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Responses of Sweet Orange (*Citrus sinensis (L.) Osbeck Cv. Agege 1)* to Intercropping in Ibadan, Nigeria

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ABSTRACT: Intercropping studies were conducted with Sweet orange (*Citrus sinensis* L. Osbeck cv. Agege 1) between 1996 and 1999 at the National Horticultural Research Institute, Ibadan, Nigeria to determine the best compatible crops for Sweet orange growth. The intercrops were maize (M) (*Zea mays* L.) in the early planting season, followed by cowpea (cp) *Vigna unguiculata* L. (Walp), in the late planting season of each year, cassava (Ca) (*Manihot esculenta* Crantz) and pineapple (p) (*Ananas comosus* L). Sole plots of sweet orange (Sct), maize(Sm), cowpea (Scp), cassava (Sca) and pineapple (Sp) were planted as controls. The treatments were assigned to plots using randomized complete block design (RCBD).

Results showed that the highest citrus plants height of 2.60 m was recorded for Ct + M/CP, the least of 2.10m was obtained in Ct + Ca, 30 months after transplanting. Citrus plant girth (5-cm below bud union) and Canopy Spread in Ct +M/CP, Ct +P and Sct stands were significantly different ($P<0.05$) from citrus intercropped with cassava. Similarly cropping systems affected yield attributes of citrus. Citrus in pure stands and Ct +M/CP produced flowers 24 months after transplanting, with 75.0% and 87% of their trees producing flowers and fruits respectively. Forty-two months after transplanting citrus, Sct stands, Ct + M/CP and Ct + Ca had 1.63, 1.45 and 0.05 citrus fruit t/ha, respectively. Citrus plants intercropped with pineapple did not produce fruit.

The study revealed that M-intercropped in the early planting season followed by cp in the late season were the most compatible crops with sweet orange in terms of early fruit yield.

Key words: Growth and yield responses, Sweet orange, Intercropping.

INTRODUCTION

Citrus is one of the most important and widely cultivated fruit crops in Nigeria (Adewale *et al.*, 1996). The fruit, industrial and economic potential is well acknowledged. Olapade (1999) has observed that the importance of citrus is not restricted to the fruit alone but virtually to all its parts. All the important species of citrus are cultivated in Nigeria. More than 90% of the production is of sweet orange (Kolade and Olaniyan, 1998). Agege 1, a local land race of sweet orange is a popular variety in the southwestern Nigeria because of its adaptability and high fruit yield.

The cropping systems of citrus in Nigeria vary with the agro ecology. In the southeastern zone of Nigeria, citrus is grown as a home compound crop with other crops, it serves for home consumption and in years of heavy bearing, surplus fruit are sold for cash. In the southwestern zone, citrus is interplanted with *Theobroma cacao* (Cocoa) *Cola spp.* (kola) and *Musa paradisiaca* (Plantain) to generate extra income (Amih, 1985; Aiyelaagbe *et al.*, 1994). In the middle belt, identified to be the largest citrus producing area in Nigeria (Martin, 1979), the farmers intercrop the alley of citrus orchard with *Vigna unguiculata* (Cowpea), *Glycine max* (soybean) and, sometimes, *Manihot esculenta* (Cassava).

Research in citrus cultivation has hitherto focused on sole cropping. The attendant cultural operation for sole citrus cultivation are usually capital intensive during the early stages, due to the wide spacing (6-8m apart) with no monetary returns in the first five years of orchard establishment. The intercropping systems being practised for citrus presently puts citrus as the minor crop in the system, the compatibility of the companion crop with citrus is therefore not of much concern. The compatibility of the different intercrops to be included needs to be carefully studied to justify their inclusion in citrus orchard alleys. Inclusion of the intercrops will encourage, the citrus farmer to maintain the young citrus plants, while trying to maintain the intercrops (Murray, 1984). Lameira and Oliveira (1992) intercropped a citrus orchard in Brazil with food crops and reported that intercrop with cassava gave the highest orange yields. Howevér Aiyelaagbe (2001)

intercropped citrus with maize /cassava in Ibadan, Nigeria on and found out that the duo had declining effect on growth and yield of citrus than any of other intercrops being studied. This study sought to determine the effects of some intercrops on citrus growth.

