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Growth Attributes of Component Crops in a Maize (*Zea mays* L.)/Cowpea (*Vigna unguiculata* L. Walp) Intercropping System as Influenced by Crop Arrangement and Proportion in Semi-Arid Nigeria

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Abstract: Field trials were conducted at Samaru, Nigeria during the 2004-2006 wet seasons to study the influence of to crop arrangement and proportion on the growth attributes of component crops in a maize-cowpea intercropping system. The treatments tested consisted of maize and cowpea intercrops with two forms of crop arrangement (intra- and inter-row), four different crop proportions (1C:1M, 3C:1M, 1C:3M and 2C:2M Cowpea:Maize) and two row arrangements (single- and paired-row) in factorial combinations. Treatments were arranged in a randomized complete block design with four replications. Crop arrangement significantly affected the growth and growth characters of maize and cowpea intercrops. The inter-row crop arrangement produced taller maize plants and higher dry weight than the intra-row crop arrangement. The 1:1 and 1:3 (Cowpea:Maize) crop proportions produced taller maize plants than the 3:1 and 2:2 (Cowpea:Maize) crop proportions while the paired-row arrangement also produced taller maize plants with low dry weight compared to the single-row arrangement. The inter-row crop arrangement produced cowpea crop with moderate height, higher dry weight and wider canopy spread. The 3:1 (Cowpea:Maize) crop proportion produced wider cowpea canopy spread and higher dry matter weight but shorter plants compared to the other proportions. The paired-row arrangement produced taller cowpea plants with low dry matter weight. Researchers conclude that the vegetative growth of maize and cowpea plants in an intercropping system can be enhanced using the inter-row crop arrangement, 1:1 or 2:2 (Cowpea:Maize) crop proportions and paired-row arrangement for subsequent high maize grain yield. Alternatively by using inter-row arrangement, 3:1 (Cowpea:Maize) crop proportion and single-row arrangement for moderate maize grain yield but higher cowpea grain yield as well as soil fertility improvement through nitrogen fixation. The provision of cowpea haulms for livestock feed would be a bonus.

Key words: Canopy spread, crop mixture, crop growth, plant geometry, dry matter accumulation, Nigeria

INTRODUCTION

Intercropping is widely practised in the tropical regions of developing countries and it is considered to be a primitive form of farming and that would in a matter of time be replaced by sole cropping. However, the practice of intercropping still remains widespread and evidence is accumulating to suggest that in many situations, it may represent a more efficient use of natural resources (Fordham, 1983; Dahmardeh *et al*., 2010). Despite the claim of superiority of sole cropping over intercropping and in spite of the efforts by extension workers to impress upon farmers this superiority, there has been no apparent shift from the adoption of intercropping to that of sole cropping in most developing countries, most especially Africa (Abalu, 1976; Ajeigbe *et al*., 2006). Farmers' insistence on intercropping systems, especially the cereal-legume intercropping system is predicated upon earlier studies which have demonstrated greater cash returns from it than from sole crop legume or cereal. In separate experiments involving intercropping of cereals with legumes, Baker (1978) and Remison (1978) found that farmers realized higher yields and income than in sole-crop. This was confirmed by the findings of Kumar *et al*. (1987) who studied maize-based intercropping systems involving various legumes at Samaru, Nigeria. These happened because of the advantages that have been associated with various intercropping systems (Willey,

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1985; Dahmardeh *et al.*, 2010). Most fundamental among the various advantages associated with intercropping systems are more efficient utilization of resources and biological yield advantage. Insurance against crop failure is also a motivation for the adoption of intercropping by smallholder farmers. There are however certain disadvantages that are associated with intercropping, some of which may take the form of yield decline because of adverse competitive effects (Lipps and Deep, 1991). Allelopathic effect has also been reported in intercropping. Another demerit is the difficulty that has to do with the practical management and determination of rate of input use by crops in intercropping in terms of fertilizer and pesticide application (Rice, 1974; Santalla *et al.*, 1999). Despite these short-comings the superiority of intercropping amongst other cropping systems has remained unchanged within the African farming systems (Abalu, 1976; Willey, 1979; Onwueme and Sinha, 1991). One of the crops frequently found in intercropping systems is maize (*Zea mays* L.). It is an important grain crop of the world and ranks third after wheat (*Triticum aestivum*) and rice (*Oryza sativa*). In many African countries, maize has almost replaced traditionally grown cereals such as sorghum (*Sorghum bicolor* L. Moench) and millet (*Pennisetum glaucum*) because it gives one of the highest yields per unit area, provides nutrients in compact form, protection (through husks) against birds and rain, easy to harvest and does not shatter and stores well when properly dried (Kassam *et al.*, 1975; Onwueme and Sinha, 1991). In developed agriculture until recently, maize is grown in monoculture while intercropping of maize with other crops such as legumes is practised by many traditional African farmers (Fordham, 1983; Onwueme and Sinha, 1991).

