INTERCROPPING CASSAVA WITH GRAIN LEGUMES IN HUMID AFRICA

3. SOYBEAN AND FARM LEVEL EVALUATION.

Humphrey C. Ezumah[1], Kenneth E. Dashiell[2] and Walter T. Federer[3]

BU-1123-M May 1991

ABSTRACT

Though not widely grown by African farmers, soybean is an important source of protein which can be used to enrich protein deficient foods such as cassava consumed by many Africans and particularly low resource farmers in the humid forest zone. Eleven soybean varieties were intercropped with TMS 30572 cassava to determine their adaptation to a humid environment. Further intercrop evaluations were done under farmers' cassava production environment, farmers' seed storage and weed management situations.

We demonstrated the compatibility of soybean with cassava in their intercrop system. The target farmers easily adapted the new crop (soybean) to their cassava-based system. No reduction of cassava root yield was observed by intercropping with soybean which instead may slightly increase yield of associated cassava by 6%. Intercropped soybean yield was higher than sole by 12%. Data from farmers' fields also suggest a minimum of two weedings required for soybean + cassava intercrop. Poor seed viability and consequent poor germination remain an important problem for farmers as none of the farm level storage methods evaluated was satisfactory.

Key Words and Phrases: Compatibility, Germination, Farm level, Intercrop, Nodulation rhizobia, Promiscuous.

[1]Agronomist, IITA, Ibadan, Nigeria, and Visiting Fellow, Cornell University, Ithaca, NY, 14853.

[2]Soybean Breeder, IITA, Ibadan, Nigeria.

[3]Liberty Hyde Professor Emeritus, Biometrics Unit, Cornell University, Ithaca, NY, 14853.

INTRODUCTION

Soybean is relatively a new crop in tropical Africa (Nyiakura, 1982). Its spread has been limited by lack of knowledge of its utilization and by some technical problems such as low seed viability and non-nodulation with indigenous legumes (IITA, 1981; Nyiakura, 1982). Soybean is spreading gradually with its increased adaptation to environmental conditions in tropical Africa, more research on its utilization as a source of rich protein and release of highly promiscuous varieties which can nodulate freely with the soil rhizobia in Africa. It is commercially grown in Zimbabwe. In Nigeria, soybean was introduced about 80 years ago (in 1908: Shannon, 1983) but has remained restricted to small areas in the moist savanna zone with non-acid soil, monomodal rainfall and long rainless period following crop maturation. Short duration of seed viability remains an important problem. However, the high yield potential of soybean in some regions of Africa (IITA, 1981; Shannon, 1983; Nyiakura, 1982) make it an important source of cheap protein with which to blend and enrich many local foods deficient in protein (Onabolu, 1988).

Cassava is an important crop from which over 160 million Africans derive most of their food energy (Hahn *et al.*, 1979). It is prepared as food in many ways depending upon location, culture and history (Jones, 1960). It can be blended with many other crops, some of which are produced in association with it (e.g., cassava) (Ezumah, Federer, and Myers, 1991). Soybean has been reported to be compatible in intercropping systems with cassava. Results from Rwanda (Nyabyenda, 1983; Neuman, 1984) show higher cassava yield when intercropped with soybean and other beans than as a sole crop. Other reports disagree with this (Mason, 1986; Balasubramanian and Sekayange, 1990; Keating *et al.*, 1982c). However, soybean as a source of rich protein is particularly important if incorporated into the diets of cassava-consuming populations. Such an example is Ohosu, where over 90% of the population derive their food energy from cassava (Nweke, Ezumah and Spencer, 1988). The results of a diagnostic survey conducted in the Ohosu area, which represent a humid, tropical environment in Southern Nigeria, showed high incidence of human malnutrition (Nweke *et al.*, 1988; Nnanyelugo *et al.*, 1989). This malnutrition was associated with high cassava consumption and the introduction of legumes into the diet became a reasonable proposition to improve the quality of food consumed by increasing the protein contents. Major clinical signs of malnutrition observed at Ohosu included skin rash and scaly skin, dental caries, skin ulcers, angular atomatitis, hair changes and oedema (Nnanyelugo *et al.*, 1988, 1989). Since the biophysical conditions in Ohosu are potentially good for growing soybean, it was readily introduced and linked with education of how to use it as food because the people have not cooked nor eaten soybean before. Studies were therefore initiated to introduce soybean to the essentially cassava-consuming communities. After discussing with the farmers, the idea of introducing soybean as a crop and food and further studies of the Ohosu environment to determine important problems, the following research objectives were developed:

1. Identification of varieties suitable for i) the ultisol complex characterized by acid sand and ii) intercropping with cassava.
2. Development of appropriate production and storage technologies to ensure that soybean seed had good germination at planting time.
3. Recommendation of appropriate weed management methods for cassava/soybean intercropping at Ohosu and other similar environments.

MATERIALS AND METHODS

Experiment 1: Intercropping soybean with cassava in Southern Nigeria (Ohosu area).

