PN-AAX-568

SUMMARY

TERMINATION REPORT FOR RESEARCH GRANT NO.
DAN 5053-G-SS-5108-00
PROJECT PIO/T NO.: 936-5053-5361540
PROJECT OFFICE, S&T/RUR

TITLE: "Screening Grain Legume Germplasm for Symbiotic Nitrogen Fixation and Efficient Rhizobium Strains."

The purpose of this research was to screen and identify grain legume germplasm, and Rhizobium strains tolerant to pH stress and then select the best macro and microsymbiont combination(s) for enhancing nitrogen fixation and grain yield. The experiments were conducted simultaneously at Fort Valley State College (FVSC), USA and at San Cristobal and Santiago in the Dominican Republic with four grain legume crops; namely, peanut, soybean, pigeon pea and dry bean. Forty genotypes, each of peanut and soybean, were tested in pot experiments in acid (pH 4.6 and 5.4) and alkali (pH 7.6 and 8.6) soils at FVSC. In the Dominican Republic, peanut, soybean, pigeon pea and dry bean genotypes were tested in pot and field experiments in acid (pH 5.0) and alkali (pH 8.0) soils. Rhizobium strains were tested in acid liquid media, containing aluminum, at low pH (4.6) and high pH (8.0) only at FVSC. A summary of the results is presented below:

1. In acid soil (pH 4.6 and 5.4), nitrogen fixation (acetylene reduction) rates were similar for all peanut genotypes but in alkali soil (pH 7.6 and 8.6) nitrogen fixation rates differed significantly among the genotypes.

2. Inoculation of peanut seeds with Rhizobia in pot and field experiments had no significant effect on percent leaf nitrogen but root and nodule dry weights were significantly higher with inoculation in alkali soil.
3. Mean yield of eight peanut varieties grown in alkali soil was 2.67 MT/ha and Comet, a genotype from Oklahoma, had significantly higher yield (2.93 MT/ha) than all the other cultivars.
4. None of the 24 peanut Rhizobium strains tested showed tolerance either to low pH (4.6) or to high pH (8.6).
5. Three soybean genotypes, Lee, GAT-3 and Forrest were found to be more tolerant both to acid and alkali soils.
6. Cultivar Braxton had significantly higher nitrogen fixation rate (42.1 μM/plant/hr) than most of the other genotypes.
7. Inoculation of soybean seeds significantly increased percent nitrogen in leaves and stems. The nodule number and nodule dry weight were also higher as compared with uninoculated controls.
8. From sixteen Rhizobium japonicum strains tested for tolerance to acid--Aluminum stress in liquid media (pH 4.6), USDA 110, USDA 143, USDA 144, Nitragin 61A101c and Nitragin 61A124a were found to be tolerant. Significant soybean genotype x Rhizobium strain interactions were also found.
9. Inoculation of pigeon pea seeds with Rhizobium strains increased percent leaf nitrogen in acid (pH 5.0) and alkali (pH 8.0) soils as compared with uninoculated control in one out of three experiments. Nodule number and dry

weight also differed significantly among pigeon pea genotypes in acid soil.

10. Pigeon pea and dry bean Rhizobia showed no tolerance to pH stress.

11. Most of the plant introductions for dry beans tested, failed to develop root nodules in acid and alkali soils.

12. The observations made in these experiments indicated that inoculation of seeds with suitable Rhizobium strains and use of the newly introduced genotypes in this project and the introduction of new germplasm especially for peanut and soybean, and probably other grain legumes is likely to improve productivity of these crops.

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INITIATED: October 1985

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Legume plants can fix atmospheric nitrogen into useable form through the process of symbiosis. Generally, most legumes grown under suitable environment and in the presence of appropriate Rhizobium strains can meet their nitrogen requirement for growth through the process of symbiosis and will need no external nitrogen application. In developing countries, grain legumes seem to be the most economic source of proteins for human nutrition and also serve as an important protein feed supplement for animals. Legumes are also an important source of vegetable oil. Grain legume yields are generally low in developing countries, including the Dominican Republic, probably due to lack of suitable cultivars and Rhizobium strains and other unfavorable soil and environmental factors. Therefore, alleviation of production constraints for legumes is considered highly desirable for developing countries. This research was undertaken with the following objectives:

1. Screen and introduce germplasm to improve nodulation and symbiotic nitrogen fixation of selected grain legumes under variable soil pH conditions in the Dominican Republic.