MATERIALS AND METHODS

The study was conducted at the National Horticultural Research Institute (NIHORT), Headquarter in Ibadan. The site lies between longitude 3°50' and 3°52' East, Latitudes 7°23' and 7°.25' North and altitude of between 150-200m above sea level. The soil in the experimental area belongs to the main soil series of Egbeda Olorunda, Iwo, Makun, Etioni and Iregun (Smyth and Montgomery, 1962). They are also classified as Alfisols (Soil survey staff, 1990) and Lixisols (FAO/UNESCO, 1986). The wet season is from April to October and the dry season is from December to February. The average annual rainfall of 1280 mm has been reported for the area. The maximum temperature range is 27.9°C - 34.7°C and minimum temperature range is 20.0° C – 22.8°C (NIHORT, meteorological record). Relative humidity of NIHORT area is fairly high (73 - 95%). The pre-planting soil sampling of the land for physical and chemical analyses was done by sampling at 0-30cm depth with soil auger. The samples were analyzed for both physical and chemical properties using the methods outlined by International Institute of Tropical Agriculture (1984) (Table 1). The plot area planted with citrus measured 21 m x 14 m (294.00 m^2) with twelve citrus seedlings. Each sole intercrop plot area except sole citrus was 4m x 10m

Table 1: Physical Soil and chemical properties of the soil at the beginning of the study in 1996.

Soil Properties	Values
pH (H_{20}) 1:1	6.07
Total Nitrogen g Kg^{-1}	0.25
Organic carbon g kg^{-1}	2.8
Available P mg kg^{-1}	4.6
Exchangeable cations cmol kg^{-1}	
Ca	3.20
Mg	2.30
K	0.30
Exch.Acidity cmol kg^{-1}	0.11
Effective CEC cmol kg^{-1}	6.30
Exchangeable micronutrients mg kg^{-1}	
Fe	6.3
Zn	2.7
Cu	5.7
Base saturation g kg^{-1}	980
Sand g kg^{-1}	819.3
Silt g kg^{-1}	111.8
Clay g kg^{-1}	68.9

($40m^2$). Citrus budlings were established simultaneously with the first planting of the intercrops in May 1996. The treatments assigned were the different intercrops, planted one meter away from the citrus. The intercrops were maize (DMR-LSR-W) planted in the early season followed by cowpea (Ife-brown) in the late season as maize/cowpea, Cassava (TMS 30572) and pineapple (smooth cayenne). The planting materials were seeds fro maize and cowpea, cuttings for cassava and suckers for pineapple. The control plots were sole citrus, maize, cowpea, cassava and pineapple. The spacing of the intercrops is as follows: maize (0.25 m x 0.75 m), cowpea. (0.30 m x 0.75 m), Cassava (1.00 m x 1.00 m), pineapple (0.50 x 0.60 x 1.00 m). The citrus plants were spaced at 7 m x 7 m. The treatments were assigned following a RCBD with four replications. The planting was for 4 cropping seasons (1996-1999). The plot was sprayed 3 times in a year with cymbush to prevent insect attack, especially on cowpea. No fertilizer was applied during the first year of cropping in 1996, subsequently basal fertilizer was applied based on citrus requirement for young orchard (Edgar, 1991) at the rate of 118N, $59P_20_5$ and $59k_20$kg/ha in 3 split doses. Harvesting for yield determination of the intercrops was done at 1m, 2m, and 3m diameter away from the citrus main stem. This was to determine the effect of distance from the citrus on the performance of the intercrops over three years period. The growth and yield data of citrus and the intercrops were subjected to ANOVA and the means compared using LSD at 5% level of probability.

RESULTS

Effect of intercrops on the growth of Sweet orange trees

During the first six months of citrus establishment, sole citrus stand recorded the highest height of 0.76 m and significantly higher than all other treatments (Table 2a). Thirty months after transplanting (MATP) citrus, maize/cowpea intercropped plots had the highest plant height of 2.63 m and was significantly higher than citrus plant height in cassava intercropped plot (Table 2a). Plant girth at 5cm above bud union for sole citrus stands, citrus + pineapple, citrus + maize/cowpea were 14.8 cm, 15.16 cm and 16.35 cm respectively, 30 months after transplanting (Table 2b), these were significantly superior to plant girth of citrus plants in citrus + cassava combination which had 12.25 cm. Citrus with pineapple intercrop had the best stem girth 5cm below bud union 6 months after citrus transplanting (Table 2c). The same trend was observed for canopy spread.

