Soybean Variety Evaluation Under Three Edaphic Conditions in Guyana[1]

Adbul H. Wahab and Imran Hassan[2]

ABSTRACT

A soybean varietal trial was conducted to test the adaptability of 15 entries to one relatively fertile and two agriculturally marginal soils which prevail along Guyana's coastal belt. The trials were established in late December 1975 and ended in May 1976. The best known soil and crop management practices were used. Rainfall was anomalously high during the trial period and totalled 75% more than the 100 year average reported for all the sites.

The mean seed yield of all entries on the three soils was 2.8 tons/ha, which included varieties that were poorly adapted on given soils. Variety Jupiter yielded highest giving 5.9 tons/ha on the fertile soils and 3.5 tons/ha on the marginal soils.

Agronomic characteristics such as plant height at maturity, days to flower, days to maturity, podding score, 100-seed weight, nodulation score, lodging and shattering are reported and discussed.

INTRODUCTION

Guyana is presently seeking to increase its agricultural output through a program of crop diversification, utilization of hitherto underdeveloped land resource and increased productivity. Leguminous crops have been identified for large scale cropping to reduce the nations's dependence on imports of vegetable oils and proteins. Soybean is especially favoured as a source of edible oils and enriched protein for livestock.

As the program of land reclamation continues, it is imperative to assess the suitability of these newly developed soils for production of crops not indigenous to Guyana but which may be adaptable to local edaphic conditions. This paper presents the results of a study to determine the soybean yield potential of a clayey, a peaty and a peaty clay soil using 15 entries representative of various maturity groups.

[1] Manuscript submitted to Editorial Board November 21, 1978.

[2] Former Crop Development Officer and Field Supervisor respectively, Guyana Sugar Corporation Ltd. The senior author is now Specialist on Agricultural Research, Inter-American Institute of Agricultural Sciences, OAS, Kingston, Jamaica. The authors are indebted to several people for assistance during the course of the work: Messrs R. A. Wilkins and J. A. A. Harlow were solely responsible for promoting the studies. Frank Dalmada and David Wilkie provided logistic support. Michael Joseph and Ralph Persaud assisted greatly in both the laboratory and field. The Engineering Experimental and Field Equipment Departments (Guysuco) greatly assisted in land reclamation and preparation of the site. Many other people at Enmore Sugar Estate willingly gave assistance when needed. Special thanks are due Miss Thecla Gonsalves for typing the manuscript. Lastly, the authors acknowledge with deep gratitude the continued support of the Guyana Sugar Corporation Ltd. which enabled them to undertake this work.

MATERIALS AND METHODS

The soils used are locally classified as Whittaker clay No. 37, Anira peat #20 and Inki clay #100. The Whittaker clays comprise several thousand hectares of acid but fertile coastal soils and are derived from relatively recent fine textured marine sediments (2). They are presently cropped to rice and sugarcane. Anira peat #20 and Inki clay #100 compose about one million hectares of extremely acidic, infertile soils. Unless drained, they are flooded most of the year (4). The Anira peat consists of dark reddish brown peat from the surface to a depth of 120 cm. The 0–15 cm, soil surface is a semidecomposed peat-peaty clay. Hydrogen sulphide is present from zero through 122 cm. Anira peat has a high swell/shrink ratio (50% or greater) and can undergo spontaneous

TABLE 1.—*Some physical and chemical properties within the 0–30 cm soil layer of three test soils under which 15 entries of soybean were evaluated*

	Anira peat #20	Inki clay #100	Whittaker clay
Texture			
Clay, %	12	63	74
Silt, %	22	24	24
Sand, %	14	3	1
Organic matter, %	52	10	1
Water held at field capacity	299	59	41
Bulk density, g/cm^3	0.24	0.94	1.30
Total soluble salts, p/m	900–1200	950–1600(M)	1000–1600
pH (1:2.5)	3.71	4.21(EA)	5.10
Cation exchange capacity (meq/100g)	18.20	15.50(M)	18.60
Available nutrients[1], meq/100g			
Calcium	2.66	3.86(L)	3.49
Magnesium	6.26	7.58(H)	7.10
Potassium	0.17	0.30(VL)	0.95
Available phosphorus, p/m	37.50	1.27(VL)	5.00
Nitrogen, %	1.46	0.47(M)	0.20

[1] Ca and Mg were determined using *N* KCl extract. K was determined using 0.5 *N* CH_3COOH extract; P by the Truog method.

combustion when dry (1). Inki clay #100 consists of a surface matt of 1–20 cm of peaty clay. The upper subsoil is a soft gray to greenish clay which is underlain by peat (1).

