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Productivity Responses of Spice and Vegetable Crops in Citrus Juvenile Orchard

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Abstract
Citrus is an economy crop usually grown at wide spacings into which staple food can be grown before the canopy closes up. Therefore, field experiments were conducted in 2010 and 2011 at the National Horticultural Research Institute, Ibadan to evaluate the response of three spices and one vegetable crop as intercrops with juvenile citrus at different spacing regimes. Citrus was intercropped with pepper, turmeric, ginger and basil at three inter spacing regimes of 1 m, 2 m and 3 m from the juvenile citrus trees with sole citrus and the sole crop of each of the components as control. The experiment was laid in randomized complete block design in three replication. Results showed that growth and yield of the juvenile citrus trees were not significantly affected by the component crops except in citrus/turmeric intercrop where significant decrease in plant height was observed in 2010. Basil plant height in the intercrop was significantly higher at 1m and 3m than other intercrops at 10WAP in both years, while pepper and turmeric heights were significantly higher at 3m spacing from the juvenile citrus trees than that of ginger at 20 WAP in 2010. Pepper produced higher number of fruits at 3m in 2010 and 2m in 2011 while that of turmeric was higher at 1m in 2010 and 2m in 2011 than the other corresponding spacing regimes which in turn were higher than the yields under their corresponding sole crops. Yields of ginger under the spacing regimes were significantly lower than what was obtained in the other intercrops and sole ginger in both years while basil produced higher leaf yield at 2m (269 g/plant) than at 1m and 3m. Pepper, turmeric and basil responded positively in the intercrop with juvenile citrus trees than ginger and can be adopted by farmers.
Keywords: Citrus, intercrop, juvenile, spices, vegetable, alleys

1. Introduction

Citrus (*Citrus spp*) is one of the most important fruit trees grown for fresh consumption and as raw materials in the tropics and sub tropics (Adewale *et al*., 1996; Olaniyan *et al*., 2001; Alamu *et al*., 2011). Sweet oranges (*Citrus sinensis* Osbeck Cv Agege 1) are the most widely grown type of citrus fruit, by far, they account for around 55% of the citrus area and over 60% of production. Taken together, tangerines, mandarin oranges and clementines are the next most widely grown, followed by lemons and limes, with a smaller area of grapefruit (FAO, 2008). Its importance is due to the high vitamin C content in the fruit, high industrial potential for manufacturing concentrates, fruit juice, squash marmalades, essential oils and flavouring purposes (Davies and Albrigo, 1994; Futch and Singh 1997; FAO 2008).

Spices are crops with specific flavours, taste and aroma. They have the ability to change and enhance character of food and play important roles in national economies of spice producing, importing and exporting countries like India (NIIR Board of Consultants and Engineers (2013).

Intercropping tree crops with staple food crops before canopy closure is a common practice by farmers (Andor and Ofosu-Budu, 2012). The cropping system of citrus 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 year of heavy bearing, surplus fruit are sold for cash (Olaniyan 2005). 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 sometime *Manihot esculenta* (Cassava).

Citrus is grown at a recommended spacing of 7m x 7m and this makes it possible and convenient to utilize the alleys for growing other crops especially at the juvenile stage. The attendant cultural operation in maintaining sole citrus are usually capital intensive during the early stages, due to the wide spacing with no monetary returns in the first five years of orchard establishment (Olaniyan 2005).

In southern part of Nigeria, a number of crops have been found to be compatible with citrus such as Cowpea, Okra, Watermelon, Amaranthus and Maize (NIHORT, 2000). In India, vegetables, leguminous crops and ginger are used as an intercrop to generate improved economic returns (Patiram *et al*, 1994). Both ginger and

turmeric have been found to perform better as intercrops than in pure and specifically in turmeric, vegetative growth parameters were significantly enhanced when intercropped with poplar (Jaswal *et al.,* 1993).

The intercropping systems being practiced for citrus presently puts citrus as the minor in the system, the compatibility of the companion crop with citrus is therefore not of much concern. The compatibility of the different intercrop needs to be carefully studied to justify their inclusion in citrus orchard alleys. Inclusion of the intercrops (fruit vegetables and spice crops) will encourage farmers to maintain the young citrus plants, serve as a source of income to the farmers. A preliminary study was carried out in 2009 which has been reported however, the findings of the preliminary study needs to be confirmed therefore, this present study was carried out to ascertain the compatibility of pepper, turmeric, ginger and basil as intercrops with juvenile citrus orchard.