2. Identify efficient Rhizobium strains for low pH and soil salinity tolerance.

3. Select the best macro and microsymbiont combinations for enhancing N-fixation and grain yield of legumes.

Experimental Procedures, Germplasm and Sites

This research was conducted simultaneously at Fort Valley State College (FVSC) USA and at Santiago (CENDA) and San Cristobal (CESDA) in the Dominican Republic, with four crops; namely, peanut (*Arachis hypogaea* L.), soybean [*Glycine max* (L.) Merr.], dry bean (*Phaseolus vulgaris* L.), and pigeon pea [*Cajanus cajan* (L.) Millsp.]. Based on the advice of reviewers less emphasis was placed on dry bean to avoid duplication of efforts. Germplasm was obtained from Southern Region Plant Introduction Station, Griffin, Georgia; Delta Branch Experiment Station, Stoneville, Mississippi; Western Regional Plant Introduction Station, Pullman, Washington, and International Crop Research Institute for Semi-Arid Tropics (ICRISAT), India. *Rhizobium* strains for the four crops were obtained from Dr. R. Stewart Smith (Nitragen Co. Milwaukee), Dr. G.H. Elkan (North Carolina State University, Raleigh) Dr. R.W. Weaver (Texas A&M University), Dr. H.H. Keyser (Beltsville, Maryland) and Niftal Project, University of Hawaii.

At FVSC, greenhouse research was conducted on soybean, peanut and dry bean (10 genotypes) germplasm for tolerance to low (5.6) and high (7.6) soil pH. The low pH was further amended with sulfuric acid to 4.6 and high pH was amended with lime from 7.6 to 8.6. The number of *Rhizobium* strains tested for peanuts, soybean, dry bean and pigeon pea were 24, 16, 8 and 10, respectively. The *Rhizobium* strains were screened in liquid media at low (4.8) and high (8.0) pH only at FVSC by using the agar

plate method for rapid screening for tolerance to acid-aluminum stress (Ayanaba et al., 1983, Journal of American Soil Science, 47:256). A total of eleven greenhouse experiments were conducted in acid and alkali soils for screening 40 genotypes each of peanut and soybean and 10 genotypes of dry beans. The seeds were inoculated at planting for all the four crops with the respective Rhizobium strains.

At San Cristobal (Dominican Republic), 12 genotypes each of pigeon pea and dry bean were tested in pots and field experiments in soil at pH 5.0 and pH 8.0, with and without inoculation. Field experiments in low pH soils, one for each crop, were also conducted at Planque Beach for pigeon pea and San Juan de Maguana for dry bean. At Santiago, nine pot experiments and six field experiments were conducted for screening 50 soybean genotypes, thirty-one peanut genotypes and twenty-three dry bean genotypes in low (5.0) and high (8.0) pH soils with and without inoculation with Rhizobia of respective crops.

The experimental design was Randomized Complete Block for greenhouse experiments and Split Plot Design for field experiments involving inoculation studies. The data collected consisted of plant dry weight, root dry weight, plant height, nodule number, nodule size, nodule dry weight, location of nodules, percent leaf nitrogen, nitrogen fixation (acetylene reduction done at FVSC only) and yield. The data were subject to appropriate statistical analysis.

RESULTS:

1. **Peanut:** The data for one peanut greenhouse experiment at FVSC is presented in Table 1. Nitrogen fixation rates (determined

by acetylene reduction) differed significantly among the genotypes. NC-6 had the highest acetylene reduction rate of 10.31 µm/plant/hour. The rate of acetylene reduction was drastically reduced for all the genotypes with increase in soil pH from 7.6 to 8.6 and NC-7 and GK-3 showed no nodule activity at pH 8.6. Dry matter accumulation of these genotypes was similar in alkali (pH 7.6) and alkali amended soil (pH 8.6). A significant interaction between pH and genotype was observed. In alkali amended soil, mean dry matter yield was significantly decreased as compared with field alkali soil. In acid soil (pH 5.6) and amended acid soil (pH 4.6), no significant differences were found in nitrogen fixation rates or dry matter yield in this experiment and others as well.

