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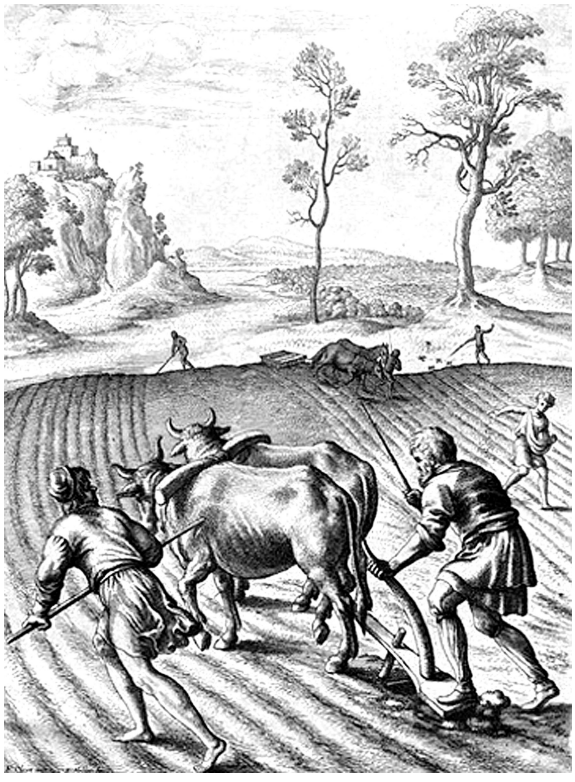

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Evaluation of the Yield Components and Yield of Onion (*Allium cepa* L.)-Pepper (*Capsicum annuum* L.) Intercrop in the Sudan Savanna

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Abstract: Field studies were conducted during the 2002/2003 and 2004/2005 cool dry seasons to assess the effect of different onion/pepper intercrop spacings (additive effect) on yield and yield components of onion (*Allium cepa* L.) and pepper (*Capsicum annuum* L.) in the Sudan Savanna, Nigeria. Eight different onion/pepper intercrop spacings and a sole each for the two crops were assigned to plots in a randomized complete block design with three replications. The results obtained for the two years were similar. The sole for both crops produced significantly ($p \leq 0.05$) higher marketable bulbs and bulb yield ha^{-1} for onion and greater number of fruits $plant^{-1}$ and fresh fruit yield ha^{-1} for pepper than the intercrops. For the onion based intercrops (onion/pepper), the spacings at 15×20/60×45 cm and 15×20/60×75 cm produced significantly ($p<0.05$) higher bulb yield ha^{-1} for both years. Whereas, for the pepper based intercrops (pepper/onion) the yield at 60×30/15×40 cm superceded the yield ha^{-1} of the other intercrops. The Land Equivalent Ratio (LER) values greater than one were obtained from the onion/pepper intercrops of 15×20/60×45 cm and 15×20/60×75 cm as well as from the pepper/onion combinations of 60×30/15×30 cm and 60×30/15×40 cm. The pepper/onion intercrop of 60×30/15×40 cm appeared as the best, with an average LER value of 1.19 for the two years; and therefore a practice to be considered most suitable when adding onion to pepper field. But when adding pepper to onion field, the onion/pepper intercrop of 15×20/60×45 cm which had a mean LER of 1.17 should be considered.

Key words: Intercrop, onion, pepper, crop yield, LER, Sudan savanna

INTRODUCTION

Onion (*Allium cepa* L.) belongs to the family Lilliaceae and is believed to have originated in Asia (Anonymous, 1999). It is the most important of the bulb crops as it is grown for consumption worldwide. Leading producers in the world include the United States of America, China and India (Burden, 2007). In Nigeria, onion is grown extensively as a dry season vegetable under irrigation. It can be eaten raw in salads, fried, boiled or roasted as well as for flavouring soups and stews. It is of high nutritional composition (Narasinga Rao *et al*., 1993).

Pepper (*Capsicum annuum* L.) belongs to the genus *Capsicum* and the family Solanaceae. It is believed to have originated in America and is now widely cultivated in most tropical and sub-tropical areas of the world (Tindall, 1992). Sweet pepper is used in soups and stews as well as in salad and are of high nutritional composition (Narasinga Rao *et al*., 1993).

