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Zero — Tillage and Intercropping on a Tropical Alfisol II Responses of Intercropped Maize and Melon

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Abstract

Two years of no-tillage (NT) and conventional tillage (CT) affected the physical properties of an Alfisol in Western Niger. At 5% probability level, maize leaf area, plant height and root density were higher under CT than NT in the first year? Maize grain yield was considerably improved during the second year of the experiment under NT. Intercropping in both tillage treatments reduced the yield of melon but significantly improved maize yield. The advantage of high available soil water under NT was offset by poorer root development which resulted in lower but insignificant leaf water potential when compared with CT. It appears that for a good yield of intercropped maize with melon, reduced tillage which is CT with one of the operations of tillage omitted, may be necessary at the early stage of fallow soil cultivation.

Introduction:

Crops respond to changes in soil physical properties. The specific tillage practice employed influences these responses although the effects may be different in different soils and under different weather conditions (Allen *et al.*, 1975 Hayward *et al.*, 1980, and Osuji, 1984). A literature survey indicates that wither CT is superior to NT or that the two tillage treatments are equally effective and give similar yield (Olaniyan, 1983; Kang *et al.*, 1980) or that NT is even superior to CT (Lal, 1976). It is not possible to make a categorical statement on this as yields in CT have been found to be unstable and progressively decrease with time (Osuji, 1984). Therefore, a short term yield record may not be enough to measure the relative performance of the tillage systems.

Evidences abound that show the yield of crops under NT to be highly dependent on soil type. For example, in areas of high erodibility and rainfall erosivity such as humid tropics, soil erosion, accentuated by poor soil management practices such as indiscriminate tillage operations, could lead to a complete loss of the fertile top soil and render fertilizer application rather ineffective (Maurya and Lal, 1979). Under such condition, NT could produce higher yield than CT. Indiscriminate tillage could

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be particularly disastrous for crop production on the shallow stone line soils of West Africa derived from basement complex rocks. This potential problem can be curtailed by appropriate tillage and cropping methods. The dearth of knowledge in intercropping under different tillage practices emphasizes the need for researchers in the tropics to focus on this popular and profitable cropping method which in addition, fits well into the peasant farmers mode of farming.

The objective of this investigation therefore was to assess the effect of different tillage practises on growth, yield and plant water status of maize intercropped with melon under NT and CT in Western Nigeria.

Materials and Methods

The experiment was carried out at Ibadan (7.22°N, 3.58°E) in the Western part of Nigeria. Ibadan is located at the northern fringe of the rainforest zone with an annual rainfall of between 1000 and 1600mm and a bimodal distribution. The two growing seasons are from late March to late July and the shorter second season begins late August and ends in December. Prior to 1952, the land use and cropping history of the experiment site was known. The field was cleared in 1952 divided into contour strips and has been subjected to mechanical tillage for approximately 25 years. The land had been under fallow for about 6 years before this study. Two tillage treatments were imposed viz:

(a) Conventional Tillage (CT): The initial vegetation was slashed with a cutlass. A small tractor (15KW) was then used to plough the plots once to depth of approximately 0.2m each cropping season. This was followed by one harrowing to ensure good tilth and seedbed preparation.

(b) No-Tillage (NT): The existing vegetation was killed with gramoxone (1, 1, — dimethyl — 4, 4 bipyridinumion) at the rate of 2.5 litres per hectare (active ingredient 0.5kg/ha) applied one week before planting. A thin layer of mulch consisting largely of residue vegetation on the plots was used to completely cover the soil surface. After the first season, crop residues left after harvest combined with bush regrowth from each plot were used as mulch.

The crop treatments were as follows:

(i) Sole Maize (*Zea mays, L*) variety TZPB developed by IITA, Ibadan.

(ii) Sole Melon (*Colocynthis vulgaris*, L.) Local variety 'Egusi' melon which is a tiny creeping herbaceous plant that does not need heavy fertilization and offers complete ground cover very soon after emergence.

iii) Intercropped maize + melon.

(iv) Uncropped plots: To eliminate the effects of canopy cover and added fertilizers, no crop was grown on the plots after the imposition of the tillage treatments. This served as the control.