Cowpea (*Vigna unguiculata* L. Walp) is the second most important food legume in tropical Africa after common bean (*Phaseolus vulgaris*). It is the most widely cultivated legume crop in Nigeria (Bichi, 1982; Arnon, 1992; Keku, 1999). Due to its beneficial effects on subsequent crops in rotation and intercropping systems, cowpea has always been grown along with other crops, especially with maize, sorghum and millet. It was reported that although, cowpea is a major component of the traditional cropping systems in Africa, Asia and America where it is grown in mixture with other crops in various combinations, its productivity is low due to certain reasons (Olufajo and Singh, 2002).

The aim of every farmer in Africa growing maize/legume intercrop is to increase overall yield using the limited available labour and capital. More attention is therefore given by this resource-limited farmer to yield and income stability at the expense of sole crop yield. The practice of intercropping over the years has helped to reduced variability in total biomass, seed production and income due to complementary effects among associated crops (Santalla *et al.*, 1999; Eskandari, 2009). For these reasons and others already mentioned, intercropping systems are very attractive, not only to small farmers but also to managers of rural development projects in sub-Saharan Africa. Since, studies have shown that subsistence farmers in African countries such as Nigeria will continue to adhere to the practice of intercropping and despite this attachment to intercropping system, most of them neither have enough knowledge of which planting pattern and crop proportion to adopt nor the understanding of the cost-revenue profile of the systems. It is important therefore, to accord them the opportunity of various options available in terms of crop combination, spatial arrangement and plant proportion and choose the best one that will help them to maximize the gains of intercropping system. The present investigation was therefore to determine the growth attributes of component crops in a maize/cowpea intercropping system under the influence of crop arrangement, proportion as well as row arrangement of the intercrops.

MATERIALS AND METHODS

Experimental site: The study was conducted during the 2004-2006 wet seasons at the Experimental Farm of the Institute for Agricultural Research (IAR), Ahmadu Bello University, Samaru (latitude 11°11'N, longitude 7°38'E and 686 m above sea level), Nigeria. The site was located in the Northern Guinea savanna ecological zone of Nigeria. The soil of the experimental site was a well-drained leached ferruginous tropical clay loam.

Treatments and experimental design: The treatments consisted of maize and cowpea intercrops with two forms of crop arrangement (intra- and inter-row) four different crop proportions (1:1, 3:1, 1:3 and 2:2 Cowpea:Maize) and two row arrangements (single- and paired-rows). These treatments were arranged in factorial combinations using the randomized complete block design with four replications. The varieties of the crops used were TZPBSR (maize, the main crop) and SAMPEA-6 (cowpea, secondary the intercrop).

Planting and cultural practices: The experimental site was ploughed, harrowed and ridged 75 cm apart. The gross plot size was 8 m by 6 m (8 rows, 6 m long) while the net plot size was 6 m by 4 m (4 rows and 6 m long). Maize was planted as soon as rainfall was established between the end of May and 1st week of June. Maize was sown at an intra-row spacing of 25 cm with two seeds per hill which was later thinned to one seedling per hill at 3 weeks. Cowpea was sown two seeds per hill in mid-July at 25 cm apart and later thinned to one seedling per hill at 3 weeks.

Measurements: Five maize/cowpea plants from each plot were randomly selected and tagged for periodic observation during the crop's growth period. The observations at 10 and 12 Weeks After Sowing (WAS) were recorded for both crops. The plant height was measured from the tagged plants using a meter rule from the base of the plant to the top of the canopy. Mean plant height was computed and expressed in centimeters per plant. Plant dry weight was measured by random selection of five plants from each plot and cut at the base (at ground level). The leaves were detached and both the stalk and leaves were dried to constant weight in a Gallenkamp oven (Model OV-420) at a temperature of 70°C and weighed with a toploading Mettler balance (Model P. 1200). The component weights were added together and the mean values recorded. The cowpea canopy spread was measured using a meter rule across the plant canopy and the mean was recorded.

