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Determination of Seed Quality of Mg IV Soybean Genotypes

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Abstract: The study was conducted to determine the planting date effect on seed quality. Twenty-seven indeterminate and nine determinate genotypes were planted and seed quality was determined by four different methods i.e., standard germination, cold emergence, field emergence and electric conductivity. Genotype x date, genotype by trial and genotype by date and trial effects were significant ($P<0.01$) for standard germination and field emergence in case of determinate genotypes. Indeterminate genotypes differed in germination, indicating that genotypes with high seed quality can be selected. Standard germination, cold emergence and field emergence were higher for seed from late-planted environments than for seed from early-planted environments, indicating that MG IV genotypes planted in May or later can produce good seed quality. Early planting gave poor quality, so more seed should be harvested per plant to compensate poor seed quality when individual plant selections are conducted from April planting vs. June planting. May and June planting dates gave acceptable seed quality.

Key words: Soybean, seed quality, early planting, genotype x planting date, maturity group

Introduction

Soybean (*Glycine max* L.) varieties of maturity group (MG) IV are popular in the mid-south region of the USA. If planted in April, these genotypes go through the drought sensitive pod-fill development stage before the occurrence of typical August drought (Edwards, 1989). These drought can reduce the yield of MG V and VI cultivars. Studies (Akhtar and Sneller, 1996 and 1996a; Browers *et al.*, 1990; May *et al.*, 1989 and 1990; Mayhew, 1991; Savoy *et al.*, 1992) have shown the yield potential of MG IV cultivars in drought avoidance production system. In addition to drought avoidance, MG IV cultivars can produce acceptable yields in the mid-south when planted in May and June. A drawback of MG IV cultivars in the mid-south is that seed quality, as determined by germination and vigor, has been poor due to maturation in warm, humid conditions (May *et al.*, 1990; Mayhew, 1991; Mayhew and Caviness, 1994). TeKrony *et al.*, (1980) also reported that during the desiccation period, warmer and drier conditions can reduce the viability and that high temperature and humidity are very deterimental to seed vigor. Though seed from late June through mid July planting often has good quality (Mayhew, 1991).

Akhter and Sneller (1996 and 1996a) studied the effect of April and June planting dates on indeterminate and determinate MG IV genotypes in the mid-south. Planting date affected many traits and their association with yield.

The above literature indicates that seed quality in early planting is poor and addresses different environmental conditions affecting seed viability and seed vigor. The literature does not show how different planting dates have an effect on seed quality of MG IV genotypes in the mid south. The April to June range of planting dates for MG IV genotypes in the mid-south can produce genotype x planting date interactions for seed quality traits.

Therefore the study was conducted to determine the planting date effect on seed quality of MG IV genotypes in mid south.

Materials and Methods

The germplasm consisted of 22 indeterminate and nine determinate late MG IV, F_4 – derived soybean lines from crosses of narow x williams 82, narow x stevens and R84-150 x douglas. Five check cultivars: asgrow A4595, douglas, FFR 464, pioneer 9461 and williams 82 were also tested. The crop was sown at Pine Tree, Arkansas, USA in the year 1992 (P92) and 1993 (P93) on calhoun silt loam (fine, silty, mixed, thermic, typic, glossaqualf) and at Keiser, Arkansas, USA in the year 1993 (K93) on a sharkey clay (very fine, montmorillonitic, non acid, thermic, vertic haplaquept). Each trial was conducted as a split-plot with planting date as the whole plot and genotypes as the split factor. The P92 planting dates were 16 April and 17 June. The P93 planting dates were 23 April and 21 June while K93 planting dates were 25 May and 7 July. The P92 trial consisted of two replications while the other trials had three replications. All plots were irrigated as needed. The P92 plots consisted of two, 3.6 m planted on 0.91 m centers that were end-trimmed to a final length of 3.0 m prior to harvest of the middle two rows. The P93 plots consisted of four rows on 0.76 m centers while the K93 plots consisted of five rows on 0.48 m centers. The P93 and K93 rows were 6 m long and were end-trimmed to the final length of 5.4 m prior to harvest of the middle two rows. Number of days from planting to maturity (R8) were counted (Fehr and Caviness, 1977). A sample was taken from the harvested beans for 100-seed weight and seed quality tests from two replications of each trial.