The design of the experiment was Randomised complete Block and the data was analysed as a two factor-factorial with cropping and tillage methods as the factors. There were three replications: The plot size was 5m x 5m with 2m spacing between the plots, located on a 3% slope. The soil is derived from fine grained biotite gneiss and schist parent material belonging to the Iwo series (Smyth and Montgomery, 1962). The chemical properties of the soil prior the experiment are shown in table 1. Planting was done manually. The sole maize and sole melon crops were planted at a spacing of 1m x 1m with two plants of each crop per hill. In the maize-, melon intercrop, maize was planted at the usual spacing of 1m x 1m with two plants per hill, hen 0.5m away from the maize stand in the same plot, melon was planted at the regular spacing of 1m x 1m with one melon per stand. The planting population in each plot was 20,000 plants per hectare in either sole maize or sole melon plot and 30,000 plants per hectare in the intercropped maize-melon plot. Planting was done twice a year during the two growing seasons.

NPK 15-15-15 fertilizer was applied at the rate of 200kg/ha two weeks after planting. The fertilizer was banded with a hoe in the CT treatments while it was surface applied in NT treatments and covered with residue mulch. At 6 weeks after planting, 50kg/ha of Urea was surface applied in all the planted plots. At 3 weeks after planting, weeding was largely carried out in the CT treatments using a hoe while weeds were hand-picked from the mulch-covered surface of no-tillage plots. At 6 weeks after planting, weeding was practically impossible in the treatments that incorporated melon because 'egusi' melon crop had completely covered the soil surface.

Starting from 3 weeks after planting, maize plant height was measured weekly from the ground level to the top of the upstreched flag leaf. Also, weekly determination of leaf area was done by measuring the length and the maximum width of every leaf on a plant. The entire leaf area thus obtained was adjusted by a shape factor of 0.75 (Ikeorgu, 1984). Maize leaf water potential monitored at the silking stage of maize using the pressure/chamber technique (Boyer, 1967). The flag leaf in maize and the young fully opened melon leaf which were fully exposed to sunlight were used for the determination. The readings were taken between 1200 - 1500 hours on sunny clear days. At the initiation of tasselling of maize, root samples were collected at 0.05m intervals to 0.3m depth using a soil core with an internal diameter of 0.065m. The cores containing roots were taken into laboratory and the roots were washed free of soil on a 1mm sieve. The root length values were obtained in the first season of each year only. Poor plant stand of melon during the second growing season of each year made it impossible to collect root samples. The root length density was determined as follows:

$$\text{Root length density} = \frac{\text{Root length}}{\text{Soil Volume}}$$

(a) Maize Yield: The plant population of each plot was counted at 120 days after planting. All the ears in each plot were used to estimate the yield Shelled and grain yield were determined at 12% moisture content.

(b) Melon Yield: The plant population of the melon was determined before the vines became dry. Fruits were collected from each plot at maturity. The number of fruits and their fresh weights were determined for all the plots. The fruits were then heaped together on each plot and broken by beating with a wooden club. The mixture was covered with refuse and left to rot for easy extraction of seeds. After 10 days, the seeds were extracted by hand and washed in a basket dipped in water. The bad seeds which normally floated were discarded. The good ones were dried and weighed. Representative samples of seeds were oven dried at 65°C for 72 hours to determine the oven-dry grain weight and then corrected to 9% moisture content.

Results and Discussion

Maize Growth

(i) Maize plant height: Plant height has been used by different workers as an indicator of overall plant development most especially maize growth (Fayemi, 1968). Maize growth as can be seen from Fig. 1 was affected by the rainfall distribution. For example, maize growth in the season of 1983 was generally less vigorous than in the other seasons of the experiment. This was probably due to a prolonged dry spell and an erratic rainfall pattern during this period. At the first planting (March 1983) NT maize was stunted and appeared chlorotic, but as the soil physical properties improved over the seasons, these symptoms disappeared and the plants assumed normal growth. In 1984, there was a decline in plant height of the maize crop under CT, while slight improvement was recorded for maize plant height under NT. This indicates the potential of the NT treatments to sustain and improve the growth of maize over time with continuous cropping. Intercropping did not significantly affect maize plant height. In some of the seasons, higher plant height of maize was recorded on the intercropped plot than the sole maize plot. This could possibly be due to an increase in soil water conservation and maximum utilization of soil nutrients resulting from reduced washing away of these nutrients by soil erosion in intercropped plots.

