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Effect of Spatial Arrangement on the Performance of Cowpea /Maize Intercrop in Derived Savannah of Nigeria

S. O. Adigbo[1*], E. Iyasere[2], T. O. Fabunmi[2], V. I. O. Olowe[1] and C. O. Adejuyigbe[3]

[1]Institute of Food Security, Environmental Resources and Agricultural Research,Federal University of Agriculture, Abeokuta, Nigeria.
[2]Plant Physiology and Crop Production Department, Federal University of Agriculture, Abeokuta, Nigeria.
[3]Soil Science and Land Management Department,Federal University of Agriculture, Abeokuta, Nigeria.

Authors' contributions

Author SOA conceptualizes the idea of the study. The field layout was put in place by authors SOA, EI and TOF. The data collection and field maintenance were done by author EI while analysis and interpretation were done by authors SOA and EI. Authors VIOO, TOF and COA contributed to literature and editing and other useful suggestions

Research Article

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ABSTRACT

Promising varieties of cowpea were found to be adaptable in the derived savannah; however, their performances in intercropping systems have not been investigated. Therefore, there is the need to investigate the effect of spatial arrangement of maize/cowpea on the performance of maize and cowpea. The experiment was a 2 x 5 factorial in randomized complete block design. A field experiment was conducted at Federal College of Education, Osiele, Abeokuta, Nigeria during the late cropping seasons of 2009 and 2010. The intercrop proportion mixture and population adopted in this study were additive and replacement series while Oloyin and Sokoto cowpea varieties were combined with TZESR-W maize variety as follows: Oloyin + maize in alternate row, Oloyin + maize in alternate row, Oloyin + maize in alternate stand, Oloyin + maize in strip cropping, Sokoto + maize in alternate row, Sokoto + maize in alternate row, Sokoto +

**Corresponding author: Email: sundayadigbo@yahoo.com,adigboso@funaab.edu.ng;*

maize in alternate stand, Sokoto + maize in strip cropping, sole maize, Sole cowpea. Land Equivalent Ratio (LER) was used to determine the productivity of the intercrop. The grain yield of cowpea obtained from alternate row intercrop and sole cowpea for 2009 and 2010 were similar. However, the grain yield of cowpea obtained from alternate row was 33, 37 and 59% higher than alternated stand, alternate row replacement and strip crop, respectively. Oloyin variety had significantly higher grain yield than Sokoto. Interaction of cowpea variety x spatial arrangement x cropping season was significant on 1000-seed weight. The two additive series had higher land equivalent ratio compared to replacement series. Maize yield was not affected in two additive series. In conclusion, intercrop was more productive than sole. The two additives arrangement enhances the performance grain yield of maize, Oloyin and Sokoto cowpea varieties.

Keywords: Intercrop; cowpea; maize; additive; replacement.

1. INTRODUCTION

Cowpea *(Vigna unguiculata* (L) Walp*)* grain contain about 24% protein [1], making it extremely valuable where people cannot afford animal protein from meat and fish. Cowpea is a major food legume in central and West Africa, where more than 60% of world cowpea were cultivated. The total world production of dry cowpea grain in 2002 was about 5 million tonnes from 14 million ha of which 64% was produced in west and central Africa. The dry savannah region of Nigeria (Northern Nigeria) alone produces 2.1 million tonnes from 5 million ha [2].

Most of the cowpea consumed in southern Nigeria (derived savannah) were produced and transported from the northern part (dry savannah). It has been reported that seven varieties of cowpea were evaluated in upland and inland valley ecologies during the rainy and dry seasons, respectively and the grain yields of Oloyin, and Sokoto local varieties were economically superior to the two improved varieties [3]. But the performances of these two varieties (Oloyin and Sokoto) have, however, not been investigated in intercrop which is the common practice by majority of the farmers in the derived savannah.

Intercropping is the agricultural practices of cultivating two or more crops in the same period of time. Cowpea is mainly grown in mixtures with other crops and a great diversity of crop mixtures has been reported [4]. Intercropping offers farmers the opportunities to engage nature's principle of diversity on their farms.

Nitrogen from legume fixation is essentially "free" N for use by the host plant or by associated or subsequent crops. Replacing it with fertilizer N would cost $7 to 10 billion annually, whereas even modest use of alfalfa in rotation with corn could save farmers $200 to 300 million [5]. The movement of potash from the legume root zone to the root zone of non-legume crops provides a source of K [6]. The most common goal of intercropping is to produce a greater yield on a given piece of land by making use of resources that would otherwise not be utilized by a single crop.

