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1) Evaluation of soybean germplasm for stress tolerance and biological efficiency.

Objectives: To evaluate soybean germplasm and cultivars for stress tolerance toward:

a. Moisture Stress

(B. Kpoghomou and V. T. Sapra, Alabama A&M University, Alabama)
Seventeen soybean genotypes were screened in a laboratory and growth-chamber experiment for water-stress tolerance characteristics. Three osmotic concentrations (0, -0.3 and -0.5 MPa) were used in an 8-day germination test conducted in the laboratory at Alabama A&M University. The Promptness Index (PI) and Germination Stress Index (GSI) were calculated (Bouslama and Schapaugh, 1984). Following the germination test, seedlings of the 17 cultivars were grown hydroponically in Hoagland solution at 0, -0.3, and -0.5 MPa. Twenty-four days after the treatments were applied, measurements on plant height, dry weight, and leaf water potential were recorded. The results showed that osmotic stress significantly affected the germination and genotypic variability among the cultivars. 'Lee', 'Wright', and 'Braxton' were most tolerant and 'RA401' and 'Bay' were most sensitive cultivars. Similar results were obtained in the seedling test. However, the germination (Table 1) test was more sensitive to osmotic stress than the seedling test.

(Bharat P. Singh, Fort Valley State College, Georgia)
Thirty soybean genotypes were screened in the greenhouse for moisture stress tolerance. Four genotypes (PI 324068, 'Coker 237', 123440, and 159322) were identified as most tolerant and three (PI 423911, AM-1007, and 416893) as least tolerant genotypes. The diffusive resistance and transpiration of the different genotypes at the time of wilting appeared to be similar. In the attached table, days taken for wilting under water stress by different soybean genotypes and their diffusive resistance and transpiration at the wilting stage are presented (Table 2).

Table 1. Germination stress indices of 17 soybean cultivars

Varieties	Means
Lee 74	63.59 a
Wright	61.09 ab
Braxton	60.99 ab
Davis	60.54 ab
Bragg	55.22 abc
Essex	54.77 abc
Centennial	53.87 abc
Bedford	52.78 abc
Forrest	49.08 abcd
Tracy	46.25 bcde
McNair 600	42.38 cde
Foster	41.93 cdef
Greenseed	37.60 defg
Hutton	32.81 efg
Stevens	29.17 fgh
RA 401	26.74 gh
Bay	18.70 h

MSE = 163.857.

Table 2. Days taken for wilting under water stress by different soybean genotypes and their diffusive resistance, and transpiration at the wilting stage

Genotype	Days for wilting	Diffusive resistance (sec cm^{-1})	Transpiration ($\mu g\ cm^{-2}\ s^{-1}$)
X 3104	15.4	2.92	2.93
PI 416937	16.7	1.71	2.37
PI 423911	14.7	1.94	2.44
MD-80IL-21	15.1	1.61	2.16
Deltapine 506	18.0	1.28	2.07
PI 408039	18.2	1.66	1.90
VR 3393	18.7	1.52	1.43
Ms_2 Ms_2	17.2	1.42	1.96
PI 417063	17.8	1.26	2.35
X 4126	17.0	1.40	2.00
Peking	17.8	1.40	2.43
Burr	15.7	1.75	3.00
PI 80837	21.0	1.78	1.94
AM-1007	14.0	1.95	2.58
PI 339984	16.7	1.55	2.19
Classic	21.3	1.68	1.89
PI 171442	17.8	1.70	1.90
PI 381668	19.0	1.41	1.87
Am-1009	19.8	1.43	1.54
PI 159319	15.0	1.51	2.21
Deltapine 246	19.0	1.38	2.18
PI 324068	23.0	2.01	1.62
Cocker 237	23.5	2.71	1.92
PI 407868C	16.0	2.45	1.40
PI 416893	14.7	2.09	2.19
PI 85437	19.3	1.52	2.19
PI 417419	16.0	1.70	2.31
Haberlandt	17.5	2.23	1.90
PI 123440	23.0	1.56	1.61
PI 159322	23.2	1.91	1.71

b. Pests

(M. Rangappa and M. E. Kraemer, Virginia State University, Virginia)
Soybean maturity groups V, VI, VII, and VIII have been screened systematically and accessions possessing potential source of natural resistance to Mexican Bean Beetle (MBB) have been identified along with several highly susceptible accessions for future studies. About 75% of the germplasm of maturity groups III and IV has been screened initially in 1985. A detailed copy of the screened germplasm can be obtained from scientists at Virginia State University.