A standard germination test was conducted on paper towels to determine seed viability (Anonymous, 1988). Two repetitions of a 50-seed sample of each treatment was placed on wet germination paper for 7 days at 25 °C, at 95 % relative humidity and under a 12 h photoperiod. At the end of 7 days, the number of seeds that germinated was counted to obtain standard germination percentage. While, cold emergence was conducted by planting 50 seeds from each treatment on individual flats of moist sand at 17 °C in environmentally controlled chambers. Emerged plants were counted at 7 and 10 days and percentage emergence was determined for each treatment (Anonymous, 1988).

An electrical conductivity test was performed by soaking 50 seeds for P92 and 20 seeds for P93 and K93 per plot individually in 4 ml of double-deionized water for 24 h from each treatment. The soaking seeds were subjected to a temperature of 23 ± 1 °C. Electric conductivity (EC) was measured in microamps (μA) by the Automatic Seed Analyzer-610 (ASA-610). The average of EC of each treatment was used for further analysis. Whereas, field emergence was conducted by planting 150 seeds in mid-May in a 6.1 m row in captina silt loam at the Main Experiment Station, Fayetteville, AR. Emerged seedlings were counted after 10 days and percentage emergence was determined.

An analysis of variance was conducted for each trial to assess the significance of main effects and interactions. Genotype and year were considered to be random effects while planting date was considered to be a fixed factor. Approximate F-tests (Snedecor, 1967) were used to test the significance of the trial and date, effects across trials and the date effect in a single trial. Phenotypic correlations were calculated using genotype averages over replications.

Results and Discussion

Planting date effect was highly significant ($P\leq0.01$) across trials for SG, but non significant for CE, FE and EC tests for indeterminate lines (Table 1). SG for the early-planted environments (indeterminate genotypes) was 65.7 % as compared to 88.4 % for the late-planted environments (Table 3). For determinate genotypes, genotype and planting date effects were not significant (Table 1), therefore, the discussion will be limited to the indeterminate genotypes.

Table 1: Mean squares of seed quality tests of determinate and indeterminate genotypes

Source of variation	Mean squares: Standard germination (SG) %	Cold emergence (CE) %	Field emergence (FE) %	Electric conductivity (EC) (μA)
Indeterminate				
Trial	6825.69**	4427.32	12514.65**	25132.140**
Rep(trial)	291.90	244.90	3601.00	9923.660
Date	40407.45**	35209.56	1855.22	980.880
Trial x Date	6354.61	9626.33	1184.83**	1529.350*
Rep(Trial x Date)	267.58	2488.38	13.13	129.220
Genotype	1708.73**	553.52**	331.84**	1693.300**
Genotype x Trial	287.45**	419.08**	120.69**	255.060
Genotype x Date	621.51**	189.95**	101.49*	289.420
Genotype x Date x Trial	238.18**	341.04	114.20**	223.820
R^2	0.89	0.82	0.86	0.770
CV%	15.08	26.00	10.88	27.260
Means	76.92	52.87	74.20	64.730
Determinate				
Trial	304.18	5392.42	3173.85**	16646.910**
Rep(Trial)	199.48	165.16	525.99	10828.540
Date	3437.69	3972.00	123.88	0.009
Trial x Date	1800.73	4107.47	23.65	1310.590
Rep(Trial x Date)	306.50	888.94	31.53	1036.410
Genotype	259.75	289.97	136.88	923.540
Genotype x Trial	213.45*	401.87**	147.96*	487.970
Genotype x Date	174.06	243.84	34.77	410.040
Genotype x Date x Trial	115.91	326.36**	99.31	542.970
R^2	0.77	0.85	0.79	0.780
CV%	12.00	22.30	11.20	36.590
Means	86.76	57.00	78.30	65.550

