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Analysis of growth of intercrop species in 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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In order to determine how the growth indices of intercrop species in an intercropping system are influenced by certain factors, field trials were conducted at Institute for Agriculture Research (IAR) farm at Samaru, Zaria during the wet seasons of 2004, 2005 and 2006. The treatments tested consisted of maize and cowpea intercrops with two forms of crop arrangement (intra-row and inter-row), four different crop proportions (1C:1M, 3C:1M, 1C:3M and 2C:2M Cowpea: Maize) and two row arrangements (single-row and paired-row) in factorial combinations. These treatments were arranged in a randomized complete block design with four replications. The crop varieties used were: maize-TZPBSR and cowpea-SAMPEA-6. Crop arrangement significantly affected the rate of growth of the two component crops. The relative growth rate (RGR) and crop growth rate (CGR) measured at 6-8, and 8-10 weeks after sowing (WAS) were higher under the inter-row crop arrangement in maize by 23 and 22.6% respectively on the average relative to those under the intra-row crop arrangement. The 3:1 and 2:2 (cowpea: maize) crop proportions had higher RGR and CGR values. The 3:1 (cowpea: maize) crop proportion in the single row arrangement produced higher growth rates of cowpea than under any of the other arrangements. In relation to the yield parameters which were measured later, the rate of growth in relation to the productivity of maize/cowpea intercropping system could be determined by using the indices of relative growth rate (RGR) and crop growth rate (CGR) particularly at the later stages of growth of the two crops. Indices of crop growth were generally higher for the components when they were grown under the single-row and inter-row arrangements.

Key words: Crop arrangement, crop proportion, growth indices, intercropping, row arrangement.

INTRODUCTION

Every smallholder farmer in Africa growing maize/legume intercrop aim at increasing overall yields using limited available labour and capital that are at his disposal. Greater attention is therefore given by such resource-limited farmers to overall stability of yield and income at the expense of sole crop yield *per se.* The practice of intercropping has over the years helped to reduce variability in total crop biomass, seed production and income due to complementary effects among associated crops (Kumar *et al*., 1987; Santaella *et al*., 1999). For these reasons intercropping systems are very attractive, not only to smallholder farmers but also to managers of

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rural development projects in sub-Saharan Africa. Cowpea (*Vigna unguiculata* L. Walp), the second most important food legume in tropical Africa after common bean (*Phaseolus vulgaris*), 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 has been 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, but for certain reasons, its productivity is low due. Such reasons include competition for growth factors such as solar radiation, water and nutrients (Olufajo and Singh, 2002: Sanari *et al.,* 2010).

Studies have been conducted to analyze intercrop radiation interception by plant canopies and its subsequent use. Radiation transfer models for plant canopies were broadly grouped into two types; namely, the statistical and geometric methods. Both methods have been used to obtain instantaneous and daily models for radiation transmission and were validated with a high degree of accuracy through the alternate intercrop canopy. In one of such experiments, Tsubo and Walker (2002) reported that radiation utilization by the intercropping system was equivalent in growth efficiency of maize to sole maize cropping. That is, there was no significant difference in radiation utilization efficiency (RUE) between sole maize and maize intercropped with legumes, whereas cowpea had 12.5 per cent greater radiation-use- efficiency in the intercropping arrangement with maize than sole cowpea. In an earlier experiment, a similar result was reported in a millet/ groundnut intercropping system where groundnut had a RUE value of 45% (Keating and Carbery, 1993). The ability of the legumes to utilize radiation efficiently was therefore averred to be responsible for the yield advantage achieved in the intercropping of both cereal and legume crops. The higher LER value obtained from maize/cowpea intercrop, especially when the crop arrangement was inter-row, is as a result of the radiation use efficiency of cowpea and not that of maize (Tsubo and Walker, 2002).

The findings from a recent study by Bedoussac and Justes (2011) re-established the usage of LER as a more reliable index of evaluation along with crop growth rate (CGR). They averred that the outcome of all competitive interactions occurring between two crops in an intercropping system can be evaluated using the CGR. While the CGR measures community of crop plants, the relative growth rate (RGR) on the other hand, measures the rate of growth of an individual plant within the environment.