Also, about 80 genotypes identified as resistant to several factors of stress tolerance and biological efficiency by other participating institutions of the project were planted at Virginia State University Research Station and evaluated for MBB resistance. Ample seed stocks of each accession were recovered for future studies.

The mechanisms of soybean resistance to the MBB are also being investigated by scientists at Virginia State University. Trypsin inhibitory activity (TIA) was found in the leaves of soybeans. Although TIA has been reported from other leguminous species, this is the first report from soybean leaves. The quantity of TIA increased with increasing plant age and MBB defoliation, and relatively large quantities were present in mature leaves (150-600 µg trypsin inhibited per g leaf). Although there was no evidence that TIA affects MBB soybean preference, it is probable that TIA increases soybean antibiosis during a critical stage in the life cycle of the MBB, i.e., preparation for adult overwintering. Also, preliminary work has been done on ultrastructural differences in cell wall, cuticle thickness, and wax-layers of selected soybean leaves using electron microscopic techniques to establish mechanisms of resistance.

c. Harvest Index

(A. Bhagsari, Fort Valley State College, Georgia)
Simultaneous investigations were conducted at experiment farms at Fort Valley State College and Maryland Eastern Shore in 1985 with 42 soybean genotypes (14 each from MG III, IV, and V) to determine seed yield efficiency (SYE) and grain yield and their relationship to other agronomic traits. The mean seed yield efficiency ranged from 34 to 51, 35 to 50, and 28 to 59% for MG III, IV, and V, respectively. The mean grain yield for three MGs was similar and ranged from 19.65 (MG III) to 22.86 (MG V) quintals/ha. On 25 July 1985,

mean leaf area index (LAI) was 3.94, 5.24, and 5.02 for MG III, IV, and V, respectively, and LAI declined for all three groups at the next sampling date of August 15. The specific leaf weight (SLW) increased at successive samplings until the R7 stage. There was a wide range in SYE within each maturity group, but it was not related to grain yield. However, mean grain yield of two cultivars included in each of the three maturity groups was 34.6 and 43.1% higher than the mean for the groups (Tables 3-5).

Table 3. Seed yield efficiency, grain yield, leaf area index, and specific leaf weight of soybeans (Maturity Group III), 1985

Cultivar/PI	Seed yield efficiency (%)	Grain yield (quintals/ha)	Leaf area index		Specific leaf weight	
			July 25	Aug. 15	July 25	Aug. 15
PI 79628	51.42	14.80	3.01	1.62	3.38	3.90
Williams-82	49.68	28.67	3.85	3.16	3.58	4.06
Williams	47.93	24.20	3.01	2.71	3.64	3.40
BSR.301	46.85	25.00	4.18	1.94	3.42	4.03
PI 54615-1	46.25	19.11	3.64	1.43	3.43	3.69
PI 84957	45.47	16.71	3.95	1.09	2.93	3.56
PI 57334	44.20	18.62	5.60	2.57	3.25	3.21
PI 70189	43.93	16.91	3.15	1.61	3.72	3.64
PI 54610-1	41.85	27.07	4.82	3.27	3.34	3.95
PI 68479-1	39.50	13.64	4.03	1.28	3.87	3.96
PI 54583	38.40	12.80	3.45	2.22	3.83	3.97
PI 68398	37.55	28.73	3.80	2.88	3.54	3.35
PI 80841	35.50	12.60	4.48	1.43	3.12	3.20
PI 62202	33.61	16.24	4.17	1.39	3.38	3.17
Mean	43.01	19.65	3.94	2.04	3.49	3.65
LSD (0.05)	10.22	14.22	1.93	1.67	0.52	0.99

Table 4. Seed yield efficiency, grain yield, leaf area index, and specific leaf weight of soybeans (Maturity Group IV), 1985

