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YIELD AND YIELD COMPONENTS OF MAIZE/COWPEA INTERCROP AS AFFECTED BY ROW-ARRANGEMENT AND COWPEA VARIETIES IN THE SUDAN SAVANNAH

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ABSTRACT

Field experiment was conducted during the 2023 rainy season at the Teaching and Research Farm of Faculty of Agriculture, Bayero University Kano (11°58N, 8°25E) and Institute for Agricultural Research Farm Minjibir (12°10'42N, 8°39'33E) to determine the productivity of maize/cowpea intercrops as affected by cowpea varieties and row arrangement in Sudan savanna of Nigeria. The treatments consisted of two cowpea varieties (SAMPEA19 and SAMPEA21) and four row arrangements (1M:1C, 1M:2C, 2M:1C, 2M:2C). Sole maize and cowpea were established in each replication for evaluation of intercrop productivity. These were laid out in a split plot design and replicated three times. Row arrangement was assigned to the main plot and cowpea variety to the sub plot. The result of the study at both locations revealed that grain yield of maize at BUK (2286.8 kg ha^{-1}) and Minjibir (1211.2 $kgha^{-1}$), was higher in 1M:1C than other row arrangement. In the case of cowpea, SAMPEA 21 recorded highest values for number of pod/plants, 100 seed weight, pod yield and grain yield at both locations, 1M:1C row arrangement recorded the highest Pod weight at BUK (2034.2 kg ha^{-1}) and Minjibir (1801.2 kg ha^{-1}) and grain yield of 1717.7 and 1596.3 kg ha^{-1} at BUK and Minjibir respectively. All the treatment combinations resulted in land equivalent ratio (LER) greater than 1.0 with combination of SAMPEA21 and 1M:1C (1.58, 1.40) recording the highest LER value in both locations.

Keywords: Maize/cowpea, intercrop, sole crop, performance, row arrangement, varieties

INTRODUCTION

Intercropping, though widely practiced particularly in tropical regions is often being considered as a "primitive" form of farming. It is a common practice among the traditional farmers of the Nigerian Savanna. It was found out that no less than 60-70% of the cropped land is devoted to the growing of crops in mixture as opposed to sole cropping. Intercropping is the growing of two or more crops together on the same piece of land at the same time in a systematic manner such that the growth of some or all the component plant types overlap in space and time (Elemo *et al.*,1990). The crops in the intercrop are not necessarily sown at exactly the same time and their harvest time maybe quite different, but they are usually "simultaneous" for a significant path of their growing period.

One popular intercropping combination is maize (*Zea mays* L.) and cowpea (*Vigna unguiculata* L.), which have been successfully intercropped in many regions around the world (Dahmardeh *et al.*, 2010). It is an important agronomic practice in which the system's efficiency is superior to the individually grown component species (Zhang, *et al.*, 2021).For instance, maize (*Zea mays*)–legume intercropping has multiple benefits over sole cropping and intercropping practices than other species (Renwick *et al.*, 2020).These benefits may have been achieved through symbiotic associations and complementarity interactions between species in harvesting limited resources (Brooker, *et al.*, 2016).When maize is planted as a wide-spaced crop, it encourages weed infestation and intensifies crop weed competition (Kumar, 2012) meanwhile, by intercropping cowpea and maize, cowpea serves as a valuable nitrogen source since it can supplement some of its fixed nitrogen into other component crops (Rodriguez *et a*l., 2020)., reducing the reliance on synthetic fertilizers and supporting sustainable agricultural practices (Hinsinger *et al*., 2011). Moreover, cowpea demonstrates strong weed competitiveness, effectively suppressing weeds (Varret *et al.*, 2017) that could otherwise hinder maize growth. This natural weed control characteristic of intercropping reduces the need for herbicides and manual weed management (Darayanto *et a*l., 2020).

Intercropping cowpea and maize also provide farmers with risk diversification. In the event of adverse weather conditions or pest and disease outbreaks affecting one crop (Huang *et al*., 2015), the other crop has the potential to thrive, ensuring a certain level of harvest and income (Emede and Adegoke 2011). Furthermore, the intercropped system can generate multiple income streams as cowpea can be marketed separately or utilized for household consumption (Mucheru-Muna *et al*., 2010; van Asten *et al*., 2011).

The performance of cowpea varieties and row arrangement present a complex agricultural challenge. Limited research has explored the synergies and potential conflicts between cowpea varieties and row arrangement when intercropped with maize as nature of the growth habit of the cowpea has to be considered and most of the improved recently released varieties have not been used in the intercrop to evaluate its performance in the intercropping system as they were selected in sole cropping system. The objectives of this study were to determine the best row arrangement the performance of cowpea varieties under the intercrop and identify which is most suited to intercropping with maize.