Crop growth rate is generally higher in C_4 plant species than in C_3 plant species (Tsubo *et al.,* 2004). Maize being a C_4 plant compared to cowpea, a C_3 plant, grows faster than cowpea. Moreover, maize forms a relatively larger upper canopy structures compared to cowpea and the roots of maize grow into greater and wider area even though of fibrous root system, than those of the beans. Thus, in maize/cowpea intercropping system, maize is generally found to be more competitive than beans (Mukhala *et al.,* 1999; Tsubo *et al*., 2004). The present study was undertaken with a view to determining the response of growth indices of component crops in a maize/cowpea intercropping system to crop arrangement and proportion.

MATERIALS AND METHODS

The study was conducted in the wet seasons of 2004, 2005 and 2006 at the Experimental Farm of the Institute for Agricultural Research (IAR), Ahmadu Bello University, Samaru (latitude 11° 11’ N, longitude 7° 38’ E and 686m above sea level), Nigeria. The site is located in the northern Guinea savanna ecological zone of Nigeria. The soil of the experimental site is a well-drained leached ferruginous tropical clay loam.

The treatments consisted of maize and cowpea intercrops with two forms of crop arrangement (intra-row and inter-row), four different crop proportions (1:1, 3:1, 1:3 and 2:2 Cowpea: Maize) and two row arrangements (single-row and paired-rows). The treatments were arranged in a factorial combination using randomized complete block design with four replications. The crop varieties used were TZPBSR (maize, the main crop) and cowpea SAMPEA-6 (the intercrop). Including the sole crops of maize and cowpea, the total number of treatments tested was eighteen.

Planting and cultural practices

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

Measurements

Five plants each of maize and cowpea from each plot were randomly selected and tagged for periodic observation during the crop’s growth period. The observations made at 6, 8, 10 and 12 weeks after sowing were recorded for maize and 6, 8 and 10 weeks after sowing for cowpea. Plant dry weight was determined by random selection of five plants from each plot, cut at the ground level and dried to constant weight in a Gallenkamp oven (model OV-420) at a temperature of 70°C and weighed with a Mettler toploading balance (model P. 1200). The dry weights were used to determine the dry matter accumulation (already presented elsewhere) and subsequently both crop growth rate (CGR) and relative growth rate (RGR). Crop growth rate (CGR), which is a measure of the rate of dry matter production per unit of time or dry matter increment per unit area of land per unit of time, was computed using the formula described by Radford (1967). Relative growth rate (RGR) on the other hand, which is the increase in plant material per unit of initial material per unit of time, was also computed using the procedure described by Radford (1967).

Statistical analysis

The data collected from the trials were subjected to analysis of variance (ANOVA) using the SAS software (SAS Institute, 2001 to determine the significant of treatment effects as described by Snedecor and Cochran (1967) were then separated using Duncan's Multiple Range Test (DMRT) (Steel *et al*., 1997).

RESULTS

Relative growth rate

Table 1 shows the effects of crop arrangement, crop proportion and row arrangement on mean relative growth rate of maize during 6-8 week after sowing in the 2004-2006 wet seasons in a maize/cowpea intercropping system. There was no significant difference between the two crop arrangements with respect to the mean relative growth rate during 6-8 WAS in 2004 and 2005 but was significantly different in 2006. Inter-row crop arrangement had higher mean relative growth rate than intra-row crop arrangement. The combined data equally showed that inter-row arrangement had higher mean relative growth rate than the intra-row arrangement. There were significant differences among the four crop proportions with respect to mean relative growth rate value in 2004-2006. In each of the wet season (2004-2006), the 3C:1M crop proportion had significantly higher mean relative growth rate than the other proportions, though it was at par with the 1C:1M proportion in 2004. Both 2C:2M and 1C:1M has similar mean relative growth rates except in 2005 when the 2C:2M proportion produced a higher RGR. The 1C:3M proportion produced the least mean relative growth rate value each year with the exceptional 2004 when it was at par with the 2C:2M and 1C:1M proportions. The pooled data showed that the 3C:1M proportion produced higher mean relative growth rate that was higher than those for the other crop proportions which were at par (Table 1). There was significant difference between the two row arrangements. The single-row arrangement had a significantly higher mean relative growth rate than the paired- row arrangement in each of the three years (2004-2006). The combined data did show that the single-row arrangement produced a significantly higher mean relative growth rate.