Spatial arrangement of component crops is one of the most important agronomic factors that determine whether an intercrop system will be advantageous or not with regard to yield gains [7]. Row arrangement, in contrast to arrangement of component crops within rows (farmers' practice), improved the amount of light transmitted to the lower legume. Hence agronomic manipulation of the dominant component (maize) can strongly affect growth of the suppressed component (cowpea). This therefore suggests the need for greater attention to the effect of the dominant component in modifying the growth environment of and resource availability to the suppressed component and the implications for growth and yield of the latter.

Maize is a principal cereal in the south western Nigeria. Previous research work had shown that improving the productivity of cowpea/cereal intercropping lies in the performance of the cowpea component which include among other things the choice of appropriate genotype [8,9]. It has been reported that maize/cowpea intercrop had no effects on the performance of maize [10]. Consequently, the thrust of this study is to evolve spatial arrangement(s) that will boost the productivity of the two cowpea varieties (Sokoto and Oloyin) without reducing the yield of maize. The objectives of this study were to determine the: 1) effect of spatial arrangement on the performance of two cowpea varieties and 2) row arrangement(s) that will give the highest yield of both component crops.

2. MATERIALS AND METHODS

The experiment was conducted during the second cropping season, which commences from mid-August and end in mid-October to early November) at Federal College of Education, Osiele, Abeokuta (7°20'N, 3°23'E) in 2009 and 2010. Cowpea is best grown in this period to reduce challenges of diseases and pests, high quality of grains because the crop matures into dry season. The textural class of the soil was loamy sand. The 2 x 5 factorial experiment was laid out in RCBD design. The two local varieties (Oloyin and Sokoto) constituted a factor while five levels spatial arrangement was the second factor. The intercrop proportion mixture and population adopted in this study were additive and replacement series. The two varieties were majorly grown in the dry savannah region of Nigeria (Northern Nigeria). They had comparable grain yield with the improved varieties. Moreover, they are preferred in the market by consumers because of their taste. TZESR-W is an early maturing variety of maize and is normally planted by farmers during the short second cropping season (Mid-August to early November). The Table 1 shows the treatment combinations.

Table 1. Treatments combinations for the study

S/No	Crop combinations	Maize plant population (no ha^{-1})	Cowpea plant population (no ha^{-1})	Series
1	Oloyin + maize in alternate row	31250 (50%)	62500 (50%)	Replacement
2	Oloyin + maize in alternate row	62500 (100%)	125000 (100%)	Additive
3	Oloyin + maize in alternate stand	62500 (100%)	62500 (50%)	Additive
4	Oloyin + maize in strip cropping	41667 (67%)	41667 (33%)	Replacement
5	Sokoto + maize in alternate row	31250 (50%)	62500 (50%)	Replacement
6	Sokoto + maize in alternate row	62500 (100%)	125000 (100%)	Additive
7	Sokoto + maize in alternate stand	62500 (100)	62500 (50%)	Additive
8	Sokoto + maize in strip cropping	41667 (67%)	41667 (33%)	replacement
9	sole maize	62500 (100%)		
	Sole cowpea.		125000 (100%)	

Values in parentheses are the population in percentage per plot

The field was ploughed and harrowed in both years. The plot size was 6.4 m x 3 m. The spacings for the various spatial arrangements used were as follows:

Strip cropping: 80 cm X 20 cm for both cowpea and maize. There were nine rows in all. Three rows of cowpea occupied the three central rows while the first and last three rows were planted to maize. Cowpea had two seedlings per hole while maize was one seedling.

Sole cropping cowpea and maize: was 80 cm X 20 cm, however, the number of cowpea seedlings were thinned to two while maize was thinned to one per stand

Alternate row (additive series): Maize to maize and cowpea to cowpea on the same row was 20 cm while the inter row was 40 cm for maize and cowpea whereas inter row spacing of maize to maize or cowpea to cowpea was 80 cm.

Alternate stand (additive series): within each row, maize follows cowpea (i.e. maize to maize was 40 cm on the same row while between maize and cowpea was 20 cm. This is the farmers' practice. Number of maize plants per stand was thinned to two whereas other spatial arrangements were thinned to one plant per stand. Thus, maize plant population for alternate stand was same as sole.

Alternate row (replacement series): Maize to maize or cowpea to cowpea on same row was 20 cm while the inter row was 80 cm (i.e. between maize and cowpea inter row).