Some physical and chemical characteristics of the three soils are shown in table 1. Anira peat is characterized by a very high organic matter content, low bulk density and high water holding capacity. It is extremely acid (pH = 3.71) and contains low levels of calcium, potassium and phosphorus within the rotting zone. Inki clay is also extremely acid (⁻H 4.21) and infertile. Whittaker clay is characterized by a very low organic

matter content, and high levels of exchangeable K and Mg (1, 3). In each of the three soils, levels of water soluble salts were within the tolerance range of most plants.

The trials were conducted at the L.B.I. Sugar Estate (Whittaker clay site) and at Enmore Sugar Estate (Anira peat #20 and Inki clay #100 sites) from December 1975 to May 1976. Sites are lat. 6°N and approximately 2–3 m below sea level. Mean annual temperature 26°C with monthly variations of less than 4°. Planting was delayed at the Anira peat and Inki clay sites until January 21, 1976 because of continuous rains. The Whittaker clay plots were seeded on December 18, 1975. During the trial period, rainfall was extremely heavy and exceeded the 100 year average for both sites by 75%. In most of the period the Whittaker clay plots suffered from soil water accumulation as indicated by positive atmospheric water balances. Plots were flooded up to 48 h several times prior to flowering and pod set. At the Enmore site there were several brief (less than 24 h) periods of flooding in February when rainfall exceeded evaporation by about 24 cm. Sunshine totalled 452 h at L.B.I. and 589 h at Enmore and during February averaged 2.8 h/day at L.B.I. compared to 6.6 h/day at the Enmore Sites.

Land preparation consisted of plowing and rotavation. Because of soil acidity the Whittaker clay plots were limed with aragonite at the rate of 4.5 tons/ha and the other two sites were limed with twice the amount of aragonite. Except for trace elements, a standard fertilizer program was adopted for each site. P (35 kg/ha) as P_2O_5 and K (66 kg/ha) as K_2O were provided at levels which should promote full expression of soybean yield potential at each location. Additionally, 11.2 kg/ha of N (urea) were applied at each site. The Anira peat and Inki clay plots also received fritted trace elements (FTE-BR12) at 45 kg/ha. FTE-BR12 contains the following minor elements: 5.5% MnO_2, 5.4% Fe_2O_3, 11.5% ZnO, 1.0% CuO, 7.0% B_2O_3 and 0.2% MoO_3. All soil amendments were applied and incorporated during seedbed preparation.

The experiment followed a randomized block design with four replications. Each plot consisted of four rows 6 m long. Rows were spaced 60 cm apart. The following varieties of soybean [*Glycine max* (L) Merrill] were tested: Bossier, Cobb, Columbus, Clarke 63, Davis, Forrest, Hampton 266 A, Improved Pelican, Jupiter, Pickett 71, Tracy, Williams and Woodworth. Jupiter was tested as three distinct entries because of different sources of origin. Except for two Jupiter entries, all others were supplied by INTSOY[3]. Variety Clarke 63 produced unacceptable plant stands at all three sites and was thus eliminated from the experiment. At the Inki

[3] INTSOY, The International Soybean Programme of the Universities of Illinois and Puerto Rico, cooperates with international and national organizations to expand the uses of soybean as human food.

clay sites, Improved Pelican was substituted for Pickett 71. All seed material obtained from INTSOY were from the United States and represented maturity groups I through IX and were selected because of their high-yielding ability in their area of adaptation. The varieties represented a wide range of genotypic and phenotypic characteristics as well as some resistance to known pests.

Seed of the 15 entries was freshly treated with inoculant and planted in 6 m long rows spaced 60 cm apart. Plots were overseeded and thinned to a plant population of 400,000 plants/ha (24 plants/m). Whittaker clay plots were sown on December 18, 1975, in very moist soil (table 2). Due to excessive wetness, the Anira peat and Inki clay plots were not sown until January 21, 1976.

