# INTERCROPPING CASSAVA WITH GRAIN LEGUMES IN HUMID AFRICA 1. COWPEA YIELDS

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## ABSTRACT

Some grain legumes such as cowpeas and soybeans may be sources of supplementary protein for nutritionally deficient staples of subsistence farmers in the tropics. Results from twelve cowpea varieties evaluated for two years, with and without insect protection, in sole and intercropped systems with cassava, in a humid tropical zone of Nigeria, showed a wide range of responses to the treatment factors and to year of cropping. The three-factor interaction differences, particularly during the relatively drier second year with high insect attacks, were better expressed by log transformation of the yield data. Yield extremes were observed for any given variety depending upon the specific environment considered and therefore generalizations were difficult to make. Nevertheless, the three varieties which produced the highest yields in both cropping systems were identified for further on-farm research evaluation. It was also shown that within the twelve cowpea varieties, those selected for high grain yield in sole crop systems correlated closely with their yields in intercrop systems. Soil fertility indices after two years were better in the cassava + cowpea intercrop than in sole cowpea. This may be useful in sustaining the cassava production.

*Key Words and Phrases*: Intercrop system, Insect protection, Soil fertility indices, Subsistence farmers, Supplementary protein.

## INTRODUCTION

Symptoms of malnutrition among farmers who grow and consume cassava are common in Southern Nigeria. In addition to symptoms of skin rashes, oedema, some nervous diseases, and

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kwashiorkor, infant mortality is usually high (Osuntokun *et al.*, 1969; Oke, 1983; Nweke *et al.*, 1988; Nnayelugo *et al.*, 1988; Ikpi *et al.*, 1986). The problem is very serious during the "hungry" dry season, i.e., December to March. By April, when the early rains have resulted in growth of a new flush of vegetables, the malnutrition symptoms virtually disappear until the next dry season. A component of a larger project started by the International Institute of Tropical Agriculture (IITA) in 1987 was to identify suitable protein-rich crops for incorporation into the cassava-based farming systems common in Southern Nigeria. The legumes selected for study were cowpea and soybeans.

Report of a diagnostic survey referred to earlier (Nweke *et al.*, 1988), show that though cowpea was not grown in certain areas of Southern Nigeria, the inhabitants spend a lot of money purchasing dry cowpea grains. Sixty-five Naira is expended per month for a family of six. An important but relatively unknown legume in Africa is soybean. Acid-soil tolerant varieties are required. In 1987, a range of cowpea and soybean varieties were introduced for screening under intercropping systems at a pilot site in a typical, humid, tropical area of Southern Nigeria. A report of the cowpea varietal trial results is given in this paper. A second report on this intercropping experiment will deal with cassava results and combined cowpea and cassava total returns from the cropping systems. A third report in the series will deal with the soybean results from the same site.

## SITE DESCRIPTION

The site lies 6°25' N latitude and 5°30' E longitude within a tropical rainfall vegetation zone of Southern Nigeria. The mean annual rainfall is about 2000 mm and the soil type is acid sand. This soil is in the tropical ultisol classification. It is classified as being highly leached and has acidic subsoil reaction, although the top soil may not be acidic, especially if the organic matter content is high. At the time of plot establishment for this experiment in 1987, the 0–15 cm layer soil data, pH, organic carbon, N, Bray-1P and exchangeable K and Ca were taken (Table 1).

The main feature of the cropping pattern in the area was multiple cropping, i.e., intercropping and sequential cropping with cassava as the main crop. Improved cassava, TMS 30572, developed by IITA, was extensively adopted, occupying an estimated 80% of the cassava fields within about a 10 km radius but reducing to less than 10%, 25 km, from the experimental site. The improved cassava yielded 75% higher than a popular local (Nweke *et al.*, 1988).

The objectives of the experiments were to determine the performance of cowpea and soybean under an intercropping system with TMS 30572 cassava and to observe their potential as a source of supplementary protein needed in the diet with cassava-based farming in humid West Africa, represented by Ohosu in Southern Nigeria.

## METHODOLOGY

In August 1987, a cassava (var. TMS 30572), and a cowpea intercropping experiment were initiated at the site already described in Southern Nigeria. Twelve cowpea varieties were established in a split-split plot design. (See Table 4 for exact identity of the cowpea varieties. The codes $V_1$–$V_{12}$ are retained throughout this paper.) Insect protection and non-protection by spraying with insecticides to control pre- and post-flowering cowpea insect pests was the main plot treatment. A cropping system of sole cowpea and intercropping with cassava was the split plot treatment. The twelve cowpea varieties, which included a local check, Akidi, and eleven improved varieties selected for their good yield and cooking quality characteristics, were the split-split plot treatment. The experiment was repeated in 1988 on the same site, using the same randomization. The 1987 planting was on 7-8 August, while the 1988 plots were planted between 17 and 19 August. Weed control was by hoe weeding whenever necessary to maintain weed-free plots.

The cowpea was established as an interrow crop between the cassava rows. Cassava spacing was 1 m × 1 m and cowpea spacing was 1 m × 0.20 m, with one cowpea plant per hill for 50,000 plants per hectare. Five cowpea rows and six cassava rows, 7 meters long, were planted per plot. Sole cowpea population was also 50,000 plants per hectare in identical spatial arrangements as the intercrop. Spraying to control cowpea pests was done three times: once with neuvacron at 2 liters per hectare to control preflowering and flowering insects, two sprayings were applied with Sherpa Plus (0.5ℓ/ha.) to control all postflowering insects (Jackai, 1984). Cowpea grain and cassava root and shoot yields were recorded in 1987 and 1988. Additional cassava yield parameters (plants per hectare, root number, and shoot weight, i.e., stem plus leaves at harvest) were obtained in 1988. The cowpea yield data were studied for potential groupings of varieties based on similarity of yield response.