2.1 Data Collection on Cowpea

Number of seeds per pod: Five pods were selected randomly from the field and threshed. The total number of seeds was divided by five.

Pod length: Five pods were selected randomly from the field and length were measured with aid of ruler.

1000-seed weight: After threshing, 1000-seed were counted and weighed with sensitive balance.

Threshing percentage: The weight of threshed grains obtained from the net plot divided by dry pod weight.

Grain yield: The harvested dried pods obtained from the net plot were threshed, weighed and converted to Mg ha^{-1}

2.2 Data Collection on Maize

Cob diameter: Five cobs were randomly selected from the field, de-husked and the diameter was determined using venier caliper.

Cob length: Five cobs were randomly selected from the field, de-husked and the length of de-husked cobs was measured with aid of ruler.

1000-seed weight: After de-husking, the seeds were shelled; 1000-seed were then counted and weighed with sensitive balance.

Threshing percentage: The weight of dried de-husked cobs obtained from the net plot was divided by weight shelled grains and then multiplied by 100.

Grain yield: The dry pods harvested from the net plot were sun dried, threshed, weighed and converted to Mg $ha^{-1.}$

2.3 Land Equivalent Ratio (LER)

LER = (intercrop yield maize /sole yield maize) + (intercrop yield cowpea/sole yield of cowpea)

2.4 Statistical Analysis

Data collected on cowpea and maize for each cropping season was analyzed separately using analysis of variance with variety and spatial arrangement as factors in a factorial design. Furthermore, for the purpose of comparison of varieties and spatial arrangement between cropping seasons 2 x 5 x 2 factorial was analyzed. All means were separated using Turkeys (Minitab version 16)

3. RESULTS

3.1 Response of Cowpea in the Different Spatial Arrangements

Table 2 shows the effect of spatial arrangement of cowpea/maize intercrop on the yield and yield components of cowpea in 2009 and 2010. The Oloyin variety of cowpea consecutively had heavier 1000-seed weight than that of Sokoto in both cropping seasons whereas the 1000-seed weights were not influenced by the spatial arrangements in 2009. But in 2010, 1000-seed weight observed in alternate row additive was significantly higher than the others except sole cropping ($P< .05$). The interaction of variety by spatial arrangement on seed-weight was significant in 2010 cropping season. Oloyin variety in 2010 had longer pods than those observed in Sokoto whereas the two varieties had similar pod lengths in 2009. Inversely, the spatial arrangement had significantly different pod lengths in 2009 whereas it was similar in 2010. Alternate stand additive had significantly higher pod length than that of alternate replacement. Other arrangements had similar pod lengths.

The two varieties had similar number of seeds per pod in 2009 but Oloyin variety had significantly higher number of seeds per pod than Sokoto in 2010. The number of seed per pod observed in alternate row additive was significantly higher than strip cropping, alternate stand and alternate replacement. It is important to note that all the various row arrangement had suppressive effects on the number of seeds per pod compared to sole. The interaction of variety by row arrangement was significant. The two varieties had similar threshing percentage in 2009. However, Oloyin variety had significantly higher threshing percentage than Sokoto in 2010. The sole cropping had higher threshing percentage than the spatial arrangements in 2009, whereas in 2010, alternate additive had significantly higher threshing percentage than strip cropping whereas other spatial arrangement had similar threshing percentage.

The grain yields obtained in 2009 were similar but significantly different in 2010 cropping season. The row arrangements had significantly different grain yields in both cropping seasons. In 2009, alternate row additive had similar grain yield with alternate stand, sole cropping and alternate replacement but significantly higher than strip cropping. However, in 2010, alternate row additive and sole cropping had similar grain yield which were superior to the other row arrangements.

Table 2. Effect of spatial arrangement on yield and yield component of Cowpea in 2009 and 2010 cropping seasons