Statistical analysis: The data collected for both maize and cowpea were subjected to Analysis of Variance (ANOVA) using the SAS software (SAS, 2001) to determine the significance of treatment effects as described by Snedecor and Cochran (1967). The means were separated using Duncan's Multiple Range Test (DMRT) (Steel *et al*., 1997).

RESULTS

Table 1 shows the effect of crop arrangement, crop proportion and row arrangement on maize plant height in the 2004-2006 wet seasons in a maize/cowpea intercropping system. There was significant difference between the two crop arrangements in 2004 and 2005. In 2004, inter-row crop arrangement produced significantly taller maize plants but the reverse was the case in 2006. When the data were pooled over the years, intra-row crop arrangement produced taller maize plants at 12 WAS. There were no significant differences in maize plant height among the different crop proportions in 2004 and 2005 but there were differences in 2006 where the 1C:3M crop proportion produced shorter plants relative to the other proportions. There was significant effect of row arrangement on maize plant height at 12 WAS in the 3 years. In each year, the paired-row arrangement

Table 1: Effect of crop arrangement, crop proportion and row arrangement on maize plant height (cm) at maturity in the 2004-2006 wet seasons in a maize/cowpea intercropping system at Samaru, Nigeria

Treatments	2004	2005	2006	Combined
Crop arrangement (A)				
Intra-row	205.20^{b}	213.90	212.90^{a}	220.10^{a}
Inter-row	233.10^{a}	213.30	198.60^{b}	205.20^{b}
SE±	1.42	1.53	1.58	1.56
Crop proportion (P)				
1C:1M	210.10	210.60	239.90^{a}	218.30
3C:1M	208.30	209.80	232.20^{b}	216.10
1C:3M	207.50	214.90	237.00^{a}	219.30
2C:2M	206.50	209.00	235.50^{a}	216.70
SE±	2.95	2.16	2.08	2.12
Row arrangement (R)				
Single-row	203.10^{b}	208.20^{b}	233.30^{b}	215.10^{b}
Paired-row	218.10^{a}	213.90^{a}	236.60^{a}	223.30^{a}
SE±	1.42	1.53	1.58	1.56

Table 2: Effect of crop arrangement, crop proportion and row arrangement on maize plant dry weight (g) at maturity in a maize/cowpea intercropping system in 2004-2006 wet seasons at Samaru, Nigeria

Treatments	2004	2005	2006	Combined
Crop arrangement (A)				
Intra-row	208.50^{b}	209.00^{b}	195.00^{b}	205.10^{b}
Inter-row	295.10^{a}	232.60^{a}	209.00^{a}	245.80^{a}
SE±	5.57	2.42	2.13	3.34
Crop proportion (P)				
1C:1M	235.90^{b}	219.40^{b}	200.10^{b}	216.10^{b}
3C:1M	266.20^{a}	243.30^{a}	219.40^{a}	243.30^{a}
1C:3M	252.00^{ab}	203.90^{d}	192.a0^{b}	216.10^{b}
2C:2M	250.10^{ab}	224.20^{a}	195.70^{b}	221.60^{b}
SE±	7.87	6.45	4.23	6.20
Row arrangement (R)				
Single-row	253.90^{a}	231.20^{a}	218.20^{a}	235.20
Paired-row	246.70^{b}	210.40^{b}	185.90^{b}	213.80
SE±	5.57	2.42	2.13	3.34

Means within the same column followed by the same letter (s) are not significantly different at the 5% probability level according to Duncan's Multiple Range Test (DMRT); M = Maize; C = Cowpea

the taller maize plants relative to the single-row arrangement. When the data were pooled over the years there was significant difference between the two row arrangements as the paired-row arrangement produced consistently taller maize plants (Table 1). There were no significant interactions among the different treatment factors on maize plant height.

