

SCREENING SOYBEAN GENOTYPES FOR TOLERANCE TO HIGH TEMPERATURE DURING GERMINATION

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SUMMARY

The ability of soybean (*Glycine max* (L.) Merrill) genotypes to germinate at above optimal temperature (38°C) was evaluated. Germination of 2278 genotypes in Maturity Groups IV through VIII and of unknown maturity were tested at 30° and 38°C. Genotypic variation at 38°C was evident. Three hundred and eighteen genotypes showing a difference in germination of less than 11.3 % between the two temperatures were considered to have above average tolerance to high temperature (38°C) during germination.

INTRODUCTION

Several studies have shown that soybeans (*Glycine max* (L.) Merrill) germinate over a range of temperatures. Wilson (1928) suggested 25°C as the optimum temperature for soybean germination. Maximum germination rate was found to be at 30°C by Delouche (1952) and this temperature was also reported optimum for hypocotyl elongation (Hatfield and Egli, 1974). Emerson and Minor (1979) reported that the predicted optimum temperature for germination of some soybean genotypes ranged from 31.6° to 33.7°C. The optimum temperature range for germination of one cultivar was reported to be as high as 33° to 36.5°C (Edwards, 1934). Limited studies have been conducted to investigate genotypic variability for germination in soybeans at extreme temperatures. Emergence ability differed among soybean cultivars at 10°C (Littlejohns and Tanner, (1976). Emerson and Minor (1979) observed that genotypic differences existed in germination at high temperature among 289 genotypes. Germination of 11% to 28 % was recorded for three genotypes at temperatures as high as 40°C (Aquino and Bakendam, 1969). Reductions in hypocotyl elongation and increase in seedling abnormalities resulted from high temperature during germination (Aquino and Bakendam, 1969; Emerson and Minor, 1979). Seedling abnormalities at 38°C included the absence of root hairs or secondary roots (Emerson and Minor, 1979).

Temperatures of tropical soils are often high at planting, exceeding the optimum temperature for soybean germination. The objectives of this study were to screen a wide range of genotypes for germination at above optimal

temperature (38°C), to determine the variability for tolerance to high temperature during germination, and to identify genotypes with superior ability to germinate at this above optimal temperature.

MATERIALS AND METHODS

Germination tests were conducted at constant temperatures of 30 and 38°C on 2278 accessions, breeding lines, and cultivars. These included 2054 Maturity Group IV and 33 Maturity Group VIII accessions from USDA germplasm collection, 123 advanced breeding lines and cultivars of Maturity Group V through VIII, and 68 of unknown maturity. The Maturity Group IV seeds were produced and maintained under cold storage at Urbana, Illinois prior to shipment to Beaumont, Texas via airmail. At Beaumont the seeds were stored at about 10°C and 45% relative humidity until tested. Breeding lines from the International Institute for Tropical Agriculture (IITA) were received directly from Ibadan, Nigeria. The other lines tested were produced at the Texas A&M University Agricultural Research and Extension Centre, Beaumont, Texas and maintained under cold storage until tested for germination. Seeds of all these entries were not stored for the same period of time.

Twenty-five seeds of each genotype were coated with maneb (manganese ethylene bisdithiocarbamate) (Manzate 200 80 WP) and incubated on moist cellulose pads (Kimpac) at each of two temperatures. Seeds were placed in total darkness in germination chambers with temperatures of 30° and 38°C ($\pm 1^\circ\text{C}$) and saturated humidity. Germination was assessed after five days of incubation. A seed was considered germinated when the length of the radicle was one and one-half times the length of the imbibed seed and apparently healthy. Generally, the normal and abnormal seedlings as classified by the Association of Official Seed Analysts (1970) were included in this category.