Treatments	Weight of 1000-seed(g)		Pod length (cm)		No of seeds per pod		Threshing %			Grain yield (Mg ha^{-1})		
	2009	**2010**	**2009**	**2010**	**2009**	**2010**	**2009**	**2010**	**Average**	**2009**	**2010**	**Average**
Variety (V)												
Oloyin	252.3^{a}	243.8^{a}	10.6	9.9^{a}	9.2	8.4^{a}	72.1	73.0^{a}	72.6	0.57	0.71^{a}	0.64
Sokoto	160.5^{b}	118.5b	10.1	8.5^{b}	8.3	7.2^{b}	72.9	69.6^{b}	71.3	0.50	0.50^{b}	0.50
Average	206.4	181.2	10.4	9.2	8.8	7.8	72.5	71.3	71.9	0.54	0.61	0.58
SEM	0.74	2.10	0.27	0.37	0.31	0.141	1.17	0.764		0.443	0.03	
P Value	.00	.00	.16	.02	.06	.00	.59	.00		.29	.00	
Spatial arrangement (S)												
Strip cropping (replacement)	205.5	172.7^{b}	10.4^{ab}	8.7	8.7	7.3^{c}	72.6^{b}	69.1^{bc}	70.9	0.31^{b}	0.33^{b}	0.32
Alternate row (additives)	205.8	197.3^{a}	11.3^{a}	9.5	9.3	8.3^{b}	71.3^{b}	76.0^{a}	73.7	0.67^{a}	0.89^{a}	0.78
Alternate stand (additive)	206.0	175.0^{b}	10.2 ^{ab}	10.2	8.3	7.3^{c}	73.0^{b}	66.6^{c}	69.8	0.50^{ab}	0.54^{b}	0.52
Alternate row (replacement)	205.0	175.8^{b}	9.3^{b}	8.2	8.0	6.7^{c}	68.5^{c}	71.8^{ab}	70.2	0.49^{ab}	0.49^{b}	0.49
Sole cropping	209.7	185.0^{ab}	10.7^{ab}	9.7	9.5	9.3^{a}	77.1a	73.1^{ab}	75.1	0.72^{a}	0.77^{a}	0.75
Average	206,4	181.2	10.4	9.2	8.8	7.8	72.5	71.3	71.9	0.54	0.60	0.57
SEM	1.16	3.326	0.42	0.59	0.49	0.224	1.85	1.208		0.70	0.049	
P value	.07	.00	.03	.15	.19	.00	.05	.00		.02	.00	
V x S	NS	*S	NS	NS	NS	**S	NS	NS		NS	NS	

NS = Not significant, S = significant

When the means of the data generated from the two cowpea varieties and spatial arrangements were pooled across the two cropping seasons, 1000-seed weight, pod length and number of seeds per pod observed in 2009 were significantly higher than those of 2010 cropping season. Oloyin variety consistently had significantly heavier seeds, longer pods, and higher number of seeds per pod and grain yield than Sokoto (Table 3). Weights of 1000-seed observed in strip cropping, alternate stand and alternate row replacement were similar but significantly lower than alternate row additive. The alternate row additive had significantly longer pod than alternate row replacement while the other spatial arrangements had similar pod length. The numbers of seeds per pod recorded in alternate row additive and sole cropping were similar but significantly higher than that of alternate row replacement. The sole cropping, alternate row additive and strip had similar threshing percentage whereas alternate stand and alternate replacement series had similar threshing percentage but significantly lower than sole cropping.

The sole cropping and alternate row additive had highest grain yield whereas strip cropping had the lowest. Comparatively, the grain yield of cowpea obtained from alternate row was 33, 37 and 59% higher than alternated stand, alternate row replacement and strip crop, respectively.

Table 3. Effects of cropping seasons and spatial arrangement on the yield and yield components of cowpea varieties

Treatments	**Weight of 1000-seed (g)**	**Pod length (cm)**	**No of seeds per pod**	**Threshing %**	**Grain yield (Mg ha^{-1})**
Cropping season (C)					
2009	206.4^{a}	10.4^{a}	8.8^{a}	72.5	0.54
2010	181.2^{b}	9.2^{b}	7.8^{b}	71.3	0.60
SEM	1.114	0.23	0.17	0.699	0.04
P Value	.00	.01	.00	.20	.28
Variety (V)					
Oloyin	248.6^{a}	10.3^{a}	8.8^{a}	72.5	0.63^{a}
Sokoto	139.6^{b}	9.3^{b}	7.8^{b}	71.2	0.50^{b}
SEM	1.114	0.23	0.17	0.699	0.027
C x V	**S	NS	NS	NS	NS
Spatial arrangement (S)					
Strip cropping replacement	189.1^{c}	9.5^{ab}	8.0^{bc}	70.8^{ab}	0.32^{c}
Alternate row additive	201.6^{a}	10.4^{a}	8.8^{ab}	73.7^{ab}	0.78^{a}
Alternate stand	190.5^{bc}	10.2^{ab}	7.8^{bc}	69.8^{b}	0.52^{b}
Alternate row replacement	190.4^{bc}	8.7^{b}	7.3^{c}	70.1^{b}	0.49^{bc}
Sole	197.4^{ab}	10.2^{ab}	9.4^{a}	75.1^{a}	0.74^{a}
SEM	1.76	0.36	0.27	1.105	0.043
P value	.00	.01	.00	.00	.00
C x S	**S	NS	NS	NS	NS
V x S	*S	NS	NS	NS	NS
C x V x S	*S	NS	NS	NS	NS