The results of the effect of inoculation on root and nodule dry weight and number of nodules for peanut genotypes grown in pots in alkali (pH 8.0) and acid soils (pH 5.0) in the Dominican Republic are shown in Table 2. Root dry matter yield differed significantly among the genotypes in acid soil but no significant differences were detected for nodule dry weight and nodule number. Significant differences in root and nodule dry weight, and nodule number were found among peanut genotypes grown in alkali soil. The range in root dry matter in acid soil was 2.6 g/plant for Spanco to 15.53 g/plant for Valentia native, the local variety. The range in root dry matter was higher in acid than in alkali soil. Root and nodule dry matter, and nodule number were higher in alkali than acid soil. Florigiant, Valencia C and NC-6 showed more consistent performance for the three parameters examined across soils. In t test comparisons made for each genotype for

inoculated versus uninoculated treatments, the data showed that nodule weight and root dry weight were significantly increased with inoculation and, thus, indicating the importance of inoculation for peanut production under the Dominican Republic conditions.

The growth response of field grown peanut in alkali soil (pH 7.6) is presented in Table 3. Forty days after planting, plant dry matter, nodule dry weight and nodule number differed significantly among the genotypes. New selection VA Bunch 46-2 had the highest nodule number and nodule dry weight. The number of nodules for Valentia native (a local variety) was lower than all the other genotypes. No significant difference in per cent leaf nitrogen was found among the genotypes during vegetative stage of growth of plants. Inoculation showed no significant effect upon the four plant traits examined in this experiment.

The evaluation of eight peanut genotypes grown in alkali soil under field conditions for Dominican Republic is presented in Table 4. Significant differences in yield, nodule dry weight and nodule number were observed among the genotypes. Comet, a cultivar obtained from Oklahoma, had higher yield (2.93 MT/ha) than all the other genotypes. The yield of RF 123 and Valencia native, two local cultivars, was similar to Comet. Nodule dry weight and nodule number per plant differed significantly among the genotypes but appear to have no relationship to yield. No significant difference in per cent leaf nitrogen was observed among the genotypes. The yield of Florunner, a premier peanut variety under Georgia conditions, was lower than all other genotypes. Although, this yield data comes from one field experiemnt, with limited number of genotypes grown in adverse

soil conditions, still it indicates that with a suitable genotype and proper management, higher yields can be obtained.

Results of the laboratory screening tests for 24 peanut Rhizobia strains for tolerance to acidity or alkalinity were not significant.

2. **Soybean:** The response of 13 strains of Rhizobium Japonicum to acid-liquid media is shown in Table 5. Five of the Rhizobium strains, that is, USDA 110, USDA 143, USDA 144, Nitragin 61A101C and Nitragin 61A148 were tolerant to acid media at pH 4.6. Thus, these studies indicate the potential for screening Rhizobium strains suitable for low pH soils.

Acetylene reduction rates and dry matter yield for one of the greenhouse experiment for soybean in alkali soil conducted at FVSC is presented in Table 6. Acetylene reduction rates differed significantly among the genotypes and ranged from 8.33 µM/plant/hr for GA80-143 to 40.09 µM/plant/hr for Braxton. There was a drastic reduction in acetylene reduction rates in alkali amended soil (pH 8.6) as compared with field alkali soil (pH 7.6). Braxton showed no nodule activity in alkali amended soil. With increase in soil pH from 7.6 to 8.6, both mean acetylene reduction rate and dry matter yields were significantly decreased. There was a significant genotype x treatment interaction for acetylene reduction.

In another experiment involving twenty soybean genotypes grown in alkali (pH 7.6) and alkali amended (pH 8.6) and acid (pH 5.6) and acid amended soils (pH 4.6), root, shoot and nodule dry weights were higher for genotypes Forrest, Lee-74 and GAT-3. There were significant reductions in dry matter yield and nodule

mass, when the soil pH was amended from 7.6 to 8.6 and 5.6 to 4.6 (data not presented).

The performance of three soybean genotypes inoculated with two Rhizobium strains in acid amended soil (pH 4.6) is shown in Table 7. There was a significant interaction between the Rhizobium strains and the soybean genotypes. Inoculation of three soybean genotypes with Rhizobium strain USDA 110 showed that nodule and root dry weights of GAT-3 were significantly higher than Forrest and GASoy S. On the other hand when these three genotypes were inoculated with USDA 143, the Forrest variety had significantly higher nodule and root dry weight, and acetylene reduction rates than GASoy S. These results indicate that screening of Rhizobium strains and soybean germplasm to soil pH stress may enhance the biological efficiency of soybeans.