The values for the mean relative growth rate during 8-10 WAS showed that there were significant differences among plant arrangements in 2005 and 2006 but not in 2004 (Table 2). The intra-row crop arrangement was significantly higher than the inter-row arrangement in 2005 while the reverse was the case in 2006. The combined data showed no significant difference between the two crop arrangements. There were significant differences in mean relative growth rates among the various crop proportions in 2004 and 2005. The 2C:2M proportion produced significantly higher RGR values than the other proportions in 2004 while both 1C:1M and 1C:3M crop proportions had higher RGR values in 2005. The least mean relative growth rate was obtained from 3C:1M crop proportion. In 2006, there was no significant difference in the mean relative growth rate for all the crop proportions. The combined data however showed significant difference with the 3C:1M proportion had lower mean relative growth rate while the other proportions were similar and had significantly higher RGR values (Table 2). Significant difference occurred between the two row arrangements in 2004 and 2005. In those two years, single-row arrangement produced higher mean relative growth rate than the paired-row arrangement. In 2006, both had similar mean relative growth rate. The combined data showed that a single-row arrangement had significantly higher mean relative growth rate values than the paired-row arrangement. The interactions between the treatment factors were not significant.

The mean relative growth rate RGR of cowpea during 8-10 WAS as affected by crop arrangement, crop proportion and row arrangement in a maize/cowpea intercropping system is shown in Table 5. There was significant difference in mean RGR between the two plant arrangements in the three years. The inter-row crop arrangement gave significantly higher mean RGR than the intra-row arrangement in each of the three years. The combined data equally showed a similar trend, where the inter-row crop arrangement produced cowpea plants with superior relative growth rate.

There were significant differences among the four crop proportions with respect to cowpea mean RGR in 2004 and 2006 but not in 2005. In 2004, only the 1C:1M proportion had a significantly lower mean RGR value while the other crop proportions were at par. In 2006, both the 1C:3M and 2C:2M crop proportions produced higher mean RGR in cowpea and were followed by the

Table 1. Effect of crop arrangement, crop proportion and row arrangement on mean relative growth rate ($g.g^{-1}.wk^{-1}$) of maize 6-8 WAS in 2004-2006 wet seasons in a maize/cowpea intercropping system at Samaru, Nigeria.

Treatment	Year			Combined
	2004	2005	2006	
Crop arrangement (A)				
Intra- row	0.16	0.23	0.23b	0.21b
Inter-row	0.16	0.28	0.27a	0.24a
SE ±	0.013	0.007	0.004	0.005
Crop proportion (P)				
1C: 1M	0.17ab	0.22c	0.24b	0.21b
3C: 1M	0.21a	0.33a	0.29a	0.28a
1C: 3M	0.15b	0.22c	0.22c	0.20b
2C: 2M	0.13b	0.26b	0.24b	0.21b
SE ±	0.071	0.010	0.006	0.022
Row arrangement (R)				
Single row	0.19a	0.28a	0.28a	0.25a
Paired row	0.14b	0.23b	0.23b	0.20b
SE ±	0.012	0.007	0.004	0.005

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). C=Cowpea, M=Maize

Table 2. Effect of crop arrangement, crop proportion and row arrangement on mean relative growth rate ($g.g^{-1}.wk^{-1}$) of maize 8-10 WAS in 2004-2006 wet seasons in a maize/ cowpea intercropping system at Samaru, Nigeria.

