



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & STUDIES

Studies of Cowpea Plant Types to Component Population Ratios in a Cowpea/Maize Intercropping System

ISSN 2319-9725

A.I. Afe

Department of Crop Production

Kwara State University, P.M.B. 1530, Malete, Nigeria

S. Atanda

Kwara State Agricultural Development Project, Ilorin, Nigeria

Abstract: Three cowpea types (erect, semi-prostrate and prostrate) were intercropped at five component population ratios with maize at Ejiba, southern guineas savanna agro-ecological zone of Nigeria in 2008 and 2009 cropping seasons. The experiment was a factorial laid out in a randomized complete block design (RCDB) and replicated three times. The result showed significant differential response to intercropping among the cowpea types and component population ratios. Prostrate cowpea significantly had more number of branches, pods and leaf area per plant and grain yield per hectare compared with the other cultivars. The effect of intercropping on maize leaf area was more pronounced in prostrate/maize system. The yield of maize was not affected by component population of cowpea types. Land equivalent ratio (LER) greater than unity (1.05-1.34) were recorded in erect and prostrate cowpea/maize system. The result also revealed the superiority of intercropping over sole cropping for the intercropping involving erect and prostrate cowpea maize mixture particularly where full population of cowpea were maintained. Therefore, it could be concluded that maize can be intercropped with prostrate and erect cowpea types.

Keywords: component population ratio, cowpea types, cowpea/maize system, land equivalent ratio

1. Introduction:

Simultaneous growing of two or more crops at the same time in the same field is a common practice among peasant small farmers. The advantages of the system over sole cropping has been reported by researchers (Iken and Amusa, 2004; Ullah et al., 2007) due to efficient utilization of natural resources, higher labour productivity and reduced risk of crop failure (Mutsears et al., 1983). Egbe (2005), recognized the positive impact of the system at solving future food problem in the developing countries.

In crop mixture, date of planting, plant architecture and choice of compatible crops among others are critical to obtain intercropping advantages.

Cowpea is an integral component of traditional cropping system due to its beneficial effect on sustainability as a source of nutritional food for man and fodder for his livestock (Henrit et al., 1997). It is commonly grown with other crops in various combinations (Motimore et al., 1997). In a survey of cropping system in west and central Africa (Singh and Ajeigbe, 2002), 15 major cropping systems involving cowpea were identified. Henriet et al., 1997 also reported the existence of 43 crop mixtures of cowpea in the Sudan savanna of Nigeria with millet/cowpea been predominant.

Intercropping maize with other crop is widely practiced throughout the world. In the forest zone of Nigeria, maize is often planted in complex mixture with other crops (IITA strategic plan 1989-2000; Alabi and Esobhawana, 2006.) The International Institutes of Tropical Agriculture (I.I.T.A) with cowpea as one of the mandated crops has studied the role of cowpea in major cropping systems, identified the production constraints in traditional system and has developed improved cowpea varieties that is suitable in crop mixture (Singh et al., 1997)

Cowpea/maize system has been subject of various studies by researchers with a view of increasing the efficiency of the system. Several of such studies had indicated a reduction in the yield of cowpea while maize yield were often not affected (Alhaji, 2008). Poor light interception has been identified as one of the factors responsible for poor yield of legume in crop mixture (Grosman and Quae, 1993). Several of such studies did not take into consideration the differences that exist in the growth habits among the cowpea varieties. This study is therefore designed to study the response of cowpea types (erect, semi -prostrate and prostrate) in combination with maize.

2. Materials And Methods:

A field trial was conducted in 2008 and 2009 cropping seasons at the Lower Niger River Basin Development Authority, Ejiba. The experimental size is located on latitude 18°, 18'N and longitude 5°, 39' E in the southern guinea savanna agro-ecological zone of Nigeria. Three varieties of cowpea (erect, semi- prostrate and prostrate) were intercropped with maize of five intercropping population ratios. Sole crops of maize and cowpea were included as control treatments. The two crops were planted simultaneously in single alternate rows on the flat after ploughing and harrowing. Phosphorous fertilizer, as single super phosphate (P_2O_5) was uniformly broadcast to the plots at the rate of 60kg P_2O_5 kg / ha two days before planting. Urea (46%N) was split applied to maize at the rate of 120kgN/ha at 3 and 6 weeks after planting (WAP). Pre-emergence herbicide (pendimethalin) was applied at the rate of 1.5kg a.i/ha immediately after planting and cylothrine (500EC), a systemic insecticide with contact action was applied to cowpea at the rate of 40ml /20ml of water. This was followed by fortnight application until harvesting of cowpea.