MATERIALS AND METHOD

The study was conducted during the 2023 rainy season at two locations; the first being at the Teaching and Research Farm of Faculty of Agriculture, Bayero University Kano, (11°58N and 8°25E) and Institute for Agricultural Research farm Minjibir (12°10'42N, 8°39'33E). The treatment consists of four (4) row arrangement of 1:1, 1:2, 2:1 and 2:2 rows of maize (SAMMAZ 27) alternated with cowpea, and sole maize crop, sole cowpea crop included) and two varieties of cowpea (SAMPEA19 and SAMPEA21) sourced from International Institute of Tropical Agriculture (IITA) Kano station. The treatment combination was laid out in a split plot design with three replications. Varieties were assigned to the subplot while planting pattern to the main plots. Plot consisted of twelve ridges of 5m length. Gross plot size of 5m×9m (45m^2) while net plot consisted of eight inner ridges with net plot size of 5m x6m (30m^2).

Composite topsoil (0 - 30cm) samples were taken from the experimental sites with an auger before land preparation randomly. The soil samples were bulked and analyzed for physical and chemical properties using standard procedure as described by Black (1965).

SAMMAZ 27 (EV99DT-W-STR): It is an early maturing variety. Drought tolerant and striga resistant with a yield potential of 5.5t/ha (IITA, 2009). SAMPEA 19 (IT08K-150-12): It is an early maturing, resistant to alectra and bacterial blight and tolerant to *striga* and drought, seed colour is white with brown eye, it is large seeded, and it has a rough seed coat or testa. The plant is semi-erect, adapted to Sudan savanna and Sahelian agro-ecologies, variety has a yield potential of 2.7 t/ha (IAR, 2018). SAMPEA 21 (IT13K-1308-5): It is an early maturing variety, resistant to striga, bacteria blight and tolerance to drought. Seed is medium in size with a white seed coat (IAR,).

Land Equivalent Ratio (LER), which is the relative land required as sole crop to produce the same yield as intercropping, mathematically expressed as;

$$LER = \frac{intercropped\ yield\ of\ crop\ A + intercropped\ yield\ of\ crop\ B}{Sole\ yield\ of\ cop\ A\ + Sole\ yield\ of\ crop\ B}$$

Data was taken on number of cobs per plant, cob weight per plant, grain yield per hectare, 100 seed weight, while for cowpea number of pods per plant, pod weight per hectare, 100 seed weight, number of seeds per pod and grain yield. Data collected was subjected to the Analysis of variance (ANOVA) using the Statistical Analysis Software (SAS) and student Newman keul's test (SNK) used to separate treatment means.

RESULTS

The effect of cowpea varieties and row arrangement on number of cobs per maize plant in at BUK and Minjibir is shown on Table 1. The results obtained showed that none of the factors used or their interaction had significant effect on the number of cobs per plant. Cob weight per maize plant as influenced by cowpea varieties and row arrangement at BUK and Minjibir is shown on Table 1. There was no significant difference on the factors used or their interaction on the weight of cob per plant in the intercrop on cowpea varieties at both locations. The grain yield of maize per hectare as influenced by cowpea varieties and row arrangement at BUK and Minjibir is presented on Table 1. Grain yield was not significantly affected by the cowpea varieties at both locations while row arrangement was significantly affected in both locations. In BUK, 1M:1C recorded the highest yield followed by 2M:1C, while 2M:2C and 1M:2C was are similar recorded the lowest. In Minjibir, 1M:1C recorded the highest yield and was statistically similar with 2M:1C and 2M:2C while 1M:2C row arrangement recorded the least. There was no significant interaction between the cowpea varieties and row arrangement on grain yield of maize at both locations. 100 seed weight of maize as influenced by cowpea varieties and row arrangement at BUK and Minjibir is shown on Table 1. It was observed that none of the factors used or their interaction had a significant effect on 100 seed weight of maize.

Table 2 showed the effect of cowpea varieties and row arrangement on number of pods per cowpea at BUK and Minjibir. Significant difference on cowpea varieties was observed on number of pods where SAMPEA 21 recorded the highest number of pods per plant while SAMPEA 19 the least in both locations. No significant difference was observed on the row arrangement or the interaction of the two factors in the intercrop. The effect of cowpea varieties and row arrangement on pod weight per hectare at BUK and Minjibir is shown on Table 2. There was an observed significant difference on the cowpea varieties in both locations with SAMPEA 21 recording the heaviest pods per hectare and SAMPEA 19 the least. Also, significant difference was observed on the row arrangement in both locations. Where in BUK 1M:1C had the heaviest pods then 2M:2C which was comparable with 2M:1C while 1M:2C recorded the least pod weight per hectare while in Minjibir, 1M:1C recorded the heaviest followed by 1M:2C and 2M:1C while 2M:1C recorded the least. There was no significant interaction between cowpea variety and row arrangement on pod weight per hectare in both location