Treatment	Year			Combined
	2004	2005	2006	
Crop arrangement (A)				
Intra-row	0.30	0.18a	0.21b	0.23
Inter-row	0.29	0.09b	0.26a	0.21
SE ±	0.016	0.008	0.007	0.007
Crop proportion (P)				
1C: 1M	0.27b	0.16a	0.24	0.22a
3C: 1M	0.27b	0.09c	0.22	0.19b
1C: 3M	0.27b	0.17a	0.24	0.23a
2C: 2M	0.37a	0.13b	0.25	0.25a
SE ±	0.020	0.012	0.010	0.009
Row arrangement (R)				
Single row	0.34a	0.16a	0.24	0.25a
Paired row	0.24b	0.11b	0.23	0.20b
SE ±	0.016	0.008	0.007	0.007

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). C=Cowpea, M=Maize

3C:1M crop proportion. The lowest mean RGR value was recorded in the case of the 1C:1M crop proportion. There was significant difference between the two crop arrangements with respect to the mean cowpea RGR in 2005 and 2006. In those two years, the single row arrangement produced cowpea plants that had higher mean relative growth rates than the paired-row arrangement. The combined data showed that single-row arrangement was superior in cowpea plants with higher RGR. The interactions among the different treatment factors were not significant.

Crop growth rate

The results in Table 3 shows maize crop growth rates during 6-8 of weeks after sowing in 2004-2006 as affected by crop arrangement, crop proportions and row

Table 3. Effect of crop arrangement, crop proportion and row arrangement on maize mean crop growth rate (g.m^{-2}.wk^{-1}) during 6-8 WAS in 2004-2006 wet seasons in a maize/cowpea intercropping system at Samaru, Nigeria

Treatment	Year			Combined
	2004	2005	2006	
Crop arrangement (A)				
Intra-row	11.5	15.7b	15.9b	14.4b
Inter-row	12.1	18.7a	19.0a	16.6a
SE ±	0.78	0.34	0.25	0.29
Crop proportion (P)				
1C: 1M	11.3b	14.8c	16.7b	14.3b
3C: 1M	15.1a	22.1a	20.8a	19.3a
1C: 3M	10.8b	14.7c	15.4c	13.0b
2C: 2M	10.1b	17.2b	17.0b	14.8b
SE ±	1.10	0.48	0.36	0.41
Row arrangement (R)				
Single row	12.9	19.2a	19.5a	17.2a
Paired row	10.8	15.2b	15.4b	13.8b
SE ±	0.78	0.34	0.25	0.29

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). C=Cowpea, M=Maize

arrangement in a maize/cowpea intercropping system. There was significant difference in the two crop arrangements on maize crop growth rate in 2005 and 2006. Inter-row crop arrangement produced maize plants with higher crop growth rates than intra-row arrangement in both years. It had a higher crop growth rate of over sixteen percent in each year than the intra-row arrangement. The combined data for the period of experiment equally showed that inter-row arrangement was significantly higher in crop growth rate than intra-row crop arrangement. There were significant difference in crop growth rate of maize during 6-8 WAS among the four crop proportions in 2004, 2005 and 2006. In each year, 3C:1M crop proportion produced maize crops with significantly higher crop growth rate than other crop proportions. This was followed by 2C:2M and 1C:1M crop proportions while 1C:3M crop proportion produced the lowest crop growth rate in 2005 and 2006. The combined data for the three years showed that the 3C:1M crop proportion produced a highest crop growth rate than did others, which were at par.

There was no significant difference between the two row arrangements in maize crop growth rate in 2004. However, significant differences existed in 2005 and 2006. In those two years, the single-row arrangement produced maize plants with higher crop growth rate than paired-row arrangement. The combined data for the period also showed that single row arrangement was statistically better in maize crop growth rate (Table 3).

The effects of crop arrangement, crop proportion and row arrangement on maize crop growth rate during 8-10 WAS in 2004-2006 are presented in Table 4. There were no significant differences in maize crop growth rate between the two crop arrangements in 2004 and 2005 but there was in 2006. In that year, the inter–row arrangement produced maize plants with higher crop growth rate than the intra-row arrangement (Table 5). However, the combined data for the three years did not show any significant difference between the two crop arrangements with respect to maize crop growth rate. Although, there was no significant difference in maize crop growth rate among different crop proportions in 2006, the situations were different in 2004 and 2005. In 2004, it was the only 2C:2M crop proportion that produced significantly higher CGR than the others, which were at par. In 2005 however, three of the crop proportions (2C:2M, 1C:1M and 1C:3M) had similar but higher crop growth values than the 3C:1M crop proportion. The combined data for the three years showed that the 2C:2M crop proportion produced significantly higher maize crop growth rates than the other crop proportions.