S - Significant (P<0.05, **P<0.01), NS = Not significant (P> 0.05)*
Values with similar alphabets vertically are not significantly different from each other

The interactions of cropping season by variety on 1000-seed weight and threshing percentage were significant. It is pertinent to note that the performance of cowpea in alternate row and sole cropping were consistently similar in all the parameters considered whereas alternate stand, strip cropping and alternate replacement were comparable. The interactions of cropping season x spatial arrangement, variety x spatial arrangement, cropping season x variety x spatial arrangement were significant on 1000-seed weight.

3.2 Response of Maize to Spatial Arrangements

Table 4 shows the performance of maize in various cropping season and spatial arrangements. The seed weight observed in 2010 was significantly higher than that 2009. Maize + Oloyin and maize + Sokoto combination in strip cropping had significantly lower 1000-seed weight than maize + Oloyin alternate stand additive whereas other arrangements had similar seed weight. However, cob weights observed in the 4 replacement series were significantly lower than maize + Oloyin alternate row additive while the others were similar. The grain yields obtained from the 4 additive series and the sole maize were similar but significantly higher than most of the replacement series except maize + Oloyin replacement series.

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3.3 Intercrop Productivity

The overall productivity of Oloyin and Sokoto in combination with maize in the different spatial arrangement was similar in both cropping season (Table 4). However, Land Equivalent Ratio (LER) of alternate row additive and alternate stand had similar but significantly higher than strip cropping (Table 5). The productivity of maize was affected by two additives series (alternate row additive and alternate stand.

Table 4. Effects of maize/cowpea intercrop on maize agronomic parameters

Treatment	1000-seed weight (g)	Cob length (cm)	Cob weight (kg)	Threshing %	Grain yield (Mg ha^{-1})
Cropping season (C)					
2009	206.8^{b}	13.8	1.01	78.5	2.24
2010	218.7^{a}	13.9	1.16	80.3	2.26
SEM	1.38	0.09	0.08	1.95	0.083
P Value	.00	.26	.19	.26	.80
Spatial arrangement (S)					
Maize + Oloyin (strip replacement series)	208.8^{b}	13.5	0.76^{b}	82.9	2.00^{bc}
Maize + Oloyin (alternate row additive)	213.3^{ab}	15.4	1.64^{a}	80.4	2.42^{ab}
Maize + Oloyin (alternate stand- additive)	223.7^{a}	14.2	1.27^{ab}	79.3	2.57^{a}
Maize + Oloyin (alternate row replacement)	212.0^{ab}	13.6	0.75^{b}	81.9	1.77^{c}
Maize +Sokoto (strip replacement series)	207.5^{b}	14.0	0.86^{b}	81.3	1.91^{c}
Maize + Sokoto (alternate row additive)	213.0^{ab}	13.8	1.14^{ab}	80.4	2.44^{ab}
Maize + Sokoto (alternate stand- additive)	216.0^{ab}	13.9	1.27^{ab}	80.4	2.71^{a}
Maize +Sokoto (alternate row replacement)	210.7^{ab}	16.4	0.82^{b}	81.4	1.88^{c}
Sole	210.0^{ab}	14.1	1.28^{ab}	66.8	2.57^{a}
SEM	2.93	7.16	0.167	4.15	0.10
P value	.02	.47	.01	.25	.00
C×S	NS	NS	NS	NS	NS

Values with similar alphabets vertically are not significantly different from each other NS = Not significant (P> 0.05)

Table 5. Land Equivalent Ratio (LER) of maize/cowpea intercrop

Treatment	LER 2009	LER 2010
Variety (V)		
Oloyin + maize	1.56±0.05	1.56±0.06
Sokoto + maize	1.56±0.05	1.60±0.06
P Value	0.988	0.667
Row arrangement (S)		
Strip (replacement series)	1.27±0.07^{b}	1.12±0.09^{c}
Alternate row (additive series)	1.86±0.07^{a}	1.83±0.09^{a}
Alternate stand (additive series)	1.73±0.07^{ab}	1.73±0.09^{ab}
Alternate row (replacement series)	1.37±0.07^{b}	1.34±0.09^{bc}
P Value	.03	.01