Three soybean pot experiments, each with twenty-five genotypes, were conducted with and without inoculation in acid (pH 5.0) and alkali (pH 8.0) soils in the Dominican Republic. The data for only inoculated treatments is presented. Significant differences were found in plant dry weight (harvested 40 days after planting), per cent leaf and stem nitrogen among the genotypes (Table 8). The range in dry matter was 3.20 g/plant for Hardee to 12.07 g/plant for D62-6289 in alkali soil. The percent leaf nitrogen ranged from 2.08 for D49-772 to 4.89% for Tanner. Per cent nitrogen in stems was about half as much as in leaves. In acid soil, dry matter accumulation also differed significantly among these genotypes. Percent nitrogen in stems differed significantly but no significant differences were found for percent leaf nitrogen in acid soil. In comparsions made by t test for inoculated versus

unioculated, seed inoculation before planting appeared to enhance %N in leaves and stems in most of the genotypes (indicated by the asterisk mark). The enhancement of dry matter accumulation with inoculation was inconsistent and about half the genotypes failed to show any enhancement in dry matter accumulation.

The effects of inoculation on plant height, nodulation and nodule dry weight of soybean is presented in Table 9. Significant differences were observed in plant height, nodule number and nodule dry weight in both acid and alkali soils among the genotypes. The nodule number per plant ranged from 42 to 118 in acid soil and from 24 to 128 in alkali soil. The range in nodule dry weight was from 0.23 to 2.90 g/plant in acid soil and from 0.55 to 2.67 g/plant for alkali soil. With the exception of two genotypes in acid soil, nodulation was enhanced in inoculated versus uninoculated plants.

The results of these experiments suggest that inoculation of soybean seed before planting may increase the leaf and plant nitrogen contents that in turn may enhance plant growth and development and may ultimately increase productivity of soybean. Improved nodulation may also enhance the residual soil nitrogen availability for the crops which follow soybean in rotation.

3. **Pigeon Pea:** The data for pigeon pea experiments for acid and alkali soils is presented in Table 10. Significant differences in per cent leaf nitrogen, nodule number and nodule dry weight were found among the pigeon pea genotypes grown in acid soil. The range in percent leaf nitrogen in acid soil was from 1.60 for ICPL-317 to 2.92 for ICRI-13. Kaki, a local genotype, had higher number of nodules and nodule dry weight than other genotypes.

In acid soil, inoculation significantly increased the per cent leaf nitrogen content but had no effect upon nodule number and nodule weight.

Per cent leaf nitrogen differed significantly among the genotypes in alkali soil. The number of nodules and nodule dry weight were similar for all the genotypes in alkali soil. Number of nodules and nodule dry weight per plant were lower in alkali soil than acid soil. Inoculation had no significant effect upon per cent leaf nitrogen, nodule number and nodule dry weight of pigeon pea genotypes grown in alkali soil. The performance of genotypes on two soil types also varied. ICRI-13 and ICRI-14 had the highest leaf nitrogen content in acid soil but in alkali soil the leaf nitrogen content of the two genotypes was lower than all the other genotypes. These experiments, though limited to smaller number of genotypes do indicate that identification of pigeon pea germplasm for tolerance to soil pH is possible.

None of the pigeon pea Rhizobia showed tolerance to acid-Al medium (pH 4.6).

4. **Dry Bean:** Four experiments, three in field and one in pots, were conducted for dry bean screening program. In the pot experiment twenty three genotypes, consisting of plant introductions from various parts of the world, were tested with and without inoculation. In alkali soil only two genotypes, PI 361177 and PI 352738 showed some nodules with inoculation. In acid soil, five genotypes, PI 361449, PI 361162, PI 385978, PI 358607 and PI 379460 showed some nodules (less than 10 each) in inoculated pots. Plant height and per cent leaf nitrogen were also

significantly increased by inoculation in acid soil but not in alkali soil. Ten dry bean plant introductions were also tested in acid and alkali soil in a greenhouse experiment with and without inocualtion at FVSC but all failed to show nodulation. One field experiment at San Juan de Maguana (Dominican Republic) could not be harvested due to heavy rains. The results of one experiment involving sixteen genotypes on alkali soil (pH 8.0) are presented in Table 11. Inoculation had no effect on the number and weight of nodules but there were significant differences in number of nodules and the dry weight of nodules among the genotypes. There was a three fold range in the number of nodules per plant and the mean number of nodules was 14.7/plant. The range in dry weight of nodules per plant was 3.6 for XAN-93 to 15.4 mg/plant for BAT 1412.