Table 2: Mean squares of seed quality tests of indeterminate lines in individual trials

Source of variation	Mean squares: Standard germination (SG) %	Cold emergence (CE) %	Field emergence (FE) %	Electric conductivity (EC) (μA)
P92				
Date	29668.72**	40498.56**	120.33	0.202
Replication	254.45	84.15	9557.82	25913.070
Rep x Date	318.33	1051.83	6.26	291.645
Genotype	814.49**	786.07**	235.25**	705.628
Genotype x Date	480.71**	326.47**	90.43	202.675
Error B	155.63	164.47	109.32	455.210
R^2	0.90	0.90	0.76	0.680
CV%	16.91	26.10	16.21	25.930
Means	73.76	49.13	64.48	82.290
P93				
Date	21978.66**	12805.33**	3326.12*	4005.880
Replication	472.76	213.92	836.84	87.210
Rep x Date	484.29	588.00	0.50	13.618
Genotype	1135.44**	297.90*	235.08**	1098.624**
Genotype x Date	460.08**	121.41	192.26**	530.457
Error B	120.72	175.50	48.10	366.960
R^2	0.90	0.73	0.86	0.709
CV%	15.48	26.99	9.60	36.775
Means	70.94	49.07	72.27	52.090
K93				
Date	674.90	65.28	778.43**	62.940
Replication	148.50	436.62	408.29	3770.700
Rep x Date	0.11	5825.30	32.64	82.425
Genotype	300.22**	259.15	102.91**	395.010**
Genotype x Date	144.35	427.97*	47.21	66.190
Error B	128.97	224.27	37.92	114.850
R^2	0.64	0.67	0.72	0.73
CV%	13.2	24.82	7.18	17.82
Means	85.99	60.33	85.76	60.13

* : $P < 0.05$ ** : $P < 0.01$

Table 3: Main effects of seed quality tests in different trials

Trials	Planting date	Maturity	Standard germination (SG) %	Cold emergence (CE) %	Field emergence (FE) %	Electric conductivity (EC) (μA)
Indeterminate						
All trials	Early	-	65.7a	42.3	71.8	65.6
	Late	-	88.4b	63.1	76.6	62.9
P92	Early	Early September	56.8a	28.2a	65.6	82.7
	Late	Early-October	91.7b	68.6b	63.4	81.9
P93	Early	Mid-September	56.7a	38.2a	66.7a	58.2
	Late	Early-October	85.2b	60.0b	77.8b	46.0
K93	Early	Mid-October	83.5	59.9	83.1a	59.4
	Late	Late-October	88.5	60.8	88.4b	60.9
Determinate						
All trials	Early	-	81.1	51.1	77.2	65.9
	Late	-	92.4	62.8	79.4	65.2

Means followed by different letters within a trial are significantly different at $P < 0.05$

Table 4: Correlation coefficients between seed quality tests and days to maturity in early-planted (upper diagonal) late-planted (lower diagonal) individual trials of indeterminate genotypes