## RESULTS AND DISCUSSION

***Rainfall.*** Monthly rainfall distribution during the two years approximated the 43-year mean (Fig. 1). However, rainfall started later (by one month) in 1988 and by almost four months in 1987. Early cut-off of rain was observed in 1988 compared with the 43-year mean [Nigerian Institute for Oil Palm Research (NIFOR), Benin] and with 1987. July rain for 1987 was exceptionally high and almost double normal values for that month. This pushed the 1987 rains to high levels in spite of the delay in their inception.

***Soil.*** Contrary to expectation, the soil at the experimental site was not acidic (pH over 6.0) and little increase in acidity was observed after two years of cropping (Table 1). In the intercropped plots of cassava with cowpeas, a large decrease, 69%, in exchangeable K from 1987 to 1989 was observed. One explanation for this is the high uptake of K by cassava. Moderate decreases in N and P from 1987 to 1989 were observed. There were small decreases in soil organic C, pH and exchangeable Ca (Table 1, Fig. 2). Relatively little change in organic carbon and percent N in the cassava + cowpea system can be explained by large quantities of cassava leaves shed by the sprayed plots. This point will be discussed in the second report in this series. A further explanation is related to nitrogen fixation by cowpea (IITA, 1975; Okigbo, 1976). Virtually all the soil fertility indices measured after two cropping years, except K, were lower (reduced more) in the sole cowpea crop than in the cassava + cowpea system (Fig. 2).

***Statistical Analysis of Cowpea Grain Yields (kilograms/hectare).*** As described previously, the experiment design was a split-split plot with spraying as the whole plot, cropping system as the split plot, and cowpea variety as the split-split plot treatments. It was conducted over two years at the same site and arrangement. Analysis of variance by years are given in Table 2. In addition to the large spray, systems and varieties effects in 1987 and 1988, a three-factor interaction of variety by system by spray appears to be present. In addition, a variety by spray interaction system and spray main effects were relatively large. Note that there was a serious insect problem in 1988 but that was not much of a problem in 1987.

Since the order of errors (b) and (c) are the reverse of expectation, especially in 1987, and error (b) was much smaller than error (c) in both years (Table 2), an inappropriate model is suspected. A logarithmic transformation of cowpea grain yields was made and analyses of variance were performed. In 1987, although error (c) was reduced relative to errors (b), error (b) was still the smallest in both years. This was attributed to sampling vagaries since error (b) is associated with only four degrees of freedom. The size of the F values for varieties and for the three-factor interaction increased in both years. Note that a logarithmic transformation decreases or removes a particular type of interaction effect such as was present in the variety by spray interaction.

Since a three-factor interaction was present, varietal recommendations would need to be made for each system-spray combination. Also, the two years were quite different with respect to insect attack (not shown here) and moisture. Hence, separate analysis of yields and log yields were made. These are presented in Table 3. The first item of note is that the mean squares for residuals for sole cowpeas are approximately twice those for intercrop mean squares in 1987 and almost three times in 1988. When log yields are used, the problems of heterogeneous residual mean squares remains, even though a logarithmic transformation is sometimes stated to be a "variance stabilizing transformation".

The F ratios for variety to residual mean squares exceeds the tabulated F value at the five percent point in all eight cases when log yields are used. Note that the transformation makes the F values larger in all cases. Since there can be little doubt of varietal differences, our attention focuses on the varietal means in Table 4.

***Yield Responses.*** In 1987, spraying for insect protection resulted in 11.6% increase (910.3 from 815.6 kg/ha) of sole cowpea grain yield. This was not significant, but in 1988 when insect pressure was high, spraying increased sole cropped cowpea grain yield by 64% (517.5 from 315.2 kg/ha) (Table 3). Differences between sprayed and unsprayed intercrop grain yields were quite small in 1987 (2.3%) but significant in 1988 (33%). This suggests that intercropping with cassava contributed to a reduction of insect pest attack of cowpea in 1988, since cowpea insect data was not recorded from the fields in 1987.

This argument derives from the fact that in 1988, spraying resulted in 64% increase in grain yield of sole cowpea, a value which was halved to 33% in intercropped cowpea yield (Table 4).

Mean cowpea grain yield is reduced by intercropping with cassava (from 867 to 568 in 1987 and from 416.4 to 260.3 in 1988), as shown in Tables 3 and 4. However, varietal differences observed in this trial suggest that some varieties may be so compatible in intercropping system with cassava that grain yield may increase, for example in 1987, unsprayed IT83-328-1 ($V_6$) and unsprayed IT83D-340-5 ($V_{12}$) (Table 4). Some other varieties with higher yields in unsprayed, intercropped or sprayed intercropped systems can also be identified in Table 4.