Dry bean is an important food crop in the Dominican Republic but due to short duration and inconsistent nodulation, successful crop is only possible with the application of fertilizer nitrogen and this puts a great limitation for small farmers who cannot afford to apply fertilizer.

The results of these experiments, especially those with plant introductions, survey of farmers fields, and experimental plots indicate that dry bean nodulation is very inconsistent among genotypes and locations. Thus, it is very urgent that dry bean research in the area of nodulation and nitrogen fixation be undertaken to improve the efficiency of this crop.

Publications:

1. Shoushtari, N.H., A.S. Bhagsari and M. Latimore, 1986. Response of soybean genotypes and Rhizobium strains to different soil pH. Agronomy Abstracts, p. 188.

2. Bhagsari, A.S., Domingo Rengifro and Luis Tejeda. 1987. Evaluation of peanut germplasm under Dominican Republic conditions. (Paper to be presented at the International Congress of Plant Physiology, February 15-20, 1988; New Delhi, India and manuscript to be submitted to Peanut Science.

3. Bhagsari, A.S., Domingo Rengifro and Luis Tejeda, 1988. Tolerance of selected soybean germplasm to acid and alkali soils. Paper to be presented at the Southern Region section of Amer. Soc. Agro. and manuscript to be submitted to Plant Soil.

TABLE 1. Nitrogen fixation (acetylene reduction and Dry matter yield for peanuts grown in greenhouse in alkali[z]

Genotype	Acetylene Reduction (µm/plant/hr)		Dry Matter (g/plant)	
	Field Soil	Amended Soil	Field Soil	Amended Soil
NC-6	10.31	0.04	5.84	5.66
Florigiant	5.50	0.34	7.35	5.09
AD-1	4.00	0.13	7.53	5.68
NC-7	3.57	0.00	6.63	5.80
NC-9	2.45	0.01	6.84	5.54
Toalson	1.59	0.12	4.92	3.48
Starr	1.30	0.02	7.08	6.11
Pronto	1.13	0.02	8.01	7.02
GK-3	1.00	0.00	8.77	4.47
Tamnut-74	0.97	9.07	6.10	4.39
MEAN	3.18	0.06	6.91	5.39
L.S.D. (.05)	3.36	0.27	N.S.	N.S.
L.S.D. (.05) (within soil)	1.06[y]	--	1.08[y]	--

y = L.S.D. for mean comparison within soil.

z = pH for field soil and amended soil was 7.6 and 8.6 respectively.

TABLE 2. Effect of Inoculation on root and nodule dry weight, and nodule number for pot grown peanut in acid and alkali soils[z]

Genotype	Acid Soil			Alkali Soil		
	Root dry wt. (g)	nodule dry wt. (mg) per plant	nodule number	root dry wt. (g)	nodule dry wt. (mg). per plant	nodu numb
Valencia (Native)	15.53 *	567	88	16.50	733	18
NC-7	14.77	533	70	11.57	700	17
Valencia-C	13.2	433	100	12.93	633	12
Florigiant	10.3	533	81	10.17	833	16
Tennessee Red	10.27	333	41	14.6	467	17
NC-6	9.87	500	97	13.13	933	24
Spanhoma	9.57	267	29	15.03	633	97
Tifrun	8.93	767	107	10.73	1167	309
Comet	8.2	400	97	16.3	367	88
Chico	8.13	333	77	10.20	367	100
Starr	7.97	267	25	16.00	667	183
Tamnut	6.93	367	84	9.97	733	175
Tifrun-13	5.40	400	75	17.03	633	195
Toalson	3.80	200	24	15.13	433	102
Spanco	2.60	233	13	10.83	433	81
Mean	9.15	414	68	13.43	649	160
L. S. D. (.05)	6.99	N.S.	N.S.	5.06	417	127

z = acid soil pH 5.0 and alkali soil pH 7.6

* The data presented is for inoculated treatments only

TABLE 3. Growth response of field grown peanut on alkali soil (pH 7.6) in the Dominican Republic