TABLE 2.—*Equivalent seed yields and 100-seed weight of 14 entries of soybean grown on three soil types*[1]

Variety	Whittaker clay		Inki clay #100		Anira peat #20	
	Yield	100-seed weight	Yield	100-seed weight	Yield	100-seed weight
	Tons/ha	*G*	*Tons/ha*	*G*	*Tons/ha*	*G*
Jupiter	5.27	16.35	2.58	19.87	3.38	18.94
Hampton 266 A	5.32	20.86	2.05	21.44	1.76	14.18
Hardee	5.39	17.27	2.51	21.14	2.70	15.17
Pickett 71[2]	4.64	18.19	2.47	17.39	1.99	13.93
Cobb	2.13	15.95	0.78	17.24	1.59	18.68
Bossier	3.72	18.13	1.70	19.82	2.18	15.02
Davis	5.91	16.92	1.17	19.28	2.80	16.20
Tracy	3.12	20.72	1.81	22.80	2.03	17.21
Forrest	4.81	15.20	1.45	17.45	2.50	13.48
Columbus	4.66	18.63	1.31	21.51	2.74	16.71
Woodworth	1.91	18.07	0.67	19.91	1.19	16.42
Williams	3.69	19.59	1.38	23.82	1.99	16.83
Jupiter (P.R.)	5.91	16.88	3.36	20.14	3.08	17.59
Jupiter (P.E.U.)	4.32	14.87	3.66	19.13	3.04	18.56
Coefficient of variation (%)	23.09	8.38	29.46	4.82	13.43	6.24
LSD (0.05)	1.47	2.12	0.81	1.38	0.45	1.46

[1] Yields and seed weight expressed at 12% moisture.

[2] Variety Improved Pelican was substituted for Pickett 71 on the Inki clay #100 soil.

All sites were intensively managed. During the trial measurements were made of days to flowering, nodule number, nodule weight, days to maturity, plant height at maturity, lodging score, shattering score, seed yields and 100-seed weight.

Flowering date was noted when 95% of the plants had flowers. The date when 95% of the pods were ripe was considered date of maturity. Nodule counts were taken from the roots of 10 plants from the two border

rows of each plots. Nodule scores were recorded when the first flowers appeared and three weeks thereafter. Following the count, nodules were removed, oven dried and weighed.

At maturity, plant height from the ground to the top of the main stem was recorded. Lodging score was estimated by rating lodged or down plants on a scale of 1 (all erect) to 5 (all down) at maturity. Shattering score was estimated by rating seed loss from the pod on a scale of 1 (none) to 5 (over 50%) at maturity. Seed yield was measured from 5 cm of each of the two centre rows. Equivalent yield (tons/ha) at 12% moisture was computed. The weight in grams of 100 randomly selected seeds was also recorded at 12% moisture.

RESULTS AND DISCUSSIONS

Mean seed yields were highest (4.34 tons/ha) on the Whittaker clay and lowest (1.92 tons/ha) on the Inki clay plots (table 2). Irrespective of source, all three Jupiter entries ranked highest on the three soils. On Whittaker clay, Jupiter yields approached 6 tons/ha whereas on the Inki clay and Anira peat yields of only 3.66 and 3.38 tons/ha, respectively, of excellent quality seeds were obtained. Jupiter yields surpassed by 54% (Inki clay) and 125% (Anira peat) those previously obtained when this variety was tested over two consecutive crops in similar soils at the Enmore Sugar Estate (5). As shown in table 2, with the exception of varieties Cobb and Woodworth, all other entries yielded over 3 tons/ha on Whittaker clay. Hampton 266A and Hardee performed as well as the Jupiter entries. It is apparent that Whittaker clay is better suited for soybean production. This is not unexpected because this soil type is inherently more fertile than the other soils.

When the mean soybean yields from Inki clay (1.92 tons/ha) and Anira peat (2.36 tons/ha) are compared to the mean yield from 20 varieties (1.61 tons/ha), tested as in this study at 60 "environmental zones" around the world, these soils can be considered to have potential for soybean production (6). Jupiter and Hardee are most adaptable to all three soils. It is also possible that these two varieties are best adapted to a range of latitudes within which Guyana falls. Indeed, INTSOY concluded in its first report of variety results that Hardee was the best adapted at sites of less than 20° latitude and 500 m elevation (6).

