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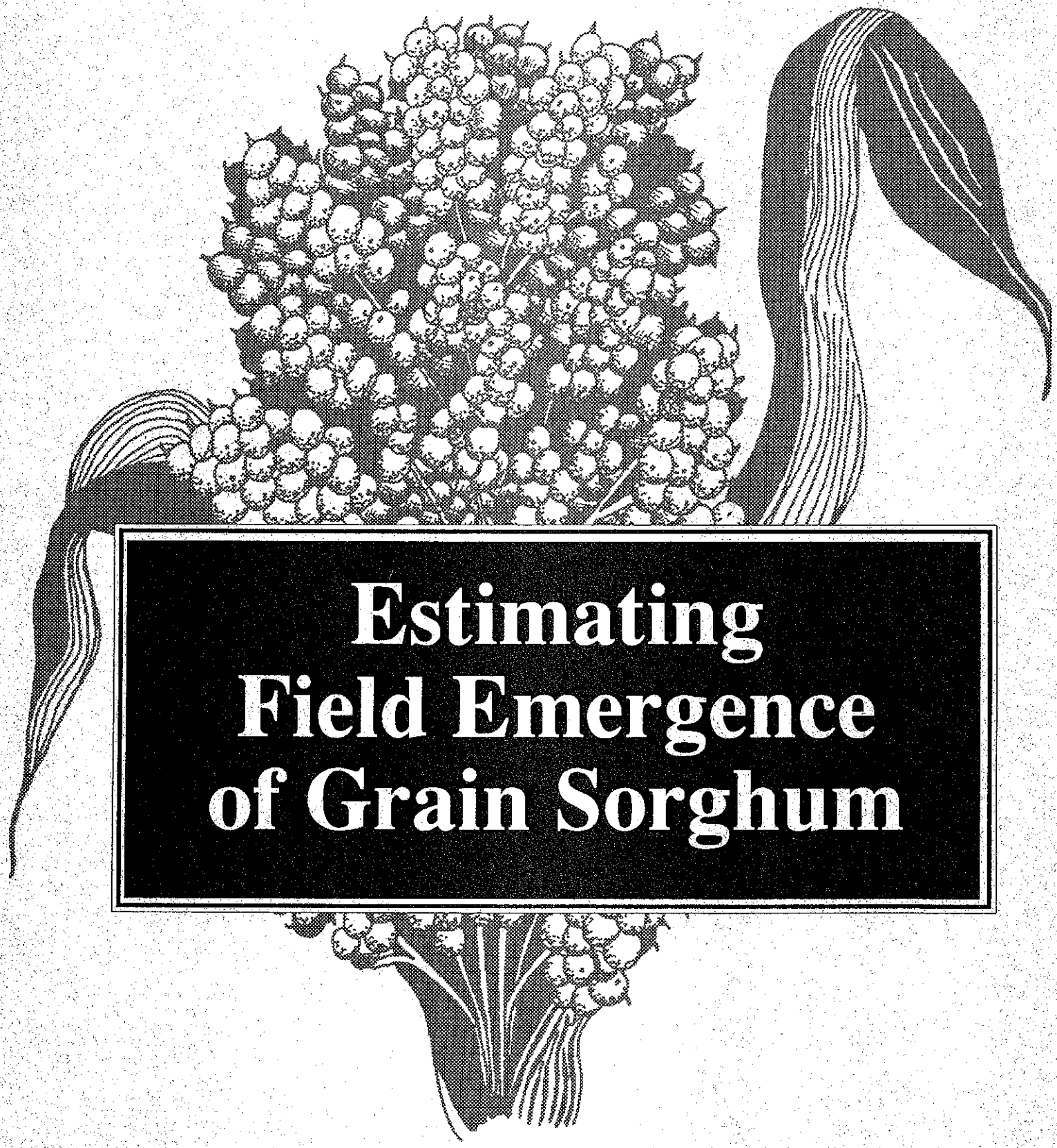