Genotype	Dry wt. g/plant	Nodule dry wt. (mg/plant)	Nodule number/ plant	% N leaves
NC-2	5.07[z]	685	79	3.45
Florunner	4.63	322	58	3.32
Sunrunner	4.36	188	30	3.55
ADI-VA	4.05	504	72	3.06
VA-Bunch 46-2	3.81	1023	103	3.54
NC-6	3.79	424	68	3.15
Mcrun	3.69	161	23	3.70
Pronto	3.55	242	28	3.19
VA-81B	3.33	307	38	3.33
GK-3	3.23	908	87	3.34
NC8-C	3.18	497	65	3.21
Comet	3.18	126	28	3.21
81-B	3.06	658	85	2.98
NC-17	2.67	208	35	2.75
Florigiant	2.56	438	62	3.68
NC-9	2.56	571	58	3.32
Valencia A	2.50	217	27	3.36
GK-7	2.49	165	34	3.73
Early Bunch	2.46	334	48	3.54
NC-7	2.43	448	58	3.52
Valencia (native)	2.30	196	19	3.35
Mean	3.28	410	53	3.35
L.S.D. (.05)	1.79	26	35	N.S.

z = significant at 0.08 probability level.

TABLE 4. Growth and yield response of field grown peanut on alkali soil (pH 7.6) in the Dominican Republic

Genotype	Yield MT/ha	Nodule dry wt. mg/plant	Number of nodules/ plant	% N leaves
Comet	2.93	48.00	8[z]	2.91
McRun	2.83	38.33	7	2.79
Valencia A	2.86	78.33	16	2.99
Valencia B	2.82	90.00	21	3.00
RF - 123	2.71	77.50	16	3.06
Valencia (Native)	2.66	37.50	8	2.81
Pronto	2.44	30.00	9	2.60
Florunner	2.09	30.00	7	3.08
Mean	2.67	53.83	12	2.91
L.S.D. (.05)	0.36	40.26	10	N.S.

z = significant at .08 probability level

TABLE 5 Response of 13 strains of Rhizobium Japonicum to Acid - Al in liquid media

Rhizobium Strain	Acid - Al [z] Response on Agar	Optical Density -Al (pH 6.0)	+Al (pH 4.6)
USDA 6	Sensitive	.35	.01
USDA 110	Tolerant	.36	.34
USDA 136	Sensitive	.38	.02
USDA 143	Tolerant	.56	.25
USDA 144	Tolerant	.43	.34
Nitragin 61A89	Sensitive	.35	.01
Nitragin 61A101C	Tolerant	.80	.65
Nitragin 61A118B	Sensitive	.32	.02
Nitragin 61A124a	Sensitive	.39	.02
Nitragin 61A148	Tolerant	.30	.14
Nitragin 61A155	Sensitive	.60	.01
TAL 377	Sensitive	.54	.04
TAL 379	Sensitive	.35	.01

z = testing of Rhizobium strains was done by the Agar Plate Method for rapid screening of Rhizobium for Tolerance to Acid Aluminum stress developed by Ayanahka et al. (1983) American Journal of Soil Science Society. 47:256.

TABLE 6. Nitrogen fixation (acetylene reduction) and dry matter yield of greenhouse grown soybean in alkali soil[z]

Genotype	Acetylene Reduction (µm/plant/hr)		Dry Matter (g/plant)	
	Field Soil	Amended Soil	Field Soil	Amended Soil
Braxton	42.09	1.60	8.25	4.47
Leflore	22.94	0.42	6.96	4.51
Wright	21.42	0.00	8.61	8.26
G81-234	18.66	0.33	7.77	5.52
Tropical	17.57	1.33	6.61	4.40
Davis	17.41	0.17	8.44	5.14
Centennial	13.23	2.70	6.54	4.81
Gordon	11.60	1.56	5.27	5.39
Ransom	9.94	0.21	7.42	4.48
GA80-143	8.33	1.58	5.16	4.31
MEAN	17.50	0.90	7.06	5.12
L. S. D.	12.09	N.S.	N.S.	N.S.
L. S. D. (within soil)	3.82[y]	--	1.10[y]	--

z = pH of field and amended soils were 7.6 and 8.6 respectively

y = L.S.D. for mean comparison within soil.