The objective of this study was to identify suitable soybean varieties for intercropping with cassava in an acidic ultisol characterized by the sandy soil in the Ohosu area.

Methodology for Experiment 1:

An improved cassava variety, TMS 30572, was intercropped with eleven soybean varieties (Table 2). The numbers 1 – 11 are maintained throughout the paper for soybean variety identification. Both crops were established at the same time, in mid-July 1987 and repeated in mid-July 1988. The 1988 experiment was planted on the same plots as the 1987 trial using the same randomization. The between-row spacing for cassava was 0.75 m and within-row spacing was 1.33 m. Cassava population was, therefore, 10,000 plants per hectare. Soybean was planted in interrow with cassava at 0.75 × 0.05 m for 266,667 plants per hectare. The plot size was four rows each of cassava and soybeans, 8 m long.

Cassava cuttings (stakes) 30 cm long, of uniform size and physiological age, were grouped into three replications. These were planted by sticking about 20 cm of the distal end of the stakes into the soil obliquely. Soybean planting was by drilling seeds into the soil in rows and thinning to 0.05 m spacing at 2-3 weeks. No fertilizer and no insecticide was applied and weeds were controlled by hand weeding at four and eight weeks after planting.

Six meters of the two centre rows of crops were used to determine yields. In 1988, soybean population at harvest was obtained by counting number of plants. Stem, pod and grain weights at harvest were also determined on field dry weight basis. Total biomass at harvest (shoot + pod) was weighed. Pods were detached and weighed. And finally, grains were weighed. Rainfall data were obtained for the experimental sites using a standard rain-gauge. Soil chemical analysis was done for the top 0-10 cm soil samples at time of planting during the first year and at time of cassava harvest during the second year.

SITE DESCRIPTION

Rainfall during 1987 was about normal with a total annual of 2,100 mm. The distribution was, however, distorted by very high rains in July with 623 mm above (87%) the 42-year mean for July. The 1988 total was quite low at 1381 mm or 28% below the 42-year mean (1914 mm). Rains started late in April and cut-off was early in October. Generally, crops yielded lower in 1988 than in 1987. The soil in the Ohosu area has been described as an acid sand with low pH values as depth increases (Nweke *et al.*, 1988). Major soil chemical characteristics at the beginning of the trial and at the termination compared with mean values from a field survey of the area (Nweke *et al.*, 1988) are given in Table 1.

RESULTS AND DISCUSSION

The cropping system had no significant effect on cassava root yield at 12 months after planting. No significant interactions were observed between year and cropping system. Therefore the two-year data were combined and interpreted together. Mean sole cassava root yield (16.8 ± 2.8 t/ha) was slightly lower (but not significantly) than intercropped root yield (17.8 t/ha). Soybean variety had no significant effect on cassava root yield in 1987, but significantly effected yield in 1988 (Table 2). Note that the mean effect of intercropping with soybean on cassava root yield was not significant but particular soybean varieties could cause significant cassava root yield variations (Table 2).

The 1987 mean soybean grain yield ranged from 1250 kg/ha for TG_x 1061-1E to 2422 kg/ha for TG_x 812-26D (Table 2). Variety × cropping system interaction was not significant in 1987 though soybean grain yield declined by 5.1% under intercropping. A reverse observation was made in 1988 when soybean grain yield increased by 21.5% under intercropping compared with sole (Tables 3 and 4). This difference was highly significant and tended to be so among all the eleven soybean varieties except four, in which sole crop yields were higher than intercrop (Fig. 1). However, the highest yielding soybean varieties under intercropping are not necessarily the highest as sole crop, resulting in significant variety × cropping systems interaction (Fig. 1). Note the significance of all the population-related yield components in Table 4.

An outbreak of web blight, which disturbed vegetative development and induced early senescence, was observed in 1988. Although no data on this problem was collected, it is believed that it, together with reduced rains, contributed to the lower soybean yields observed in 1988. During the first year, the top 0-10 cm soil was higher in organic carbon (2.57%). This declined to 1.83% in the second year during harvesting. The pH in 1989 (at second-year harvest) declined to 5.2 ± 0.33 from 5.9 ± 0.41.

Further explanation of the reduced soybean yield in 1988 was attempted by relating observed population with yield. Figure 2 and Table 5 indicate a weak but positive relationship between increasing soybean population with pod weight, stem plus pod weight, and almost no relationship with grain weight. This implies that pods farmed were, for some reasons, not filled to produce grains. Note also that Figure 3 shows about 110 thousand plants per ha as the estimated population giving the highest yield in 1988. The highest yielding variety in 1988, TG_x 849-294D, had only 97,400 plants/ha. Population may not, therefore, be the main reason for reduced grain yield in 1988, leaving factors responsible for non-pod filling as the remaining options. Reduced moisture and related stress

(Boyer, 1971; Mota, E.S. da, 1978) and early leaf senescence accentuated by web blight appear to cause the yield reduction in 1988. The low harvest indices of the later maturing soybean varieties, e.g., Malayan and Samsoy 1, despite the relatively high pod weight, indicate higher incidence of barren pods which suggests some stresses at some critical growth phase (Table 5) (Shibles *et al.*, 1985). Moreover, soil reaction (particularly pH) was not low for soybean growth and no obvious nutrient deficiency symptoms were observed.