The five population ratios and the three cowpea types treatments were arranged as 5x3 factorial in a randomly complete block design and replicated three times. Ten plants from the two inner rows were tagged for data collection on number of pods, and branches/plant. The leave area/plant was estimated by finding the products of leave length and breadth of five randomly selected plants. The value is transformed by the leave area fixed factor of 0.612 (Polster Reichenbach, 1958) for cowpea and 0.710 (Lazarov, 1965) for maize.

$$\text{Area} = bL \times B$$

$$B = \text{Leaf area co-efficient (fixed factor)}$$

$$L = \text{leaf length}$$

$$B = \text{leaf breadth}$$

All the pods in each plot were harvested, threshed, and winnowed for cowpea grain yield, while maize cobs from each plot were harvested. The average grain yield of each treatment was computed as grain yield/hectare. The efficiency of the mixture was estimated using the land equivalent ratio index (Ofori and Stern, 1987).

$$LER = Y_{ab}/Y_{aa} + (Y_{ba}/Y_{bb})$$

Where; Y_{aa} and Y_{bb} are crop sole Yield of cowpea and maize and Y_{ab} and Y_{ba} are the intercrop yield of cowpea and maize. The data collected were subjected to analysis of variance for test of significance using the PROC GLM procedures (SAS, 1989) and treatment means compared using Duncan's Multiple Range Test at five percent level of probability ($P \leq 0.05$)

3. Results:

The prostrate cowpea had more number of branches and pods/plant than the erect and semi-prostrate cowpeas either as intercrop or as sole crop in the two cropping seasons (Tables 1-3). Irrespective of cowpea type, the number of branches increased as the population of component maize decreased. All the cultivars recorded the least number of branches and pods at component population ratio of 1.00C: 0.75M. The erect cowpea competes favourably with the semi-prostrate at the intercrop but was inferior in pure stand.

There was a significant difference in the leaf area among cowpea types at different population ratios (Table 4). Prostrate cowpea consistently had more leaf area than the other cultivars and was appeared not to be influenced by intercropping. The erect cowpea recorded the least leaf area (230.13cm^2) and (285.25cm^2) in 2008, and 2009 respectively. The highest leaf area 408.93cm^2 and 400.74cm^2 were recorded in prostrate cowpea at sole stand, though not significantly higher than component population ratio of 1.00C: 0.25M.

Component population ratios	2008 Cowpea plant type				2009 Cowpea plant type			
	Erect	Semi prostrate	Prostrate	Mean	Erect	Semi prostrate	prostrate	Mean
C : M								
1.00 : 0.75	3.00d	3.00d	4.00b	3.00d	3.00c	3.00c	5.00b	3.00b
1.00 : 0.50	3.00d	3.00d	5.00b	4.00c	3.00c	3.00c	6.00a	4.00b
1.00 : 0.25	4.00c	4.00c	5.00b	4.00c	4.00b	4.00b	6.00a	4.00b
0.75 : 0.25	4.00c	4.00c	5.00b	4.00c	4.00b	4.00b	6.00a	4.00b
0.50 : 0.50	4.00c	4.00c	6.00b	5.00b	4.00b	4.00b	6.00a	5.00b
Sole	4.00c	5.00b	6.00b	5.00b	4.00b	5.00b	6.00a	5.00b
Mean	4.00c	4.00c	5.00b		4.00b	4.00b	5.00a	
Se		0.10				0.10		
C.V (%)		9.82				9.41		

*Values with the same letter(s) in the same column or row under the same year are not significantly different at 5% level of probability by Duncans Multiple Range Test (DMRT).

C = Cowpea, M=Maize

Table 1: Interactive effects of component population ratios and cowpea plant type on the number of branches/plant in a cowpea/maize intercropping system in 2008 and 2009*