There were significant differences as to weight of 100 seeds among varieties (from 15.20 g for Forrest to 20.86 g for Hampton 266 A on Whittaker clay (table 2). On Inki clay, seed weight ranged from 17.24 g for Cobb to 23.82 g for Williams; on Anira peat, seed weight was lowest (13.48 g) for Forrest and highest (18.94 g) for Jupiter. Mean seed weight was 18.04 g/100 seeds. Mean seed weight among sites ranged from 16.35

g/100 on Anira peat to 20.07 g/100 on Inki clay. There was no significant correlation between seed weight and yield.

Plant height (table 3) differed significantly between varieties at all three sites. At maturity, mean plant height was essentially the same on the Whittaker clay and Anira peat plots (30 cm). However, on the Inki clay plots plant height averaged 10 cm less. Irrespective of soil, Jupiter entries were significantly taller than the others. Cobb was the shortest of all varieties on the Whittaker clay, and Anira peat plots; it ranked similarly to 10 others on the Inki clay. Plant height was positively correlated with yield on the Inki clay ($r = 0.76$), but not in the other soils.

TABLE 3.—*Plant height at maturity and number of pods per plant of 14 soybean entries grown on three soil types*

Variety	Whittaker clay		Inki clay #100		Anira peat #20	
	Height	Pods/plant	Height	Pods/plant	Height	Pods/plant
	Cm	*No*	*Cm*	*No*	*Cm*	*No*
Jupiter	46.3	33.5	29.8	14.0	56.4	12.3
Hampton 266 A	23.5	20.8	18.5	9.8	24.7	11.0
Hardee	23.8	23.0	16.8	11.3	26.9	12.5
Pickett 71[1]	22.5	16.8	23.0	12.5	23.8	7.8
Cobb	19.3	23.0	17.8	9.5	17.8	14.8
Bossier	20.8	17.0	18.5	9.3	23.5	10.0
Davis	23.3	21.3	17.8	8.8	25.4	9.0
Tracy	23.0	12.0	17.8	7.5	26.1	9.8
Forrest	26.5	20.5	19.8	8.8	27.9	9.8
Columbus	31.3	16.5	16.3	3.5	27.5	10.3
Woodworth	25.5	13.3	17.0	3.0	25.6	10.0
Williams	29.5	15.3	17.0	4.8	23.5	7.3
Jupiter (P.R.)	48.8	27.5	36.3	15.5	46.5	14.5
Jupiter (PEU)	43.0	26.8	28.3	14.8	48.5	12.8
Coefficient of variation (%)	9.4	14.0	9.9	34.9	3.3	9.2
LSD (0.05)	3.9	4.1	3.0	4.7	4.2	N.S.

[1] Variety Improved Pelican was substituted for Pickett 71 on the Inki Clay #100.

Number of pods per plant varied significantly between varieties on the Whittaker clay and Inki clay plots, but not on the Anira peat (table 3). Pods averaged 21, 10 and 11 per plant on the three soils and were most prolific on Whittaker clay. The Jupiter entries produced the greatest number of pods on all three soils averaging 29 on the Whittaker clay and 14 on the two other soils. There was a highly significant correlation ($r = +0.81$) on Inki clay between podding and seed yields, not on the other two soils.

Mean days to flower for the 14 entries among locations was 32.5 (table 4). The lowest site mean of 28.6 days was obtained on Anira peat. Irrespective of soil, Jupiter required the greatest number of days, 42, to flower, whereas all other varieties flowered within 1 to 4 days of each other. Days to flower were correlated with yield on Anira peat ($r = +0.69$) and Inki clay ($r = +0.742$), but not on Whittaker clay.

Days to maturity (table 4) differed significantly between varieties at the three locations. The greatest number, 106 days, were required for varieties grown on Inki clay. At the Anira peat site, varieties matured earliest (97 days). Jupiter matured later than all others, requiring 108

TABLE 4.—*Number of days to flowering and maturity of 14 soybean entries grown on three soils*