There was significant difference in dry weight of maize at 12 WAS between the two crop arrangements in all the years of the experiment (Table 2). Inter-row arrangement produced significantly higher dry weight than intra-row arrangement. The combined data showed that inter-row crop arrangement produced maize plants with higher dry weight than the intra-row arrangement. Generally, there were significant differences in maize dry weight among the different crop proportions. The 3C:1M crop proportion produced significantly higher in maize dry weight than the other proportions but was at par with 2C:2M and 1C:1M crop proportions in 2004 as well as the

Table 3: Interaction between crop arrangement and crop proportion and between crop arrangement and row arrangement on maize dry weight 10 WAS in the 2004-2006 wet seasons at Samaru, Nigeria

	Crop arrangements					
	2004		2005		2006	
Crop proportion	Intra	Inter	Intra	Inter	Intra	Inter
1C:1M	143.9^{b}	160.0^{a}	124.9^{c}	145.9^{a}	156.3^{c}	165.7^{bc}
3C:1M	166.8^{a}	190.5^{a}	125.8^{c}	156.3^{a}	160.6^{c}	183.6^{a}
1C:3M	149.8^{ab}	169.2^{a}	131.2^{bc}	141.4^{ab}	149.9^{c}	178.9^{ab}
2C:2M	170.5^{a}	192.5^{a}	119.4^{c}	149.8^{a}	152.3^{c}	178.3^{ab}
SE±	15.35	6.82	5.88			
Row arrangement						
Single-row	173.8	168.2	125.6^{b}	156.8^{a}	170.6^{a}	174.0^{a}
Paired-row	153.7	176.1	125.2^{b}	139.2^{ab}	137.3^{b}	172.5^{a}
SE±	14.05	8.22	5.26			

Means within the same column followed by the same letter (s) are not significantly different at 5% probability level according to Duncan's Multiple Range Test (DMRT); M = Maize; Intra = Intra-row; Inter = Inter-row; WAS = Weeks After Sowing

2C:2M and 1C:3M crop proportions in 2005 and 2006, respectively. The pooled data showed that the adoption of 3C:1M crop proportion resulted in higher maize plant dry weight at 12 WAS than the other proportions all of which were similar.

There was significant difference between the two row arrangements at 12 WAS in 2004-2006. In all these years, single-row arrangement produced higher and significantly different maize dry weight than the paired-row arrangement. The pooled data for the period showed that single-row arrangement produced significantly higher maize dry weight than the paired-row arrangement.

Table 3 shows the interactions between crop arrangement and crop proportion and between crop arrangement and row arrangement on maize dry weight at 10 WAS during 2004-2006 wet seasons. The crop proportion had no effect on maize dry weight using the inter-row arrangement in each year except 2006. Also, crop proportion had no effect on maize dry weight using the intra-row arrangement in 2005 and 2006. Meanwhile, the 1C:1M crop proportion gave a lower maize plant dry weight compared to 3C:1M and 2C:2M in 2004. The interaction between crop arrangement and row arrangement on maize dry weight on the other hand showed that in the case of the single row arrangement maize dry weight was higher using the inter-row arrangement compared with intra-row crop arrangement. When the crop arrangement is considered, both intra and inter-row arrangements produced similar maize plant dry weights in 2004 and 2005. However, the dry weight was lower for the paired-row arrangement using intra-row crop arrangement in 2006 relative to that of single-row arrangement.

Table 4 shows cowpea plant height at 10 WAS in 2004-2006 wet seasons as affected by crop arrangement,

Table 4: Effect of plant arrangement, crop proportion and row arrangement on cowpea plant height (cm) at 10 weeks in the 2004-2006 wet seasons and combined in a maize/cowpea intercropping system at Samaru, Nigeria

Treatments	2004	2005	2006	Combined
Crop arrangement (A)				
Intra-row	80.20^{a}	89.10^{a}	87.60^{a}	85.70^{a}
Inter-row	58.70^{b}	71.30^{b}	72.16	67.40^{b}
SE+	2.14	1.04	1.09	1.40
Crop proportion (P)				
1C:1M	77.60^{a}	84.30^{ab}	83.10^{a}	81.80^{a}
3C:1M	74.50^{bc}	68.60^{c}	70.10^{a}	67.20^{c}
1C:3M	62.90^{c}	87.60^{a}	85.10^{a}	78.60^{b}
2C:2M	72.90^{ab}	80.60^{b}	82.20^{b}	78.20^{b}
SE+	3.00	1.48	1.62	2.01
Row arrangement (R)				
Single-row	63.30^{b}	76.80^{b}	75.30^{b}	71.80^{b}
Paired-row	73.60^{a}	83.70^{a}	84.10^{a}	80.50^{a}
SE+	2.14	1.04	1.09	1.49

Means within the same column followed by the same letter (s) are not significantly different at 5%probability level according to Duncan's Multiple Range Test (DMRT); M = Maize; C = Cowpea

crop proportion and row arrangement in a maize/cowpea intercropping system. There were significant differences between the two crop arrangements over the years (2004-2006). The intra-row plant arrangement produced taller cowpea plants that were significantly different from the inter-row crop arrangement. The combined data equally showed that intra-row crop arrangement produced significantly taller cowpea plants than inter-row crop arrangement.