In spite of the environmental differences, certain soybean varieties produced relatively high seed yield in both years. These are TG_x 814-26D, TG_x 539-5E, TG_x 536-02D, and TG_x 849-294D (Figure 3, Table 2).

Experiment 2: Soybean yield in Southern Nigeria under farmers' production system.

Objective and Methodology

Having ascertained that intercropping soybean with cassava did not reduce cassava root yield and that the mixture may be so compatible that intercropping may increase soybean grain yield compared with sole, the next task was to introduce the system to farmers in the Ohosu area. Note that these farmers had never grown soybeans but had observed the plots in experiment 1 during an organized visit.

About 1,000 grams of TG_x 191-021D (not included in Experiment 1) was supplied to 36 farmers at sites approximately similar to that described in Experiment 1. The soybean was superimposed into cassava plots at time of cassava planting. Observations were taken on farmer management and yield. This trial was carried out in close collaboration with a World Bank-financed Bendel State Agricultural Development Project. Farmers were drawn from three villages, the farthest Egbetta (about 50 km from Ohosu), the Cassava Based System's main village site. Seeds were drilled into soil and population count taken at about three weeks after planting.

Results and Discussion

Only 23 of 35 farmers who received seeds in 1989 planted the soybean. Of these, no yield was obtained from five farmers who either did not weed the plots or stands were so poor that no harvest could be taken (Table 6). Soybean stand establishment was generally poor. The average population was only 22% of intended population, ranging between 17 and 28% with mean of 19.4 ± 8.7 percent. Grain yield ranged from 191-600 kg/ha. Average of farmers' yield was 369 kg/ha. Yield by the best farmer (600 kg/ha) was about 67% mean experimental plot yield in 1989 (904 ± 109, Table 6), indicating that in spite of the generally poor germination, poor management, and early cut-off of rain in the Ohosu area in 1988. Soybean managed by farmers has potential for high grain yields under intercropping with cassava in the Ohosu area. Further observation of the yield distribution shows that the upper 75% quartile yielded 493 kg/ha, while the lower 25% quartile was 236 kg/ha (Fig. 4). The yield distribution is skewed in favor of lower yields (Fig. 4) showing that most of the farmers need more education on soybean management.

Areas of management which needed to be improved included stand establishment and timely weeding. If seeds were viable enough, the stand establishment and spacing problem could be overcome. Experiments 3 and 4 were carried out to study the seed storage and the weeding problems.

Experiment 3: Effect of seed storage conditions on soybean germination.

Objective and Methodology

One of the major problems of farmers is storage of soybean seeds to ensure high viability and therefore high germination rate at planting. Findings reported in Experiments 1 and 2 show that soybean germination was less than 50% of expected rate and in fact averaged about 20% at farmers' level. From harvest of soybean in October/November to the next planting season in July in the Ohosu area is about 9 months. A study was conducted to monitor the viability of soybean seeds under farmers storage conditions on the Ohosu area.

Each of four farmers was provided 9 containers with 200 g soybean seeds in each. The containers were: 1) locally purchased jute bags or 2) thin black colored plastic bags also available in local markets (Plate 1). The third container was a relatively thick (0.1 mm) translucent plastic bag not usually available in local markets. Three varieties of soybean were stored in the containers by four farmers for 9 months.

Storage conditions varied with farmers. Farmer 1 placed the containers on bare floor under his bed, farmer 2 placed the containers in a carton under a bed, farmer 3 suspended individual containers from a roof within her room and finally, farmer 4 placed the containers on a platform in his room. In the original design, individual farmers were regarded as replicates; however, since storage conditions by individual farmer varied so much, each farmer's data were analyzed separately for varietal and container effects. Germination was determined by placing one hundred seeds in rolled moist pads and allowing 72 hours for sprouting. Percent germination was determined.

Results and Discussion

Generally, soybean viability under farmer storage conditions were very poor (Table 7). Though none of the conditions was good enough, it appears that placing the seeds in thick translucent plastic bags on some platform (Farmer 4) or suspended from a ceiling in a cool room (Farmer 3) gave relatively better germination counts than the other two methods (Table 7). The importance of cool circulating air temperature in the extension of the viability of soybean seeds has been reported in literature reviewed by Shannon (1983). Variety TG_x 949-294D was more viable than the other varieties irrespective of storage method and type of container used for seed storage (Table 7). Seed quality at commencement of storage, especially appropriate seed moisture level, need to be determined. Rather than solve the problem, this trial highlights it and further studies to resolve farmers' soybean seed storage problems are recommended.