Component population ratios	2008 Cowpea plant type				2009 Cowpea plant type			
	Erect	Semi prostrate	Prostrate	Mean	Erect	Semi	Pro	Mean
C : M								
1.00 : 0.75	14.00f	14.00f	17.00d	15.00e	15.00d	15.00d	18.00b	16.00d
1.00 : 0.50	14.00f	14.00f	19.00c	16.00de	16.00cd	16.00cd	19.00b	17.00cd
1.00 : 0.25	15.00ef	16.00de	22.00b	18.00c	16.00cd	17.00c	19.00b	17.00cd
0.75 : 0.25	15.00ef	17.00d	21.00b	18.00c	16.00cd	17.00c	20.00ab	18.00bc
0.50 : 0.50	15.00ef	16.00de	23.00a	18.00c	17.00c	17.00c	20.00ab	18.00bc
Sole	15.00ef	19.00bc	23.00a	19.00bc	17.00c	19.00b	21.00a	19.00b
Mean	15.00ef	16.00de	21.00b		16.00c	17.00c	20.00ab	
Se		0.85				0.79		
C.V (%)		14.55				9.42		

*Values with the same letter(s) in the same column or row under the same year are not significantly different at 5% level of probability by Duncans Multiple Range Test (DMRT).

C = Cowpea, M=Maize

Table 2: Interactive effects of component population ratios and cowpea plant types on the number of pods/plant of cowpea in a cowpea/maize intercropping system in 2008 and 2009*

The effects of intercropping on leaf area of maize is more pronounced with maize/prostrate cowpea system, though not statistically manifested as compared with erect and semi-prostrate/maize intercropping system.

Component population ratios	2008 Cowpea plant types				2009 Cowpea plant types			
	Erect	Semi Prostrate	prostrate	Mean	Erect	Semi Prostrate	Prostrate	Mean
C : M								
1.00 : 0.75	230.13f	252.03f	462.46a	314.87c	285.25f	302.47ef	471.00a	352.70c
1.00 : 0.50	373.39f	286.34f	465.63a	314.79c	298.23ef	329.26de	439.86a	373.80bc
1.00 : 0.25	326.16e	352.89e	479.80a	386.28b	323.26de	356.52cd	498.80a	392.86b
0.75 : 0.25	332.86e	351.77e	486.65a	390.42b	334.82d	352.61cd	494.65a	394.72b
0.50 : 0.50	351.27de	350.82de	446.31a	382.80b	330.82cd	358.71c	479.80a	389.44b
Sole	361.14d	376.16d	489.50a	408.93b	342.74d	374.32c	485.18a	400.74b
Mean	312.16c	328.33d	471.73a		319.20d	345.60cd	486.72a	
Se		13.52				14.39		
C.V (%)		17.85				16.92		

*Values with the same letter(s) in the same column or row under the same year are not significantly different at 5% level of probability by Duncans Multiple Range Test (DMRT).

C = Cowpea, M=Maize

Table 3: Interactive effects of component population ratios and cowpea plant types on leaf area/plant (cm²) of cowpea in a cowpea/maize intercropping system in 2008 and 2009*

Component population ratios	2008 Cowpea plant types				2009 Cowpea plant types			
	Erect	Semi Prostrate	prostrate	Mean	Erect	Semi Prostrate	Prostrate	Mean
C : M								
1.00 : 0.75	379.52c	373.37cd	362.92d	371.94d	365.62cd	359.48d	347.62d	357.24cd
1.00 : 0.50	390.33c	385.04cd	374.05d	383.14d	379.00bc	362.17d	368.53c	369.90c
1.00 : 0.25	408.00ab	407.46ab	396.59b	404.02b	381.43ab	378.87bc	370.13bc	376.81bc
0.75 : 0.25	410.71ab	404.90ab	399.42b	405.01ab	385.29ab	380.43bc	376.40bc	380.71bc
0.50 : 0.50	412.44ab	411.68ab	401.16b	408.43ab	384.54ab	381.98ab	374.11bc	380.21bc
Sole	416.58a	416.58a	416.58a	416.58a	392.61a	392.61a	392.61a	392.61a
Mean	402.93b	399.83b	391.62b		381.42ab	375.92b	5371.40bc	
Se		6.01				5.60		
C.V (%)		18.16				15.60		

*Values with the same letter(s) in the same column or row under the same year are not significantly different at 5% level of probability by Duncans Multiple Range Test (DMRT).

C = Cowpea, M=Maize

Table 4: Interactive effects of component population ratios and cowpea plant types on leaf area/plant (cm²) of maize in a cowpea/maize intercropping system in 2008 and 2009*

There was a general decreased in the yield of cowpea as the population of component maize decreased (Table 5). The prostrate cowpea yielded higher than the erect and semi-prostrate varieties either as sole or as in intercrop.

Irrespective of cowpea type, reasonable yield was recorded in the mixture at component population ratio of 1.00C: 0.25M. The erect cowpea was inferior to semi-prostrate cowpea in a sole stand, but not when in the mixture.