2.0 Materials and Methods

Field experiments were carried out in 2010 and 2011 at the National Horticultural Research Institute, Ibadan longitude N07^0 24.443' and latitude E003^0 50.707',180m above sea level to evaluate the productivity response of ginger, turmeric, basil and pepper as intercrops with young citrus trees. The experimental plot was a juvenile citrus orchard of two years old and the experiment was laid out in a randomized complete block design with three replicates. Turmeric, ginger, basil and pepper were planted in the alleys of the juvenile citrus trees at three spacing regimes of 1m, 2m and 3m from the citrus trees. Prior to planting, the alleys were ploughed and harrowed. All the spices and vegetable crops were planted directly to the field except pepper which was raised in seed trays and transplanted 4 weeks after planting. Turmeric and ginger were planted into the field at an inter and intra row spacings of 1m x 0.30m, 2m x 0.30m and 3m x 0.30m from the citrus trees while pepper was transplanted to the field at 1m x 0.45m, 2m x 0.45m and 3m x 0.45m. Basil seeds failed to germinate in 2011 due to loss of viability, however, few seedlings growing from the previous year's experiment at the different spacings from the citrus trees were used. Sole turmeric, ginger and pepper were also established. Routine cultural practices were carried out while growth and yield parameters were collected on each component crop of the intercrop at 10 and 20 WAP. Only growth parameters were taken on citrus. Data collected were subjected to analyses of variance using SAS package.

3.0 Results

3.1 Effect of spacing regimes on plant height of component crops in juvenile citrus/spices intercrop

Pepper plant height in the intercrop with juvenile citrus was higher at 2m spacing (62.4cm) than at 1 and 3m and sole pepper at 10 WAP while it was higher at 3m than at 1m but at par with 2m spacing (Table 1) and sole pepper (Table 4) at 20 WAP in 2010. Turmeric plant height was higher at 1m (18.6 cm) than other spacing regimes and sole turmeric at 10 WAP while plant height was higher in sole turmeric than all the spacing regimes at 20 WAP. Ginger plant height was higher at 3m (17.7 cm) spacing than other spacing regimes and sole ginger at 10 WAP in 2010 while sole ginger produced tallest plant at 20 WAP compared to all the regimes. Plant height of basil was higher at spacing regimes of 1 and 3m from the juvenile citrus trees than at 2m spacing at 10 WAP with corresponding values of 58.0 and 57.3 and 44.0 cm in 2010 (Table 1). Basil plant height was not taken at 20 WAP because senescence set in before then. Across the spacing regimes basil plant height in citrus/basil intercrop was significantly higher at 1m than other intercrops at 10 WAP, while pepper and turmeric plant heights were significantly higher at 3m spacing from the juvenile citrus trees than that of ginger at 20 WAP in 2010.

Table 1: Effect of spacing regimes on plant height of spices and vegetable crops in Citrus/spices intercrop in Ibadan, Nigeria

	Plant height (cm)											
	2010						2011					
	10 WAP			20 WAP			10 WAP			20 WAP		
TRT	1m	2m	3m	1m	2m	3m	1m	2m	3m	1m	2m	3m
C/P	33.0	37.1	28.3	55.3	62.1	62.4	46.0	27.3	28.0	30.8	33.1	31.3
C/T	18.6	13.8	16.0	60.8	62.1	62.4	36.1	40.3	29.3	49.3	52.7	42.0
C/G	8.33	11.0	17.7	29.3	27.7	29.7	30.4	24.0	24.2	43.5	33.4	38.3
C/B	58.0	44.0	57.3	-	-	-	64.1	59.3	68.4	0.0	0.0	0.0
LSD	11.96	37.47	16.28	33.14	18.09	17.39	34.90	24.70	9.30	12.90	20.10	4.10

Note: TRT = Treatments, C/P = Citrus/Pepper, Citrus/Turmeric, Citrus/Ginger, Citrus/Basil