Variety	Whittaker clay		Inki clay #100		Anira peat #20	
	Days to flower	Days to maturity	Days to flower	Days to maturity	Days to flower	Days to maturity
			No			
Jupiter	39.0	109.0	40.8	110.0	31.0	105.0
Hampton 266 A	31.0	99.3	31.0	110.0	28.0	99.0
Hardee	34.3	107.5	35.3	110.0	28.0	96.0
Pickett 71[1]	30.3	98.0	31.0	106.3	28.0	93.0
Cobb	31.0	99.3	31.0	110.0	28.0	99.0
Bossier	31.0	93.8	31.0	102.5	28.0	93.0
Davis	34.0	96.0	34.0	104.5	28.0	93.0
Tracy	31.0	89.8	31.0	90.0	28.0	93.0
Forrest	31.0	95.3	31.0	98.8	28.0	93.0
Columbus	31.0	99.3	31.0	106.3	28.0	93.0
Woodworth	32.0	88.0	31.0	101.8	28.0	93.0
Williams	31.0	96.0	31.0	110.0	28.0	93.0
Jupiter (P.R.)	47.0	109.0	47.0	110.0	31.0	105.0
Jupiter (PEU)	47.0	109.0	47.0	110.0	31.0	105.0
Coefficient of variation (%)	7.1	4.6	4.6	5.5	38.6	3.3
LSD (0.05)	3.5	6.4	2.3	8.3	N.S.	4.5

[1] Variety Improved Pelican was substituted for Pickett 71 on the Inki Clay #100.

days. Tracy, Forrest and Woodworth were the earliest to mature with a mean among sites of 93.6 days. The longer the plants were in the field before maturity the higher they yielded on Whittaker clay ($r = 0.61$) and Anira peat ($r = 0.53^*$). However, there was no significant correlation between days to maturity and yield on Inki clay.

Mean nodules per plant, at flowering, varied from 12 on Whittaker clay to 14 on Anira peat (table 5). At three weeks, nodules increased 2-fold at all sites. Nodulation did not vary significantly between varieties at all soils. On the extremely acidic Anira peats, nodulation exceeded by about

40% that on Whittaker clay having a much more favorable soil reaction. Apparently, liming the marginal Anira peat and Inki clay plots, at twice the rate applied on Whittaker clay, enhanced nodulation. However, although mean nodulation on Anira peat distinctly exceeded the mean on Whittaker clay, nodule dry weight (table 6) was actually higher on the latter compared to the former soil. Thus, it is apparent that nodules were much smaller on Anira peat than on Whittaker clay and smallest on Inki clay. It is possible that this situation resulted from inadequate levels of plant available molybdenum which is essential for satisfactory nodula-

TABLE 5.—*Number of root nodules at flowering and three weeks thereafter in 14 soybean entries grown on three soil types*

Variety	Whittaker clay		Inki clay #100		Anira peat #20	
	Nodules at flowering	Nodules 3 weeks later	Nodules at flowering	Nodules 3 weeks later	Nodules at flowering	Nodules 3 weeks later
			No			
Jupiter	118	231	145	173	116	265
Hampton 266 A	151	231	131	188	168	263
Hardee	108	201	154	217	126	257
Pickett 71[1]	118	174	136	190	131	298
Cobb	99	159	129	305	176	338
Bossier	151	231	117	199	161	257
Davis	87	152	124	193	166	361
Tracy	124	183	144	216	137	221
Forrest	92	169	126	264	128	253
Columbus	123	198	148	194	124	240
Woodworth	112	160	117	176	166	242
Williams	167	273	97	182	145	240
Jupiter (P.R.)	111	197	122	217	123	286
Jupiter (PEU)	124	215	133	210	130	280
Coefficient of variation (%)	31.2	24.1	28.5	35.8	28.8	222.6
LSD (0.05)	N.S	N.S	N.S	N.S	N.S	N.S

[1] Variety Improved Pelican was substituted for Pickett 71 on the Inki Clay #100.

tion. There appeared to be no relationship between nodulation score or nodule weight and seed yield.

It is desirable to obtain high yielding varieties which either lodge slightly or remain erect at maturity. Also, the ability of plants to hold their seed during and after maturation is a desirable trait. The overall mean lodging score was 1.04 of the range from 1 (no lodging) to 5 (completely lodged). The overall mean shattering score for all three soils was 1.04 when rated on a scale of 1 (no shattering) to 5 (more than 50% shattered).