Values with similar alphabets vertically are not significantly different from each other

4. DISCUSSIONS

The differences observed in 1000-seed weight, pod length and number of seeds per pods between the two cropping seasons could be attributed to the role of environment during seed development (Tang, 1982). The varietal difference in 1000-seed weight, pod length and number of seeds per pod could be attributed to yield contributing traits. This confirms the findings of [11,12,13] who reported that the weight of 1000-seed was one of the prominent grain-yield determinants of cowpea. Moreover, demand for seed grains for human consumption is linked to size and shape [14]. Thus, the preference for Oloyin in the market apart from it taste could be linked to heavy seed weight which is related to the seed size.

The superior grain yield obtained from Oloyin was also reported by [3]. The consistent higher grain yield of cowpea in alternate row additive in all the parameters could be attributed to interaction between cowpea and maize [15,16] and partly because of the population of cowpea (i.e.100% plant population in relation to the sole) in the mixture. Moreover, the growth resources such as light, nutrient and water between the inter rows were efficiently utilized in alternate row additive. This confirms the findings of Midmore [17] who reported that intercropping through more effective use of water, nutrients and solar energy can significantly enhance crop productivity compared to the growth of sole crops.

The demand for seed grains for human consumption is linked to size and shape [14]. Therefore the consistency of the seed size, which is a function of seed weight, in any cropping season and spatial arrangement, is an essential parameter to be considered if the varieties are to be adopted by farmers in the South western Nigeria. The significant interaction of cowpea variety x cropping season on 1000-seed weight indicated that cowpea variety responded differently in the two cropping seasons. The similarities in 1000-seed weight of Oloyin variety in the two cropping seasons suggest that the variation between cropping seasons and perhaps different environments may not likely affect it seed weight unlike Sokoto. The observed variation of 1000-seed weight among the spatial arrangement and between the cropping seasons implies that the seed weights of two varieties were influenced differently. While the seed weight of Sokoto variety ranged between 132.67 and 153.5 g whereas Oloyin had 245.5 and 251.67 g. It further indicated that the alternate row additive minimized the variation in seed weight of both varieties in the two cropping seasons. Besides, the grain weight recorded for Oloyin cowpea variety was indifferent to whatever spatial arrangement whereas Sokoto had reduction. The significant interaction of cropping season by variety by spatial arrangement on seed-weight clearly revealed the superiority of Oloyin grain weight stability between seasons and among spatial arrangements. Since seed weight, to a large extent, is a function of seed size. Seed size and shape are important determinant of grain quality grading [18]. Therefore, the seed size of Oloyin cowpea variety is likely to be stable in any crop mixture and variation in weather parameters during the cropping seasons.

The similarity in grain yield of maize obtained from maize + Oloyin, maize + Sokoto in the additive series and that of sole was as a result of the same population adopted. The results agreed with those of [10] who reported that cowpea/maize intercrop had no suppressive effect on the maize yield.

4.1 Land Equivalent Ratio

The land equivalent ratio in 2009 and 2010 was similar (Table 4). However, the land equivalent ratio was affected by the spatial arrangement. Alternate row additive consistently had highest LER in both in cropping seasons while strip cropping had the lowest. The higher LER observed in alternate row (additive series) and alternate stand (additive series) could be attributed to the higher plant population of cowpea plants (i.e. 100% and 50% of cowpea plants for alternate row additive and alternate stand, respectively in relation to the plant population of sole cowpea). Although all the spatial arrangement adopted in this study had LER greater than one suggesting that they are more productive than the sole. Consequently, alternate row additive and alternate stand arrangement is efficient utilizer of growth resources in the environment compared to the strip cropping (replacement series) and alternate row replacement. This is in line with the opinion of Dhima et al. [19] who reported that LER verifies the effectiveness of intercropping for using the resources of the environment compared to sole cropping.

5. CONCLUSION

The study shows that alternate row additive and alternate stand spatial arrangements have the potential to enhance the productivity of the two cowpea varieties without reducing maize yield in derived savannah of Nigeria. It also shows that Oloyin variety had a superior grain yield. The replacement series reduce the productivity of maize.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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