Productivity of Intercropping Systems Using *Amaranthus cruentus* L and *Abelmoschus esculentus* (Moench) in Edo State, Nigeria

B.O. Obadoni, J.K. Mensah and S.A. Emua

Department of Botany, Ambrose Alli University, Ekpoma, Edo state, Nigeria.
E-mail: berndonis@yahoo.com

Abstract: *Amaranthus cruentus* L. (Large green) and *Abelmoschus esculentus* L. (Moench) (Okra) were grown at various replacement ratios (100/0, 67/33, 50/50, 33/67 and 0/100) in a randomized complete block design with four replications. Experiments were conducted during the growing seasons (November – February) of 2006 and 2007 in Ekpoma in the rainforest zone of Nigeria. At 4 and 6 WAP, large green in equal proportions with okra significantly ($P<0.05$) produced higher dry matter per plant while at 8 and 10 WAP, 67% large green grown in mixtures with 33% okra gave higher dry matter yield. Dry matter yield in Okra did not significantly ($P>0.05$) vary at all planting combinations. There was a significant linear correlation ($r=0.51$) between total dry matter production and yield. Combining large green and okra at 67/33% respectively gave a higher yield and consequently greater monetary returns than all other planting frequencies. In the mixtures, large green yield was slightly significant while okra (fruit yield) varied depending on its proportion in the mixtures: the lower the proportion of okra, the higher its yield. It is therefore more economical to intercrop these two crops.

[B.O. Obadoni, J.K. Mensah and S.A. Emua. **Productivity of Intercropping Systems Using *Amaranthus cruentus* L and *Abelmoschus esculentus* (Moench) in Edo State, Nigeria.** World Rural Observations 2010;2(2):53-60]. ISSN: 1944-6543 (Print); ISSN: 1944-6551 (Online). http://www.sciencepub.net/rural.

Key words: Productivity, Inter-cropping, large green/okra, Nigeria.

1. Introduction

Large green and okra are important vegetables grown separately and sometimes in mixtures by farmer in Edo State, Nigeria in lowland and upland areas during the dry and rainy seasons respectively. Large green is cultivated for its large, dark green leaves while okra is grown for its edible fruits. Both crops are widely cultivated in the central and southern states of Nigeria, provided adequate moisture is available through irrigation or from rainfall.

The productivity of these crops is limited by insect pests, most of them are skeletonizers. Therefore, profit margins have recently been reduced as a result of rising cost of insecticides and their application. One practical way of optimizing profit margins might be to intercrop large green and okra so that large green could benefit from the insecticidal sprays applied to okra, so saving on production costs, as demonstrated by Natarajan and Naik (1992) and Myaka and Kabissa (1993) in cotton cowpea mixtures.

Intercropping is the most popular crop production in subsistence tropical agriculture (Adelana,1986). Intercropping provides more profit and less risk of crop failures to the farmers, minimizes weed infestation (Egharevba,1984) enhances utilization of soil nutrients, space and reduction in spread of diseases and pests (Ezumah *et al.*,1987). Published information is available on the intercropping of cowpea and other crops (Gunkel and Mulligan, 1953; Igwilo,1998; Karel *et al.*, 1982 and Kumar *et al.*, 2008), maize/tomato (Lawson *et al.*, 2007), maize/okra (Mbowe,1990) and cowpea and rice Egharevba,1984),mucuna (/canavalia/maize (Myaka andKabissa,1993) radish/carrot/onion/galic/clusterbean and dolichos (Natarajan and Naik, 1992) and pearlmillet and clusterbean (Okonkwo and Chibuzo, 1998) but none on these two important crops, inspite of the growing popularity of this cropping combination in Edo State. Consequently, little is known about the plant interaction, yield and economic returns of the crop mixtures involving them. These experiments were therefore carried out in order to obtain information on the appropriate combination(s) that would improve plant growth, give higher yields and more monetary returns when grown in mixtures.