Intercropping is a crop management system involving two or more economic species grown together for at least a portion of their respective productive cycle and planted sufficiently close to each other so that inter-specific competition occurs (Sulliva, 2003; Dugje, 2004). The advantages of intercropping system include better use of available land resources, yield stability, reduced crop loses due to weeds, pests or diseases. Others include erosion control, reduced leaching of nutrients, soil fertility maintenance, balanced distribution of labour and higher economic returns than sole cropping (Odo and Futuless, 2002; Alamu *et al*., 2002; Blaser *et al*., 2007).

Although the onion-pepper intercropping system is popular among resource poor farmers in the Sudan savanna, not much research work has been carried out for improving the productivity of this binary mixture, especially in relation to the spatial arrangements and the relative plant population densities per hectare of the components in the mixture. The determination of the appropriate productive onion/pepper population mixture is therefore imperative.

This study is an investigation of the optimum spacing of pepper that can be intercropped with a fixed standard onion spacing of 15×20 cm without agronomically depressing onion yield as well as to determine the optimum spacing of onion that can be intercropped with a fixed standard pepper spacing of 60×30 cm without agronomically depressing pepper yield.

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MATERIALS AND METHODS

Field experiments were conducted during the 2002/2003 and 2004/2005 cool dry season of October to March of each year in the Sudan Savanna ecological zone of Nigeria. The soil of the site was sandy loam, low in nitrogen (0.13%), P (5.6 mg kg^{-1}) and K (0.26 meq/100 g soil). The organic carbon content was 1.36% (Zephaniah, 2001).

The experiment was a two factor experiment i.e., two crops combined under different intercropping spacings, laid out in a Randomized Complete Block Design (RCBD), replicated three times. There were ten treatments as follows:

T_1 = 15×20 cm sole onion
T_2 = 60×30 cm sole pepper
T_3 = 15×20 cm onion/60×30 cm pepper
T_4 = 15×20 cm onion/60×45 cm pepper
T_5 = 15×20 cm onion/60×60 cm pepper
T_6 = 15×20 cm onion/60×75 cm pepper
T_7 = 60×30 cm pepper/15×20 cm onion
T_8 = 60×30 cm pepper/15×30 cm onion
T_9 = 60×30 cm pepper/15×40 cm onion
T_{10}= 60×30 cm pepper/15×50 cm onion

Bama Red variety of onion and Damasak variety of pepper, which are the high yielding and most popular varieties in the area, were used. For both the onion and pepper, seeds were used to raise seedlings for the experiments.

Uniform standard agronomic and management practices were kept at equal levels for both the intercrop and each of its reference monocultures. Phosphorus and nitrogen were applied at 45 kg P_2O_5 ha^{-1} and 65 kg N ha^{-1}, at once during transplanting and in two half split doses at two and six weeks after transplanting, respectively (BOSADP, 1993). Some yield parameters (bulbs diameter, bulb weight/plant, percentage marketable [bulbs with diameter >3 cm] and non-marketable bulb [bulbs with diameter ≤3 cm], total bulb yield ha^{-1} and percentage missing stands at harvest) of onion and (number of fruits/plant, fruit length, fresh weight of fruits/plant and total fresh fruit yield ha^{-1}) of pepper were determined for the two years and subjected to analysis of variance. Difference among treatment means were identified using Duncan's Multiple Range Test (DMRT). Other intercropping analytical model used for productivity measure was:

Land equivalent ratio (LER) determination: Land Equivalent Ratio (LER) is interpreted as relative land requirements for intercrops versus monocultures (Odo and Futuless, 2002) expressed as:

$$LER = Ry_{onion} + Ry_{pepper} = \frac{P_{onion}}{M_{onion}} + \frac{P_{pepper}}{M_{pepper}}$$

Where:
Ry_{onion} = Partial LER of onion
Ry_{pepper} = Partial LER of pepper
P_{onion} = Onion yield in intercrop
P_{pepper} = Pepper yield in intercrop
M_{onion} = Onion yield in monocrop
M_{pepper} = Pepper yield in monocrop

RESULTS

Yield parameters of onion: Similar results were obtained in both years. Bulb initiation began at about 6 weeks after transplanting for all the intercrops and the bulb diameter (of the initiated bulb) maintained an increasing trend up to harvest period for all the treatments. Sole onion (15×20 cm) produced significantly ($p \leq 0.05$) large bulb diameter which was comparable to the rest of the treatments except onions grown at 15×20/60×30 cm onion/pepper intercrop spacing (Table 1).