Cultivar/PI	Seed yield efficiency (%)	Grain yield (quintals/ha)	Leaf area index		Specific leaf weight	
			July 25	Aug. 15	July 25	Aug. 15
PI 82264	49.56	23.38	7.38	5.45	2.74	3.09
PI 83891	46.95	23.82	5.24	4.17	3.24	3.21
PI 86103	45.79	24.27	5.52	4.14	3.24	2.89
PI 83889	45.54	20.60	4.17	3.39	3.12	4.01
PI 70242-2	45.25	23.27	6.43	3.33	2.92	3.60
PI 85469	44.65	21.51	6.62	3.66	3.06	3.75
PI 61947	43.31	21.02	3.68	3.76	3.08	3.85
PI 19976-1	42.95	26.20	4.74	3.28	3.06	3.78
PI 84644	42.49	19.85	5.32	3.35	3.18	4.05
PI 84751	41.49	24.69	6.38	4.65	2.61	3.06
Douglas	41.29	33.56	4.42	4.87	2.18	3.30
Union	39.24	28.80	5.44	2.95	3.63	3.98
PI 63468	36.57	14.31	4.44	1.28	3.26	3.68
PI 60970	34.56	14.80	3.61	2.78	3.12	4.45
Mean	42.83	22.86	5.24	3.65	3.03	3.62
LSD (0.05)	12.78	11.19	2.61	2.19	0.59	0.73

Table 5. Seed yield efficiency, grain yield, leaf area index, and specific leaf weight of soybeans (Maturity Group V), 1985

Cultivar/PI	Seed yield efficiency (%)	Grain yield (quintals/ha)	Leaf area index			Specific leaf weight		
			July 25	Aug. 15	Sept. 3	July 25	Aug. 15	Sept. 3
PI 416447	59.23	25.29	4.65	4.79	2.03	3.39	3.45	3.61
PI 416838	49.29	29.38	7.04	6.07	3.38	2.86	3.28	3.43
Forrest	44.87	37.31	6.58	6.15	3.84	3.12	3.69	4.04
PI 423762	42.27	14.04	6.36	4.19	1.61	3.16	3.67	3.71
PI 423799	40.83	16.76	4.04	4.96	2.77	3.06	3.45	3.25
PI 417141	39.54	18.45	5.72	3.86	1.87	3.02	3.67	4.01
PI 417356	38.31	16.42	3.14	1.49	1.07	3.79	3.97	2.92
PI 417493	37.82	16.36	4.00	3.48	1.44	3.48	3.68	3.42
PI 417090	37.19	20.00	4.10	4.08	1.44	2.67	2.81	6.25
PI 417494	36.95	20.53	4.48	3.80	2.95	2.89	3.14	3.12
PI 417418	34.80	18.89	4.50	3.75	3.33	3.86	4.08	4.42
PI 417172	34.76	15.51	3.75	3.91	1.47	3.41	3.43	3.10
PI 417337	34.13	14.75	5.81	4.21	2.18	3.27	3.23	3.59
Essex	27.72	20.85	6.11	6.11	6.48	2.63	3.12	3.37
Mean	39.84	20.32	5.02	4.35	2.56	3.19	3.48	3.73
LSD (0.05)	13.16	7.26	2.36	2.26	2.56	0.55	0.39	1.60

d. Micronutrients

(M. R. Reddy, North Carolina A & T, North Carolina)

A greenhouse experiment was conducted to evaluate the response of different soybean genotypes to manganese application. Twenty-five soybean genotypes belonging to different maturity groups were grown in a greenhouse using a Lynchburg sandy loam soil collected from Sampson County, NC. It is a coastal plain soil deficient in manganese. Manganese rates were 0, 15, and 30 kg per hectare. The experimental design was a split plot with three replications.