2. Materials and Methods

2.1 Experimental Site

Experiments were conducted at the Experimental Farm of the Department of Botany, Ambrose Alli University, Ekpoma during the growing seasons (November, 20 – February, 15) of 2006 and 2007. The dry season was preferred because yields were usually higher and crops were less prone to insect attacks. Ekpoma is situated between latitude 6.45 N and longitude 6.09 E in the Esan West Local Government Area of Edo State, receiving an annual rainfall of 1,550 mm, characterized by bi-modal peaks occurring in July and September with a short dry spell in August. The dry season starts in November and ends in March; mean daily temperatures throughout the period of field study was 30^0C ± 2^0C. Twenty soil samples were randomly collected from the experimental site at a depth of 15 cm; the samples were thoroughly mixed to form a homogenous mixture and sent to Green Consultants Limited, Benin City, for analyses. The soil characteristics were: pH 5.2, percentage organic matter 1.63, total nitrogen (N)% 0.13, available P (mg/kg) 7.35 and exchangeable K (Meg/100g of soil) 0.18.

2.2 Experimental Layout

The experimental design was a randomized complete block consisting of five treatments and four replicates. Okra (Clemson variety) was obtained from Pioneer Hi-breed Seed Nigeria Limited, Ibadan, Nigeria and large green from National Horticultural Research Institute, Ibadan and were grown at the following replacement ratios: 100/0, 67/33, 50/50, 33/67 and 0/100 in plots measuring 3 m x 2 m with a space of 1 m between plots to ease cultural operations. The plots were ploughed and harrowed with a hoe prior to planting following the cultural practice of the indigenous farmers.

Large green seeds were broadcast evenly in lines 30 cm apart into the plots except the ones containing sole okra and gently covered with soil. Okra seeds were sown (3 per hole) at a depth of 2.0 cm into the plots the same day large green seeds were broadcast and at 30 cm between and within rows. At one week after planting (1 WAP), large green seedlings were thinned to desired densities maintaining the same spacing as okra but between okra stands. A basal dressing of 50 kg ha^{-1} of NPK fertilizer was applied as a side-banding at 3 WAP to enhance growth. Karagas (lambda cyhalothrin) was sprayed at 4 and 6 WAP at the rate of 0.21 kg ai ha^{-1} to control insect pests that skeletonize and sometimes defoliate these crops. The plots were watered daily in the mornings to field capacity using watering cans except on days that the insecticide was applied.

2.3 Data Collection

Dry weights were determined at 4,6,8 and 10 WAP by harvesting 4 plants every fortnight at random from plots containing sole crops, while 8 plants (4 of each component crop) in the intercropped. Plants were harvested by gently pulling the plants out of the soil after heavy application of water to minimize breakage of smaller roots. The harvested plants were carefully tied, labeled and were dried in an electric oven at a temperature of 100^0C for 48 hours, weighed with an electronic balance (and mean weight per plant was calculated).

Number of nodes and internodes were counted at 10 WAP when no further growth was observed. Plant height, leaf area index (LAI) was determined as reported by Gunkel and Mulligan (1953) at 40 days after planting when maximum foliage was observed. Picking of okra capsules commenced after they have attained marketable size between 6 – 10 days from fertilization (Oyolu, 1980). Periodic pick within these number of days ensured palatability of the capsules as evident from the ease at which their tips could be broken between the fingers. At last picking, fresh okra capsules were purchased from the market in Ekpoma and weighed in the laboratory. This was to enable us estimate the monetary returns from the various cropping frequencies; the same procedure was carried out in large green. Large green was harvested every two weeks at a height of 20 cm above ground level. In the market, 77.5 g of fresh capsules were selling for ten naira (₦10.00) while 338.5 g of edible large green leaves sold for twenty naira (₦ 20.00).*

Analyses of variance were carried out on mean arithmetic data pooled for the two years since they did not vary at 5% level of significance.

* ₦ 126.00 exchanged for $1.00 US dollar during the periods of stay.

3. RESULTS

3.1 Vegetative Characters

Sole large green produced an average of 25 nodes per plant at 10 WAP, but the highest number of 44 nodes was recorded in 67/33 large green / okra mixture. At 50/50 and 33/67 large green okra combinations, large green produced an average of 39 and 34 nodes per plant respectively. Sole large green significantly ($P<0.05$) produced fewer nodes but visually longer internodes, others were similar, (Table 1). In okra, highest mean of 5 nodes per plant was recorded in the sole crop, while 33% okra combined with 67% large green produced 4, others had 3 each. The various cropping frequencies in okra showed no significant ($P \geq 0.05$) differences in the number of nodes observed (Table 1).