For ease of varietal comparison, the sole sprayed cowpea grain yields were ranked from the lowest yielding ($V_9$) to the highest ($V_{12}$) for the 1987 sole crop, sprayed treatment (Table 4). With this as a baseline, all the other varieties across the two years for all the treatment combinations were compared for cowpea grain yield (Figs. 3a,b). Obviously the different varieties were affected differently by the various treatment combinations (Fig. 3). The local variety ($V_9$) responded to neither spraying nor to cropping system. It produced the lowest mean grain yield, and spraying appears to reduce the grain yield in 1987 (Fig. 3a). A similar yield reduction was obtained for $V_2$ and $V_3$ in 1987. Generally in 1988, spraying for insect protection increased grain yields of all the cowpea varieties but $V_8$, especially as a sole crop (Fig. 3b). The 1988 response to insect protection is expected since attack was serious that year. In fact no cowpea insects were recovered from the fields in 1987 (IITA, 1987), a result attributed to nonintroduction of cowpeas into the experimental area for decades (Nweke *et al*, 1988). Further yield variations due to the treatments were exhibited by $V_5$, $V_3$, $V_7$, $V_8$ and $V_{10}$, whose grain yields when sprayed for insect-protected sole crop in 1987 appear not to differ much from unsprayed (Fig. 3a). Reduction in grain yield due to nonspraying was not only limited to the good year with respect to rainfall (1987), but also was observed for $V_8$ in 1988.

Since the observations of the yield fluctuations (Fig. 3) did not give a clear picture of the varietal yield responses to spray and cropping systems, their two-factor interaction contrasts (Table 5), and log of the same data set, were calculated from $\mu_{11}-\mu_{12}-(\mu_{21}-\mu_{22})$. The values used are shown in Table 5. This result of the interactions are calculated as presented in Table 5. Note the highly significant deviation from the zero interaction line of most of the cowpea varieties in 1987 (Fig. 4a). The contrast yield values for five cowpea varieties in 1987 ($V_1$, $V_2$, $V_6$, $V_{11}$ and $V_{12}$), were greater than $\pm 429$ (LSD, $p = 0.05$). Those of $V_2$, $V_6$ and $V_{12}$ were highly significant (LSD $0.01 = 558$). In 1988, five varieties ($V_3$, $V_4$, $V_7$, $V_{11}$ and $V_{12}$) deviated significantly from the zero interaction line (Fig. 4a).

Log transformation of the data brought out the significance of the three-factor interaction much better than untransformed yields, especially in 1988 (Tables 2 and 4). It also resulted in a redistribution of the data about the zero interaction line (Fig. 4b). Highly significant deviations from the zero interaction line were thus observed for $V_9$ and $V_4$ in 1988; and for $V_2$ and $V_{12}$ in 1987 (Fig. 4b). The significant spray by cropping system by variety interaction observed when the 1988 data was transformed can thus be explained by the strong deviations from the zero interaction line by $V_9$ and $V_4$, which were also the lower yielding varieties.

Further examination of the four-factor interaction of year (1987 and 1988 grain yields) by spray by cropping system by cowpea variety (Fig. 4) shows that in both years $V_1$, $V_2$, $V_4$, $V_6$, $V_{11}$ and $V_{12}$ yielded very high under some environments and very low in some, causing extreme contrasts (pooled LSD $0.01 = 366$). It is also noted that some varieties such as $V_6$ and $V_{12}$, although producing very high and very low yields relatively depending upon treatment environment of growth, also yielded higher than some more stable varities in absolute terms. Some examples are $V_9$ and $V_5$ with little deviations from the zero interaction line (Fig. 4a) but low yielding in absolute terms. Others, for example $V_{11}$ (1321 kg/ha sprayed sole in 1987 but only 193 kg/ha in unsprayed sole in 1988), are in Table 4. One can, therefore, observe that many conclusions can be drawn depending upon treatment and year of growth of these cowpea varieties. However, certain varieties do show some general trends. Varieties $V_3$, $V_6$ and $V_{12}$ appear to be superior to all the others in both sole and intercropped systems with cassava. The high relationship of all these varieties in the two cropping systems, $R^2 = 0.769$, seem to suggest that within the twelve cowpea variety range, those selected for high grain yield as intercrops also yield highly as sole crops and vice versa (Fig. 5). The same relationships were reanalyzed for the relatively good year (1987) and the bad year (1988). The three cowpea varieties $V_3$, $V_6$ and $V_{12}$ retained their top performance position. The $R^2$ were 0.713 in 1987 and 0.785 in 1988.

Soil fertility indices measured showed more reduction for all indices after two years of cropping (pH, organic carbon, percent N, P and Ca) but one (K), under sole cowpea than in intercropping with cassava. Little organic carbon was observed in sole cowpea, a result attributable to low generation of organic matter by cowpea. Soils cropped intensively with cassava may be deficient in K, an element removed in large amounts (Cheng, 1980; Obigbessan, 1979). The soil analysis result also confirms some soil-improvement effects attributed to intercropping compared with monocropping (Aina *et al.*, 1978).

## SUMMARY AND CONCLUSIONS

Yield extremes of the cowpea varieties were observed due to the spray, cropping system and year effects and through log transformation, the three-factor interaction effects were expressed better. It also appears that cowpea varieties selected in the sole crop system performed similarly as intercrops, at least within the twelve-variety range. Three varieties, $V_3$, $V_6$ and $V_{12}$, were particularly good over a wider range of environments than others and are suggested for further on-farm testing. One variety, $V_{11}$, could be evaluated further in a specific environment, i.e., a sole cropped, unsprayed environment. Soil fertility indices measured in a cowpea + cassava intercropping experiment showed reduction of most elements in the sole crop system after two years of cropping except K, which is known to be extracted in large amounts by cassava. K deficiency of soils cropped extensively with cassava has been noted by Chan, 1980 and Obigbessan, 1977. Soil fertility differences of the two cropping systems may be attributed to indirect effects, e.g., higher vegetative soil cover in the intercropped system (Aine *et al.*, 1978).