Significant differences occurred in cowpea plant height as due to the four crop proportions. The 1C:1M crop proportion produced taller plants throughout the period of experiment. In 2006, the 3C:1M crop proportion marched up with 1C:3M crop proportion to produce similar but significantly taller cowpea plants than the 2C:2M crop proportion. Except in (2006), the 3C:1M crop proportion however produced shorter cowpea plants than the other crop proportions. The pooled data showed that the 1C:1M crop proportion produced significantly taller cowpea plants than the other crop proportions while the 3C:1M crop proportion produced shorter cowpea plants heights. In the case of the row arrangement, there was significant difference between the two arrangements with respect to cowpea plant height. The paired-row arrangement produced significantly taller plants than the single-row arrangement in each of the 3 years.

Table 5 shows the canopy spread of cowpea as affected by crop arrangement, crop proportion and row arrangement in 2004-2006 cropping seasons and combined at 10 WAS in a maize/cowpea intercropping system. There was significant difference between the two crop arrangements with respect to canopy spread in each of the 3 years of the study. The inter-row crop arrangement consistently produced significantly higher canopy spread

Table 5: Effect of crop arrangement, crop proportion and row arrangement on cowpea plant canopy spread (cm) at 10 weeks in the 2004-2006 wet seasons and combined in a maize/cowpea intercropping system at Samaru, Nigeria

Treatments	2004	2005	2006	Combined
Crop arrangement (A)				
Intra-row	56.40[b]	70.30[b]	64.90[b]	63.90[b]
Inter-row	91.60[a]	89.50[a]	106.90	96.00[a]
SE+	1.12	0.64	0.70	0.83
Crop proportion (P)				
1C:1M	62.10[c]	80.90[c]	89.00[c]	77.30[b]
3C:1M	79.30[a]	110.70[a]	111.30[a]	100.30[a]
1C:3M	66.30[b]	76.00[d]	77.80[c]	73.40[c]
2C:2M	68.40[b]	85.90[b]	95.30[ab]	83.50[b]
SE+	1.16	0.90	7.80	3.13
Row arrangement (R)				
Single-row	72.00[a]	92.70[a]	99.40[a]	90.10[a]
Paired-row	66.00[b]	84.10[b]	82.40[b]	77.10[b]
SE+	1.12	0.54	0.64	0.83

Means within the same column followed by the same letter (s) are not significantly different at 5% probability level according to the Duncan's Multiple Range Test (DMRT); M = Maize; C = Cowpea

Table 6: Effect of plant arrangement, crop proportion and row arrangement on cowpea plant dry weight (g) at 10 WAS during 2004, 2005 and 2006 cropping seasons at Samaru, Nigeria

Treatments	2004	2005	2006	Combined
Crop arrangement (A)				
Intra-row	18.90[b]	19.80[b]	19.90[b]	19.60[b]
Inter-row	39.80[a]	46.30[a]	47.70[a]	44.20[a]
SE+	0.50	0.32	0.57	0.48
Crop proportion (P)				
1C:1M	38.20[ab]	29.20[c]	28.00[c]	31.80[c]
3C:1M	43.90[a]	41.00[a]	42.40[a]	42.60[a]
1C:3M	36.30[b]	26.80[d]	29.10[c]	30.70[c]
2C:2M	36.40[b]	34.40[b]	35.70[b]	35.50[b]
SE+	0.70	0.45	0.80	0.65
Row arrangement (R)				
Single-row	31.10[a]	37.10[a]	38.10[a]	35.40[a]
Paired-row	27.60[b]	29.20[b]	29.60[b]	28.80[b]
SE+	0.50	0.32	0.57	0.48