Table 2 shows the effect of the various onion/pepper intercrop spacings on bulb weight/plant, percentage marketable bulbs, percentage non-marketable bulbs and total bulb yield (mt ha^{-1}).

Bulb weight/plant varied significantly ($p \leq 0.05$) with the intercrop spacing treatments. Sole onion produced significantly higher bulb weight/plant than onions grown at 15×20/60×30 cm and 15×20/60×60 cm onion/pepper and 60×30/15×20 cm pepper/onion intercrop spacings in both years (Table 2).

Percentage marketable bulbs showed no significant difference ($p \leq 0.05$) in response to the intercrop spacing treatments (Table 2). However, pepper/onion spacings of 60×30/15×40 cm gave the highest percentage marketable bulbs than all the other treatments used. Similarly, the percentage non-marketable bulbs did not differ significantly between the treatments. Bulb yield (mt ha^{-1}) varied significantly ($p \leq 0.05$) among the various intercrop spacings. Sole onion gave higher bulb yield ha^{-1} and the lowest value was obtained under the pepper/onion intercrop of 60×30/15×50 cm (Table 2).

Yield parameters of pepper: The results obtained were similar for both the two years of the trial. Generally, mixtures with lower plant densities produced higher number of fruits/plant as well as longer fruits than those with higher plant densities.

Table 1: Effect of onion/pepper intercrop spacings on onion bulb diameter (cm) at the specified weeks after transplanting

	Weeks after transplanting									
	6		8		10		12		14	
Treatments	2002	2004	2002	2004	2002	2004	2002	2004	2002	2004
Onion/Pepper										
15×20 cm sole onion	2.90^{a}	2.72^{a}	3.28^{a}	3.00^{a}	4.70^{a}	4.20^{a}	5.98^{a}	5.31^{a}	6.57^{a}	6.35^{a}
15×20/60×30 cm	1.50^{bc}	1.28^{bc}	1.98^{a}	1.72^{a}	2.95^{a}	2.82^{a}	4.15^{ab}	4.00^{ab}	4.20^{b}	4.77^{b}
15×20/60×45 cm	2.00^{abc}	1.93^{abc}	2.71^{a}	2.60^{a}	3.58^{a}	3.05^{a}	4.63^{ab}	4.51^{ab}	5.40^{ab}	5.12^{ab}
15×20/60×60 cm	1.05^{c}	1.00^{c}	1.61^{a}	1.35^{a}	3.20^{a}	3.00^{a}	4.12^{ab}	4.11^{ab}	4.28^{ab}	4.20^{ab}
15×20/60×75 cm	2.62^{ab}	2.35^{ab}	3.06^{a}	2.88^{a}	3.55^{a}	3.10^{a}	4.97^{ab}	4.92^{ab}	5.08^{ab}	5.00^{ab}
Pepper/Onion										
60×30 cm sole pepper	-	-	-	-	-	-	-	-	-	-
60×30/15×20 cm	1.13^{c}	1.01^{c}	2.12^{a}	2.00^{a}	3.32^{a}	2.80^{a}	4.42^{b}	4.13^{b}	4.55^{ab}	4.31^{ab}
60×30/15×30 cm	2.12^{abc}	1.52^{abc}	2.28^{a}	2.00^{a}	3.47^{a}	3.00^{a}	4.48^{b}	4.20^{b}	5.13^{ab}	4.72^{ab}
60×30/15×40 cm	2.09^{abc}	1.80^{abc}	2.28^{a}	2.21^{a}	3.65^{a}	3.42^{a}	4.47^{ab}	4.41^{ab}	5.07^{ab}	5.01^{ab}
60×30/15×50 cm	2.13^{abc}	1.70^{abc}	2.27^{a}	2.11^{a}	3.77^{a}	3.45^{a}	4.83^{ab}	4.61^{ab}	5.32^{ab}	5.06^{ab}
SE±	0.39	0.35	0.52	0.45	0.54	0.50	0.69	0.55	0.69	0.63

Means within the same column followed by the same letter(s) are not significantly different ($p \leq 0.05$) from each other, according to Duncan's Multiple Range Test (DRMT)

Table 2: Effect of onion/pepper intercrop spacings on yield components and yield of onion