Estimating Field Emergence of Grain Sorghum

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MISSISSIPPI AGRICULTURAL & FORESTRY EXPERIMENT STATION Verner G. Hurt, Director Mississippi State, MS 39762
Donald W. Zacharias, President Mississippi State University R. Rodney Foil, Vice President

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C. C. Baskin
Professor Emeritus
Department of Agronomy-Seed Technology

S. Paliwal
Agronomist, Pioneer International
Caroua, Cameroon

J. C. Delouche
Professor and Agronomist
Department of Agronomy-Seed Technology

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Introduction

Stand establishment, i.e. an adequate number of plants surviving in the field, is essential to optimize crop yield.

Estimating field emergence of crop seed is difficult because of the wide variations in field conditions. The lower the quality of the seed, the more difficult it is to estimate emergence and to obtain an acceptable stand.

The standard germination test is the basic test for seed quality evaluation, but it has deficiencies. Munn (1926) compared laboratory and field viability tests and found a difference of 34% in favor of laboratory germination when garden pea (*Pisum sativum* L.) seeds were planted in the field under normal cultural conditions.

The inability of the standard germination test to predict field emergence has been demonstrated for sorghum [*Sorghum bicolor* (L.) Moench.] (Camargo and Vaughan, 1973; Pinthus and Rosenblum, 1961; and Vanderlip et al., 1973); for corn (*Zea mays* L.) and sorghum (Vanderlip, 1974); and for soybean [*Glycine max* (L.) Merril] (Edje and Burris, 1971).

Rice (1960), Pinthus and Rosenblum (1961), Tatum and Zuber (1943), Grabe (1967), Waters and Blanchett (1983), and Knake (1986) used a cold test to evaluate seeds and predict field performance of different crops.

The objective of this study was to estimate field emergence of grain sorghum under both favorable and adverse field conditions from results obtained in laboratory tests – the standard germination test and the soil cold test.

Seed Material

Seeds of 32 lots of commercial grain sorghum hybrids were obtained from Asgrow Seed Company, Cargill Hybrid Seeds, and Funk Seeds International in 1986. Lots were selected by the respective companies to represent a range in seed germination. Particular hybrids were not identified in any year and grain type was not determined. Seeds of three breeding lines were also obtained from Funk Seeds International in 1986 and included in this study. All 35 lots were evaluated in laboratory and field tests in 1987.

In 1987, samples of five additional seed lots of commercial grain sorghum hybrids were obtained from Funk Seeds International and combined with 25 seed lots selected from those obtained in 1986. This made 25 of the lots common to the 1987 and 1988 field tests. The three breeding lines and seven of the commercial lots were discarded because they were below 80% germination or were closely duplicated by other lots.

Seeds of 30 additional commercial hybrid sorghum lots were obtained from commercial sources in 1988. These seed lots were tested in the laboratory using standard germination tests and soil cold tests in 1988, and tested in field emergence under cold wet conditions in 1989.

Seeds were tested for standard germination as they were received from the respective seed companies, then stored at 10°C and 50% RH (relative humidity) until soil cold tests and field emergence tests were conducted.

Laboratory Tests

Standard germination tests were conducted and evaluated according to the Association of Official Seed Analysts (AOSA) "Rules for Testing Seeds" (1985). Seed were germinated on blotters at an alternating temperature of 20°-30°C.

Soil cold tests were conducted using a 1:1 mixture of screened field soil and unsterilized builders sand by volume. No identification of pathogens or measure of level of soil pathogens were made.

One thousand grams of the sand-soil mixture (approximately 2 cm in depth) were placed in a 20 x 27 x 9.5 cm plastic crisper. After leveling and firming the sand-soil mixture, four replications of 50 seeds each were planted (two replications/crisper), then covered with an additional 1,000 grams, of sand-soil mix (approximately 2 cm deep). After leveling and firming the sand-soil mix again, enough water (pre-chilled to 10°C) was added to each crisper to bring soil moisture content to 60% of saturation. The crispers were covered, placed at 10°C for 168 hours (+ 1 hour), then placed in a 25°C environment. Emerged, normal seedlings were counted after approximately 120 hours at 25°C.