Experiment 4: To determine the effect of weeding and variety on soybean and cassava yields under intercropping at farm level.

Objectives and Methodology

Three varieties of soybean were superimposed into farmers' cassava plots at time of cassava planting. The soybean varieties are given in Table 8. Cassava variety was TMS 30572. The soybean was planted by the researcher at spacing of 0.75 m $\times$ 0.05 m for a population of 266,667/ha. Farmers' cassava population was counted by the researcher and averaged 7,670 $\pm$ 261.

The soybean plots were replicated three times per farm. Each soybean plot was split to impose two weed control treatments: one weeding only at 4 weeks after planting and two weedings at 3 weeks and 7 weeks after planting. Weeding was by the farmers under researcher's close supervision. Any variations attributed to farmers were monitored. The dominant weed species were noted at time of planting and also in the course of crop growth.

Yield data were taken from 5 m × 4 m plots and converted to equivalent weights per hectare. Soybean harvest was at maturity prior to any shattering, while cassava yield was at 12 months. The rainfall for 1988 and general soil conditions of the Ohosu area are as presented in Experiment 1.

Results and Discussion

The major weeds in the area were the broad leaf types. *Chromaelina odorata* was dominant but, in one of the farmers' fields (Farmer 1, Table 8), *Euphorbia heterophylla* L. competed with *Chromaelina*.

By weeding once at 4 weeks after planting (WAP) mean soybean grain yield across farmers was reduced by 40%, i.e., from 447 kg/ha when weeding was twice (at 3 WAP and 7 WAP) to 319 kg/ha when weeded only at 4 WAP (Table 9). Each of the three soybean varieties also gave slightly higher grain yield if weeded twice (Table 9). Succession of *Chromaelina odorata* by *Euphorbia heterophylla* resulted in a significant reduction of soybean grain yield (by 82%), especially when weeded only once (Farmer 1, Table 8).

Farmers' average cassava population was 7670 ± 261, which was higher than the 67,000/ha mean farmer population reported in a broadly based field survey of the area (Nweke *et al.*, 1988). Intercropped cassava root yield was reduced by 17% by weeding only once (Table 9). This was not significantly different from the two-weeding cassava yield. As reported in Experiment 1, soybean had no significant effect on cassava root yield (Table 9).

Thus depending upon the weed species competing with soybean intercropped with cassava, two weedings may be the minimum required for a crop of soybean. Where *Euphorbia heterophylla* is the dominant weed species, more than two weedings may be necessary. This trial is location-specific and cannot be used to generalize for situations in which grasses and more noxious weeds prevail.

REFERENCES

Balasubramanian, V. and Sekayange, L. (1990). Area harvest equivalency ratio for measuring efficiency in multiseason intercropping. *Agron. J.* **82**: 519-522.

Boyer, J.S. (1971). Resistances to water transport in soybean, bean and sunflower. *Crop Sci.* **11**: 403-407.

Ezumah, H.C., Federer, W.T., and Myers, G.O. (1991). Intercropping cassava with grain legumes in humid Africa. 1. Cowpea yields. Unpublished technical report BU-1108-MC of the Biometrics Unit, Cornell University, Ithaca, NY.

Hahn, S.K., Terry, E.R., Leuschner, K., Akobundu, I.O., Okah, C. and Lal, R. (1979). Cassava improvement in Africa. *Field Crop Research* **2**: 193-226.

IITA (1980). International Institute of Tropical Agriculture Annual Report, Ibadan, Nigeria.

IITA (1981). International Institute of Tropical Agriculture Annual Report, Ibadan, Nigeria.

Jones, W.O. (1969). *Manioc in Africa.* Stanford University Press, Stanford, California.

Keating, B.A., Evenson, J.P., and Fukai, S. (1982). Environmental effects on growth and development of cassava (*Manihot esculenta* Crantz). III. Assimilated distribution and storage organ yield. *Field Crops Res.* **5**: 293-303.

Mason, S.C., Leihner, D.E., and Vorst, J.J. (1986). Cassava-cowpea and cassava-peanut intercropping. 1. Yield and land use efficiency. *Agron. J.* **78**: 43-46.

Mota, E.S. da. (1978). Soya bean and weather. *Technical Note 060*, World Meteorological Organization. WMO No. 498.

Neumann, I.F. (1984). La promotion des cultures associées au projet. *Etudes et Experiences*, **No. 4**: 80 pp.

Nnanyelugo, D.O., Ngwu, E.K., Asinobi, C.O., Ezumah, H.C., and Nweke, F.I. (1988). Magnitude and distribution of stunting and wasting among cassava farm households in Bendel State (Nigeria). In *Proceedings, Cassava-Based Cropping Systems Research* **II**, IITA, pp. 101-118.