RESULTS AND DISCUSSION

The mean germination percentages of soybean genotypes in Maturity Groups IV through VIII and of unclassified maturity at 30° and 38°C are listed in Table 1. Mean germination percentages of the entire 2278 genotypes were respectively 42.7 and 81.0 at 38° and 30°C. The ratio of abnormal to dead seedlings was 3.5:1 and that of abnormal seedling to decayed seed was 1.4:1 at 30°C. The number of abnormal seedlings, dead

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seedlings, and dead seeds increased in approximately equal proportion when the temperature was increased to 38°C. Germination percentages of individual genotypes ranged from zero to 100 at both temperatures. This wide variation in germination may be partly attributed to the age of the seed, which was not the same for all the genotypes tested.

A frequency distribution of the differences in germination percentages at 30° and 38°C is shown in Figure 1. The data indicate the existence of genotypic variability for tolerance to above optimal temperature (38°C) during germination. The genotypes showing a germination percentage difference between the two temperatures of less than 11.3%, one standard deviation from the mean, might have better high temperature tolerance during germination than those with greater differences. Three hundred and eighteen genotypes listed in Table 2, showing a difference of less than 11.3%, were tentatively classified as tolerant to high temperature during germination.

The selected genotypes amounted to 14% of the total tested. The mean germination percentages of these "select" genotypes at both temperatures are shown in Table 3. Twenty-seven of the lines found by Emerson and Minor (1979) to have no difference in germination at 32° and 38°C were screened in this experiment. Two of these lines showed a difference of 12% to 20% in germination at 30° and 38°C in our test and none of the lines was classified as tolerant. These differences in results could be explained by variation in screening techniques or differences in seed age. Emerson and Minor (1979) used fresh seed while we used seed of various ages. They also found that only nine of the genotypes they classified as tolerant germinated significantly greater than 0° at 38°C when aged 12 to 18 months.

Averaged over the selected genotypes, germination at 38°C was only 1.5 percentage points less than the average germination of these lines at 30°C (Table 3). This compares an average difference of 38.3% for the total number of genotypes tested (Table 1). The seedlings of all genotypes tested did not develop secondary roots at 38°C with the exception of PI 438345, which formed secondary roots on 60% of the seedlings. The number of both abnormal and dead seedlings was higher at 38° than at 30°C, but the greater increase was in proportion of dead seedlings. The absence of secondary roots at high germination temperatures was also observed by Aquino and Bakendam (1969) and Emerson and Minor (1979). Hypocotyl elongation was also markedly less under high temperatures, an observation reported earlier (Aquino and Bakendam, 1969; Emerson and Minor, 1979).

The use of seeds that have been stored for different lengths of time may have led to misclassification of some of the lines. However, this was probably still the best approach in dealing with such a large number of genotypes in a short time. It is possible that we erroneously discarded some tolerant lines in the first screening but with 318 selected lines there should be a sufficient amount of material from which to work. If some of the lines selected were screened using older seed it is possible that we selected material of superior storability in addition to tolerance to high temperature during germination. Fresh seed of the selected lines will be produced prior to beginning a second cycle of screening. This second screening should confirm tolerance of these lines to high temperatures.

The susceptibility of many high yielding soybean cultivars to high temperatures during germination limits their usefulness in soybean production in the tropics. In this study, soybean genotypes that appear to have better tolerance to above optimum temperature (38°C) were identified. These genotypes merit further examination and might be used either directly in production or included in breeding programmes for the improvement of locally adapted cultivars.

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Table 1. Mean germination percentages of 2278 soybean genotypes incubated at 30 and 38°C.

<i>Maturity group</i>	<i>Number of genotypes tested</i>	<i>Percentage germination*</i>	
		<i>30°C</i>	<i>30°C</i>
IV	2054	88.9	36.9
V	51	52.4	42.2
VI	14	80.8	61.5
VII	31	84.8	36.7
VIII	60	95.1	43.1
Unknown	68	84.1	35.8
Grand mean		81.0	42.7

* Includes sprouted normal and abnormal seedlings.

Table 2. Selected soybean genotypes for tolerance to high temperature during germination.