(ii) Maize leaf area: The leaf of the maize crop in both tillage treatments reached a maximum at about 9 weeks after planting and thereafter decreased (Fig. 2) In 1983, leaf area was significantly higher in CT than NT, the reverse was the case in 1984. This was attributed to higher soil moisture recorded in 1984. This implies that for the soil under study, the climatic elements rather than the tillage treatments played a more significant role in the leaf area growth of maize. The higher leaf area in 1983 of CT could be attributed to better soil physical environment and adequate moisture caused by the freshly tilled soil. However, when the rainfall was limited in amount and was poorly distributed as in the second season of 1983, the NT treatment with mulch cover was able to conserve

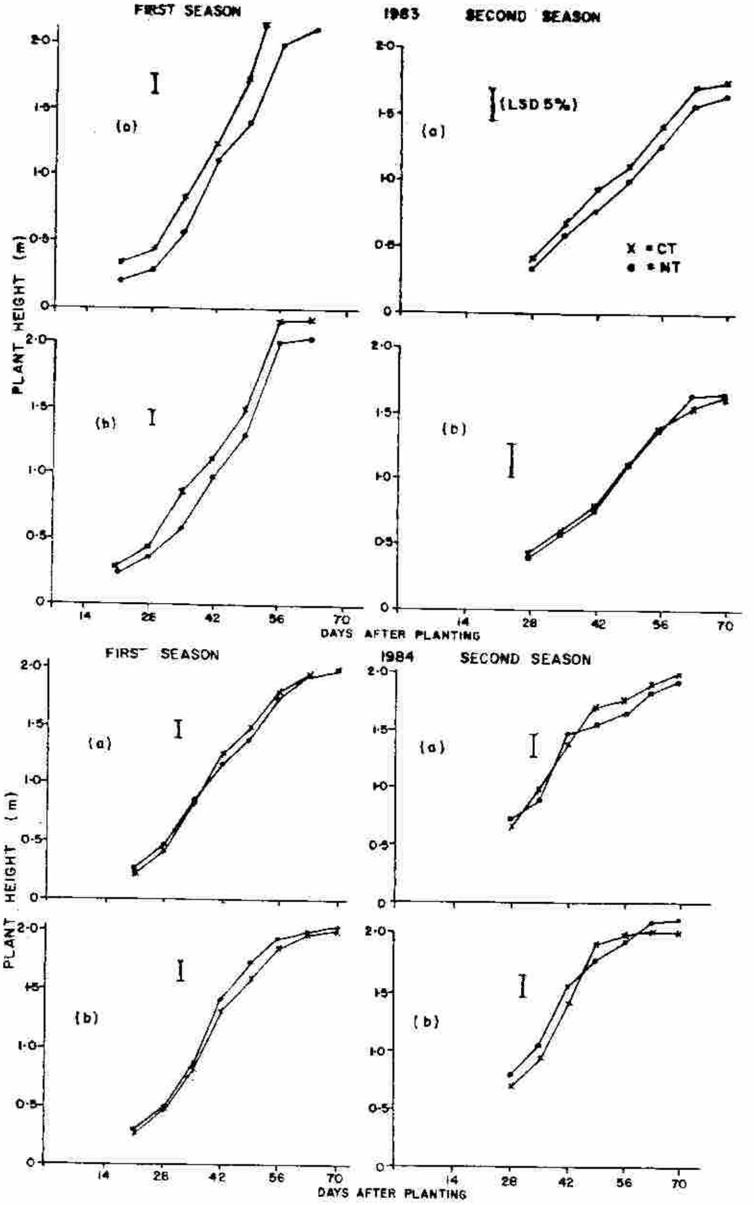

Fig. I

Changes in plant height over the growing period as affected by tillage method and the cropping system.