Maize grain yield decreased as the number of maize stand in the mixture decreased (Table 6). Similar maize grain yield was recorded where we had equal maize population in the mixture. Intercropping maize with erect and semi-prostrate cowpeas seemed to be superior to the maize intercropped with prostrate variety, though not statistically manifested.

Component population ratios	2008 COWPEA PLANT TYPES				2009 COWPEA PLANT TYPES			
	Erect	Semi	Pros	Mean	Erect	Semi	Pro	Mean
C : M								
1.00 : 0.75	0.76f	0.88ef	2.09b	1.24de	0.82g	0.94g	2.08bc	1.28ef
1.00 : 0.50	0.93f	1.19ef	2.38ab	1.53cd	1.09fg	1.38ef	2.55ab	1.67d
1.00 : 0.25	1.08ef	1.48ef	2.65a	1.73cd	1.15fg	1.51def	2.80a	1.82cd
0.75 : 0.25	1.02ef	1.10ef	2.13b	1.42de	1.09fg	1.18fg	2.25bc	1.51def
0.50 : 0.50	0.78f	0.92ef	1.67d	1.12ef	0.85g	1.14fg	1.90cd	1.30ef
Sole	1.10ef	2.15b	2.71a	1.98c	1.28ef	2.18bc	2.88a	2.11bc
Mean	0.95ef	1.28de	2.22b		1.02fg	1.39ef	2.32bc	
Se		0.22				0.19		
C.V (%)		19.72				18.65		

*Values with the same letter(s) in the same column or row under the same year are not significantly different at 5% level of probability by Duncans Multiple Range Test (DMRT).

C = Cowpea, M=Maize

Table 5: Interactive effects of component population ratios and cowpea plant types on grain yield of cowpea in a cowpea/maize intercropping system in 2008 and 2009*

Component population ratios	2008 COWPEA PLANT TYPES				2009 COWPEA PLANT TYPES			
	Erect	Semi prostrate	Prostrate	Mean	Erect	Semi prostrate	prostrate	Mean
C : M								
1.00 : 0.75	2.80b	2.71b	2.68b	2.73b	2.72b	2.60b	2.52bc	2.61b
1.00 : 0.50	2.18c	2.27c	2.01c	2.14c	1.83d	1.79d	1.67d	1.73d
1.00 : 0.25	1.61d	1.94d	1.61d	1.65d	1.56e	1.54e	1.43e	1.51e
0.75 : 0.25	1.67d	1.49d	1.62d	1.59d	1.50e	1.56e	1.40e	1.49e
0.50 : 0.50	2.32c	2.12c	2.23c	2.22c	1.89d	1.75d	1.60d	1.74d
Sole	4.82a	4.82a	4.82a	4.82a	4.12a	4.12a	4.12a	4.12a
Mean	2.58b	2.53b	2.50b			2.27c	2.12c	
Se		0.13				0.11		
C.V (%)		18.38				16.95		

*Values with the same letter(s) in the same column or row under the same year are not significantly different at 5% level of probability by Duncans Multiple Range Test (DMRT).

C = Cowpea, M=Maize

*Table 6: Interactive effects of component population ratios and cowpea plant types on grain yield of maize in a cowpea/maize intercropping system in 2008 and 2009**

Based on the LER (Table 7), intercropping was superior to sole cropping for the intercropping involving erect and prostrate cowpea/maize system particularly when full population of cowpea were maintained in the two years. There were no intercropping advantages from intercropping semi-prostrate cowpea with maize in the two cropping seasons. Intercropping maize at 75% population with prostrate cowpea at full population (1.00C: 0.75M) had the highest LER of 1.33 and 1.34 in 2008 and 2009 respectively.

Component population ratios	2008				2009			
	Erect	Cowpea plant type		Mean	Erect	Cowpea plant type		Mean
		Semi prostrate	Prostrate			Semi prostrate	Prostrate	
C : M								
1.00 : 0.75	1.27a	0.97cd	1.33a	1.18b	1.30a	1.06ef	1.34a	1.25b
1.00 : 0.50	1.31a	1.04c	1.26ab	1.22b	1.29a	1.06ef	1.27a	1.21b
1.00 : 0.25	1.32a	1.04c	1.31a	1.22b	1.27ab	1.06ef	1.33a	1.21b
0.75 : 0.25	1.16b	0.82e	1.12b	1.03c	1.20c	0.91h	1.12de	1.08e
0.50 : 0.50	1.18b	0.87e	1.07cd	1.04c	1.12d	0.96g	1.05ef	1.04ef
Sole	1.00c	1.00c	1.00c	1.00c	1.00c	1.00fg	1.09fg	1.00fg
Mean	1.22ab	0.95d	1.19b		1.20ab	1.03ef	1.18cd	
Se		0.04				0.03		
C.V (%)		7.02				5.02		

*Values with the same letter(s) in the same column or row under the same year are not significantly different at 5% level of probability by Duncans Multiple Range Test (DMRT).