Maturity group IV

PI 84679	PI 398344	PI 398820	PI 407734	PI 407932A
91719	398441	398830	407736	407932B
229326	398446	398832	407733	407946
229327	398492	398867	407805B	407952A
243519	398519	398883	407805C	407952B
243546	398626	398886	407805D	407959B
253665B	398717	398887	407851	407960B
323734	398741	398889	407862	407965A
340041	398746	398935	407875B	407966B
340046	398750	398988	407886	407972A
360846	398754	399039	407892A	407973A
377574	398762	404170	407897	407975A
378682B	398765	404179B	407898A	407976A
378682C	398768	404190	407904	407978B
398198	398774	405691	407907B	407977
398226	398775	406708	407913B	407979
398233	398790	407727	407914C	407988C
398248	398791	407729	407914D	407998A
398298	398815	407730	407917	408006
398315	398816	407733	407924	408008
408016B	408125A	408199	424168B	424278B
408017	408125B	408210	424180	424282
408025	408126A	408211A	424181	424285D
408028	408126B	408211B	424215	424287
408029	408131A	408212A	424219A	424288
408032B	408132	408214	424220A	424294B

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Table 2. Continued

PI 408033	PI 408133	PI 408215A	PI 424223	PI 424295
408036	408134A	428225A	424224	424296A
408039	408137A	408229	424225	424307
408048A	408137B	408269A	424228	424308
408048B	408138B	408269B	424229A	424311
408052C	408138C	416858	424337A	424313
408067A	408140A	423752A	424239	424320
408068B	408140B	423850	424247A	424321
408074C	408166A	424024	424249D	424328
408083A	408166B	424149	424249E	424342A
408084B	408169B	424153	424250A	424343
408089	408173	424154A	424251A	424348A
408092A	408174	424154B	424254	424348B
408092B	408178	424156B	424265	424348C
408095A	408181D	424158	424274A	424349A
408108	408187	424159A	424274B	424350
408110A	408196A	424162	424275	424351
408124	408196B	424164A	424276	424355
408124C	408198	424165	424277A	424375B
424383	424444B	424495	424533	437397
424384	424459	424497	424535A	437580
424385	424466	424498	424535B	437798
424395	424471	424499A	424549B	437800
424405C	424472B	424499C	424552	437845B
424406A	424476	424503	424554	438073
424406B	424479	424505	424569B	438278
424409	424481B	424509	424584	438307
424410	424485	424519	424592	438346
424426	424487A	424521A	424599	438424
424427	424488B	424528	424610	438491
424436	424489A	424529	424614	
424443	424490D	424531	430620	
<i>Maturity group V</i>				
D78-3238	Nathan	R75-576	T79-493-3	T79-593-3
N77-179	R74-511	S77-7865	T79-531-1	V76-600
<i>Maturity group VI</i>				
Centennial	D77-12	D78-5502	Jeff	R74-39K
D76-9665	D77-6166	D78-5576	N75-2213	
<i>Maturity group VII</i>				
D77-6057	F76-8757	F77-1880	F77-7142	N77-114
<i>Maturity group VIII</i>				
F77-7450				
<i>Maturity group (unknown)</i>				
TGX302-66C°	TGX311-49C	TGX324-375D	TGX340-296D	TGX303-14D

TGXlines were obtained directly from International Institute for Tropical Agriculture, Nigeria.

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Table 3. Mean germination percentages of 318 selected soybean genotypes incubated at 30° and 38°C.

<i>Maturity group</i>	<i>Number of selected genotypes</i>	<i>Percentage germination*</i>	
		<i>30° C</i>	<i>38° C</i>
IV	288	87.2	84.7
V	10	43.3	44.8
VI	9	73.3	70.0
VII	5	70.0	69.7
VIII	1	96.0	92.0
Unknown	5	90.3	90.3
Grand mean		76.7	75.2

* Includes sprouted normal and abnormal seedlings.