Nyabyenda, P. (1983). Association de patate douce et du manioc avec d'autrea cultures. In *Culture et Sélection du Manioc et de Patate Douce au Rwanda, 1983*, Ndamage, G. *et al.*, eds. Compte-rendu, Rwanda, Institut des Sciences Agronomiques du Rwanda, pp. 66-67.

Nyiakura, O. (1982). An address on soybean production in Nigeria: prospects and problems. *II Annual Meeting of Nigerian Soybean Scientists, Abu, Zaria*, 18-20 February 1982.

Nweke, F.I., Ezumah, H.C., and Spencer, D.S.C. (1988). Cropping systems and agronomic performance of improved cassava in a humid forest ecosystem. *Research Monograph No. 2*, Resource and Crop Management Program, IITA, Ibadan, Nigeria. 45 pp.

Onabolu, A. (1988). *Sweet Cassava, a Food for all Seasons.* Book Builders for UNICEF, Ibadan, Nigeria.

Shannon, D.A. (1983). A study of factors responsible for variable growth of soybeans in the Southern Guinea Savanna of Nigeria. Unpublished Ph.D. thesis, Cornell University, Ithaca, NY.

Shibles, R.M., Anderson, I.C., and Gibson, A.H. (1975). Soybean. In *Crop Physiology: Some Case Histories*, Evans, L.T., ed. Cambridge University Press, Cambridge, England.

Table 1. Soil chemical composition (0-10cm layer) of the soybean experimental site and mean values from the Ohosu area.

Soil Characteristic	Ohosu Mean*	Plot Average at Inception (1987)	Sole Soybean Plot Average (1989)	% Reduction over 1987	Intercropped Plot Average (1989)	% Reduction over 1987
pH	6.80	6.64	5.95	−12.5	6.71	+ 1.1
Org C(%)	2.29	2.57	1.96	− 3.6	1.83	− 4.0
ppm P(Bray-1)	12.00	12.42	8.63	−44.0	11.37	− 9.2
Exch K(me $100g^{-1}$)	0.50	0.52	0.38	−37.0	0.48	− 8.3
Exch Ca(me 100 g^{-1})	16.03	16.41	11.39	−44.0	13.51	−21.5

* Source: Field Survey: Nweke *et al.*, 1988.

Table 2. Soybean yield in 1987 and 1988 averaged over sole and intercropping system and cassava root yield in the 1987-88 and 1988-89 growing seasons.

Soybean variety	Soybean Seed yield 1987	1988	Cassava root 1987/88	1988/89
	kg/ha^{-1}		t/ha^{-1}	
1. TG_x 814-26D	2422	1126	20.5	15.2
2. TG_x 539-5E	2382	1043	24.2	25.6
3. TG_x 536-02D	2325	991	17.1	17.7
4. TG_x 1061-29E	2218	1106	20.2	17.7
5. TG_x 1051-8E	2208	891	17.3	13.8
6. SAMSOY 1	1992	832	22.2	14.9
7. TG_x 1025-8E	1709	816	22.4	13.9
8. TG_x 996-26E	1570	752	22.8	14.6
9. Malayan	1343	430	23.2	18.3
10. TG_x 849-294D	1312	1216	23.2	15.2
11. TG_x 1061-1-1E	1250	743	25.1	17.7
No Soybean	0	0	20.7	17.8
Mean SE (±)	1885(336)	(829)109.3	21.6(3.8)	16.9(2.28)
CV (%)	22.4	29.6	17.5	28.5

Table 3. Effect of cropping system and soybean variety on mean soybean grain yield, 1988, and on the contrasts of the two cropping systems, $\mu_1-\mu_2$.

Soybean variety	Intercropped (μ_1)	Sole (μ_2)	$\mu_1-\mu_2$
	kg/ha^{-1}		
1. TG_x 814-26D	1143	1109	34
2. TG_x 539-5E	1127	959	168
3. TG_x 536-02D	889	1094	–205
4. TG_x 1061-29E	1503	709	794
5. TG_x 1051-8E	1061	721	340
6. SAMSOY 1	861	802	59
7. TG_x 1025-8E	787	846	–59
8. TG_x 996-26E	831	673	158
9. Malayan	423	436	–13
10. TG_x 849-294D	1585	846	739
11. TG_x 1061-1E	703	783	–80
SE ±	154.5		
Means	992	816	
SE (±)	46.6		

Table 4. Effect of cropping systems on mean agronomic characters of eleven soybean varieties in a humid ecozone, 1988.

Agronomic character	Cropping system: Intercropped with cassava	Sole cropped	SE (±)	P
Population/ha, 1988	110,580	98,960	2,933	0.0008
Pod weight, kg/ha, 1988	1,936	1,417	88.2	< 0.001
Stem + pod wt, kg/ha, 1988	3,165	2,670	154.4	0.028
Grain yield, kg/ha, 1988	992	816	46.6	0.011

Table 5. Agronomic characters of eleven soybean varieties averaged over sole and intercropped systems with TMS30572 in Southern Nigeria in 1988.