	Bulb weight per plant (g)		Percentage marketable bulbs (%)		Percentage non-marketable bulbs (%)		Bulb yield (mt ha^{-1})	
Treatments	2002	2004	2002	2004	2002	2004	2002	2004
Onion/Pepper								
15×20 cm sole onion	120.00^{a}	117.00^{a}	65.72^{a}	64.00^{a}	34.28^{a}	36.00^{a}	24.24^{a}	22.20^{a}
15×20/60×30 cm	60.00^{ab}	58.00^{ab}	48.78^{a}	46.78^{a}	51.22^{a}	53.22^{a}	12.12^{bc}	10.81^{bc}
15×20/60×45 cm	80.00^{ab}	80.00^{ab}	61.49^{a}	60.90^{a}	38.51^{a}	39.10^{a}	16.20^{ab}	16.00^{ab}
15×20/60×60 cm	40.00^{b}	42.00^{b}	35.62^{a}	36.00^{a}	69.98^{a}	64.00^{a}	8.08^{bcd}	9.00^{bcd}
15×20/60×75 cm	90.00^{ab}	86.51^{ab}	61.84^{a}	60.01^{a}	38.16^{a}	39.99^{a}	18.20^{ab}	16.52^{ab}
Pepper/Onion								
60×30 cm sole pepper	-	-	-	-	-	-	-	-
60×30/15×20 cm	50.00^{b}	50.00^{b}	43.04^{a}	42.01^{a}	56.96^{a}	57.99^{a}	10.10^{bcd}	10.00^{bcd}
60×30/15×30 cm	70.00^{ab}	67.10^{ab}	42.94^{a}	40.82^{a}	57.06^{a}	59.18^{a}	7.86^{bcd}	7.52^{bcd}
60×30/15×40 cm	80.00^{ab}	78.50^{ab}	69.50^{a}	69.00^{a}	30.50^{a}	31.00^{a}	7.18^{bcd}	7.00^{bcd}
60×30/15×50 cm	60.00^{ab}	57.81^{ab}	54.56^{a}	55.00^{a}	45.44^{a}	55.00^{a}	4.04^{d}	3.91^{cd}
SE±	16.38	16.00	10.61	10.53	11.00	11.20	2.41	2.23

Means within the same column followed by the same letter(s) are not significantly different ($p \leq 0.05$) from each other, according to Duncan's Multiple Range Test (DRMT)

Table 3: Effect of onion/pepper intercrop spacings on yield components and yield of pepper

	Number of fruits plant^{-1}		Fruit length plant^{-1} (cm)		Fresh fruit yield plant (g)		Fresh fruit yield ha^{-1} (mt)	
Treatments	2002	2004	2002	2004	2002	2004	2002	2004
Onion/Pepper								
15×20 cm sole onion	-	-	-	-	-	-	-	-
15×20/60×30 cm	8.00^{c}	10.00^{c}	7.13^{b}	7.21^{b}	39.28^{c}	40.10^{c}	2.4^{cd}	2.81^{cd}
15×20/60×45 cm	20.00^{ab}	23.00^{ab}	8.82^{a}	9.00^{a}	108.03^{ab}	108.60^{ab}	4.25^{bcd}	4.74^{bc}
15×20/60×60 cm	10.00^{bc}	11.00^{bc}	9.20^{a}	9.18^{a}	54.17^{bc}	53.90^{bc}	1.63^{d}	2.13^{cd}
15×20/60×75 cm	20.00^{ab}	21.00^{ab}	8.28^{ab}	8.25^{ab}	101.23^{ab}	101.00^{ab}	2.27^{cd}	2.58^{cd}
Pepper/Onion								
60×30 cm sole pepper	22.00^{a}	24.00^{a}	9.30^{a}	9.20^{a}	131.03^{a}	130.02^{a}	8.56^{a}	9.00^{a}
60×30/15×20 cm	18.00^{abc}	19.00^{abc}	9.69^{a}	9.80^{a}	78.41^{abc}	79.00^{abc}	4.88^{abc}	5.20^{bc}
60×30/15×30 cm	18.00^{abc}	18.00^{abc}	8.99^{a}	9.20^{a}	91.54^{abc}	92.00^{abc}	5.82^{abc}	6.31^{abc}
60×30/15×40 cm	22.00^{a}	23.00^{a}	9.81^{a}	9.91^{a}	115.21^{a}	116.00^{a}	7.52^{ab}	8.00^{ab}
60×30/15×50 cm	18.00^{abc}	18.00^{abc}	9.59^{a}	9.50^{a}	88.05^{abc}	88.00^{abc}	5.75^{abc}	6.00^{abc}
SE±	22.10	22.30	0.46	0.47	17.34	17.48	1.01	1.03