Results indicated differences in shoot weight among the genotypes tested due to manganese rates (Table 6). Genotypes (PI 96089, PI 279621, PI 423911, PI 417063, PI 417136, PI 423986, FC 31668, FC 31737, PI 416937, and L-76-0132) responded positively to manganese application and resulted in higher shoot weights. Some of the above genotypes gave favorable increase in shoot weight at 15 and 30 kg per hectare manganese, whereas others resulted in higher shoot weight at either 15 or 30 kg per hectare manganese. Genotypes 'Bedford', PI 230978, PI 417123, and PI 123440 responded negatively to manganese by giving a lower shoot weight than the control. There was no significant response by remainder of the genotypes to manganese addition. There was a significant increase in manganese concentration in leaf tissue of the genotypes (Table 7) as the rate of manganese increased. Relatively higher manganese concentration (30 kg/ha) in leaf of some genotypes resulted in poor plant growth and lower shoot weight.

e. Diseases

(R. P. Pacumbaba and V. T. Sapra, Alabama A&M University, Alabama)

Screening of improved soybean lines from Alabama A&M University for multiple resistance against bacterial blight, stem canker, and soybean cyst nematode in the greenhouse and in the field continued at Alabama A&M University. Lines obtained from Virginia State University in MG IV (PI 339984, PI 408039, PI 80837); MG V (PI 96089, PI 123440, PI L-76-0132, PI L-77-0049, 'Hill', 'Essex'); MG VI (FC 31665, PI 407868C, PI 159322, PI 416937, PI 379621, PI 221713, PI 230978, 'Lee'); MG VII (PI 423911, PI 229358); and MG VIII (PI 417134, PI 417063, PI 417061, PI 416893) were screened. Initial results indicated PI L-76-0049 is resistant to bacterial blight, PI 159322 and PI 230978 are resistant to soybean cyst nematode (race 3 and 5), and PI 417061 has multiple resistance to bacterial blight and stem canker. Other screened lines, viz., PI L-76-0132, PI 96089, PI 123440, PI 221713, and PI 417063, showed doubtful

resistance to bacterial blight, stem canker, and soybean cyst nematode. Further screening for resistance to these diseases will be continued.

Table 6. Effect of Mn rate on shoot weight of soybean genotypes

Soybean genotypes	Shoot weight (g/plant)		
	0 kg/ha Mn	15 kg/ha Mn	30 kg/ha Mn
FC 31665	2.3	2.8	3.5
FC 31737	2.2	3.0	3.2
PI 96089	2.2	3.3	3.0
PI 123440	3.6	2.9	2.2
PI 171442	2.8	3.3	2.7
PI 200506	3.3	3.2	3.0
PI 208788	3.2	3.2	3.6
PI 230978	3.1	3.2	1.7
PI 279621	1.2	3.0	1.8
PI 324924	3.0	3.3	2.9
PI 379618	2.2	2.1	2.4
PI 381668	2.1	2.4	2.3
PI 416900	2.3	2.9	2.5
PI 416937	2.2	2.5	2.8
PI 417063	2.4	2.6	2.8
PI 417123	3.0	2.8	2.7
PI 417136	2.3	2.8	2.9
PI 423911	2.4	2.7	3.7
PI 423986	2.8	2.7	3.4
L-76-0049	3.2	3.3	3.1
L-76-0132	2.3	2.6	2.9
Bedford	2.6	2.6	1.5
Cocker 237	2.9	3.2	2.7
Deltapine 506	2.5	3.5	2.8
Easy Cook	3.3	3.3	2.9

Table 7. Relationship between Mn rate and Mn concentration in soybean genotypes

Soybean genotypes	Leaf Mn (µg/g)		
	0 kg/ha Mn	15 kg/ha Mn	30 kg/ha Mn
FC 31665	29.7	36.0	52.3
FC 31737	24.2	25.7	43.3
PI 96089	25.8	26.8	37.0
PI 123440	30.2	33.2	43.7
PI 171442	26.5	34.0	59.5
PI 200506	26.7	24.8	53.5
PI 208788	25.7	24.3	40.2
PI 230978	19.0	25.0	55.5
PI 279621	15.3	21.3	39.5
PI 324924	24.0	24.7	50.5
PI 379618	28.8	28.0	52.3
PI 381668	28.3	27.0	46.3
PI 416900	20.8	26.5	51.0
PI 416937	21.5	25.3	43.8
PI 417063	29.2	24.8	45.3
PI 417123	27.8	27.0	58.7
PI 417136	24.0	28.5	49.8
PI 423911	25.8	23.3	55.5
PI 423986	23.7	27.0	48.0
L-76-0049	22.3	34.3	57.3
L-76-0132	24.8	34.5	43.0
Bedford	21.8	30.8	52.3
Cocker 237	33.7	40.8	66.0
Deltapine 506	26.2	30.3	67.7
Easy Cook	24.0	27.6	44.0

f. Nitrogen Fixation

(McArthur Floyd, Alabama A&M University, Alabama)