Parameters	Standard germination (SG)	Cold emergence (CE)	Field emergence (FE)	Electric conductivity (EC)	Days to maturity	100-Seeds weight
Standard germination		0.19	0.58**	-0.55**	0.72**	-0.41**
(SG)		[0.44*]	[0.76**]	[-0.40*]	[0.71**]	[-0.52**]
		(0.47**)	(0.44*)	(-0.36)	(-0.13)	(-0.36)
Cold emergence	0.34		0.55**	-0.04	-0.08	-0.02
(SG)	[0.49**]		[0.47**]	[-0.08]	[0.34]	[-0.13]
	(-0.29)		(0.55**)	(-0.39*)	(-0.36)	(-0.31)
Field emergence	0.59**		0.68**	-0.32	0.19	-0.30
(FE)	[0.11]	[0.35]		[-0.38*]	[0.41*]	[-0.64**]
	(0.32)	(-0.11)		(-0.66**)	(-0.20)	(-0.47**)
Electric conductivity	-0.41*	-0.09	-0.47**		-0.29	0.59**
(EC)	[-0.56**]	[-0.22]	[0.12]		[-0.33]	[0.47**]
	(-0.56**)	(0.11)	(-0.55**)		(0.18)	(0.72**)
Days to	0.13	0.15	0.34	-0.50**		-0.21
maturity	[0.60**]	[0.21]	[-0.28]	[-0.24]		[-0.31]
	(0.23)	(-0.30)	(0.18)	(-0.51**)		(-0.07)
100-Seeds	-0.45**	-0.28	-0.46**	0.47**	-0.18	
weight	[-0.52**]	[-0.41*]	[-0.11]	[0.65**]	[-0.3]	
	(-0.48**)	(-0.05)	(-0.44*)	(0.59**)	(-0.16)	

[ ] = P93, ( ) = K93 and without parenthesis = P92 trials *: $p<0.05$, **: $p<0.01$

The main effect of trials was significant ($P<0.01$) for SG, FE and EC but not for CE. Genotypes effect was significant for all seed quality tests (Table 1) Genotype x date (G x D), genotype by trial (G x T) and genotype by date and trial (G x D x T) effects were significant for SG and FE, while only G x D and G x T effects were significant for CE in case of indeterminate genotypes. The significant two-way and three-way interactions indicate a complex interaction of genotypes with both dates and trials and a need to thoroughly examine the results in individual trials. Genotype effect was significant for all seed quality tests except CE (K93) and EC (P92) in individual trials (Table 2). The significance of date and G x D effects varied for several seed quality tests in different trials. The variation may be due to different growing conditions and may also be due to difference in planting dates. For example the "early" planting date for K93 was 4 weeks later than any other early date. SG, CE and FE were higher for seed from late-planted environments than for seed from early-planted environments in the individual trials except Keiser where SG was non-significant (Table 3), indicating that MG IV genotypes planted in May or later can produce good seed quality. The K93 early planting was planted in late May and produced good quality seed. Apparently the environmental conditions that normally affect seed quality did not differ between K93 planting dates. Seed from the early planted environments had reduced seed viability and seed vigor, but the problem was alleviated by planting in June. These results are in accordance with that of Mayhew (1991) and Mayhew and Caviness (1994).

Phenotypic correlations were calculated between seed quality measures by taking the averages by genotype over replications. The correlations of SG, FE and CE were highly significant for seed from early-planted plots in individual trials (Table 4), indicating that all seed quality testing methods gave similar results. The associations were not strong in late-planted environments. As expected, the germination by these methods were negatively associated with electric conductivity values in both early and late planting dates. High electric conductivity value indicate poor seed quality and therefore lower the seed germination.

Days to maturity was positively and significantly correlated with SG in early-planted environments at Pine Tree trials but in late-planted environments only at P93. No correlation of SG and maturity at P93 might be due to less weather effect at maturity of genotypes in September. Genotypes maturing late in the growing season in mild conditions produce good quality seed. Mayhew and Caviness (1994) also found positive correlation between germination and days to maturity. The strong negative correlation between 100-seed weight and SG and FE indicate that bigger seed size had lower germination than smaller seed size. Bigger seed size might be more vulnerable to mechanical damages during harvesting and ultimately to diseases due to the breakdown of seed coat.

In conclusion, genotypes differed in germination, indicating that genotypes with high seed quality can be selected. Much of the variation was due to maturity in early-planted plots but not in late-planted plots. Early planting gave poor quality, so more seed should be harvested per plant to compensate poor seed quality when individual plant selections are conducted from April planting vs. June planting, as, May and June planting dates gave acceptable seed quality. So seed for early planting can also be produced by planting MG IV cultivars in mid-May through late-June.

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