The highest number of internodes (32) was recorded in large green at 67/33% large green / okra mixture, its sole crop had 21. At equal (50/50) proportions and 33/67% large green/okra combinations, 19 and 17 internodes respectively were produced by large green. In okra, the varying planting frequencies had the same number of internodes, (Table 1). The different cropping ratios significantly ($P \leq 0.05$) affected plant height in large green, but in sole okra, the plants were significantly ($P \leq 0.05$) taller than others grown at different frequencies (Table 1).

TABLE 1

Cultivation of these crops at varying combinations significantly ($P \leq 0.05$) affected their leaf area indices (LAI). In both *A. cruentus* and *A. esculentus*, the largest LAI were observed in their sole crops while the least values were recorded in large green at 33/67% large green – okra, and in okra 67/33% large green – okra combinations, these were 1.8 and 1.1 respectively

(Table 1).

Dry matter production in both crops varied greatly (Fig. 1). Increase in dry matter production was rapid in large green from 4 to 6 WAP and this continued till 8 WAP. In Okra, dry matter accumulation was faster from 4 to 6 WAP compared to large green for the same period (Figs. 1b and c). At 8 and 10 WAP, higher proportions of large green / okra (100/0 and 67/33) mixtures significantly ($P \leq 0.05$) produced more dry matter than those grown in lower proportions with okra.

The highest mean dry matter output of 26.85 g from both crops was reported in 67/33% large green – okra mixture at 8 WAP whereas it was 6.84 g at 6 WAP in 50/50 combination. Combined highest mean yield of 44.1 g for both crops was recorded in the same planting ratio (67% large green / 33% okra) at the termination of the studies at 10 WAP (Fig. 1d). Also 67/33% large green / okra mixture significantly ($P \leq 0.05$) produced the highest dry matter per hectare compared to other planting frequencies (Fig. 1d); whereas the least was recorded in sole large green. There was a significant correlation (r = 0.51) between total dry matter production and yield of okra capsules.

3.2 Reproductive Characters/Yield

There were no clearly defined flowering pattern in the two crops at various cropping frequencies studied. Fifty percent (50%) flowering was first recorded in large green in 33/67% large green / okra mixture at 45 days after planting (DAP). This was closely followed by sole okra at 47 DAP while 50/50 ratio of both crops attained 50% flowering at 49 DAP; the remaining cropping combinations achieved 50% flowering at 51 DAP.

Varying cropping frequencies significantly ($P \leq 0.05$) affected yields in both large green and okra. Yields in sole and 67% large green were the same while the highest of 812.50 kg ha^{-1} was harvested in 33% large green. In okra, the sole crop gave the highest yield of 1114.00 kg ha^{-1}, this was followed by 33% okra and the least of 71.76 kg ha^{-1} in 67% okra (Table 2).

TABLE 2

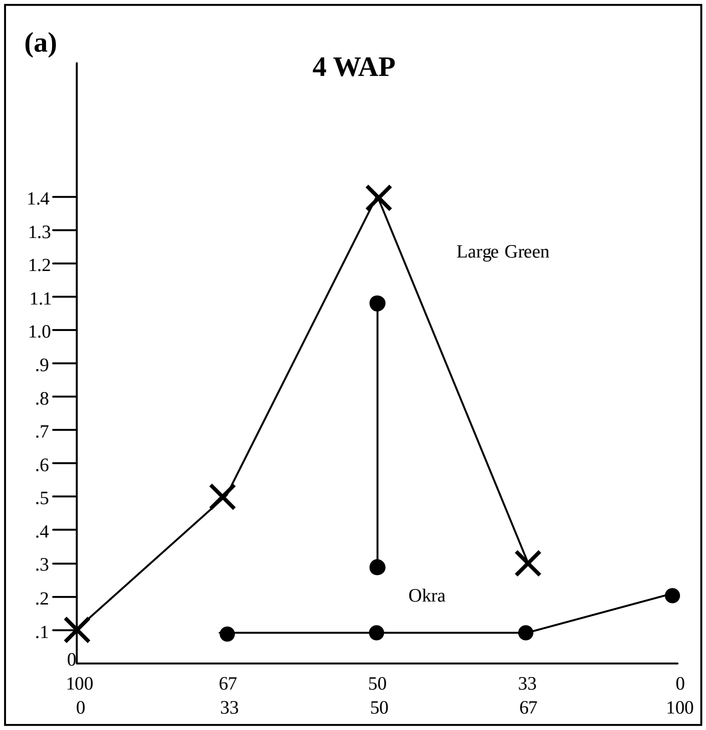
For sole large green and okra, the estimated monetary returns were ₦ 38892.76 and ₦ 143,741.92 respectively per hectare, whereas the least returns (₦ 9,259.34) from okra was recorded in 67% okra. A combination of the returns from the cropping frequencies showed that 67/33% large green – okra mixture gave the highest returns of ₦ 160,607.60 while the least was obtained in sole large green (Table 2). The estimated revenue from growing okra alone was 11.7% lower than growing them in 67/33% large green – okra mixture and 269.6% more profitable than growing large green alone.