The effect of crop arrangement, crop proportion and row arrangement on cowpea CGR during 8-10 WAS in 2004-2006 wet seasons is shown in Table 6. There was significant difference between the two crop arrangements with regard to cowpea CGR. In the three years, the inter-row crop arrangement produced cowpea plants that had significantly higher CGR values than the within-row arrangement. The inter-row crop arrangement had 215, 214, and 140% higher cowpea CGR values than the within-row arrangement in 2004, 2005 and 2006 respectively. The combined data also revealed that on the average inter-row crop arrangement had 164% higher cowpea CGR relative to the intra-row arrangement.

Significant differences were also recorded among the four crop proportions. While both 1C:3M and 2C:2M

Table 4. Effect of crop arrangement, crop proportion and row arrangement on maize mean crop growth rate ($g.m^{-2}.wk^{-1}$) during 8-10 WAS in 2004-2006 wet seasons and combined in a maize /cowpea intercropping system at Samaru, Nigeria.

Treatment	Year			Combined
	2004	2005	2006	
Crop arrangement (A)				
Intra-row	28.2	17.0	21.8b	22.3
Inter-row	29.2	19.8	27.5a	22.2
SE ±	1.36	0.81	0.71	0.58
Crop proportion (P)				
1C: 1M	24.3b	16.1a	24.7	21.4b
3C: 1M	29.1b	10.0b	24.8	21.3b
1C: 3M	26.1b	15.5a	23.5	21.7b
2C: 2M	35.4a	12.9ab	25.7	24.7a
SE ±	1.92	1.51	1.01	0.81
Row arrangement (R)				
Single row	32.2a	16.3a	26.1a	24.9a
Paired row	25.3b	10.4b	23.2b	19.6b
SE ±	1.36	0.81	071	0.58

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). C=Cowpea, M=Maize

Table 5. Effect of crop arrangement, crop proportion and row arrangement on cowpea relative growth rate ($g.g^{-1}$ wk^{-1}) at 8-10 WAS during 2004 – 2006 wet season in a maize/cowpea intercropping system at Samaru, Nigeria.

Treatment	Year			Combined
	2004	2004	2005	
Crop arrangement (A)				
Intra- row	0.28b	0.66b	0.65b	0.51b
Inter- row	0.65a	0.90a	0.80a	0.78a
SE±	0.059	0.046	0.026	0.027
Crop proportion (P)				
1C: 1M	0.26c	0.67a	0.57c	0.51b
3C: 1M	0.60a	0.87a	0.70b	0.73a
1C: 3M	0.41ab	0.85a	0.83a	0.70a
2C: 2M	0.59a	0.68a	0.78ab	0.69a
SE±	0.083	0.065	0.037	0.037
Row arrangement (R)				
Single row	0.50a	0.85a	0.79a	0.71a
Paired row	0.44a	0.69b	0.65b	0.59b
SE+	0.059	0.046	0.026	0.027

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). C=Cowpea, M=Maize

produced significantly higher cowpea CGR values in 2004, the subsequent years showed that the 3C:1M crop proportion was significantly higher than the other proportions. In 2005 and 2006, only the 2C:2M crop proportion produced cowpea plants that had CGRs that closely followed the 3C:1M crop proportion. The 1: 1 (cowpea; maize) crop proportion produced the lowest CGR cowpea values throughout the period of experimentation. The combined data also showed that both 3C:1M and 2C:2M crop proportions ranked signi-ficantly higher in CGR than both the 1C:3M and 1C:1M crop proportions, which came second and third respectively in crop CGR.

Both row arrangements did not show any significant effect on cowpea CGR in 2004. However in 2005 and 2006, there was significant difference between the two row arrangements. In these years, the single-row arrangement produced cowpea plants with significantly higher CGR values than the paired-row arrangement.

Table 6. Effect of crop arrangement, crop proportion and row arrangement on cowpea crop growth rate ($g.m^{-2}.wk^{-1}$) during 8-10WAS in 2004-2006 wet seasons and combined in a maize /cowpea intercropping system at Samaru, Nigeria.