Means within the same column followed by the same letter(s) are not significantly different ($p \leq 0.05$) from each other, according to Duncan's Multiple Range Test (DRMT)

Fresh fruit yield plant^{-1} as well as per hectare differed significantly ($p \leq 0.05$) among the various intercrop spacings. Sole pepper (60×30 cm) gave higher fresh fruit yield plant^{-1} as well as per hectare than the intercrop treatments. However, among the intercrops, the pepper/onion intercrop spacing of 60×30/15×40 cm gave the highest fresh fruit yield ha^{-1} (Table 3).

Table 4: Effect of onion/pepper intercrop spacings on land equivalent ratio

	Land Equivalent Ratio (LER)					
	2002			2004		
Treatments	Partial		Total	Partial		Total
Onion/Pepper						
15×20 cm sole onion	-	-	1.00	-	-	1.00
15×20/60×30 cm	0.50	0.32	0.82	0.46	0.35	0.84
15×20/60×45 cm	0.67	0.51	1.18	0.65	0.50	1.15
15×20/60×60 cm	0.33	0.23	0.56	0.30	0.25	0.55
15×20/60×75 cm	0.75	0.29	1.04	0.65	0.36	1.01
Pepper/Onion						
60×30 cm sole pepper	-	-	1.00	-	-	1.00
60×30/15×20 cm	0.48	0.42	0.90	0.42	0.50	0.92
60×30/15×30 cm	0.75	0.32	1.07	0.75	0.30	1.05
60×30/15×40 cm	0.89	0.30	1.19	0.85	0.33	1.18
60×30/15×50 cm	0.73	0.17	1.00	0.65	0.20	0.85
SE±	0.12	0.10	0.18	0.11	0.10	0.17

Intercrop efficiency: The measures of intercrop efficiency determined in the study also follow similar trend for both the two years of the experiment (Table 4). For onion the highest partial LER value was obtained at the onion/pepper condition of 15×20/60×75 cm and the lowest value was at the treatment where onion was added at the spacing of 15×50 cm to pepper grown at the fixed standard spacing of 60×30 cm. For pepper the highest partial LER value was obtained at the pepper/onion combination of 60×30/15×40 cm while the least value was obtained at the onion/pepper combination of 15×20/60×60 cm.

Total Land Equivalent Ratio (LER) values were generally higher for 15×20/60×45 cm onion/pepper and 60×30/15×40 cm pepper/onion and lowest for 15×20/60×60 cm onion/pepper (Table 4).

DISCUSSION

Effect on yield components and yield of onion: The additive effect of pepper to onion/pepper intercrop achieved the highest onion bulb yield at 15×20/60×45 cm and 15×20/60×75 cm spacings, which had lower populations of pepper. Whereas, the additive effect of onion to pepper/onion intercrop produced the highest bulb yield of onion at the highest population of onion (Table 2). This was due to the shading effect of the pepper which had greater spatial aerial competition than the onion (Odo, 1991).

Intercropping did not affect bulb size in this study, as values obtained did not show any significant difference from the sole. However, the pepper/onion intercrop of 60×30/15×40 cm produced the highest marketable bulb which subsequently produced similar comparative bulb yield ha^{-1} as the sole onion in both years.

Sole onion (15×20 cm) produced the highest bulb yield per hectare. This was not unexpected as the sole onion is not subjected to any intercrop competition. Among the intercrops used, the 15×20/60×75 cm onion/pepper combination produced the highest bulb yield per hectare, because the least density of pepper subjected the mixture to less competition for the growth resources. This agrees with the study of Dugje and Odo (2006) on pearl millet intercropped with groundnut, as well as that of Ghosh *et al.* (2006) on soyabean/sorghum intercropping system.

Effect on yield components and yield of pepper: Yield components of *Capsicum annuum* L. such as number of fruits $plant^{-1}$, fruit length and fresh fruit weight $plant^{-1}$ were affected by intercropping. The higher values obtained for the yield components and yield with sole pepper, might be due to limited resources in the intercrops.