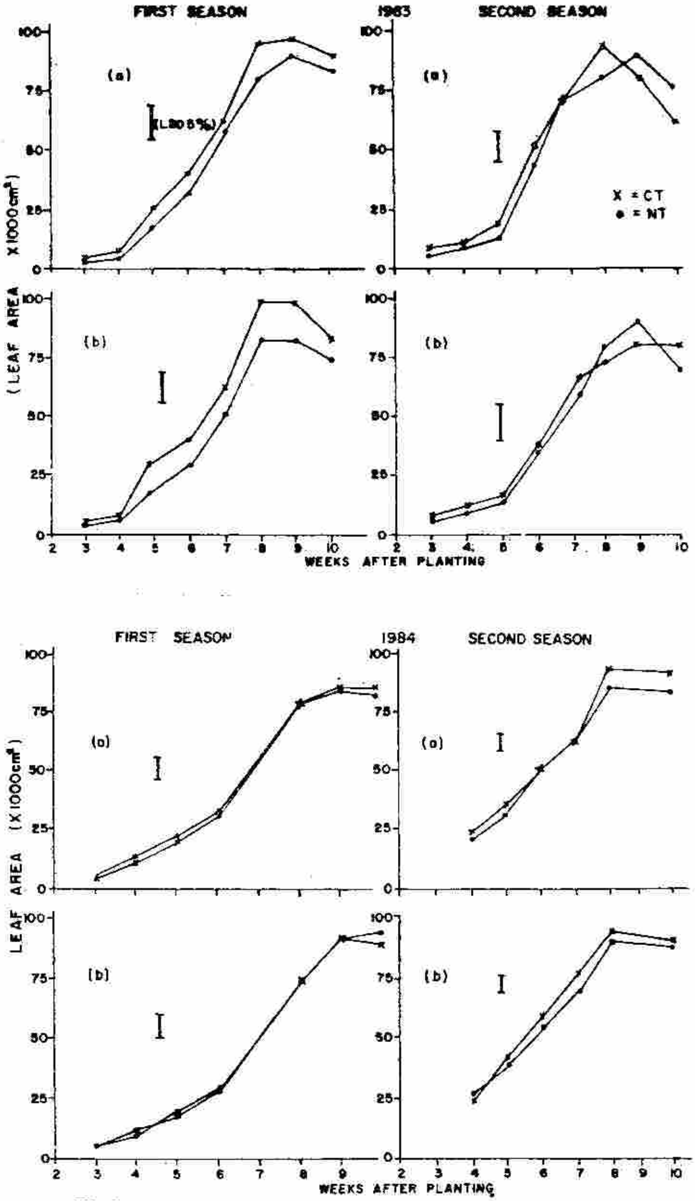

Fig. 2

Changes in leaf-area over growing period as influenced by tillage method and the cropping system.

moisture and produced significantly higher leaf area. It is significantly to note that the intercropped maize had greater leaf area than the sole maize of CT. Generally, the presence of melon in NT treatments led to reduce leaf area of maize but in this instance the leaf area of the intercropped maize in NT was comparable to that of sole maize and intercropped maize of CT. This shows that the melon crop did not adversely affect the leaf area growth of maize. Despite the lower leaf area of the intercropped maize of NT for all the seasons considered, comparable yields were obtained with the sole maize crops of both tillage treatments. The added advantage of better soil and water conservation in NT supports the intercropping of maize and melon under NT.

Root Length Growth

Generally, the root density decreased with increase in depth (Fig. 3). This pattern of root distribution strongly indicates the zone of water and nutrient availability to these plants. At the 0-0.1m depth, the CT treatments had higher root density than the NT treatments. This contradicts the earlier work of Maurya and Lal (1979) who reported more maize roots near the surface layer (0-0.1m) with NT than CT plots. The greater number of years on which NT was practised on their soil compared with the soil under study could have been responsible. Maurya and Lal (1979) practised NT on their soil for at least 6 years after the land had been opened up. NT had just been started on the soil under study after a long period of CT. The findings in this study confirm the works of Baeumer and Bakermans (1973) that plant roots elongate more slowly at first under NT than CT plots. With improved soil physical conditions over time, less energy will be spent in overcoming the soil mechanical resistance and increased root growth results in the NT treatments (Maurya and Lal, 1979). The root density was found to be the lowest for the maize and melon mixtures under NT and generally the mixtures had lower root density than the sole crops. This confirms earlier research finding that there is always difficulty in recovering all the roots in a multi-specific crop association (Ikeorgu, 1984). However, despite the low root density recovered in the mixtures, especially the mixtures of NT, the available roots supported adequate growth in terms of leaf area, plant height and seed production.