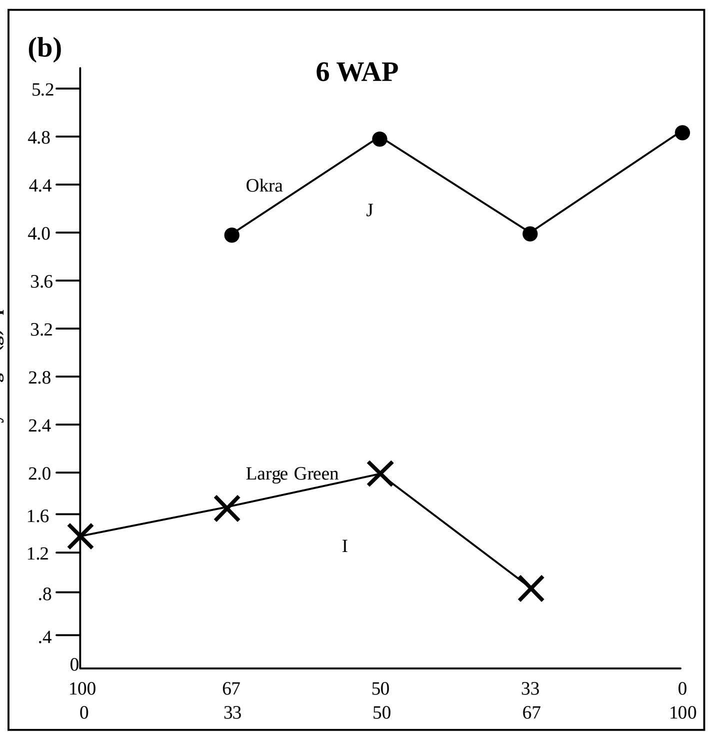
4. DISCUSSION

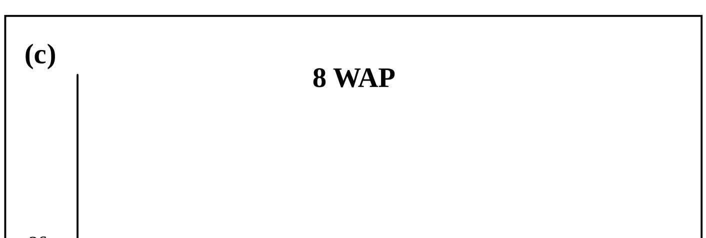
Okra and large green are fast growing fruit and leafy vegetables. Although, okra was taller than large green in all the treatments studied, the latter had more nodes and internodes than the former; this was due to the type of phyllotaxy exhibited by large green. Okra had visually much longer internodes than large green, that explained why okra had fewer nodes and internodes. The interaction between okra and large, though not significant, may have adversely affected the growth of both crops as evident from the heights of their monocultures. Stunting as observed in large green was probably due to shading by okra leaves and periodic cutting of large green stems. Intercropped plants may therefore decrease, increase or maintain their normal height depending on the nature of interference of the component crops. A previous study has shown that sole maize plants grew taller than maize plants grown in intercrops (Lawson, 2007). This difference in height could be attributed to competition for space and nutrients among the intercropped plants.