The pepper/onion combination of 60×30/15×40 cm appeared to have encouraged higher productivity among the intercrops. The reason for this could be attributed to good and better growth of pepper and onion at this combination. This agrees with Sulliva (2003) who reported that the optimum plant density of individual crops in a mixture should not be exceeded beyond certain limits to avoid interplant competition between the intercrops.

Intercrop efficiency (land equivalent ratio): In this study, LER values were greater than one for 15×20/60×45 cm; 15×20/60×75 cm onion/pepper intercrops as well as for pepper/onion combinations of 60×30/15×30 cm and 60×30/15×40 cm, which suggests that these combinations were highly efficient and therefore exhibiting higher degree of mutual compensation (Odo, 1991). Higher tendency of mutual inhibition were exhibited by the onion/pepper intercrop of 15×20/60×30 cm producing the least LER values.

Land Equivalent Ratio (LER) values greater than one implies that, although yield of component crops in an intercropping combination is reduced, total yield of the intercrop is significantly greater than that of each crop grown in sole (Pal *et al.*, 1993).

CONCLUSION

In conclusion, the present study has shown that the possibility of achieving a productive onion/pepper combination in the Sudan Savanna for a farmer whose primary interest is in onion is imposing pepper on onion at 15×20/60×45 cm and for a pepper based farmer is imposing onion at 60×30/15×40 cm.

REFERENCES

Alamu, J.F., J.D. Olarewaju and A.A. Coker, 2002. Profitability assessment of tomato and pepper produced under Fadama Development Programme in Kaduna State. Nig. J. Hortic. Sci., 6 (1): 44-48.

Anonymous, 1999. Plant Vegetative Morphology and Vegetables. Plants and People, Botany 328-Laboratory. www.csdl.tamu.edu/FLORA/pp/s99/veglablist.htm.

Blaser, B.C., J.W. Singer and L.R. Gibson, 2007. Winter cereal, seeding rate and intercrop seeding rate effect on red clover yield and quality. Agron. J., 99: 723-729.

BOSADP, 1993. Borno State Agricultural Development Programme: Package of Cropping Recommendations for Borno State. Nigeria.

Burden, D., 2007. Onion Profile. Iowa State University, djburden@iastate.edu.

Dugje, I.Y., 2004. The performance of pearl millet varieties in mixture with groundnut in the Nigerian Sudan savanna. Samaru J. Agric. Res., 20: 3-17.

Dugje, I.Y. and P.E. Odo, 2006. Effects of planting pattern and variety on leaf area index and grain yield of pearl millet intercropped with groundnut. Nig. J. Exp. Applied Biol., 7 (1): 63-69.

Ghosh, P.K., M.C. Manna, K.K. Bandyopadhyay, A.K. Tripathi, R.H. Wanjari, A.K. Misra, C.L. Acharya and A.S. Rao, 2006. Interspecific interaction and nutrient use in soyabean/sorghum intercropping system. Agron. J., 99 (4): 1097-1108.

Narasinga Rao, B.S., Y.G. Deosthale and K.C. Pant, 1993. Nutritive Value of Indian Foods. National Institute of Nutrition, Indian Council of Medical Research, India.

Odo, P.E., 1991. Evaluation of short and tall sorghum varieties in mixtures with cowpea in the Sudan savanna of Nigeria: Land equivalent ratio, grain yield and system productivity index. Exp. Agric., 27: 435-441.

Odo, P.E. and K.N. Futuless, 2002. Millet-soyabean intercropping as affected by different sowing dates of soyabean in a semi-arid environment. Cereal Research Communications, Hungary, 28 (1-2): 153-160.

Pal, U.R., T.O. Oseni and J.C. Norman, 1993. Effect of component densities on the productivity of soybean/maize and soybean/sorghum intercrops. J. Agron. Crop Sci., 170: 66-70.

Sulliva, P., 2003. Intercropping Principles and Production Practices. NCAT, ATTRA Publication #IP135, http://attra.ncat.org/attra-pub/PDF/intercrop.pdf.

Tindall, H.D., 1992. Commercial Vegetable Growing. 2nd Edn. Oxford University Press, pp: 193.

Zephaniah, L., 2001. Absorption of copper by some soils of Borno State. Final Year Project, University of Maiduguri, Nigeria.