C = Cowpea, M=Maize

Table 7: Interactive effects of component population ratios and cowpea plant types on Land Equivalent Ratio (LER) in a cowpea/maize intercropping system in 2008 and 2009*

4. Discussion:

The significant decreased in the cowpea yield among the cowpea types particularly at high population of component maize could be ascribed to decrease in the number of branches and pods/plant due to competition for natural resources. The branches decide the final yield in legume as it affects the number of leaves which produce the photosynthate (source) and the number of pods (sink). Decreased number of pods/plant with increase population of component maize has been reported (Olufajo, 1988; Adeniyi *et al.* 2004)

The intercropped yield of cowpea was highest in prostrate followed by erect and least in semi-prostrate. The following reasons are tenable for this observation. The prostrate cowpea had more leaf area/plant to intercept more light with longer period than did the erect and semi-prostrate cultivars. In a much earlier study, Crobies (1982) and Davies (1992) reported that longer retention of effective leaf area in hybrid maize contributed significantly to increase yield over open pollinated maize. Studies has also shown that planophiles(prostrate leaves) intercepted more light per unit area than erectophiles (erect leaves) Nelli *et al.*, 1974).

Differences in the grain yield among the cultivars could also be due to genetic yield potential of the cultivars and possibly their adaptability to intercropping.

These can be explained in the significant differences in the number of branches, pods and leave area/ plant between sole stand and the intercropped system. Terrao et al (1997), reported that spreading cowpeas perform well under intercropping due to substantial root system and high translocation efficiency. In another study, N'tare (1989) observed that early maturing erect cowpea lines are adapted to intercropping in a cereal based intercropping system.

The slight decreased in the yield of maize intercropped with prostrate cowpea could be due to vigorous growth of the cultivar particularly at the later growth stage that probably increased the competition for growth resources. Late maturing cowpea has been reported to be more competitive and reduced the yield of millet in cowpea /millet intercrop (Ntare, 1989, 1990).

The superiority of intercropping over the sole cropping particularly in erect and prostrate cowpea maize/system agreed with the work of earlier researchers in cowpea/maize system (Adeniyi et al., 2004, Vestargar, 2008). Maize is naturally taller than cowpea, sole or intercrop, the differences in plant height between the components might have accounted for better utilization of intercepted light and the increased intercropping advantage. Clark and Francis (1985), observed that if tall crop (C_4) is intercropped with a shorter crop (C_3), there could be an enhanced usage of total light. In another study, Squire (1990) reported that in a mixed canopy of a cereal-legume, the intercrop used solar energy much more efficiently than the sole legumes and sometimes slightly more than the cereals.

The result of this study showed that the efficiency of production system in cowpea/maize varied significantly and to large extent depended on the component population ratios and cowpea plant types. The intercropping advantages were those involving erect and prostrate cowpeas/maize intercropping where full populations of cowpea were maintained. Therefore full population of cowpea should be maintained for intercropping involving erect and prostrate cowpea in combination with maize.

References:

1. Adeniyi, O.N, Agbaje, G.O and Ayoola, O.T. (2004). The performance of cowpea intercropped and cassava. Institute of Agricultural Research and Training Annual Review. 2004
2. Alabi, R.A. and Esobahawan, A.O. (2006). Relative economic value of maize-okro intercrops in rain forest zone, Nigeria. Journal of central European Agriculture. Vol 7 (2006) No 3 :433-438.
3. Alhaji, I.H. (2008). Performance of some cowpea varieties under sole and intercropping with maize. African Research review vol. 2 (3) 278-291.
4. Clark, E.A and Francis C.A. (1985). Transgressive yielding in bean/maize intercrops interference in time and space. Field Crop Research. 11: 37-53.
5. Crossbie, T.M (1982). Changes in physiological traits associated long term breeding effects to improve grain yield in H. Loden and D. Wilkinson (eds). Proceedings 37th annual corn and sorghum Research conference Chicago. 11th American seed trade association. Washington DC. 206-223.
6. Davies, D.N (1992). Genetic contribution to yield of maize. Maydica 37:67-79
7. Egbe, O.M (2005). Evaluation of some agronomic potentials of pigeonpea genotypes for intercropping with maize and sorghum in southern guinea savannah .P.h.D thesis, University of Agriculture, Markudi Nigeria.
8. Grossman, J. and Quales, W. (1993). Strip intercropping for biological control. IPM Practitioner 1-11.
9. Henriët, J., G.A. Van, Ek, Blade, S.F and Singh B.B. (1997) Quantitative assessment of traditional cropping systems in the Sudan savanna of northern Nigeria. I Rapid surveillance of prevalent cropping systems. Samaru Journal of Agricultural Research 14:37 -45.
10. IITA, Strategic plan 1989-2000, June, 1988.
11. Iken, J.E and Amusa, N.A. (2004). Maize research and production in Nigeria. African Journal of Biotechnology. Vol. 3 (6); pp 302-307
12. Lazarov, R. (1965). Koefitsientiza opredelyana na listnata por'enchhnost prinyakoi selkostonopanski Kulturi (coefficients for determining the leaf area in certain agricultural crops) Rast , Nauki (Sofia) 2(2):27-37, 1965.
13. Mortimore, M. J, B.B. Singh, F. Harris and S. F. Blade. (1997). Cowpea in traditional cropping systems. Pages 99 – 113 in advances in cowpea research, edited by B. B

- Singh, D. R. Mohan raj, K.E Dashiell and L.E.N Jackai. Copulication of international institute of tropical agricultural (IITA) and japan international research center for agricultural sciences (JIRCAS) IITA, Ibadan, Nigeria.
14. Mutsears, H.J.W, Ezumali, H.C and Osiru D.S.O. (1993). Cassava –based intercropping: A Review in field crops research, 34. 431-457.
 15. Nelliat, E.V, Bavappa, K.V.A and Nair, P.K.R. (1974). Multistorey cropping new dimension of multiple cropping in coconut plantations. World crops 26: 262-266.
 16. Ntare, B.R. (1990). Intercropping morphorologically different cowpeas with pearl millet in short season environment in the sahel. Experimental Agriculture. 26: 41-47.
 17. Ofori, F. and Stern, W.R. (1987). Cereal legume intercropping systems. Advance in Agronomy.41: 4-90.
 18. Olufajo, O.O. (1988). Effects of component population on the productivity of maize-cowpea intercrop. Nigeria Agricultural Journal 23: 25-34.
 19. Polster, H., REichenbach, H. Bestimmungvon Blattflächen (1958). In situ durch lineare messungen. Biol.zentruabl, 77:265-277.
 20. SAS (Statistical Analysis System Institute Inc) 1989. SAS/STAT Users version 4th edn. Vol. 1,cary, North Carolina ,USA.
 21. Singh, B.B and Ajeigbe, H.A. (2002). Improving cowpea – cereals – based cropping system to savannas of West Africa. Pages 276 – 284 in challenges and opportunities for enhancing sustainable cowpea production. Edited by C.A. Fatokun, S.A Tarawali, B.B, Singh, P.M. Kormawa and M. Tamo IITA, Ibadan, Nigeria.
 22. Squire, G.R. (1990). The Physiology of tropical crop production. C.A.B. International Cambridge, U.K.
 23. Terroa, T.,I Watanabe, R Matsunaga, S Hakoyama, and B.B. Singh. (1997). Agro physiological constraints in intercropped cowpea: an analysis. Pages 129 – 140 in Advances in cowpea research, edited by B.B Singh, D.R. Mohan Raj, K.E. Dashiell, and L.E.N Jackai. Copulication of international institute of tropical agricultural (IITA) and Japan International Research Center for Agricultural Sciences (JIRCAS) IITA, Ibadan, Nigeria.
 24. Vesterager, J.M, Nielsen, N.E, and Hogh-Jensen. (2008). Effects of cropping History and Phosphorus Source on Yield and Nitrogen Fixation in sole and Intercropping Cowpea-maize System. Nutrient Cycling in Agroecosystems. 80 (1): 61-73.

25. Ullah, A, Ashraf Bhatti M, Gurmani Z.A and Imran M. (2007). Studies on planting patterns of maize (*Zea mays* L.). Facilitating legumes intercropping. (2007). Journal of Agricultural Research Vol 45 (2). 113-118.