Field Tests

All field emergence tests were planted in very fine sandy loam soil on the MAFES Plant Science Research Center at Mississippi State University. There were four replications of 100 seeds each in rows 1 m apart and 3 m long. Seeds were planted with a hand planter approximately 2.5 cm deep.

One planting was made on May 15, 1987, when seedbed conditions were warm and moist. At planting, soil temperature was 27°C at the 5-cm depth. Soil moisture was adequate for germination. Precipitation occurred on the afternoon of May 16. Soil temperatures at the 5-cm depth ranged from 21° to 22°C between 7:00 and 8:00 a.m. through May 19, when seedling emergence was evident in all plots.

Another planting was made on July 29, 1987, when seedbed conditions were hot and dry. Soil temperature at the 5-cm depth at planting was 38°C at 11:00 a.m., and by 3:00 p.m had reached 46°C. Soil temperatures measured between 3:00 and 4:00 p.m. reached a high of 47°C on July 30. Adequate rainfall for emergence occurred August 1. Soil temperature dropped to 27°C at 5 cm but reached 42°C on August 2. Emergence was evident in all plots on August 2.

Other plantings were made on October 6, 1987, April 7, 1988, and April 14, 1989 when field seedbed conditions were cold and wet. Soil temperatures were measured daily at depths of 5 cm after each planting. In 1987, soil temperature between 7:00 and 8:00 a.m at the 5-cm depth was 9°C on October 5. Planting was made October 6 beginning at 2:00 p.m. Soil temperature at the 5-cm depth at planting was 16°C. On October 7, plots were sprinkle irrigated to create a wet soil condition. Soil temperatures between 7:00 and 8:00 a.m. at the 5-cm depth ranged from a high of 12°C on October 7 to a low of 9°C on October 13 and 14. Sorghum emergence did not occur until October 16.

Soil temperatures under cold, wet conditions in 1988 were more moderate than in 1987. At planting on April 7, soil temperature at the 5-cm depth was 19°C. The lowest temperature, 9°C, occurred on April 13. Emergence was evident in all plots on April 17.

Soil temperature at planting April 14, 1989 at the 5-cm depth was 14°C, and, when measured between 7:00 and 8:00 a.m., ranged from 12°C on April 15 to 17°C on April 19, dropping to 12°C again on April 20. Emergence was evident in all plots on April 22.

Stand counts were made for all plantings when sorghum plants were in the 3-4 leaf stage or larger.

Experimental Designs

The experimental design of all laboratory tests was a completely randomized design with four replications. Field tests were planted in a randomized complete block design with four replications. All randomizations were performed for both of these designs as outlined by Peterson (1985).

Results and Discussion

Soil cold tests were more effective in predicting field emergence under all soil conditions than was the standard germination test. Although correlation was high between standard germination and field emergence when soil temperature and moisture were favorable for emergence, the coefficient of correlation between soil cold test emergence and field emergence was slightly higher than the coefficient of correlation between standard germination and field emergence (0.848 for soil cold test and 0.825 for standard germination). Both were significant at the 0.01 level of probability.

Results of the standard germination tests and the soil cold emergence tests for 1987, 1988, and 1989 are presented in Table 1. In 1987, standard germination ranged from 63% to 99% with a mean of 89.5%. Four lots germinated below 80% and five other lots below 85%. In 1988, 29 of the 30 seed lots germinated above 80% with a range from 74% to 99% with a mean of 89.7%. In 1989, all lots but one germinated above 80% with a range from 79% to 98% with a mean of 88.6%. Soil cold test emergence in 1987-1988 ranged from 52% to 96%, with eight lots emerging below 70%. Mean emergence was 79.5%. In 1989, soil cold test emergence ranged from 27% to 93% with 13 lots emerging below 70%. Mean emergence was 72.1%.