Leaf Water Potential

There were generally no significant differences in the leaf water potentials of plants under the different tillage and cropping treatments. The mean leaf water potential averaged over the measuring periods were - 1.4MPa for the maize and -0.16MPa for the 'egusi' melon. The difference in the leaf water potential of the two different crops could be due to physiological differences in the plants. The average values were as shown in Table 2. Even though these values were not significantly different from each other, the lower moisture potential of the CT plots indicate a decrease in water supply to the roots and a higher moisture stress under CT than NT.

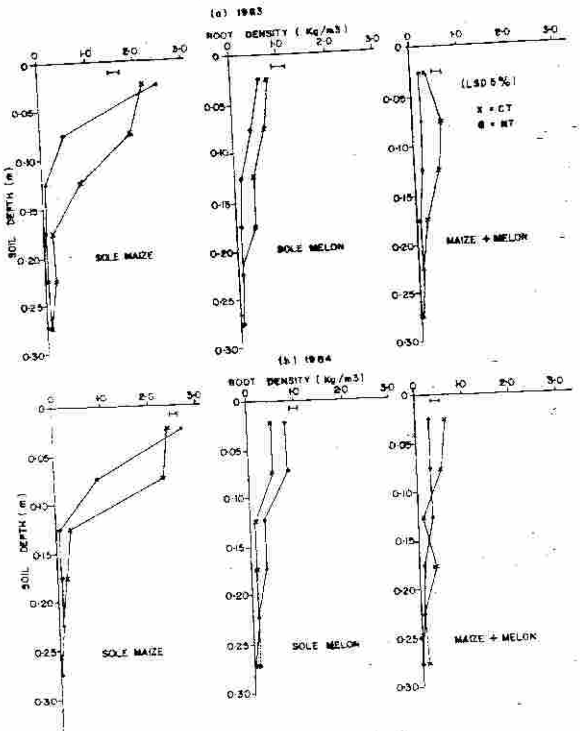

Fig. 3 Effect of soil depth on root density.