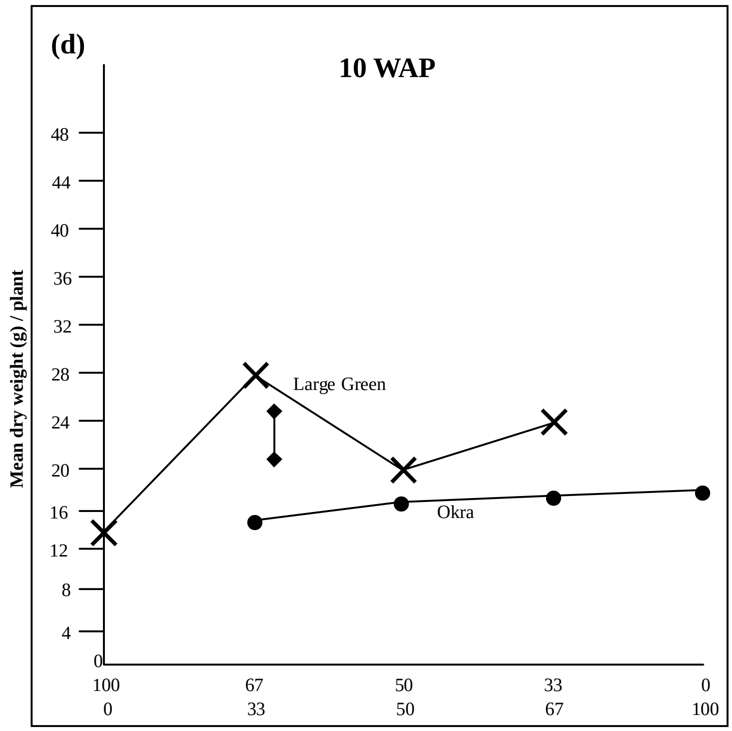
Periodic cutting of large green significantly reduced its dry matter yield at 6 WAP (Fig. 1b). Also, cutting stimulated the growth of its axillary buds and delayed flowering hence at 8 WAP, differences in mean dry weight per plant of both crops were significantly reduced (Fig. 1c). The low dry matter recorded in okra at 10 WAP (Fig. 1d) was attributed partly to senescence and fall of older leaves and picking of okra fruits which were the major sink for photosynthates. In this study, at 4,6,8 and 10 WAP, the dry weight of sole okra was consistently and significantly higher than its intercropped components (Figures 1a,b,c and d). This result was in agreement with the findings of (Abou-Hussein *et al*.,,2005) in greenbean, lettuce and green onion intercrop. The same trend was reported by Sharma (2008) in pearlmillet and clusterbean intercropping.

In this study, the highest LAI values were obtained in their sole crops. Since both crops were fast growing and established at the same time, LAI was dependent on planting frequencies; plots having higher proportions of one crop had higher LAI as they tried to out-compete the other component. Crops that were established at different times with varying growth habits attained higher LAI since the degree of inhibition was less as reported by Igwilo (1998) on maize, okra and yam mixed cropping and Egharevba (1984) in sorghum cowpea mixtures.


(a)
4 WAP
Mean dry weight (g) / plant
1.4
1.3
1.2
1.1
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
Large Green
Okra
100 67 50 33 0
0 33 50 67 100


(b)
6 WAP
Mean dry weight (g) / plant
5.2
4.8
4.4
4.0
3.6
3.2
2.8
2.4
2.0
1.6
1.2
.8
.4
0
Okra
J
Large Green
I
100 67 50 33 0
0 33 50 67 100


(c)
8 WAP



Large green
Okra

Figs. 1a, b, c and d. Effects of different planting ratios on the dry weight of large green and okra at 4,6,8, 10 weeks after planting (WAP) averaged for 2006 and 2007 planting seasons. ● —— Okra ✕ —— Large green

Vertical lines represent LSD at 5% level of significance.

Table 1: Effects of Different planting frequencies on the number of nodes, internodes, plant height and

leaf area index (LAI) averaged for 2006 and 2007 growing seasons.