Field emergence is presented in Table 2. Seed lots planted when field conditions were favorable in 1987, ranged from 69% to 97% in emergence. Only one seed lot emerged below 70%. Seed lot 27 had a standard germination of only 63%, yet field emergence was 75% under favorable conditions. Mean emergence was 86.5% compared to mean standard germination of 89.5%. Under these field conditions, emergence of all seed lots was at a level that would produce acceptable plant populations.

Range in emergence under cold wet conditions was from 20% to 86% in 1987; from 32% to 85% in 1988, and from 39% to 76% in 1989. Mean field emergence under cold wet conditions was 60.1% in 1987, 61.7% in 1988, and 65.9% in 1989. Mean field emergence under favorable conditions in 1987 was 26.4% greater than under cold, wet conditions.

Field emergence under hot, dry conditions in 1987 ranged from 34% to 69% with a mean of 55% compared to a mean of 86.5% under favorable field conditions. Emergence under hot, dry conditions was not conducted in other years because these conditions did not occur. Maximum emergence and mean emergence

were lower under hot, dry field conditions than under cold wet field conditions. Emergence under both stress conditions was considerably below that under favorable field conditions demonstrating the need for tests(s) to measure the potential field emergence of sorghum seed lots when field conditions are not favorable for seedling emergence.

Field emergence occurred in the same number of days under favorable and hot, dry soil conditions. At 4 days after planting, however, emergence was lower and more erratic when conditions were hot and dry. Field emergence required much longer when soil conditions were cold and wet, 8, 10, and 11 days in 1989, 1988, and 1987 respectively.

Correlation coefficients between laboratory tests and emergence under different field conditions are presented in Table 3. Standard germination was a relatively good predictor of field emergence under favorable soil conditions that occurred in 1987 (r-value = 0.825). Only three lots had more than 10% difference between standard germination and field emergence (two lower, one higher). This is considerably less variation between standard germination and field emergence under favorable conditions than reported by other investigators (Barnes, 1960; Munn, 1926).

Soil cold test emergence gave the highest correlations with all field emergence tests. A correlation of 0.752 was obtained when the cold test was related to

Table 1. Standard germination and soil cold test emergence of sorghum seed lots.

Lot No. 1987-88	Std Germ 1987 (%)	Std Germ 1988 (%)	Soil Cold Test Emerg. 1987-1988 (%)	Lot No. 1989	Std. Germ 1989 (%)	Soil Cold Test Emerg. 1989 (%)
1	79	–	54	41	88	65
2	97	–	92	42	86	64
3	93	93	85	43	85	70
4	90	90	79	44	85	61
5	87	87	71	45	90	69
6	86	86	73	46	82	48
7	87	87	68	47	90	81
8	74	74	59	48	90	62
9	91	91	83	49	89	86
10	84	84	69	50	89	84
11	90	90	78	51	88	84
12	97	97	88	52	93	89
13	98	98	95	53	87	56
14	99	99	96	54	89	85
15	80	80	72	55	90	76
16	95	–	91	56	84	85
17	98	98	94	57	81	63
18	96	96	80	58	79	27
19	92	–	88	59	95	80
20	87	87	72	60	93	93
21	98	98	92	61	95	82
22	97	97	94	62	85	68
23	81	81	72	63	95	88
24	84	84	70	64	93	83
25	81	81	64	65	98	89
26	89	89	73	66	91	85
27	63	–	52	67	92	50
28	94	94	91	68	81	81
29	97	–	92	69	90	67
30	97	–	91	70	86	43
31	92	92	88			
32	95	95	89			
33	89	–	80			
34	98	–	96			
35	77	–	66			
36	–	93	86			
37	–	88	85			
38	–	89	77			
39	–	87	77			
40	–	86	59			
Mean	**89.5**	**89.7**	**79.5**	–	**88.6**	**72.1**

Table 2. Field emergence of sorghum seed lots under various soil conditions.