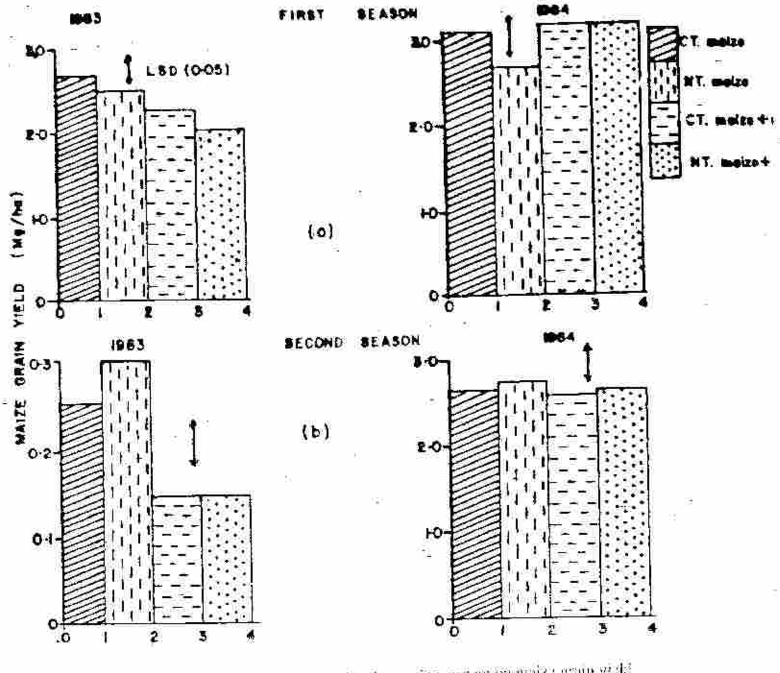

Fig. 4 Effects of tillage method and cropping system on maize grain yield

Maize Grain Yield

Maize grain yields for the 4 consecutive seasons are shown in Fig. 4. Generally, the maize grain yield was rather low for the Variety used. This could be attributed to the low population density of the maize crop, the purpose of which was to reduce shading of the melon cover crop. In the first season of 1983, the highest grain yield was obtained on the sole maize plot of CT (2.69Mg/ha) while the lowest yield was obtained on the NT plots of the mixture (1.99Mg/ha). No significant difference was obtained in the sole maize plots of CT and NT treatments while intercropped CT plots yielded higher than intercropped NT. The higher yield of CT during the first growing season might be due to better initial soil physical condition discussed earlier in this paper.

However, this yield difference between crop treatments in the first season of 1983 (for example sole maize of CT and NT) was not significant. This could be due to the initial soil characteristics and the sandy nature of the soil. This agrees with the findings of Griffith et al. (1973) who reported that on a well drained soil in the United States, crop yield under CT and NT were about the same under favourable rainfall condition. However, during seasons of poor rainfall such as the 1983 second season, the NT treatment because of its water conservation ability had better yields than CT even though the overall yield was poor for that season (about 10% of the first season). The yield of intercropped maize obtained was about 50% of the sole maize value irrespective of the tillage treatments. The competition for water during the dry spell could possibly account for the lower yield of the intercropped maize. This indicates that during a period of water stress, competition among the maize and melon crops becomes sufficiently great as to cause a considerable reduction in the yield of maize. When rainfall distribution becomes favourable such as during the first season of 1984, the intercropped maize had higher maize grain yield than the sole crop. This shows that the climate rather than the tillage treatment is important for the intercropped plants. This also has its implication for soil conservation such as effective soil cover to prevent erosion during seasons of high rainfall. The yield advantage during the favourable rainfall season is attributed to the ability of the melon crop to act as a live mulch which improved the hydrothermal regime of the soil. In all the seasons considered, the seed weight of maize was not significantly affected by tillage and cropping treatments (Table 3). The fact that intercropping did not reduce maize seed weight shows that the melon crop must have competed less strongly for soil micro-environmental growth factors than the associated maize. This state of affairs has led many workers to identify the maize crops as the dominant and most aggressive component (Okigbo, 1974). It further shows that is possible to adopt the 'egusi' melon crop as a live mulch in NT studies. However, it is suggested that for good field establishments and proper development, some tillage may be necessary, at the opening of the land, to ensure good establishment for the melon crop in continuous NT cultivation.

TABLE 1: SOME SOIL CHEMICAL PROPERTIES OF THE SITE AT IBADAN

Soil depth (cm)	Organic Carbon %	pH H_2O	pH $CaCl_2$	Total N %	Available-P(PPM)		Exchangeable Ca	Cations Mn	K	(me/100g) Na
0 — 15	1.40	6.8	6.1	0.08	27.33	2.0	1.12	0.03	0.17	0.086
15 — 30	0.49	6.2	5.9	0.06	21.28	1.1	0.37	0.02	0.14	0.061
30 — 60	0.72	6.2	6.0	0.07	20.63	0.72	0.15	0.04	0.08	0.091
60 — 100	0.24	5.9	5.7	0.05	23.10	0.54	0.08	0.01	0.07	0.08

TABLE 2: LEAF WATER POTENTIAL OF SOLE MAIZE, SOLE MELON AND INTERCROPPED MAIZE + MELON.