3.2 Number of Leaves

Number of leaves of pepper was higher at 2m and 3m spacings from the juvenile citrus at 10 and 20 WAP in 2010 with 20 and 97 leaves/plant respectively than other spacing regimes while that of turmeric was consistent at all the spacing regimes at 10 WAP and higher at 2m spacing than other regimes at 20 WAP (Table 2). Ginger

produced higher number of leaves at 3m and 2m spacing regimes with 14 and 23 leaves/plant at 10 and 20 WAP respectively than at other spacing regimes while basil produced maximum number of leaves at 2m (565/plant) compared to other spacing regimes at 10 WAP. In 2011, pepper and turmeric produce maximum number of leaves at 2m spacing at 10 and 20 WAP with corresponding values of 138 and 141 leaves/plant for pepper; 40 and 20 leaves/plant for turmeric while ginger produced similar results at 1m with 9 and 18 leaves/plant respectively.

Table 2: Effect of spacing regimes on number of leaves of spices and vegetable crops in Citrus/spices intercrop in Ibadan, Nigeria.

	Number of leaves (no/plant)											
	2010						2011					
	10 WAP			20 WAP			10 WAP			20 WAP		
TRT	1m	2m	3m	1m	2m	3m	1m	2m	3m	1m	2m	3m
C/P	17	20	9	27	30	97	76	138	107	77	141	140
C/T	9	9	9	23	29	26	36	40	29	17	21	17
C/G	9	90	14	18	23	18	9	7	8	20	17	17
C/B	356	565	462	0	0	0	435	405	530	0	0	0
LSD	21.68	669.96	108.38	34.04	28.49	82.38	183.00	148.7	144.2	38.60	68.40	50.1

Note: TRT = Treatments, C/P = Citrus/Pepper, Citrus/Turmeric, Citrus/Ginger, Citrus/Basil

3.3 Yields of component crops

Pepper produced higher number of fruits at 3m in 2010 and 2m in 2011 while that of turmeric was higher at 1m in 2010 and 2m in 2011 than the other corresponding spacing regimes which in turn were higher than the yields under their corresponding sole crops (Tables 3 and 4). Yields of ginger under the spacing regimes were significantly lower than what was observed in the other intercrops and sole ginger in both years while basil produced higher leaf yield at 2m (269 g/plant) than at 1 and 3m. In 2011, pepper and basil produced higher yields at 2m as was obtained in 2010, while turmeric yield was higher at 2m than at 1 and 3m. Zero yields were recorded for sole turmeric and ginger.

Table 3: Effect of intercropping of citrus/spices and vegetable crops on the yields of component crops in Ibadan, Nigeria.

	Yields of spices and vegetable crops (g/plant)					
	2010			2011		
Treatments	**1m**	**2m**	**3m**	**1m**	**2m**	**3m**
Basil	235.7	269.0	183.3	153.7	220.7	396.7
Turmeric	681.7	539.7	660.0	318.3	400.0	135.0
Ginger	10.0	33.3	61.7	3.3	25.0c	8.7
Pepper	291.3	467.3	522.0	327.3	370.1	360.7
LSD	665.4	631.4	890.1	320.9	187.3	206.9

Table 4: Effect of sole cropping on plant height and yields of pepper, turmeric, ginger and basil in Ibadan, Nigeria.

	Plant height (cm)				Yield of crops (g/plt)	
	2010		2011		2010	2011
Treatments	**10WAP**	**20WAP**	**10WAP**	**20WAP**		
Pepper	36.7	62.0	26.4	35.0	200	0
Turmeric	16.9	74.0	43.5	55.0	427	218
Ginger	10.7	37.1	28.0	34.5	97	0.0
Basil	0	0	57.3	0	0	211
LSD	11.96	33.14	13.30	20.10	665.42	1.72

g/plt (gram/plant)

3.4 Growth and yield of juvenile citrus trees in the intercrop

In 2010, juvenile citrus intercropped with the component crops had significant effect on citrus plant height (Table 5). Plant height of juvenile citrus in the intercrop with ginger was significantly higher (269.0 cm) than that of intercrop with turmeric (191.0 cm). Similar results were obtained in 2011 but there were no significant differences among the means. Citrus stem girth and canopy spread were not significantly affected in the intercrop in both years. Citrus number of fruits and weight per tree were higher in sole citrus but not significantly different from those of the intercrops.