TABLE 6.—*Root nodule dry-weight at flowering and three weeks thereafter in 14 soybean entries grown on three soil types*

Variety	Whittaker Clay #37		Inki Clay #100		Anira Peat #20	
	At flowering	Three weeks later	At flowering	Three weeks later	At flowering	Three weeks later
Jupiter	0.77	2.15	0.29	0.64	0.40	1.78
Hampton 266 A	0.57	2.01	0.21	0.80	0.47	1.70
Hardee	0.69	2.20	0.26	0.80	0.34	1.86
Pickett 71[1]	0.67	1.50	0.22	0.69	0.40	1.72
Cobb	0.51	1.66	0.16	0.98	0.59	2.23
Bossier	0.93	2.08	0.18	0.65	0.51	1.69
Davis	0.32	1.80	0.20	0.64	0.45	2.15
Tracy	0.18	1.61	0.17	0.77	0.39	1.37
Forrest	0.66	1.79	0.18	0.94	0.34	1.73
Columbus	0.60	1.89	0.38	0.82	0.28	1.41
Woodworth	0.56	1.03	0.17	0.70	0.44	1.30
Williams	0.80	1.96	0.13	0.56	0.48	1.41
Jupiter (PR)	0.72	1.57	0.19	0.68	0.43	1.44
Jupiter (PEU)	0.77	1.64	0.21	0.63	0.46	1.48
Coefficient of variation (%)	42.3	24.1	38.0	43.3	22.6	19.1
LSD (0.05)	N.S	N.S	N.S	N.S	0.14	0.45

[1] Variety Improved Pelican was substituted for Pickett 71 on the Inki Clay #100 soil.

CONCLUSIONS

The results obtained in this investigation show that large yields of high quality soybean seeds can be obtained from Guyana's Anira peat #20 and Inki clay #100 soils which are presently considered marginal for conventional agriculture. Of the 14 entries of soybean evaluated, variety Jupiter is unquestionably the best adapted in terms of seed yields and plant height at maturity. In 110 days, this variety yielded 6 tons/ha on the relatively fertile Whittaker clay and 3.2 tons/ha on the infertile Anira peat and Inki clay soils. It appears that the varieties which are not representative of the same maturity group (IX) as Jupiter, such as Hardee and Hampton 266 A (Group VIII), can also produce favorable seed yields.

These results confirm those of an earlier trial (5) in which economically acceptable soybeans yields were obtained from these marginal and currently unexploited soils.

RESUMEN

Se realizaron pruebas para evaluar el comportamiento de 15 variedades de soja en un suelo relativamente fértil y en dos suelos marginales en la zona costanera de Guyana de diciembre de 1975 a mayo de 1976. Se utilizaron las prácticas agrícolas más adecuadas. La lluvia fue 75% mayor que el promedio de 100 años en los campos experimentales. Los

rendimientos medios de todas las variedades, en los tres suelos, alcanzaron a 2.8 T/ha. Este promedio incluyó variedades de pobre adaptación a determinados suelos. La variedad Júpiter dio los más altos rendimientos: 5.9 T/ha en el suelo fértil y 3.5 T/ha en los suelos marginales. En este trabajo se ofrecen datos sobre características agronómicas de las variedades, tales como altura al momento de la madurez, días hasta la floración, producción de vainas, peso de 100 semillas, nodulación, acamado de las plantas y el desgrane de las vainas.

LITERATURE CITED

1. Mahadeo, C., 1975. Soil Survey-New Land, Private Circulation, Bookers Sugar Estates Ltd., Georgetown, Guyana.
2. Mahadeo, C. and R. Pariag, 1974. Survey of the sugarcane soils of Enmore Estate, Private circulation, Bookers Sugar Estates Ltd., Georgetown, Guyana.
3. Paul, C. L., 1975. Physical properties of sugarcane soils of Guyana, Private Circulation, Bookers Sugar Estates Ltd., Georgetown, Guyana.
4. Steele, J. G. and Ramdin, H. N., 1975. Soil resources of Guyana, Ministry of Agriculture, Central Agricultural Station, Mon Repos, Guyana.
5. Wahab, A. H., 1976. Performance of soybean in Guyana's peats and peaty clays, J. Agri. Univ. P. R. 63 (4): 343–354, 1978.
6. Whigham, D. K., 1975. International soybean variety experiment, International Agricultural Publication, INTSOY Series No. 8, Coll. Agri. Univ Ill., Urbana-Champaign, Ill., U.S.A.