Means within the same column followed by the same letter (s) are not significantly different at 5% probability level according to Duncan's Multiple Range Test (DMRT); M = Maize; C = Cowpea

than the intra-row arrangement. The combined data showed that the inter-row crop arrangement had better canopy spread by a margin of 50%. The 3C:1M crop proportion produced the widest spread of cowpea canopy than the other proportions except in 2006 when it was at par with the 2C:2M crop proportion. The 2C:2M crop proportion was significantly better in cowpea canopy spread than the other two proportions in 2005 and 2006. The 3C:1M proportion produced the widest canopy spread followed by 2C:2M and 1C:1M while 1C:3M crop proportion gave the narrowest canopy spread when the data were combined. The general performance of the four crop proportions with respect to the cowpea canopy spread was in order of 3C:1M, 2C:2M, 1C:1M and 1C:3M in descending order. There was significant difference between the two row arrangements on canopy spread of cowpea at every sampling stage with single-row arrangement having significantly higher canopy spread than the paired-rows arrangement. The combined data equally showed that single-row arrangement produced a significantly wider canopy spread than the paired-row arrangement. The combined data equally showed that the single-row arrangement produced wider canopy spread at 10 WAS than the paired-row arrangement.

The data on cowpea plant dry weight as affected by crop arrangement, crop proportion and row arrangement at 10 WAS in 2004-2006 cropping seasons are shown in Table 6. There was significant difference in cowpea plant dry weight at 10 WAS in response to the crop arrangement. The inter-row crop arrangement produced significantly higher cowpea plant dry weight than the intra-row arrangement. The combined data showed that inter-row crop arrangement was superior to the inter-row arrangement with regard to cowpea dry matter production. In each of the cropping seasons, the 3C:1M crop proportion produced higher dry matter than the other proportions except in the 2004 season when the 1C:1M crop proportion gave similar and higher dry matter weight. The 2C:2M proportion produced next best dry weight during the cropping seasons of 2005 and 2006 with 1C:3M crop proportion being lowest during the period. The combined data showed that the 3C:1M crop proportion produced the highest cowpea plant dry matter. This was followed by the 2C:2M crop proportion while both 1C:1M and 1C:3M were similar and lowest in cowpea dry matter production.

There was significant difference in cowpea plant dry weight as affected by the two row arrangements at 10 WAS. The single-row arrangement consistently produced significantly higher cowpea plant dry weight than the paired-row arrangement in each of the 3 years. The average data over the years also showed that single-row arrangement was better in cowpea dry matter production than the paired-row arrangement.

DISCUSSION

The performance of the intercrops (maize and cowpea) with respect to growth and development was good in each of the 3 years of the study. The initial presence of stem borers (*Busseola fusca*) observed in the early part of the trial in 2004 was not seen again in subsequent trials of 2005 and 2006. Their natural control of the pest may be attributed to the ability of maize/cowpea intercrops to reduce or eliminate prevalent rate of maize crop pests such as stem borers. This is in agreement with the findings of Chabi-Olaye *et al.* (2005). Also in their own study, Ajeigbe *et al.* (2006) reported similar result in a maize/cowpea intercropping system. Earlier on, Elemo *et al.* (1990) had reported that the problem of insect infestation in crop mixture is marginally lower compared to sole crops because crop mixtures exert some control over insect-pests either by encouraging predators of the pests of the affected crop in the mixtures or by restricting the migration of the crop pests from one intercrop to the other.

Maize crop: There were significant differences between intra- and inter-row crop arrangements and also between paired- and single-row arrangements on the plant height and plant dry weight of maize crop component of the intercrops. The intra-row crop arrangement and paired-row arrangement produced significantly taller plants than the inter-row crop arrangement and single-row arrangement respectively probably because each of the maize plants on the same bed (ridge) which were quite close to each other would be seeking for more solar radiation and in the process grew taller. Whereas the situation was dissimilar in the case of inter-row crop arrangement and single-row arrangement where there was relatively greater space for the penetration of sunlight to the crop. The inter-row crop arrangement and 3C:1M crop proportion produced maize plants with significantly higher dry weights than the intra-row crop arrangement and other crop proportions, respectively because there was less interplant competition among the plants for growth resources (nutrient, water, solar radiation) in these arrangements as a result of greater available space per plant. Fininsa (1997) obtained 30% increase in dry matter and grain yields of maize from the intercropping system and attributed this to less crop competition for growth resources in the inter-row arrangement.