	NT	CT
Sole Maize	—1.38MPa	—1.42MPa
Sole Melon	—0.15MPa	—0.16MPa
Maize in Maize + Melon	—1.37MPa	—1.41MPa
Melon inMaize + Melon	—0.15MPa	—0.15MPa

TABLE 3: MEAN MAIZE SEED WEIGHT (G) FOR THE FOUR SEASONS UNDER CONVENTIONAL TILLAGE (T) NO-TILLAGE (NT) AND CROP TREATMENTS

Treatments	First Season 1983	Second Season 1983	First Season 1984	Second Season 1984
CT	27.10a*	24.30a	27.40a	27.30a
NT	27.00a	25.70a	27.00a	27.10a
Sole Maize	27.40a	25.30a	27.00a	27.20a
Mixed Maize + Melon	26.91a	25.90a	27.30a	27.50a
Standard Error	0.12	0.32	0.12	0.11

Only means followed by different letter(s) within each column differ at $p<0.05$ (DMRT)

TABLE 4: MEAN MELON SEED YIELD, NUMBER OF FRUITS AND FRESH FRUIT WEIGHT UNDER CONVENTIONAL TILLAGE AND NO-TILLAGE IN (A) FRIST SEASONS AND (B) SECOND SEASONS OF 1983 AND 1984

Treatments		Seed Yield Mg/ha		Number of Fruits No/ha		Fresh Fruit Weight Mg/ha	
		1983	1984	1983	1984	1983	1984
(a)	CT	1.10a*	0.78a	57187a	45336a	36.441a	27.971a
	NT	0.62b	0.63a	47969b	3857ab	28.931b	26.401a
	Sole Melon	0.91a	0.48a	55531a	35985b	32.691ab	23.31a
	Mixed Maize + Melon	0.77a	0.45a	53625a	31403a	30.521ab	20.2a
	Standard Error	0.21	0.40	5213	7234	6.96	7.87
(b)	CT	0.18a	0.08a	7046a	4175a	5.85a	3.70a
	NT	0.10b	0.06a	5797b	3188c	4.53c	3.61a
	Sole Melon	0.12b	0.06b	0.06a	6498a	5.18b	3.55a
	Mixed Maize + Melon	0.10b	0.06a	5363b	3066c	4.07c	3.49a
	Standard Error	0.05	0.04	691	435	0.35	0.28

**Only means followed by, different letter(s) within wach column differ at P<0.05 (DMRT)>*

Melon Seed Yield

Due to poor yield of the melon crop in the second season the discussion presented here will be based on first season of each year only. The melon yield during the second seasons was found to be about 10% of the first seasons yield (Table 4). This could not be fully explained by any specific factor, however, the photoperiodic life of the plant is suspected. It was also observed that during the second seasons, fungi attack on the melon crop was excessive despite the use of Furadan (Methyl 1-2-3 - Dimethl 1-7-benzofurany ester) at the rate of about 5g per hill at planting. During this period the melon crops were generally stunted and had delayed flowering and fruiting. Further work needs to be done to ascertain some of the reasons for this poor yield.

Based on the first season, the CT treatments had better yield than NT especially at the beginning of the study (Table 3). This suggests that initially some tillage may be necessary in the melon plots to enable the melon crop to become an effective live mulch in NT field. Thereafter, the improvement in the soil physical properties under NT, will make mechanical tillage unnecessary in the melon plots. Intercropping melon with maize the yield of melon but improved the yield of maize as discussed earlier. The reduction in the melon seed yield has been attributed to the aggressiveness of the maize crop and the poor light interception ratio of the melon crop due to the shading effect of the maize crop and the poor light interception ratio of the melon crop due to the shading effect of the maize crop (Ikeorgu, 1984). However, in terms of economic returns, the reduction in melon yield has been shown to be more than compensated for by the maize yield (Ikeorgu, 1984). Furthermore, the better resource utilization coupled with improved soil and water conservation in intercropping (Ajayi, 1987) supports the recommendation of intercropping melon with maize under the NT method of land preparation.

Conclusions

From the point of growth and particularly yield, the CT treatments had no significant advantage over the period of two years. However, the CT had slightly higher yield than the NT treatments. But over a longer period, it is speculated the NT, with its better soil and water conservation properties, will perform better than the CT. The use of crop residue and bush mulch can be minimized in NT by the inclusion of the melon crop into NT practice and thereby increase the acceptability of the NT system by the peasant farmers who engage in intercropping in the humid tropics.

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