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Table 1. Some chemical composition (0–10 cm layer) of the cowpea experimental site.

| Soil Characteristics | Plot Average at Inception (1987) | Sole Cowpea Plot Average (1989) | % Reduction | Intercropped Plot Average (1989) | % Reduction |
|---|---|---|---|---|---|
| pH | 6.40 | 6.11 | – 4.7 | 5.91 | – 8.3 |
| Org. C(%) | 1.89 | 1.79 | – 7.4 | 1.08 | –75.0 |
| ppm P(Bray-1) | 11.32 | 9.55 | –18.5 | 9.05 | –25.1 |
| Exch K(me $100g^{-1}$) | 0.44 | 0.26 | –69.2 | 0.33 | –33.3 |
| Exch Ca(me $100g^{-1}$) | 14.31 | 13.15 | – 8.8 | 10.04 | –42.5 |

Table 2. Analyses of variance of cowpea grain yield in Southern Nigeria.

| Source | df | 1987 yield Mean square | 1987 yield F | log (yield) 1987 Mean square | log (yield) 1987 F |
|---|---|---|---|---|---|
| Block | 2 | 23,672 | | 0.0251 | |
| Spray (Spr) | 1 | 104,060 | 0.88 | 0.3443 | 0.62 |
| Error(a) | 2 | 117,972 | | 0.5559 | |
| System (Sys) | 1 | 3,130,246 | 119.75*** | 6.4669 | 101.70*** |
| System × spray | 1 | 60,393 | 2.31 | 0.0509 | 0.80 |
| Error(b) | 4 | 26,139 | | 0.0636 | |
| Variety | 11 | 586,642 | 7.54** | 3.1386 | 14.45** |
| Var × sys | 11 | 75,346 | 0.97 | 0.1709 | 0.79 |
| Var × spray | 11 | 75,379 | 0.97 | 0.2208 | 1.02 |
| Var × sys × spr | 11 | 222,785 | 2.86* | 0.6386 | 2.94* |
| Error(c) | 88 | 77,780 | | 0.2172 | |

| Source | df | 1988 yield Mean square | 1988 yield F | log (yield) 1988 Mean square | log (yield) 1988 F |
|---|---|---|---|---|---|
| Block | 2 | 186,518 | | 3.9723 | |
| Spray | 1 | 686,965 | 7.34 | 12.5372 | 4.37 |
| Error(a) | 2 | 93,624 | | 2.8718 | |
| System | 1 | 877,032 | 39.05** | 8.5401 | 32.38** |
| System × spray | 1 | 148,482 | 6.61* | 0.0996 | 0.38 |
| Error(b) | 4 | 22,460 | | 0.2638 | |
| Variety | 11 | 146,724 | 6.48** | 4.0294 | 9.99** |
| Var × sys | 11 | 16,052 | 0.71 | 0.4307 | 1.07 |
| Var × spray | 11 | 47,238 | 2.09 | 0.5709 | 1.42 |
| Var × sys × spr | 11 | 41,288 | 1.82* | 1.0403 | 2.58* |
| Error(c) | 88 | 22,645 | | 0.4033 | |

Table 3. Analysis of variance of cowpea grain yield in kilograms/hectare by system and spray.

| Source | df | Mean square | F | CV | Mean square | F | CV |
|---|---|---|---|---|---|---|---|
| **1987 cowpea grain yield** | | | | | | | |
| | | sole-sprayed | | | log (sole-sprayed) | | |
| Block | 2 | 25,860 | 0.32 | | 0.0354 | 0.25 | |
| Variety | 11 | 439,123 | 5.47 | | 1.5129 | 10.58 | |
| Residual | 22 | 80,261 | | 31.1% | 0.1429 | | 5.7% |
| Mean | | 910.3 | | | | | |
| | | sole-unsprayed | | | log (sole-unsprayed) | | |
| Block | 2 | 18,274 | 0.14 | | 0.0974 | 0.53 | |
| Variety | 11 | 243,546 | 1.90 | | 0.7504 | 4.12 | |
| Residual | 22 | 128,388 | | 43.9% | 0.1824 | | 6.5% |
| Mean | | 815.6 | | | | | |
| | | inter-sprayed | | | log (inter-sprayed) | | |
| Block | 2 | 112,689 | 2.13 | | 0.3603 | 2.30 | |
| Variety | 11 | 106,105 | 2.00 | | 0.4792 | 3.07 | |
| Residual | 22 | 52,939 | | 40.1% | 0.1563 | | 6.3% |
| Mean | | 574.4 | | | | | |
| | | inter-unsprayed | | | log (inter-unsprayed) | | |
| Block | 2 | 37,050 | 0.75 | | 0.2151 | 0.56 | |
| Variety | 11 | 171,379 | 3.46 | | 1.4265 | 3.68 | |
| Residual | 22 | 49,531 | | 39.6% | 0.3871 | | 10.2% |
| Mean | | 574.4 | | | | | |
| **1988 cowpea grain yield** | | | | | | | |
| | | sole-sprayed | | | log (sole-sprayed) | | |
| Block | 2 | 46,085 | 1.28 | | 0.1042 | 0.27 | |
| Variety | 11 | 136,983 | 3.81 | | 1.5935 | 4.10 | |
| Residual | 22 | 35,936 | | 36.6% | 0.3815 | | 10.3% |
| Mean | | 517.5 | | | | | |
| | | sole-unsprayed | | | log (sole-unsprayed) | | |
| Block | 2 | 148,840 | 5.19 | | 2.4895 | 5.43 | |
| Variety | 11 | 43,505 | 1.52 | | 1.0954 | 2.39 | |
| Residual | 22 | 28,695 | | 53.7% | 0.4587 | | 12.4% |
| Mean | | 315.2 | | | | | |
| | | inter-sprayed | | | log (inter-sprayed) | | |
| Block | 2 | 127 | 0.01 | | 0.0106 | 0.07 | |
| Variety | 11 | 30,532 | 2.36 | | 0.6096 | 3.74 | |
| Residual | 22 | 12,963 | | 38.3% | 0.1628 | | 7.2% |
| Mean | | 297.2 | | | | | |
| | | inter-unsprayed | | | log (inter-unsprayed) | | |
| Block | 2 | 130,013 | 10.01 | | 4.7672 | 7.81 | |
| Variety | 11 | 40,282 | 3.10 | | 2.7727 | 4.55 | |
| Residual | 22 | 12,985 | | 51.0% | 0.6100 | | 15.8% |
| Mean | | 223.3 | | | | | |