Dahmardeh *et al.* (2010) also obtained higher dry matter and grain yield but attributed this to the increase in nutrient content of the soil through the intercrop. Reduction in the dry weight of maize plant in the intra-row crop arrangement could therefore be attributed to competition for light as it is well-known that shade decreases maize dry matter production and grain yield. Mbewe and Hunter (1986) observed similar decrease in maize dry matter and grain yield when light to the maize crop was reduced by 65% during its vegetative and reproductive growth stages.

The arrangement of plants in a way that allows for better leaf inclination, leaf angle and canopy architecture will allow proper penetration of solar radiation through the crop canopy and this is expected to be of benefit to the growth and development of the crop. This could partly explain why higher plant dry weights were found in maize crops planted using inter-row crop arrangement. Better utilization of light in inter-row arrangement had earlier been advanced by some other workers as a reason for higher maize crop dry weight at the advanced stage of growth (Osiru, 1974; Nelliat *et al.*, 1974; Tsubo and Walker, 2002).

Cowpea crop: Cowpea plants were significantly taller under the intra-row crop arrangement compared to that of the inter-row crop arrangement, especially at later stages of growth. The paired-row arrangement also produced taller cowpea plants than did the single-row arrangement while both 1C:3M and 1C:1M crop proportions produced cowpea plants that were relatively taller than other proportions.

These results could be attributed to the more competitive situations the cowpea plants were subjected to by maize plants in the intra, paired-row and 1C:3M and 1C:1M crop arrangements. Under such situations, cowpea plants actually competed with maize for solar radiation, a very important growth resource and therefore tended to grow taller even to the extent of almost becoming etiolated, in an attempt to receive sufficient solar radiation for its growth and development. The earlier findings of Tsubo and Walker (2002) are strongly supported by the present finding while Keating and Carberry (1993) had earlier averred that legumes such as cowpea utilize solar radiation efficiently when intercropped with cereals. The attempt by the cowpea plant to trap enough solar radiation had brought the disproportionate growth in height in those arrangements than one would have under any other situation.

The inter-row crop plant arrangement, the 3C:1M and 2C:2M crop proportions and the single-row arrangement produced wider cowpea canopy spread than the other arrangements. This finding could be attributed to relatively reduced competition for space and reduced shading effect from component maize crop. These arrangements must have created adequate space for the cowpea plant to grow and thus express its full potential in terms of producing more branches, more leaves and associated growth characters in the presence of available nutrients and other growth factors. All these might have contributed to make the cowpea plant foliage spread further thus resulting in a better canopy formation. Elemo *et al.* (1990), Tsubo and Walker (2002) and Ajeigbe *et al.* (2006) reported similar results in which Elemo *et al.* (1990) reported that better yield advantage in crop mixtures is associated with better utilization of light because of different canopy structures of the intercrops. Tsubo and Walker (2002)on the other hand used Radiation Transmission Model in alternate intercrops canopy study to arrive at such a result while Ajeigbe *et al.* (2006) obtained higher fodder yields from alternate arrangement of maize and cowpea crops with cowpea having more plant rows than maize. The single-row arrangement also produced higher cowpea dry weight per plant than the paired-row arrangement. These could be attributed to the result of better canopy formation and spread in these arrangements which later translated into weight gain by the crop plants. Better canopy spread could have allowed a better mean light interception and increased leaf area for such interception which ultimately resulted in higher dry matter production in the presence of other growth factors such as water and nutrients. Eskandari (2009) had a similar result with high fodder yields in such an arrangement. The lower dry weight recorded in intra-arrangement and other crop proportions could be as a result of the excessive shading of the cowpea crop by maize, a situation which reduced light absorption and other growth factors through competition. Competition for light had been identified as a major reason for low dry matter production of cowpea in mixture with cereal crops (Olufajo and Singh, 2002; Ajeigbe *et al*., 2006). The proximity of the component crops to each other has also been known to increase competition thus reducing the dry matter production (fodder yields) and ultimately grain yields (Ajeigbe *et al*., 2006).

CONCLUSION

Based on the results of the present study, it can be concluded that the productivity of maize intercropped with cowpea could be enhanced by using inter-row crop arrangement, a 3C:1M or 2C:2M crop proportions and paired-row arrangement. Alternatively, inter-row crop arrangement, a 3C:1M crop proportion and single-row arrangement could be adopted for improve soil fertility through nitrogen fixation by the legume and perhaps higher haulms production for livestock feed.

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