Soybean variety	Population $\times 10^3$/ha	Pod wt kg/ha	Stem + Pod kg/ha	Grain yield kg/ha	HI
1. TG_x 814-26D	104.0	1926	3482	1126	0.21
2. TG_x 539-5C	103.5	1741	2852	1043	0.23
3. TG_x 536-02D	119.3	1833	2518	991	0.23
4. TG_x 1061-29E	119.0	1741	3037	1106	0.23
5. TG_x 1051-8E	114.7	1778	2778	891	0.20
6. SAMSOY 1	98.1	1704	3037	832	0.18
7. TG_x 1025-8E	111.2	1444	2481	816	0.21
8. TG_x 996-26E	92.8	1444	2852	752	0.18
9. Malayan	117.4	1593	4111	430	0.08
10. TG_x 849-294D	97.4	1963	3130	1216	0.24
11. TG_x 1061-1E	75.2	1278	1814	743	0.24
Significant +	**		NS	*	**
Mean (SE ±)	104.8 ± 6.87	1677 ± 207	2917 ± 109	904 ± 109	0.04 ± 0.11
CV%	16.1	30.2	30.2	29.6	

Table 6. Performance of soybean variety TG_x 191-02D at farm level.

		Percent
Total # of farmers	35	100
Farmers who planted	23	66
Unsampled farms, no yield	5	14
Farms with soybean yield	18	51
Yield range (kg/ha)	191-600	
Overall mean yield	368	
CV%	58	

Table 7a. Effects of farmer environment, soybean variety, and storage container on germination of soybean stored for 9 months.

Soybean Mean variety	Farmer 1	Farmer 2	Farmer 3	Farmer 4	Mean	Type of container: Jute bag	Type of container: Thick plastic	Type of container: Thin plastic	
	Percent germination					Percent germination			
TG_x 536-02D	9.0	20.7	13.8	25.7	17.3	6.9	39.3	21.9	22.7
TG_x 849-294D	9.0	12.7	34.2	38.2	23.5	9.5	39.0	22.0	23.5
TG_x 996-28E	10.5	6.7	22.2	17.5	14.2	5.1	27.5	10.0	14.2
Mean	9.5	13.4	30.6	27.1		7.2	35.3	18.0	
CV (%)	55.1	52.0	27.0	18.5			52.9		

Table 8. Effects of weeding treatment and soybean variety on soybean grain yield, grown by four farmers in a humid zone of Nigeria.

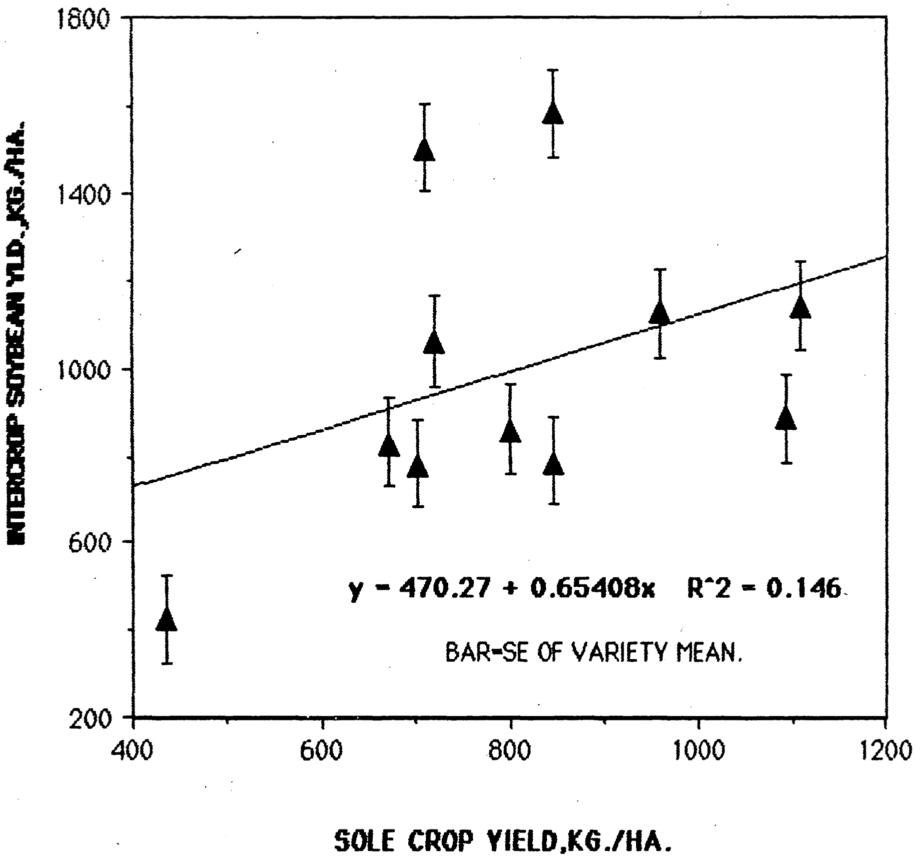
Soybean variety	Weeding	Farmer 1	Farmer 2	Farmer 3	Farmer 4	Mean
		kg/ha soybean				
TG_x 536-02D	1	157	302	298	553	328
TG_x 849-294D	1	231	360	343	790	431
TG_x 996-28E	1	153	230	181	226	198
TG_x 536-02D	2	437	428	340	642	462
TG_x 849-294D	2	339	494	539	876	562
TG_x 996-28E	2	207	352	219	483	
Mean		254 ± 66.5	361 ± 76.1	320 ± 54.4	595 ± 105.0	
CV (%)		37.2	43.5	45.7	24.6	

