2$ might be as effective as KNO_3 in increasing germination without the production of so many abnormal seedlings.

CONCLUSIONS

Preliminary germination tests on freshly-harvested seed of *Bothriochloa ischaemum* suggested that an average of 65 days is required for seed of this species to reach maximum germination. As a result of the ability of some accessions to germinate readily in one enviroment while requiring months to germinate in other environments, it appears that the different accessions were very exacting in their temperature and/or temperature regime requirements.

Results from 2 years of data having the same accessions in common showed that the nature of the environment × variety interaction can vary between years of harvest. A few accessions seem to have little preference whether the germination environment is alternating or constant. Only one tetraploid accession, A-6985 from Iran, was consistent in its performance, there being little difference between alternating and constant temperatures during both years of study. Six of the 9 accessions studied had a total average germination per environment higher in the 15-30° and 20-35° C. alternates than in the 20-30° alternate or 30° constant in 1958. In 1959, however, the highest average germination was in favor of the 20-30° alternate environment.

Seeds of different *B. ischaemum* varieties will respond differently to environment, and treatments within environments, between years of harvest. The environment required to give maximum germination is dependent upon the type of pre-germination treatment used and upon the degree of seed dormancy. A pre-germination treatment that does well one year in a particular environment may not perform in the same manner the next year.

The difference in degree of seed dormancy between years may be in part attributed to the micro-climatic conditions occurring during seed development and the stage of maturity at the time of harvest.

The fact that the germination capacity is stimulated by removing the caryopses suggests the inhibition of germination is due in part to the enclosing appendages.

The occurrence of more than one functional embryo in this species, as measured by the average occurrence of twin and triplet seedlings combined per 100 seed units, seems to be divided into groups having low, medium and high frequencies.

The best treatments and environments for measuring the germination capacity of the *B. ischaemum* varieties, as indicated in these data, are a salt solution of 0.2 percent KNO_3 as a substrate moistening agent alone or in combination with a 5-day pre-chill at 5-10° C. and in either a 15-30° or a 20-30° alternating environment. Where a pre-germination treatment is required to aid germination in these species, the use of KNO_3 as a moistening agent is just as effective, if not more so, than the 14-day pre-chill treatment.

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Appendix A.—Average Germination and the Significant Pre-Germination Treatments For Each of 9 Accessions Within 5 Environments, 1958 and 1959.

Accession		20° C.								30° C.								15 - 30° C.							
Number	Year	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
A-5110	'58	--	--	--	--	--	--	--	--	46	--	--	76	81	88	84	85	72	--	--	84	95	92	91	94
	'59	45	53	76	80	86	89	75	59	38	71	66	82	75	87	72	68	--	--	--	--	--	--	--	--
A-7044	'58	--	--	--	--	--	--	--	--	30	--	--	56	88	88	71	83	49	--	--	68	90	89	87	91
	'59	68	81	86	73	95	82	73	79	74	76	79	83	94	91	65	86	--	--	--	--	--	--	--	--
A-6982	'58	--	--	--	--	--	--	--	--	40	--	--	85	92	86	90	88	41	--	--	82	88	90	92	93
	'59	67	83	85	87	91	82	85	81	70	86	82	80	90	73	85	68	--	--	--	--	--	--	--	--
A-726	'58	--	--	--	--	--	--	--	--	7	--	--	46	83	95	94	74	16	--	--	76	94	94	86	90
	'59	42	83	91	90	94	92	84	85	50	80	92	91	92	91	78	88	--	--	--	--	--	--	--	--
A-7041	'58	--	--	--	--	--	--	--	--	65	--	--	76	88	88	88	88	65	--	--	92	90	90	83	83
	'59	33	66	84	80	85	88	78	69	52	74	86	87	69	82	93	76	--	--	--	--	--	--	--	--
A-6572	'58	--	--	--	--	--	--	--	--	15	--	--	44	96	91	63	89	28	--	--	59	93	91	82	91
	'59	60	66	80	84	96	91	77	84	78	93	91	91	88	89	88	89	--	--	--	--	--	--	--	--
A-562-b	'58	--	--	--	--	--	--	--	--	10	--	--	58	83	84	72	77	14	--	--	54	81	91	74	78
	'59	43	38	71	44	90	88	73	80	74	73	84	84	89	85	69	79	--	--	--	--	--	--	--	--
A-3457	'58	--	--	--	--	--	--	--	--	7	--	--	17	46	74	43	76	23	--	--	47	70	89	59	90
	'59	49	52	52	43	80	84	49	60	52	72	84	62	83	79	53	78	--	--	--	--	--	--	--	--
A-6985	'58	--	--	--	--	--	--	--	--	29	--	--	80	90	87	85	85	22	--	--	17	88	88	80	91
	'59	87	83	81	83	80	68	59	43	43	79	78	85	82	72	55	73	--	--	--	--	--	--	--	--
Average germination by environment per treatment																									
	'58	--	--	--	--	--	--	--	--	28	--	--	59	83	87	76	82	36	--	--	64	88	90	82	89
	'59	54	67	78	74	88	85	72	71	59	78	82	83	85	83	73	78	--	--	--	--	--	--	--	--
Average by environment																									
	'58								--								69								75
	'59								74								78								--