Table 2. Effect of intercropping cassava, pineapple and maize/cowpea with citrus on performance of citrus in Southwestern Nigeria in 1996-1999)

a. Plant Height (cm)	Months after transplanting			
Cropping system	6	18	30	42
Sole Citrus	0.76	1.34	2.44	2.95
Citrus + Cassava	0.62	1.29	2.07	3.00
Citrus + Pineapple	0.65	1.65	2.40	3.14
Citrus + maize cowpea	0.70	1.75	2.63	3.21
LSD (5%)	0.05	0.19	0.31	NS
b. Stem girth (5cm above bud union)				
Sole Citrus	4.01	10.72	14.80	26.03
Citrus + Cassava	3.80	8.36	12.25	27.33
Citrus + Pineapple	4.29	12.62	15.16	29.37
Citrus + maize cowpea	4.19	10.61	16.35	27.31
LSD (5%)	NS	NS	2.12	NS
c. Stem girth (5cm below bud union)				
Sole Citrus	4.66	11.65	21.49	33.12
Citrus + Cassava	4.10	9.76	16.74	29.67
Citrus + Pineapple	5.34	13.07	21.45	32.75
Citrus + maize cowpea	4.75	12.09	23.34	34.31
LSD (5%)	0.89	NS	3.87	3.98
d. Canopy spread (m)				
Sole Citrus	0.38	1.19	2.09	2.68
Citrus + Cassava	0.30	0.75	1.41	2.39
Citrus + Pineapple	0.47	1.10	1.86	2.74
Citrus + maize cowpea	0.40	1.37	1.95	2.84
LSD (5%)	0.05	0.25	0.21	0.25

Effects of intercrops on Sweet Orange yield attributes.

Percentage of flower and fruit producing trees.

Citrus sole stand and citrus + maize/cowpea recorded 75% and 87.5% flower count respectively at 24 MATP (Table 3) whereas citrus + cassava and citrus + pineapple treatments did not produce flowers during this period. Similarly, at 36 MATP, sole citrus stand and citrus + maize/cowpea recorded 100% flowering, while citrus + cassava had 12.5% of the tree population and citrus + pineapple yet to produce flower.

The percentage of fruiting trees for sole citrus and citrus + maize /cowpea were 50% and 75% respectively at 25 MATP (Table 3). Citrus + cassava and citrus + pineapple had no fruit set. Thirty-seven months after transplanting citrus, sole citrus and citrus + maize/cowpea had 100% fruit set. Citrus + cassava recorded 12.5% fruit set, while citrus + pineapple did not set fruit 37 MATP. It was observed that, not all the citrus trees that produced flower at 25 MATP finally set fruit but those that flowered at 37 MATP finally set fruit.

Number and weight of citrus fruit as affected by the intercrops

The intercrops affected the number and weight of citrus fruit. Thirty months after transplanting the number of fruits for citrus + maize/cowpea was 1377/ha, sole citrus had 1020/ha but there was no significant difference between these two treatments (Table 3). Cassava + citrus and citrus + pineapple combination did not produce any fruit. At 42 MATP, sole citrus, citrus+maize/cowpea intercrop and citrus + cassava intercrop had fruit number of 8160, 6528 and 255/ha respectively. Citrus with pineapple intercrop did not produce any fruit. The fruit weights observed were similar to the trend observed for the number of fruits. At 30 MATP, fruit weight for sole citrus and citrus + maize/cowpea intercrop were 0.17 and 0.21t/ha respectively but there was no significant difference between the two treatments (Table 3). Fruits weight recoded 42MATP showed that sole citrus, citrus+ maize/cowpea and citrus + cassava had 1.63, 1.45 and 0.05t/ha respectively. Sole citrus and citrus+ maize/cowpea were significantly higher than citrus fruit weight of citrus intercropped with cassava.

Table 3: Effect of intercropping on flowering and fruiting attributes of juvenile Sweet orange (Cv. Agege 1).