Table 9. Effects of weeding treatments and soybean variety on mean grain yield and mean cassava root yield under intercropping in the Ohosu area.

Soybean variety	Weeding	Crop Yields kg/ha soybean	Crop Yields t/ha cassava
TG_x 536-02D	4 WAP+	328	13.1
TG_x 849-294D	4 WAP	431	13.2
TG_x 996-28E	4 WAP	198	11.4
TG_x 536-02D	3 and 7 WAP	462	17.5
TG_x 849-294D	3 and 7 WAP	562	12.4
TG_x 996-28E	3 and 7 WAP	317	14.5
Mean ± SE	383 ± 33.8	13.7 ± 2.91	
CV %		35.2	25.3

+ WAP = Weeks After Planting.

FIG.1 CROPPING SYSTEMS EFFECTS ON SOYBEAN GRAIN YIELD,KG./HA.



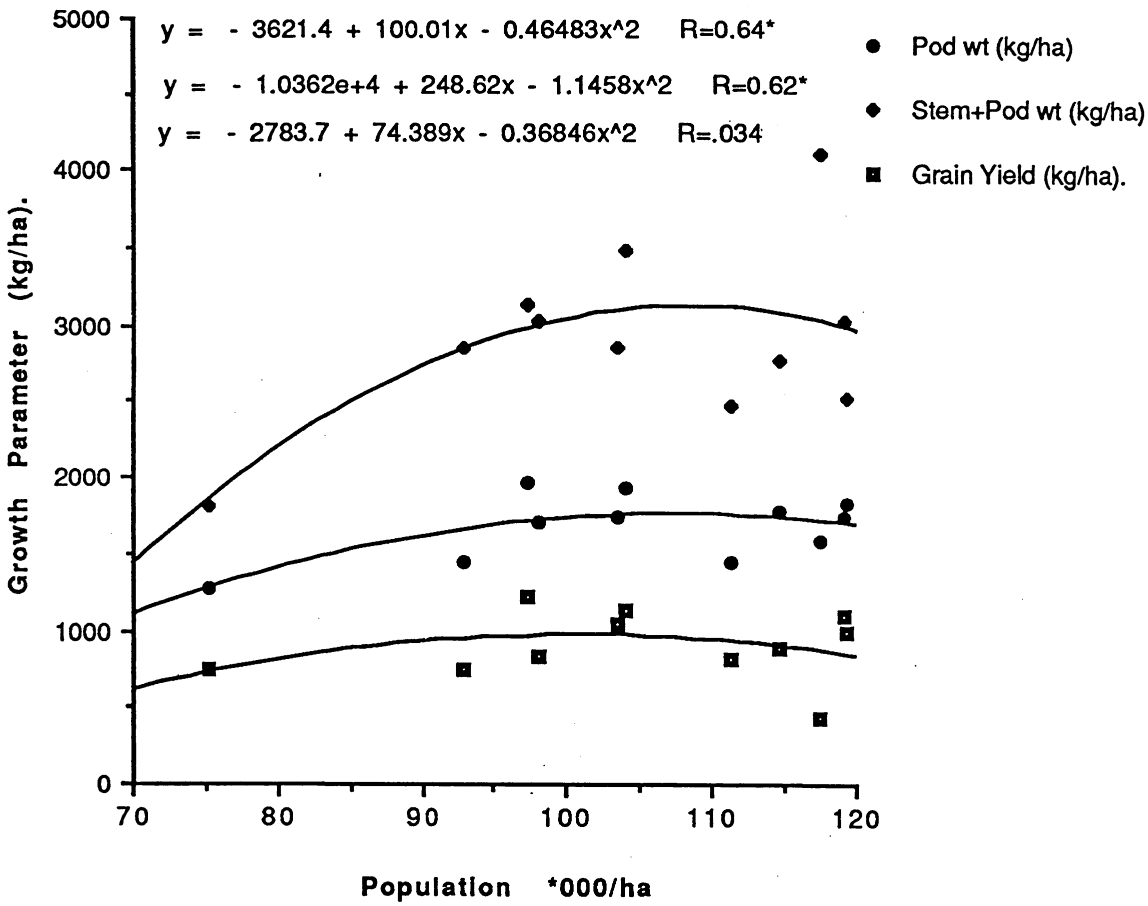


Figure 2: The relationships of some agronomic characters of soybean varities with soybean population, 1988

FIG. 3.RELATIONSHIP OF 1987 SOYBEAN VARIETY YLD.,WITH 1988 YLD.,KG./HA.