Treatment	Year			Combined
	2004	2005	2006	
Crop arrangement (A)				
Intra-row	2.0b	3.0b	4.0b	3.3b
Inter-row	6.3a	10.2a	9.6a	8.7a
SE ±	0.34	0.29	0.16	0.16
Crop proportion (P)				
1C: 1M	2.1c	5.3c	5.8c	4.4c
3C: 1M	3.7b	9.1a	9.0a	7.3a
1C: 3M	5.5a	5.8c	5.1d	5.5b
2C: 2M	5.4a	7.8b	7.2b	6.8a
SE ±	0.48	0.41	0.22	0.22
Row arrangement (R)				
Single row	4.4	7.9a	7.6a	6.6a
Paired row	4.0	6.1b	6.0b	5.3b
SE ±	0.34	0.29	0.16	0.16

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). C=Cowpea, M=Maize

The combined data showed that the single-row was significantly better than the paired-row arrangement with respect to cowpea CGR. The interactions between the treatment factors were not significant.

DISCUSSION

The relative growth rate values for maize were significantly higher in most cases when grown under inter-row crop arrangement than under the intra-row arrangement. This observation may be attributed to the ability of maize plants having a wider area/space to grow and accumulate dry matter per unit area faster with the upper canopy positioned for a better light interception while its fibrous root system, with no strong competition from the other intercrop in such an arrangement was able to spread widely to access more underground growth resources. This is in conformity with the findings of Mukhala *et al.* (1999) and Tsubo *et al.* (2004) who in their separate reports stated that maize forms relatively larger upper canopy structures compared to beans, and the roots of maize grow to a greater depth than those of beans. Thus, in a maize-bean intercropping system, maize is more competitive than beans and maize usually has higher relative growth rate and crop growth rate being C_4 plant which has the capacity to grow faster.

Although the crop growth rate values for maize in both intra and inter-row crop arrangements were statistically similar in some cases, the average crop growth rate values showed that inter-row crop arrangement was significantly higher in a number of cases. This could also be attributed to the crop plants in this arrangement having better access to growth resources than the ones available to crops grown under the intra-row arrangement. Expectedly too, as CGR determination entails a community of plants, an aggregate of individual plants growing luxuriantly will undoubtedly produce a higher CGR. That was the observation with respect to the inter-row crop arrangement. This is in agreement with the findings of Bedoussac and Justes (2011) where they compared most of the commonly used indices for evaluating species interactions and intercrop efficiency using durum wheat-winter pea intercrops as case study. In this present study, the companion crop in the intercrop, cowpea, is in addition, not a nitrogen-consuming crop and rather fixes its own nitrogen symbiotically in the soil. Thus, an arrangement that allows less competition for these growth resources will make the maize crop to grow well and produce higher dry matter as was observed with respect to the 3C:1M crop proportion as determined through crop growth rate (CGR) and relative growth rate (RGR). This superiority was more evident in the former growth character than the latter at virtually every measurement interval. The higher growth rates observed for the 3C:1M proportion and single row arrangement relative to the other crop proportions and the paired-row arrangement respectively could be ascribed to the lesser competition between two contiguous maize or cowpea plants. It could also be attributed to the ability of maize, which is a C_4 species, to quickly respond to available resources, most especially when there is less competition while cowpea thrives well when the shading effect against solar radiation is less. Similar findings of Tsubo *et al.* (2004) stated that crop growth rate is generally higher in C_4 plant species, whereas beans are C_3 plants; the former grows faster than beans and is more competitive. In a more recent finding, Sanari *et al.* (2010) averred that a higher plant density of 40,000 plants per hectare compared to a lower density of 10-20,000 plant per hectare impacted negatively on the growth of the cowpea plant in a maize/cowpea intercropping system.

Conclusion

It can be concluded from the result of this investigation that the rate of growth in relation to the productivity of maize/cowpea intercropping system could be determined by using the indices of relative growth rate and crop growth rate especially at a later stage of growth of the crops. The crop arrangement, crop proportion and row arrangement have significant effect on both RGR and CGR of maize and cowpea intercrop. Inter–row arrangement, the 3C:1M or 2C: 2M crop proportion and single row arrangement favoured both indices of growth.

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