Planting Frequencies	**Number of nodes**		**Number of internodes**	
	Large green	**Okra**	**Large green**	**Okra**
Sole large green	25	-	21	-
Sole okra	-	5	-	4
67% large green + 33% okra	44	4	32	3
50% large green + 50% okra	39	3	19	3
33% large green + 67% okra	34	3	17	3
LSD (P≤0.05)	3.58	NS	3.60	NS

Planting Frequencies	**Plant Height (cm)**		**Leaf Area Index (LAI)**	
Sole large green	82.4	-	2.90	-
Sole okra	-	131.2	-	2.70
67% large green + 33% okra	69.1	122.0	2.60	1.10
50% large green + 50% okra	68.7	124.0	2.26	1.90
33% large green + 67% okra	72.5	122.7	1.8	2.0
LSD (P≤0.05)	3.76	0.89	1.15	0.92

Table 2: Effects of Different planting ratios on total dry weight, yield and monetary returns from growing okra and large green together averaged to 2006 and 2007 growing seasons.

Planting Frequencies	**Total dry Weight (Kg ha^{-1})**	**Yield (Kg ha^{-1})**		**Total Yield (Kg ha^{-1})**	**Monetary returns(N) (ha^{-1})**		**Combined returns (* N ha^{-1})**
	Large green + Okra	**Large green (Fresh leaves)**	**Okra (Fresh fruits)**	**(Large green + Okra)**	**(Large green**	**Okra)**	
Sole large green	54.04	658.26	-	658.26	38,829.79	-	38892.79
Sole okra	67.76	-	1114.00	1114.00	-	143741.92	143741.92
67% large green + 33% okra	177.80	658.26	943.26	1601.50	38892.76	121714.84	160607.60

50% large green + 50% okra	148.36	735.89	123.26	859.15	43476.46	15904.52	59380.98
33% large green + 67% okra	163.60	812.50	71.76	884.26	48005.90	9259.34	57265.24
LSD (P<0.05)	6.40	12.49	34.69	-	-	-	-

* One hundred and twenty six naira (N126.00) exchanged for US$1 during the period of study.

The total stand yield was largely determined by the yield of the highest yielding component, that was large green, as evident from its consistency at varying planting ratios (Table 2). The highest total stand yield was observed in the mixture containing 67/33% large green – okra mixture, it was 43.70% higher than sole okra. Though pod yield in okra was highest in the sole crop, results from the mixtures indicated that okra yield was higher in lower proportions with large green. This was due to the increased space available to okra which favoured branching and subsequently improved flowering and fruiting. Other planting combinations had lower total yields than sole okra but higher than sole large green.

The results from these studies showed that 67/33% large green – okra mixture gave the highest monetary return of ₦ 160,607.60; this was 11.7% higher than the returns from pure okra and ₦ 121,714.84 more than the value of sole large green (Table 2). Even though large green showed fairly consistent yield at different planting frequencies, okra contributed more to the total income because it commanded a higher price in the market. In other combinations, total returns were higher than sole large green but lower than the value of sole okra. Similar results were reported by Okonkwo and Chibuzo (1998) in potato – soyabean intercrop where the intercropped gave higher monetary returns and the value determined by potato yield and price. Kumar *et al.,* (2008) showed that intercropping had an added advantage over their component sole crops and mixed cropping in terms of yields, land equivalent ratio, benefit: cost ratio and monetary advantage over sole cropping. Also, Sharma (2008) indicated that pooled results for a two-year-trial involving pearlmillet and clusterbean intercropping with a row ratio of 2:2 gave maximum values of land equivalent ratio, price equivalent ratio, high net returns and benefit: cost ratio. These reports support the findings in the present study; intercropping continues to dominate in the tropics as subsistence agriculture in widely practised.

CONCLUSION

From the above findings, it could be concluded that the interaction between large green and okra was dependent on planting ratios. From the practical point of view, maximum yield of okra can be obtained from monoculture but not from large green. Combining large green and okra at 67/33% was most profitable and would not only provide higher income but prevents total crop failure that may occur in a sole crop.

ACKNOWLEDGMENT

We are very grateful to the Management of National Horticultural Research Institute, Ibadan, Nigeria for providing us with large green seeds and to the technical staff for maintaining the crops in the field.