Table 4. Cowpea variety grain yields in response to spraying and intercropping in a humid zone of Southern Nigeria.

| Cowpea Variety | 1987 | | | | 1988 | | | |
|---|---|---|---|---|---|---|---|---|
| | Sprayed | | Unsprayed | | Sprayed | | Unsprayed | |
| | Sole $\mu_{11}$ | Intercrop $\mu_{12}$ | Sole $\mu_{21}$ | Intercrop $\mu_{22}$ | Sole $\mu_{11}$ | Intercrop $\mu_{12}$ | Sole $\mu_{21}$ | Intercrop $\mu_{22}$ |
| $V_9$ AKIDI | 157 | 193 | 192 | 92 | 76 | 102 | 195 | 17 |
| $V_2$ IT84E-1-108 | 245 | 555 | 740 | 435 | 299 | 128 | 196 | 71 |
| $V_{11}$ IT84D-449 | 790 | 675 | 1321 | 768 | 633 | 282 | 193 | 218 |
| $V_5$ IT85F-1517 | 859 | 412 | 693 | 390 | 647 | 384 | 414 | 182 |
| $V_3$ IT83D-442 | 948 | 521 | 1108 | 659 | 754 | 444 | 351 | 379 |
| $V_7$ IT84S-2246-4 | 960 | 874 | 845 | 505 | 731 | 338 | 237 | 188 |
| $V_8$ IT82D-889 | 971 | 423 | 835 | 649 | 187 | 310 | 433 | 286 |
| $V_{10}$ IT84D-666 | 1001 | 732 | 1080 | 411 | 532 | 323 | 389 | 140 |
| $V_4$ IT84S-2163 | 1066 | 620 | 724 | 672 | 548 | 231 | 108 | 254 |
| $V_1$ IT84E-124 | 1110 | 579 | 584 | 545 | 669 | 365 | 417 | 209 |
| $V_6$ IT83-328-1 | 1350 | 815 | 896 | 964 | 462 | 363 | 457 | 353 |
| $V_{12}$ IT83D-340-5 | 1467 | 497 | 768 | 935 | 622 | 296 | 391 | 384 |
| SE | 231.3 | 187.9 | 292.6 | 181.7 | 154.8 | 93.0 | 138.3 | 93.0 |
| Mean | 910.3 | 574.4 | 815.6 | 574.4 | 517.5 | 297.2 | 315.2 | 223.3 |

Table 5. Cropping system (sys) by spray (spr) interaction contrasts for each of the varieties for each year. Log transformed and untransformed in 1987 and 1988.

| Cowpea Variety | Spr × Sys 1987 | Spr × Sys 1988 | Log Spr × Sys 1987 | Log Spr × Sys 1988 |
|---|---|---|---|---|
| $V_9$ | −137.0 | −204.0 | −1.200 | −2.724 |
| $V_2$ | −615.0 | 46.0 | −1.616 | −0.338 |
| $V_{11}$ | −438.0 | 376.0 | −0.809 | 0.199 |
| $V_5$ | 144.0 | 31.0 | 0.075 | −0.580 |
| $V_3$ | 22.0 | 338.0 | 0.062 | 0.667 |
| $V_7$ | −254.0 | 344.0 | −0.380 | 0.538 |
| $V_8$ | 362.0 | −270.0 | 0.709 | −1.097 |
| $V_{10}$ | −400.0 | − 40.0 | −0.969 | −0.467 |
| $V_4$ | 394.0 | 463.0 | 0.722 | 2.096 |
| $V_1$ | 492.0 | 96.0 | 0.492 | −0.078 |
| $V_6$ | 603.0 | 99.0 | 0.582 | −0.386 |
| $V_{12}$ | 1137.0 | 326.0 | 1.426 | 0.889 |

| | 1987 | 1988 | (1987 + 1988) | 1987 | 1988 | (1987 + 1988) |
|---|---|---|---|---|---|---|
| ± LSD*0.05 | 429 | 247 | 302 | 0.7318 | 1.0915 | 0.8014 |
| 0.01 | 558 | 321 | 366 | 0.9486 | 1.4207 | 0.9737 |
| F.df | (11,88) | | (22,176) | (11,88) | | (22,176) |

* The 1987 and 1988 least significant differences are from the three-factor interaction of the AOV shown in Table 2 with f, df of 11,88. The pooled LSD for 1987 and 1988, f, df, 22,176, are also shown.