Twenty-two soybean germplasm lines were grown in 1/5 Steinberg solution containing 6 ppm Al in 4L pots at pH 4.4 during the 1985 growing season to evaluate their tolerance to acidity and aluminum stresses. Plants were grown in three replications and separated on the basis of relative root lengths ratios (RRL = root length [cm] of plants grown in 6 ppm Al divided by root length [cm] of plants grown without Al). The system of classification was RRL >100% = highly tolerant; 85-99% = tolerant; 74-84% = sensitive; and <74% = highly sensitive. The data indicated ten lines (PIs 96089, 159322, 221713, 230978, 379621, 416937, 423986, 116893, FC 31665, and 'Deltapine 246') were highly tolerant; three lines (PIs 159319, 381668, and 'Deltapine 506') were tolerant. The sensitive lines were PI 324924, L-760132, and L-760049. Highly sensitive lines were PIs 123440, 324068, 417061, 417136, and 117258.

Twenty-one additional soybean germplasm lines were evaluated for their symbiotic performance with an acid tolerant rhizobium strain (USDA 110) at pH 4.4 in solution culture. Triplicate replications of plants were grown in the growth chamber in 4L black plastic pots containing N-free Fahreaus solution inoculated with USDA 110 rhizobium. Plants were harvested after 35 days. Nitrogenase activity (μmole C_2H_4/h/pl) ranged from 4.8 to 44.4. The lines with the highest nitrogenase activities were PI 423824 and FC 31737 with 44.0 and 44.4 μmoles C_2H_4/h/pl, respectively.

Plants with nitrogenase activity greater than 30 μmoles C_2H_4/h/pl included PIs 70188, 80834-1, 423824, 97150, 181565, and FC 31737. Lines with nitrogenase activity ranging between 20-29 μmoles C_2H_4/h/pl were PIs 70013, 417135, 227557, 90768, and 423969.

g. Soil Acidity

(S. C. Tewari and P. W. Igbokwe, Alcorn State College, Mississippi)

Three years of field trials (1981-83) with six cultivars of soybeans ('Bedford', 'Bragg', 'Braxton', C-237, 'Forrest', and 'Tracy M') conducted on the Memphis silt loam soil showed greater resistance to low pH (5.0-5.5) for Forrest and Bedford as compared to the other cultivars. However, at pHs lower than 5.0, seed formation of all the cultivars was adversely affected, especially under moisture stresses. Greenhouse and laboratory studies during the same time period indicated higher P absorption for Forrest and Bedford at pH 5.0 to 5.5.

Two years of study (1984-85) with 12 and 19 cultivars in the field indicated little reduction in the Harvest Index with lower pHs for 'Ogden', 'Gassy', PI 324924, PI 90768, PI 89469, FC 31727, 'Ransom', 'Kirby', 'Centennial' and 'Foster' as compared with the other cultivars. In greenhouse and laboratory studies during the same time period, these cultivars were comparable to Bedford and Forrest in efficiency for absorbing P (more than 650 ppm). These same cultivars also absorbed less Al (less than 23 ppm) and may be considered as acid resistant at a pH of 5.0 and above when compared with the other cultivars tested. Out of a total of 34 cultivars evaluated in the greenhouse and in the laboratory, five cultivars ('Peking', PI 479491, 'Tracy M', PI 96089, and PI 123440) absorbed more than 23 ppm of Al from the soil at a pH of 5.5. These cultivars may be considered intermediate in acid tolerance at a pH of 5.5. The extractable Al and P in the soil at a pH of 5.5 was 1.5 ppm and 18.5 ppm, respectively. Further screening and testing of these promising genotypes are being conducted.

Reference

Bouslama, M. and W. T. Schapaugh. 1984. Stress tolerance in soybean. I. Three screening techniques for heat and drought stress. Crop Sci. 24: 933-937.