	% of flowering trees			% of fruiting trees
	Months after transplanting			
	24	36	25	37
Sole Citrus	75	100.0	50.0	100.0
Citrus + Cassava	0.0	12.5	0.0	12.5
Citrus + Pineapple	0.0	0.0	0.0	0.0
Citrus + maize/cowpea	87.5	100.0	75.0	100.0
LSD (5%)	9.4	22.4	15.7	22.4
	Number of fruits/ha		Weight of fruit (t/ha)	
	Months after transplanting			
	30	42	30	42
Sole Citrus	1020.00	8160.00	0.17	0.63
Citrus + Cassava	0.00	255.00	0.00	0.05
Citrus + Pineapple	0.00	0.00	0.00	0.00
Citrus + maize/cowpea	1377.00	6528.00	0.21	1.45
LSD (5%)	400.00	1960.00	0.02	0.59

Effect of citrus on the yield of the intercrops

Maize grain yield

Table 4 shows maize grain yield as affected by intercropping. There was no significant difference between maize intercropped and sole plot in maize grain yield for the three cropping seasons (1996, 1997

Table 4: Influence of citrus on intercropped maize and cowpea grain yield (t/ha).

	Sole and intercropped maize compared Year Planted		
	1996	1997	1998
Citrus + maize	2.08	2.19	2.28
Sole maize	2.16	2.11	2.04
t (0.05)	0.06	0.09	0.06
Maize distance from citrus compared			
Distance away from citrus			
	1996	1997	1998
Citrus + maize 1m	2.14	2.02	1.62
2m	2.15	2.66	2.38
3m	2.20	2.20	2.35
Sole maize	2.16	2.11	2.04
LSD (P=0.05)	NS	NS	0.38

Influence of citrus on intercropped cowpea grain yield (t/ha).

	Sole and intercropped maize compared Year Planted		
	1996	1997	1998
Citrus + cowpea	0.45	1.20	0.87
Sole cowpea	0.41	1.32	0.83
t (0.05)	ns	ns	ns
Distance away from citrus			
	1996	1997	1998
Citrus + cowpea 1m	0.42	0.99	0.65
2m	0.44	1.03	0.98
3m	0.45	1.48	0.99
Sole cowpea	0.41	1.32	0.83
LSD (P 0.05)	NS	NS	0.13

and 1998). Maize planting distance away from citrus did not affect maize grain yield in 1996 and1997 (first and second year cropping seasons). However, in 1998 (third year cropping) maize planted at 2 and 3m distances from citrus plant recorded maize grain yield weight of 2.38 and 2.35 t/ha respectively and were significantly better (1.62 t/ha) than for 1m maize planting distance form the citrus plant (Table 4).

Cowpea Seed Yield

In all the three cropping (1996-1998) there was no significant difference in grain yield of cowpea intercropped with citrus or grown sole. Cowpea planting distances of 1-3m away from the citrus plant did not affect cowpea seed yield during the first two cropping in 1996 and 1997 (Table 4) During the third cropping in 1998, 2m and 3m cowpea planting distances were significantly superior to 1m planting distance in cowpea grain yield (Table 4).

Cassava tuber yield

There was no significant difference between tuber yield (t/ha) of intercropped cassava and cassava planted in sole stand for all the three-year of cassava cultivation (Table 5). The yield decreased as planting period progressed. When distances away from the citrus plant was considered the tuber yield of cassava planted 2m and 3m away from the citrus were significantly better than cassava tuber yield planted 1m which was closer to the citrus plant during the second and third cassava harvesting in 1998 and 1999 respectively (Table 5).

Table 5: Influence of Citrus on root tuber yield of cassava planted in the alley of citrus tree (t/ha).

	Sole and intercropped maize compared Year Planted		
	1997	1998	1999
Citrus + cassava	29.92	21.76	21.50
Sole cassava	28.90	23.98	22.12
t (0.05)	ns	ns	ns
Effect of distance compared			
Distance away from citrus			
	1997	1998	1999
Citrus + cassava 1m	29.52	18.95	19.42
2m	29.96	21.45	21.16
3m	30.27	24.88	23.92
Sole Cassava	28.90	23.09	22.12
LSD (P=0.05)	ns	1.61	0.76

Pineapple fruit yield

Pineapple fruit harvesting started at 16 months after planting and stopped at 24 months after planting, when 95% of the first ratoon have been harvested. The mean number of fruits of 23,000/ha for sole pineapple was

not significantly different from 19,830/ha of pineapple intercropped with citrus. The fruit weight of sole pineapple was 42.31t/ha and was also not significantly different from pineapple intercropped with citrus with the yield of 40.24t/ha (Table 6). Considering pineapple planting distances away from the citrus, pineapple fruit yield was affected. The 3m planting distance of pineapple away from the citrus was significantly higher in fruit yield than that of 1m and 2m distances.