## List of Tables and Figures


| | |
|---|---|
| Table 1 | Some chemical composition (0-10 cm layer) of the cowpea experimental site. |
| Table 2 | Analyses of variance of cowpea grain yield in Southern Nigeria. |
| Table 3 | Analyses of variance of cowpea grain yield in kilograms/hectare by system and spray. |
| Table 4 | Cowpea variety grain yields in response to spraying and intercropping in a humid zone of Southern Nigeria. |
| Table 5 | Cropping system (sys) by spray (spr) interaction contrasts for each of the varieties for each year. Log transformed and untransformed in 1987 and 1988. |
| Fig. 1 | Mean 1987 and 1988 rainfall compared with 42-year monthly mean in Ohosu. |
| Fig. 2 | Percent reduction of soil fertility indices after two years of cropping. |
| Fig. 3a | Spraying and cropping system effects on grain yield of cowpea varieties, 1987. |
| Fig. 3b | Spraying and cropping system effects on grain yield of cowpea varieties, 1988. |
| Fig. 4a | Interaction cowpea variety by spray by cropping system on grain yield. |
| Fig. 4b | Interaction log yield, cowpea variety by spray by cropping system. |

FIG.1 MEAN 1987& 1988 RAINFALL COMPARED WITH 42 YR. MONTHLY MEAN IN OHOSU.

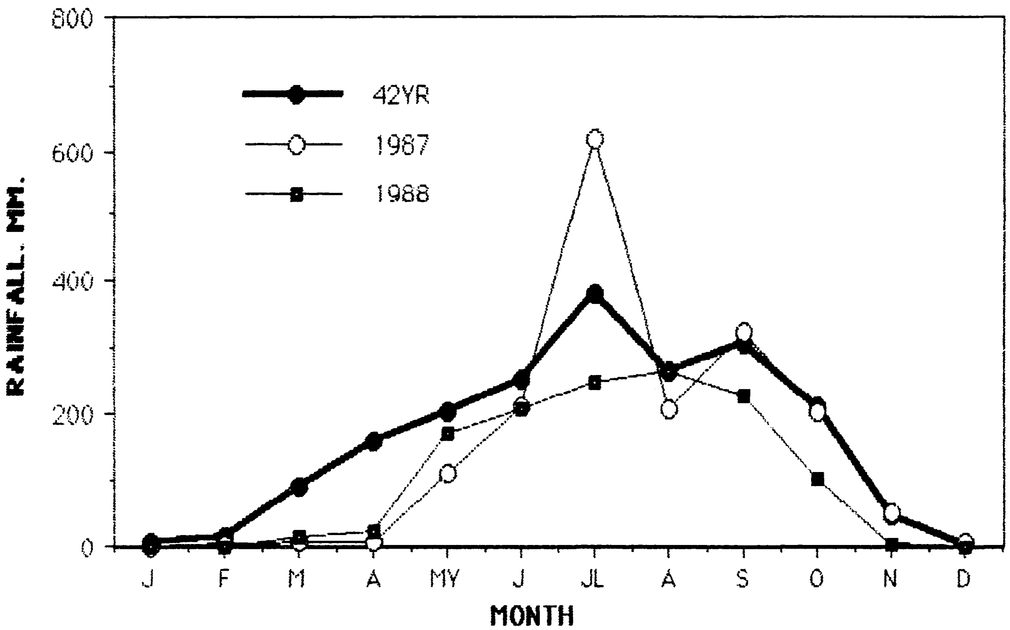

FIG.2. PERCENT REDUCTION OF SOIL FERTILITY INDICES AFTER TWO YRS. OF CROPPING.