Lot No.	Favorable Condition 1987 (%)	Cold Wet 1987 (%)	Cold Wet 1988 (%)	Hot Dry 1987 (%)	Lot No.	Cold Wet 1989 (%)
1	79	20	–	48	41	58
2	93	76	–	62	42	67
3	91	57	62	59	43	63
4	76	55	59	50	44	60
5	83	55	48	47	45	61
6	86	45	56	54	46	61
7	78	37	46	37	47	70
8	69	38	35	34	48	61
9	87	69	60	67	49	68
10	78	37	64	44	50	73
11	87	60	63	55	51	68
12	94	61	79	45	52	69
13	96	63	80	64	53	72
14	97	69	84	63	54	70
15	81	60	62	49	55	74
16	94	81	–	63	56	68
17	92	79	69	70	57	62
18	83	67	61	50	58	39
19	86	72	–	61	59	56
20	87	59	54	54	60	76
21	91	71	85	61	61	71
22	90	86	85	62	62	65
23	93	57	70	46	63	74
24	80	44	50	34	64	66
25	82	45	58	51	65	75
26	92	58	64	61	66	68
27	75	40	–	40	67	54
28	88	70	63	66	68	62
29	93	72	–	63	69	66
30	92	72	–	64	70	52
31	84	73	72	52		
32	88	75	72	62		
33	89	56	–	62		
34	94	71	–	69		
35	80	56	–	58		
36	–	-	57	–		
37	–	-	61	–		
38	–	-	49	–		
39	–	-	52	–		
40	–	-	32	–		
Mean	**86.5**	**60.1**	**61.7**	**55.0**	–	**65.9**

Table 3. Simple correlation coefficients between laboratory tests and field emergence of grain sorghum.

Test	Field Conditions: Favorable (1987)	Cold-Wet (1987)	Cold-Wet (1988)	Cold-Wet (1989)	Hot-Dry (1987)
	r-values				
Soil Cold	.848**(33df)	.880**(33df)	.811**(28df)	.845**(28df)	.752**(33df)
Std Germ	.825**(33df)	.751**(33df)	.703**(28df)	.501* (28df)	.677**(33df)

* Significant at the 0.05 level of probability
** Significant at the 0.01 level of probability

hot, dry field emergence in 1987. Under cold, wet field conditions the correlations with soil cold test results were 0.880, 0.811, and 0.845 in 1987, 1988, and 1989 respectively. Soil cold test emergence had a slightly higher correlation (r= 0.848) with field emergence under favorable conditions than did standard germination in 1987.

Soil cold test is widely used to evaluate seed vigor in corn. Similar correlations between soil cold tests and field emergence of corn and soybeans have been reported by Tao (1980).

Summary

This study was conducted to determine relationships between the standard germination test, soil cold test emergence, and field emergence of grain sorghum. Samples of 37 commercial lots (hybrids) and three breeding lines of grain sorghum used as female parents were evaluated in the laboratory using the standard germination test and soil cold test in 1987-88. Results of these tests were correlated with field emergence tests conducted under favorable (1987), hot, dry (1987), and cold, wet (1987, 1988) field conditions. Thirty additional lots of grain sorghum (hybrids) from commercial sources were evaluated in the laboratory using standard germination and soil cold tests in 1988. These results were correlated with emergence under cold, wet field conditions in 1989.

The differences that existed among these 70 sorghum seed lots were more evident from the results of the soil cold test than from standard germination tests. Under cold, wet soil conditions coefficients of correlation were highest between the soil cold test emergence and field emergence [0.880 (1987), 0.811 (1988), and 0.845 (1989)]. Under hot, dry conditions, the correlation coefficient was 0.725 (1987) and under favorable conditions, 0.825 (1987).

Conclusions

This study demonstrates that tests in addition to standard germination are needed for evaluation of grain sorghum seed in order to more accurately determine planting value, particularly when field conditions are adverse. The soil cold test appears to be an excellent test for this purpose.

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