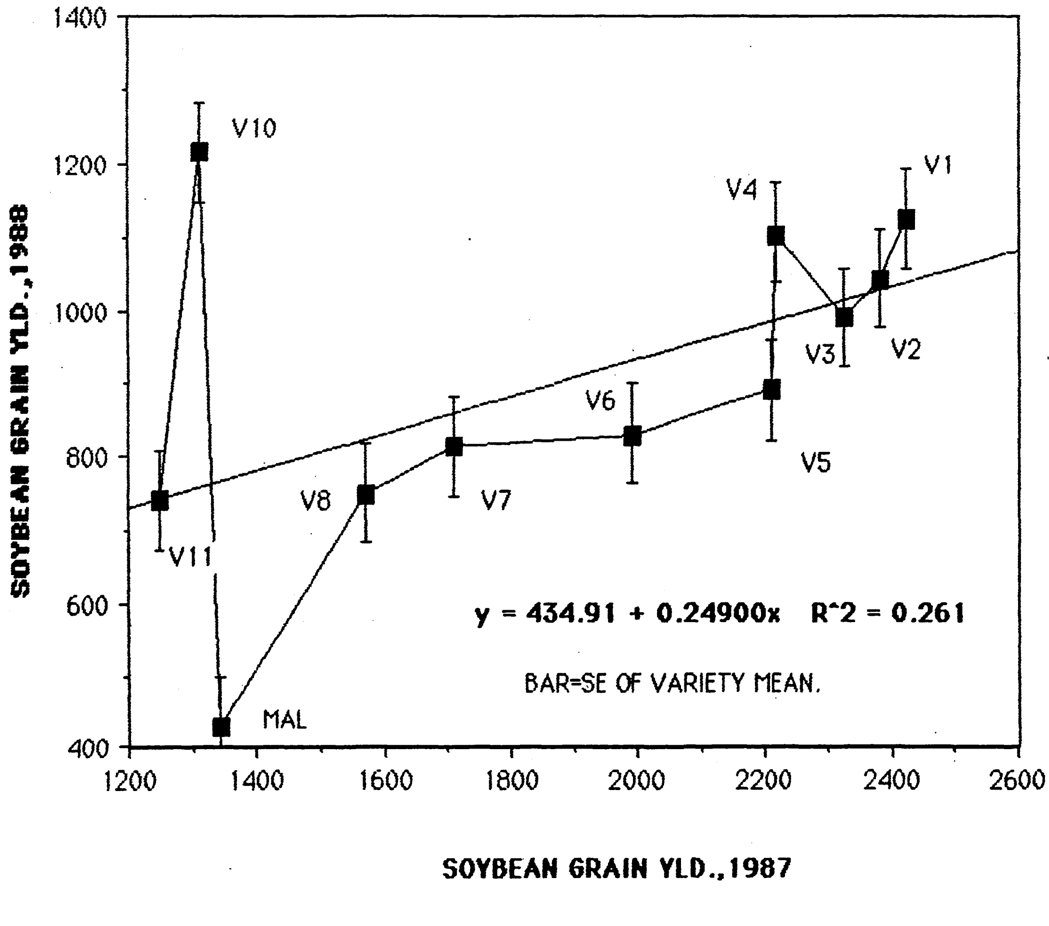
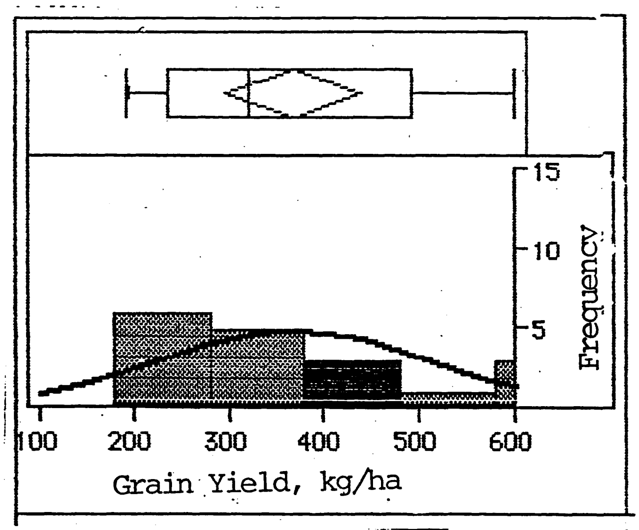


Figure 4: Distribution of soybean grain yield in farmers' fields at Ohosu, Southern Nigeria



N = 18
Mean = 320 kg/ha
75% Quartile = 492.75 kg/ha
25% Quartile = 235.50 kg/ha
SE(+/-) = 34.29 kg/ha