TABLE 7. Biomass and acetylene reduction as influenced by genotypes and rhizobium strains in acid amended soil (pH 4.6)

Strain	Genotype	Nodule wt. (mg/plant)	A-R[z] µm/plant/hr	Root wt. mg/plant
USDA-110	Forrest	1.8 a	0.20 a	265 ab
	GAT-3	30.8 b	3.73 b	380 a
	GASOY S	3.8 a	1.43 ab	153 b
USDA 143	Forrest	21.0 a	3.77 a	490 a
	GAT-3	20.8 a	2.50 ab	585 a
	GASOY S	0.8 b	0.38 b	233 b

P · < .01, LSD test

z = A·R. = Acetylene seduction

TABLE 8. Effect of inoculation on dry matter, per cent leaf and stem nitrogen of pot grown soybean in alkali and acid soils (Dominican Republic)

Genotype	Alkali Soil			Acid Soil		
	Dry Matter (g)/plant	Percent N Leaves	Percent N Stems	Dry Matter (g)/plant	Percent N Leaves	Percent N Stems
D62-6289	12.07*	2.65*	1.82*	7.13*	4.77*	1.82*
D51-5100	11.06*	3.91*	1.70*	7.70*	4.43*	1.93*
D55-4159	10.53*	3.21*	1.22*	6.47*	4.44*	1.66*
D71-6631	10.40*	3.41*	1.25*	7.27*	4.48*	1.57*
PI 171-443	9.93*	3.76*	2.03*	5.37*	4.47*	2.06*
PI 208-434	9.93*	2.76*	1.19*	6.32*	4.55*	1.69*
CENDA-6	9.93	2.81*	1.58*	6.37*	4.53*	1.92*
D73-9442	9.55*	2.88*	1.44*	7.27*	4.44*	1.85*
Bragg	9.33*	2.52*	1.28*	6.30*	4.37*	1.84*
D96-6344	8.95	2.27*	1.47*	5.77	3.90*	1.67*
Orba	8.87	3.65*	1.14*	8.00*	4.72*	1.66*
Yelfredo	8.67	3.63*	1.62*	8.80*	4.50*	1.79*
PI 159-925	8.63	3.48*	1.08*	6.37	4.36*	1.41*
PI 229-358	8.57*	2.64*	2.07*	7.70*	4.09*	2.06
PI 170-886	8.00	3.45*	1.61*	5.50	4.41*	1.81*
PI 175-176	7.93	3.69*	1.48	3.50	3.37*	1.62
D55-2232	7.70	3.24*	1.30*	4.20	----	1.41
PI 166-147	7.50*	3.94*	2.34*	5.53	4.46*	1.90*
PI 9698	6.65	3.32*	1.94*	6.63	4.26*	1.85*
D55-4090	6.60	3.39*	2.30*	6.87*	4.34*	2.38*
Hood	6.30*	4.60	1.98	4.83*	4.15*	1.72*
Tanner	5.10	4.89*	2.37*	5.30*	4.22*	1.88*
Centennial	3.60	4.43*	1.95*	5.80*	4.43*	1.73*
Hardee	3.20	2.77*	1.17*	4.20	4.71	1.69
D 49-772	-----	2.08	1.11	6.03*	4.44*	1.22*
Mean	8.47	3.33	1.61	6.37	4.36	1.78
L. S. D. (.05)	4.61	1.49	0.38	2.27	N.S.	0.45

* Asterisks indicate that in t test comparisons for each genotype, inoculation significantly affected the traits examined as compared with uninoculated control.

TABLE 9. Effect of inoculation on plant height, number and dry weight of nodules of pot grown soybean in acid and alkali soils.