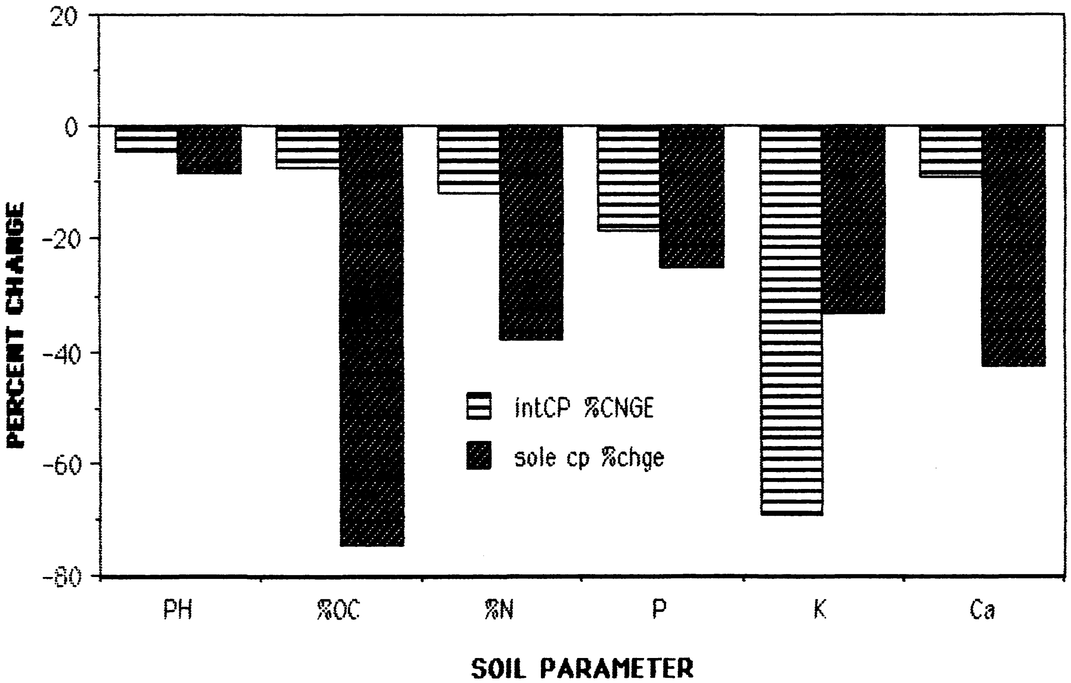

FIG. 3a SPRAYING AND CROPPING SYSTEM EFFECTS ON GRAIN YIELD OF COWPEA VARIETIES, 1987.

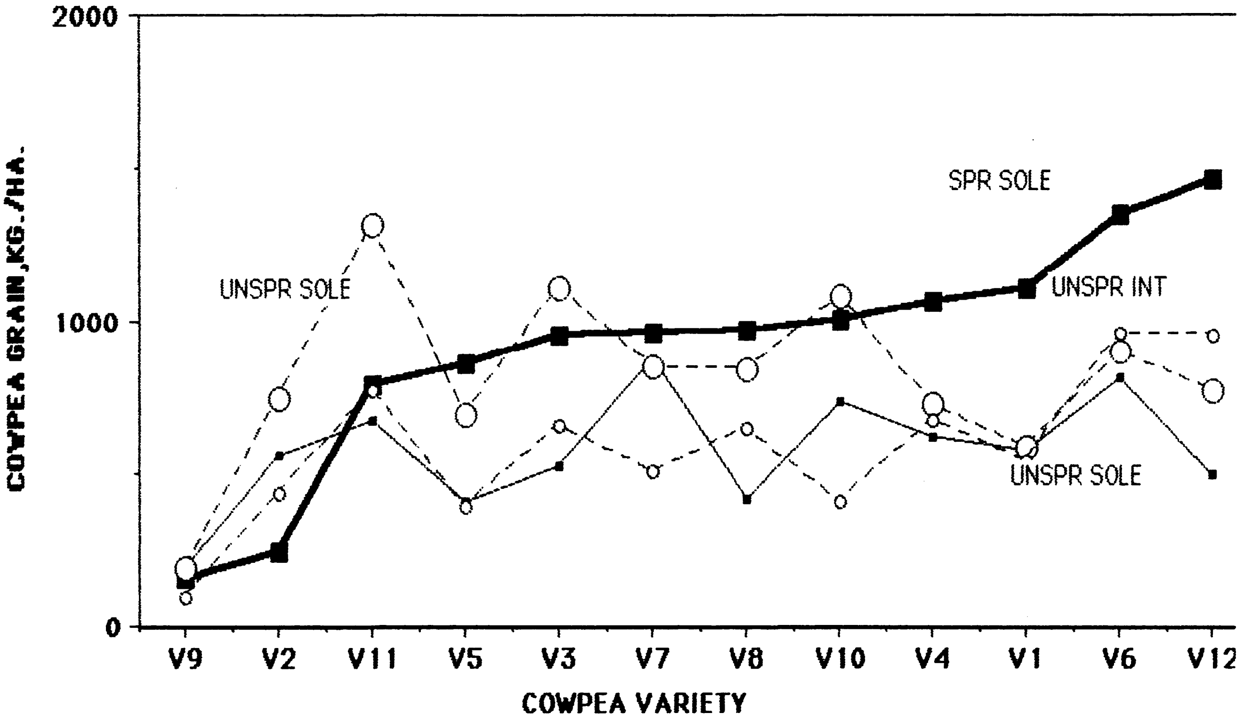

FIG.3b SPRAYING AND CROPPING SYSTEM EFFECTS ON GRAIN YIELD OF COWPEA VARIETIES,1988.