Table 5: Effect of citrus/spices and vegetable intercrop on growth and yield of citrus in Ibadan, Nigeria.

	Plant height (cm)		Stem girth (cm)		Canopy spread (cm)		Yield (2011)	
Trts	2010	2011	2010	2011	2010	2011	No of fruits (no/plant)	Fruit weight (kg/plant)
C/B	223.0	253.0	5.3	6.6	113.0	196.0	11.0	3.0
C/T	191.0	233.0	4.7	7.0	123.0	219.0	22.8	5.0
C/G	269.0	262.0	7.0	7.3	219.0	241.0	13.0	3.0
C/P	221.0	237.0	5.3	6.7	127.0	190.0	19.1	4.0
SC	212.0	244.0	5.0	7.2	131.0	192.0	39.0	8.0
LSD	70.3	87.9	2.6	2.9	78.4	122	ns	Ns

TRT = Treatments, C/P = Citrus/Pepper, Citrus/Turmeric, Citrus/Ginger, Citrus/Basil

4.0 Discussion

The responses of pepper, turmeric, ginger and basil in the intercrop with juvenile citrus varied at the different spacing regimes and years which confirms the earlier report of the preliminary study (Oyedele *et al*., 2011) . Pepper plant height and yield were higher either at 2 of 3m away from the juvenile citrus trees which indicates that pepper may perform better as an intercrop with juvenile citrus at spacing farther than 1m from the citrus probably because of the canopy cover of the citrus trees. Turmeric plant height was not consistent in both years. Highest plant height was obtained at 3m spacing in 2010 and at 2m in 2011 at 20 WAP while, number of leaves was higher at 2m spacing from the juvenile citrus in both years at 20 WAP. Higher rhizome yield of turmeric at 1m spacing in 2010 and 2m spacing from the juvenile citrus in 2011 shows that it can tolerate both shade and sunlight for optimum performance. Ginger yield was very low at all the spacing regimes in both years which may be as a result of poor establishment in both cases. Ginger may not tolerate shade as the poorest yields were produced at 1m spacing form the juvenile citrus. Of all the component crops, ginger seems not to be compatible with citrus as an intercrop due to poor establishment in both in years. Basil leaf yield was higher at 2m spacing from the juvenile citrus in both years which confirms the earlier report of the preliminary study (Oyedele *et al*., 2011).

Significant increase in plant height of citrus in citrus/ginger intercrop might be as a result of the poor establishment of ginger earlier mentioned while stem diameter and canopy spread were not significantly affected in the intercrop. No fruit was produced by the juvenile citrus trees in 2010 while higher fruit yield was produced in sole citrus in 2011 which was not significantly different from the yields obtained from the component crops this confirms the result of the preliminary work (Oyedele *et al*., 2011) and earlier work of Andor –Mensah and Ofosu-Budu (2012) who reported that intercropping did not hinder the optimum growth and yield of citrus.

5.0 Conclusion

The results of this study showed that growth and yield of the juvenile citrus trees were not significantly affected by the component crops except in citrus/turmeric intercrop where significant decrease in plant height was observed in 2010. Across the spacing regimes, basil plant height in the intercrop was significantly higher at either 1m or 3m than other intercrops at 10 WAP in both years, while pepper and turmeric plant heights were significantly higher at 3m spacing from the juvenile citrus trees than that of ginger at 20 WAP in 2010. Pepper produced higher number of fruits at 3m in 2010 and 2m in 2011 while that of turmeric was higher at 1m in 2010 and 2m in 2011 than the other corresponding spacing regimes which in turn were higher than the yields under their corresponding sole crops. Yields of ginger under the spacing regimes were significantly lower than what was obtained in the other intercrops and sole ginger in both years, while basil produced higher leaf yield at 2m (269 g/plant) than at 1m and 3m. Thus pepper, turmeric and basil responded positively in the intercrop with juvenile citrus trees than ginger and can be adopted by farmers in southwest of Nigeria.

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