Genotype	Acid Soil (pH 5.0)			Alkali Soil (pH 8.0)		
	Plant Height (cm)	Nodule Number/ Plant	Nodule Dry wt. (g)/plant	Plant Height (cm)	Nodule Number/ Plant	Nodule Dry wt. (g)/pla
PI175176	65.8*	61*	1.63	43.5*	74*	1.43*
Yelfredo	58.3*	71*	2.43*	43.4*	65*	1.47*
D51-5100	52.8*	101*	2.43	51.50*	82*	2.40*
Tanner	47.7*	51*	1.60*	30.0	35	1.23*
Orbea	46.7*	88*	2.13*	45.0*	43*	1.10*
PI159925	46.0*	84*	2.60*	34.7	61*	1.17*
D73-9442	45.2*	77*	1.77	38.8*	53*	1.50*
D49-772	42.7*	90*	2.13*	28.0	24	0.80
PI170886	42.7*	87*	2.13*	35.5	48*	1.70*
Bragg	42.5*	118*	2.57*	33.5	117*	2.23*
Cenda-6	41.1*	83*	2.50*	35.9	100*	1.70*
Hardee	40.7	60*	1.17*	35.0	33*	0.55*
D71-6631	40.4*	98*	2.23*	39.3	67*	1.37*
D62-6289	39.9*	42*	1.33*	39.8	50*	1.73*
PI9698	39.5*	70*	2.90*	31.8	63*	1.20*
Centennial	39.0*	73*	1.53*	31.0	70*	0.83*
D96-6344	38.6*	68*	1.80*	38.3*	53*	1.35*
PI171443	38.0*	54*	1.73	42.9*	52*	1.93*
D55-4159	37.0*	101*	1.87*	34.7*	46*	1.27*
Hood	35.7*	95*	1.37*	43.0*	50*	1.20*
PI229358	35.1*	66*	2.70*	29.0*	67*	1.53*
D55-2232	34.0	27*	0.23	31.5	90*	1.60*
D55-4090	33.4*	74*	2.10*	26.8*	58*	1.47*
PI208434	32.2*	95*	2.27*	31.2*	128*	2.67*
PI166147	31.6*	77*	1.57*	22.9	72*	1.67*
Mean	42.1	76	1.95	35.9	66	1.52
L.S.D. (.05)	14.7	44	0.99	11.4	59[z]	1.21[z]

z = significant at (.06) probability level

* Asterisks indicate that in t test comparisons for each genotype, inoculation significantly affected the traits examined as compared with uninoculated control.

TABLE 10. Evaluation of pigeon pea genotypes on acid (pH 5.0) and alkali soils (pH 8.0) in the Dominican Republic.

Genotype	Acid Soil[z]			Alkali Soil		
	%N Leaves	Nodule Number/ Plant	Nodule Dry wt./ Plant	%N Leaves	Nodule Number/ Plant	Nodule Dry wt./ Plant
ICRI -13	2.92	161	2326	2.19	22	177
ICRI -14	2.77	36	1451	2.06	18	283
ICRI -15	2.44	102	745	2.25	12	55
ICRI -17	2.15	28	1058	2.90	14	88
81-W	2.14	28	153	3.65	41	491
99-W	2.03	15	139	3.05	22	96
Kaki	2.03	282	4491	2.36	23	1145
76-W	2.00	38	263	3.75	53	526
ICPL-175	1.79	27	351	3.31	21	211
USAD	1.66	78	1554	2.28	31	696
ICPL - 317	1.60	8	279	3.26	8	133
Mean	2.14	75	1185	2.82	24	355
L.S.D. (.05)	0.39	129	1389	0.42	N.S.	N.S.
Mean inoculated	2.21	82	1089	3.00	21	465
Mean uninoculated	2.07	68	1276	2.64	27	244
L.S.D.(.05)	0.02	N.S.	N.S.	N.S.	N.S.	N.S.

z - acid soil experiment was planted at Planque Beach and alkali soil experiment was planted at San Cristobal (CESDA)

TABLE 11. Effect of inoculation on nodule number and nodule dry weight of dry bean genotypes grown on alkali soil (pH 8.0) in the Dominican Republic.

Genotype	Number Nodules/plant	Dry wt. nodules (mg)/plant
BAT - 1274	22.5	12.3
PC-50	21.8	12.7
BAT-1382	21.5	9.9
Arroyo Loro	20.8	12.4
ICA-PIJAO	18.5	11.7
PC-157	18.3	7.1
BAT-1412	18.3	15.4
BAT-1385	16.0	11.6
ZAA-84066	13.8	6.4
XAN-93	11.0	3.6
H-270	9.8	4.6
Talamanca	9.3	4.1
MCD-251	9.0	5.4
PAI-1	8.5	3.9
Fidelita	8.0	3.7
Yacomelo	7.8	3.7
Mean	14.7	8.0
L.S.D.	6.6	5.8
Mean inoculated	20.3	12.2
Mean unioculated	9.0	3.9
L.S.D. (.05)	2.33	2.03