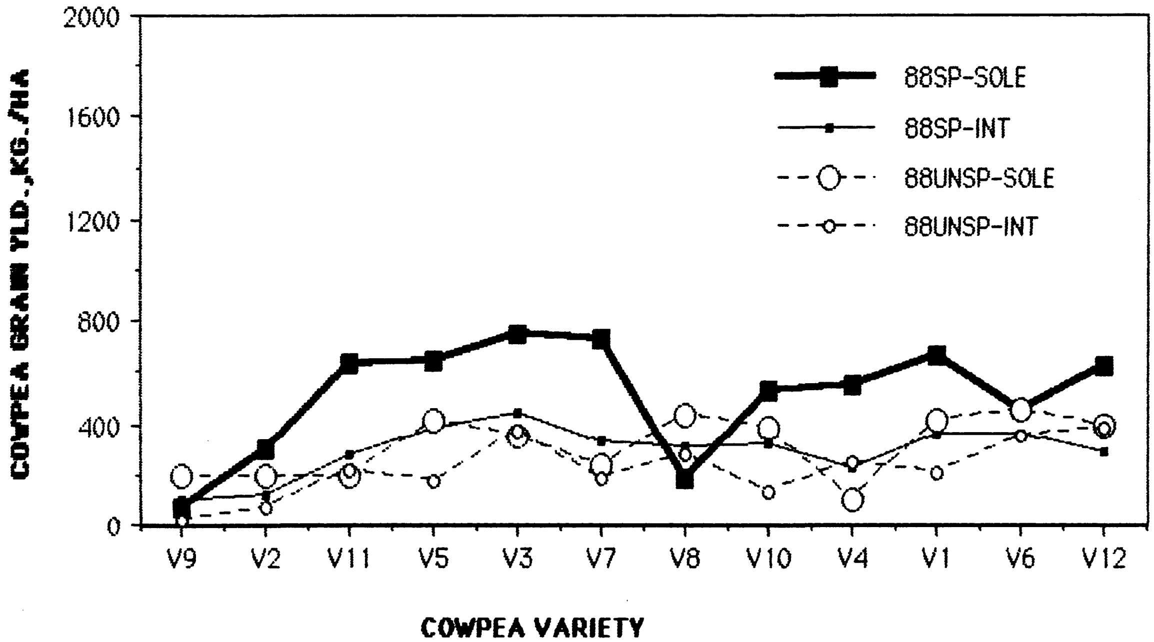

FIG.4aINTERACTION COWPEA VARIETY BY SPRAY BY CROPPING SYSTEM ON GRAIN YLD.

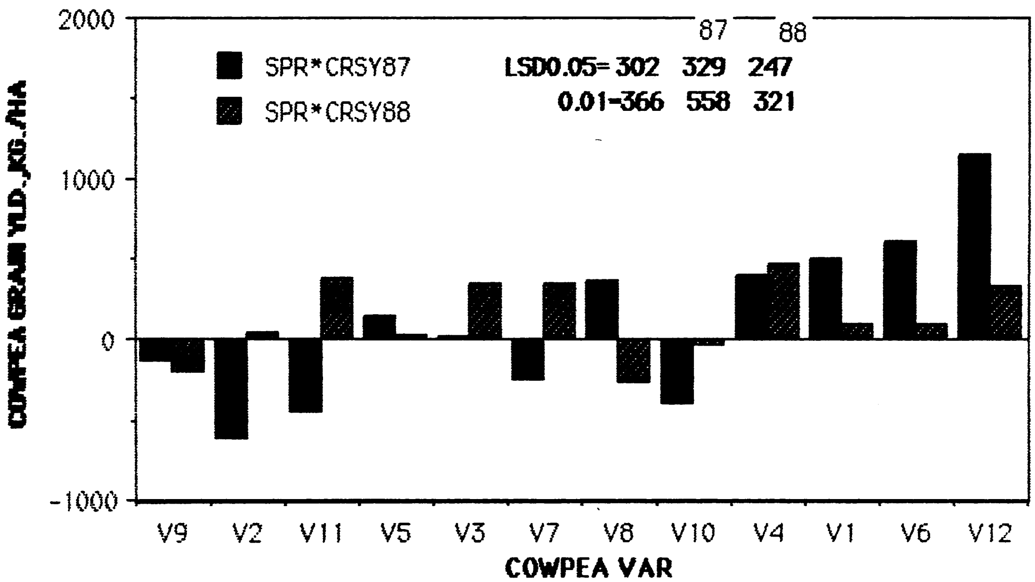

FIG.4b INTERACTION LOG. YIELD,COWPEA VARIETY BY SPRAY BY CROPPING SYSTEM

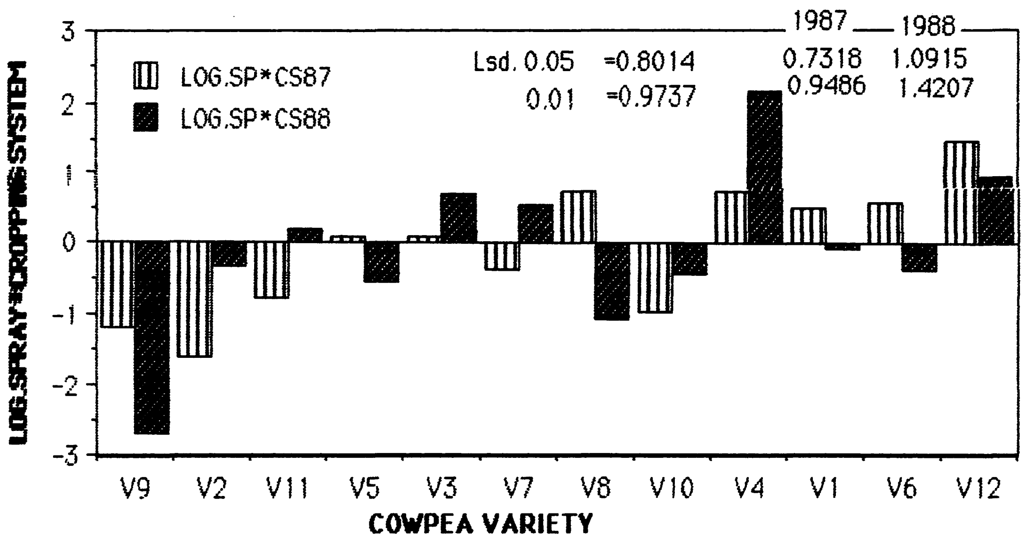

FIG.5 RELATIONSHIP OF SOLE AND INTERCROP COWPEA GRAIN YLDS., 2-YEAR MEANS.