Table 6: Influence of citrus on the fruit yield of intercropped Pineapple

	Sole and intercropped compared	
	Fruit wt (t/ha)	Number of fruits (No/ha)
Citrus + Pineapple	40.24	19829.30
Sole Pineapple	42.31	23000.00
t (0.05)	ns	ns
Effect of Pineapple distance from citrus compared		
Distance away	Sole and intercropped compared	
	Fruit wt (t/ha)	Number of fruits (No/ha)
1m	34.01	19108.19
2m	40.30	22203.00
3m	46.58	25265.12
Sole Pineapple	43.07	23000.00
LSD (P0.05)	5.22	2600.00

DISCUSSION

The vegetative growth of citrus with cassava intercrop was affected during the first two cropping seasons (1996-1997), this might have been caused by more than six months of shade cast over the citrus plants in each cropping cycle and citrus root disturbance during cassava harvesting. Citrus is a relatively slow growing crop; hence the cassava rapidly grew above it.

The interception of light from reaching the citrus canopy might have impaired the photosynthetic ability, though effect of shade was not monitored in this study. Also the root damage of citrus during cassava harvesting may reduce nutrients absorption. However, during the fourth season in 1999, there were no significant differences in citrus plant height among the treatments. Citrus was high enough to compete with the aggressiveness of cassava plant. Citrus root damage during cassava harvesting in 1999 was also reduced in older citrus plant, which had sent the roots farther into the soil. This result corroborates the work of Ofoh (1990) and Aiyelaagbe (2001) using oil palm and citrus respectively. In these studies cassava caused reduction in plant height, number of leaves, leaf area, root development and reduction in the girth of the young trees. Initial competition for light caused reduction in the growth of citrus but it recovered and performed well as intercropping period progressed. In silk cotton intercropping for three consecutive years, Suresh and Vinaya (1991) reported that during the first six months, the tree growth rate was not affected by the intercrops. Similarly, a year after intercropping cotton enhanced the tree height growth rate, but fodder grass completely inhibited the sapling growth. However, tree growth was not affected by the intercrops.

Citrus yield attributes (flowering and fruit yield) might have been influenced by nutrient status of the soil caused by the different nutrients demand of the intercrops. Delayed and absence of flowering and fruiting by intercrop respectively perhaps was as a result of high nutrients withdrawal from the soil by cassava and pineapple especially potassium which is a major nutrient in citrus fruit production (Reitz *et al.*, 1974). Some workers have reported great affinity for potassium by pineapple and cassava (Samson 1980, Kapinga *et al.*, 1995). The production of fruits by citrus with cassava intercrop during the fourth cropping season was as a result of fertilizer applied and the ability of citrus to exert itself and compete with cassava for the nutrients in the soil. In different reports by Onwubuya (1983) and Ofoh (1990) on evaluation of oil palms intercropped with various food crops during early establishment, cassava caused delayed inflorescence emergence in a young palm plantation. However, Lameira and Olveira (1992) intercropping an established citrus (sweet orange) orchard with some arable crops, reported that citrus + cassava intercrop gave the highest orange yield.

The early flower and fruit production by citrus planted sole and those intercropped with maize/cowpea suggest the compatibility of citrus with maize/cowpea. The residue of maize/cowpea left to decay on the plots improved the soil organic matter status and enhanced nutrients status. It also conserved the soil moisture and increased the availability to the citrus plants. Cowpea, a leguminous plant is known for its nitrogen fixing ability and might have increased the supply of nitrogen to the citrus plants. The sole citrus stand did not compete for growth resources (light moisture and nutrients) therefore it could make use of them for physiological processes.

Maize in the early planting season followed by cowpea in the late season did not affect the growth and yield of citrus, their inclusion is therefore recommended as an intercrop in citrus alley

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