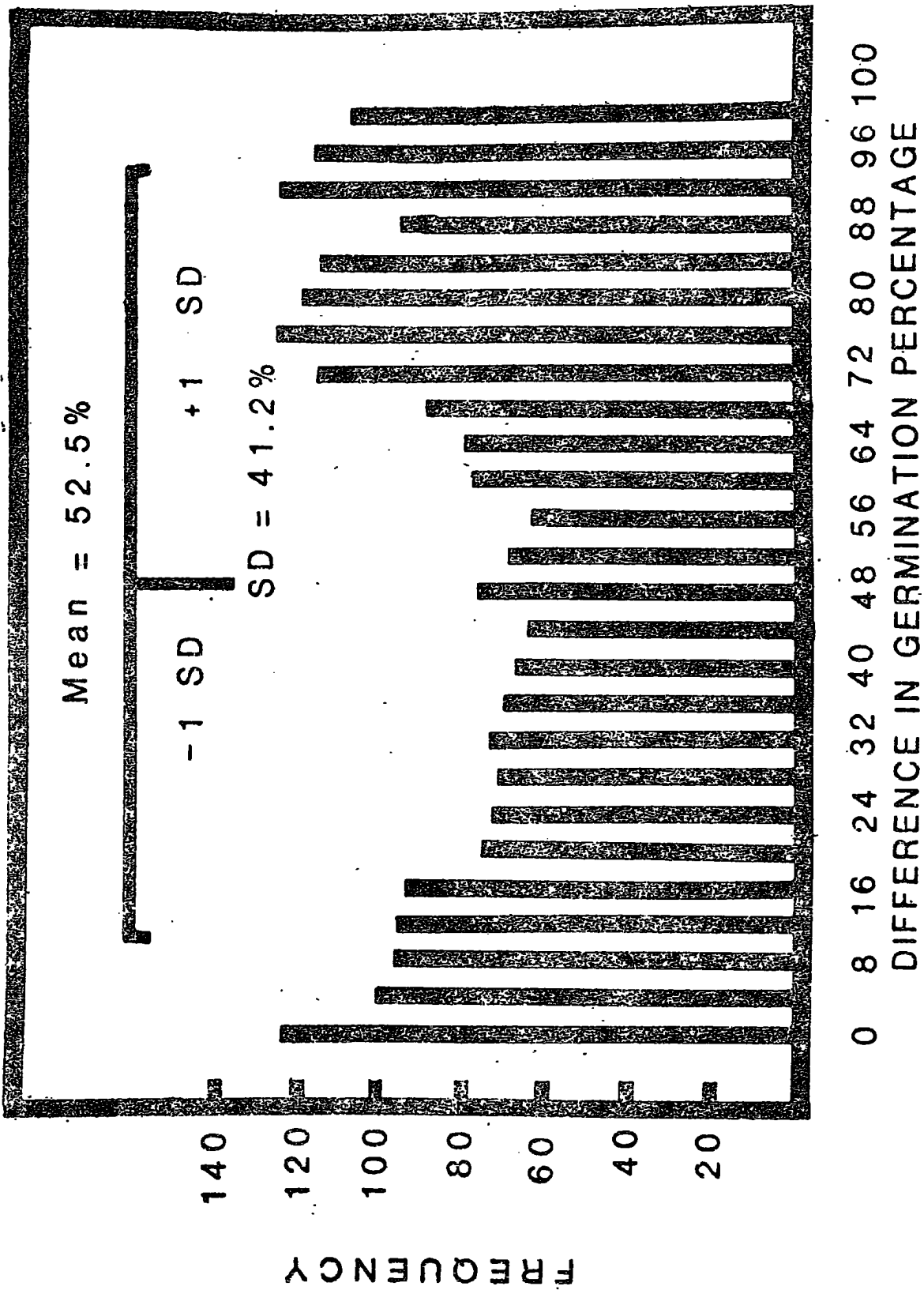


Figure 1. Frequency distribution of differences in germination percentages for genotypes at 30 and 38°C