REFERENCES

1. Abou-Hussein, S.D., S.R. Salman, A.M.R. Abdel-Mawgoud and A.A. Ghoname,2005. Productivity, Quality and Profit of sole or Intercropped green bean (*Phaseolus vulgaris* L.) crop. Journal of Agronomy, 4(2): 151-155.
2. Adelana, B.O., 1984. Evaluation of maize – tomato mixed cropping in South-Western Nigeria. Indian Journal of Agric. Sc., 57:564-569.
3. Adelana, B.O., 1986. Neighbour effects in Maize – Okra mixed cropping. In: Paper presented at Hortson 8th Annual Conference, Ibadan. 10 – 14th November, 9p.
4. Egharevba, P.N. 1984. The effects of planting pattern on the performance of mixed sorghum and cowpea. Samaru J. Agric. Res.; 2:57-66.
5. Ezumah, H.C; N.K. Nam and P. Wlaker, 1987. Maize and cowpea Intercropping as affected by nitrogen Fertilizers. Agron. J., 29:275-280.
6. Gunkel, W.W., C.W. Mulligan, 1953. Leaf punch foliage samples. Farm Res. 19:3.
7. Igwilo, N., 1998. Yield of Yam tubers grown from Minisetts in relation to height of stakes and Intercropping with Okra in the rainforest zone of Nigeria, Niger. Agric. J., 29:95-105.
8. Karel, A.K., D.A. Lakhani and B.J. Ndunguni, 1982. Intercropping of Maize and Cowpea: effect of Plant Population on insect pest and yield. In:

Proceedings of the Second Symposium on Intercropping in Semi-arid areas. Morogoro, Tanzania, August, 1980. (Keswani, C.L. and B.J. Ndunguni, (eds) pp 102-109.
9. Kumar, N, V. Prakash, B.L. Mina, K.A. Gopinath and A.K. Sirvastva, 2008. Evaluation of toria (*Brassica compestris*) and lentil (*Lens culinaris)* Varieties in Intercropiing System with wheat (*Triticum aesstivum)* under rainfed Conditions. Indian Journal of Agronomy, 53(1): 61-64
10. Lawson, Y.D.I., I.K. Dzomeku and Y.J. Drisah, 2007. Time of planting Mucuna and Canavalia in an Intercrop System with Maize. Journal of Agronomy, 6(4): 534-540.
11. Mbowe, E.F.A., 1990. Intercropping an early maturing maize variety with cowpea and green gram. In: Proceedings of the First Tanzania National Maize Research Workshop, Arugha, June 1988 (Moshi, J.K. and J.K. Ramson (eds) pp 150 – 153.
12. Myaka, F.A; and J.C.B. Kabissa, 1993. Cotton and Cowpea Relay Intercropping: Preliminary results on its Economics and effect on some Agronomic Characters of both Crops. In: Trends in cowpea research, Proceedings of the Cowpea Research Seminar, Harare, Zimbabwe, pp 60 – 67.
13. Natarajan, M. and O.M. Naik, 1992. Competitive Effect of a Short Duration, bush type Cowpea when Intercropped with Cotton in Zimbabwe. Experimental Agric, 28:409 – 416.
14. Okonkwo, J.C. and A.C. Chibuzo, 1998. Effect of intra-row spacing on the performance of potato/soyabeans intercrop in Jos Plateau Area. Nigeria Agric. J., 29: 53 – 61.
15. Oyolu, C., 1980. Maximizing the Contributions of Okra – *A. esculentus* L. (Moench) to National diet. Annual Conference of the Horticultural Society of Nigeria, Ile Ife. pp. 1 – 4.
16. Rajkhowa, D.J. and S.R. Baroova, 2002. Competitive Behaviour of different Legumes grown as Intercrop with direct Seeded Upland Rice. Legume Research, 23: 61 – 63.
17. Remison, S.U., 1980. Interaction between Maize and Cowpea at various Frequencies. J. Agric. Sci., 94: 617 – 621.
18. Sharma, K.C. 2008. Fodder productivity and economics of multi-cut pearlmillet (*Pennisetum glaucum)* Intercropped with clausterbean (*Cyamopsis tetragonoloba*). Indian Journal of Agronomy, 53(1): 51-56
19. Suresha, B.A, T.B. Allolli, M.G. Patil, B.K. Dessai and A.H. Syed, 2007.

5/1/2010