Appendix A.—cont'd.

Accession Number	Year	20 - 30° C.								20 - 35° C.								Average per Environment				
		1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	20°	30°	15-30°	20-30°	20-35°
A-5110	'58	52	--	--	76	94	88	87	82	61	--	--	79	93	92	91	87	--	76	88	80	84
	'59	63	83	74	90	80	82	84	75	52	76	68	81	87	87	78	62	70	70	--	79	74
A-7044	'58	29	--	--	59	84	92	77	80	59	--	--	79	84	85	86	90	--	69	79	70	81
	'59	74	90	91	89	93	95	94	79	75	88	87	91	93	88	92	88	80	81	--	88	87
A-6982	'58	36	--	--	64	92	86	78	89	48	--	--	86	88	89	89	92	--	80	81	74	82
	'59	74	92	90	86	87	90	84	80	74	88	86	86	88	85	86	62	82	79	--	85	82
A-726	'58	13	--	--	43	79	89	81	90	24	--	--	82	87	82	81	91	--	66	76	66	75
	'59	52	83	91	88	85	89	75	88	45	84	92	91	94	94	90	63	81	83	--	81	82
A-7041	'58	44	--	--	70	87	93	80	90	74	--	--	86	90	86	86	91	--	80	84	77	85
	'59	47	82	84	99	82	85	77	78	61	89	89	86	89	87	83	87	73	78	--	79	84
A-6572	'58	17	--	--	39	91	95	64	90	22	--	--	48	92	97	77	91	--	65	74	66	71
	'59	73	90	92	94	89	88	88	91	83	89	86	92	86	90	87	91	80	89	--	88	88
A-562-b	'58	13	--	--	53	87	90	67	77	27	--	--	60	84	86	70	81	--	64	65	64	68
	'59	60	61	81	77	93	87	78	81	55	50	81	49	89	84	77	80	66	80	--	76	70
A-3457	'58	13	--	--	32	67	83	42	79	34	--	--	47	89	89	74	87	--	44	63	53	70
	'59	50	70	80	71	84	85	70	78	70	73	83	39	84	84	64	84	59	70	--	73	72
A-6985	'58	17	--	--	53	89	88	64	86	27	--	--	75	88	83	83	88	--	76	73	66	74
	'59	82	83	83	84	80	74	62	78	82	80	79	87	83	70	73	83	73	71	--	78	80
Average germination by environment per treatment																						
	'58	26	--	--	54	86	89	71	85	42	--	--	71	88	88	82	88					
	'59	64	82	85	86	86	86	79	81	66	80	83	78	88	85	81	78					
Average by environment																						
	'58								68								76					
	'59								81								80					

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