Table 2 shows the effect of cowpea varieties and row arrangement on number cowpea seed per pod at BUK and Minjibir. There was no significant difference on factors used or their interaction at both locations. 100 seed weight of cowpea as influenced by cowpea varieties and row arrangement at BUK and Minjibir is shown on table 2. There was a significant difference in 100 seed weight of cowpea on the two cowpea varieties at both locations where SAMPEA 21 recorded the highest weight and SAMPEA 19 the least. No significant difference was observed on the row arrangement or the interaction of the two factors in the intercrop at both locations. The effect of cowpea varieties and row arrangement on grain yield of cowpea at BUK and Minjibir is shown on Table 2. Cowpea grain yield was significantly affected by variety at both locations. At both sites, SAMPEA 21 recorded the highest grain yield while SAMPEA 19 the least. Also, a significant difference was observed in respect to row arrangement at both locations. In BUK, plants at 1M:1C was observed to produce highest grain yield which was statistically comparable with 2M:2C then 2M:1C row arrangement while 1M:2C row arrangement recorded the least yield. A similar trend was observed in Minjibir, where 1M:1C produced then highest grain yield followed by 2M:2C and 1M:2C, whereas plants at 2M:1C produced the least grain yields.

Table 3 shows variety x row arrangement interaction on grain yield at Minjibir. It was observed that SAMPEA 21 with 1M:1C row arrangement had the highest yield followed by SAMPEA19 with 1M:1C and the least grain values was obtained from SAMPEA19 with 2M:1C row arrangements. Table 4 shows the measurement of land productivity (LER) from the combined cultivation of maize and cowpea at BUK and Minjibir. Generally, it was observed that there was a great benefit in growing the two crops together in both locations because the LER values of the various treatment combinations were above 1.0. In BUK the yield advantage varied from 10% to 58% while in Minjibir it varied from 9% to 40%. The most productive treatment combinations in Buk were that of LER values of 1.58 which involved intercropping SAMPEA21 into 1M:1C row arrangement while the least was that with LER values of 1.10 where SAMPEA19 was intercropped into 1M:2C row arrangement. In Minjibir the best result was from LER values of 1.40 involving SAMPEA21 and 1M:1C row arrangement while the least was with LER values of 1.09 which involved SAMPEA 21 and 1M:2C row arrangement.

DISCUSSION

Yield of maize had a significant effect on row arrangement where 1M:1C indicated superiority over other row arrangement however lower than the yield of the sole cropping of maize. The population at harvest in 1M:1C was higher than other arrangement this could have accounted for higher yield as it is known that different crop species complement each other more especially if they differ in the use of growth resources. Similar result was reported by Elemo *et al* (1990) where a higher population of maize to cowpea produced higher grain yield of both crops. Zama and Malik (2000), Mutungari *et al.* (2001*)* have reported lower grain yield records from plots where maize was intercropped with two and three rows respectively of bean compared to 1:1 row arrangement .100 seed weight of maize had no significant effect on row arrangement in both locations. This is in line with the result of Undies *et al.* (2012) have reported that intercropping and crop management had no significant effect on 100 grain weight.

Similarly, yield of cowpea component of the intercrop indicated the superiority of SAMPEA 21 over SAMPEA 19. The higher yield of this variety could be due to their relatively high number of pods per plant, number of seed per pod and 100 seed weight. The higher values for the aforementioned parameters were observed in SAMPEA 21 over SAMPEA 19. This could be associated with the genetic makeups which ultimately transfer on the growth and yield habit of the variety. This is in line with the findings of Abubakar (1992) where a soybean was used as a test crop. Variation on yield and yield component among the cowpea varieties could be due to genetic makeup and how these genes interact with the environment (Tang, 1982). The varietal difference in 100 seed weight where SAMPEA 21 had the highest weight than SAMPEA 19 could be attributed to yield attributing traits. This confirms the findings of Brolmarn and Stofellia (1986); Siddique and Gupta (1991) and Akbar and Kamram (2006) who reported that 100 weight of seeds was one of the prominent pod yield determinants of cowpea. The superiority of SAMPEA21 in terms of pod yield could be due to the fact that it was bred as high yielding compared to SAMPEA 19. This finding is in agreement with that of Haruna and Usman (2013) that observed significant variation in growth and yield characters of some improved varieties of cowpea at the same location and attribute to genetic makeup of the varieties examined. Higher yield was observed on 1M:1C over other row arrangement. This confirms the findings of IITA (1995) as cited by Isom and Worker (1997) in which single alternate row of maize and legume produced more yield than double or quadruple row planting of the same crops. Also, Zama and Malik (200), Mutungamiri et al. (2001) have reported lower grain yield records from plots where maize was intercropped with 2 or 3 rows respectively of bean compared to 1M:1C row arrangement.

Number of pods/plants were found statistically identical in the row arrangement. Nudungu *et al.* (2005) similarly reported non-significant influence of special arrangement on grain accumulation in each pod. The results indicate that cowpea variety and row arrangement did not affect the number of seed per pod of cowpea, these observations are contrary to the findings of Mariga (1990) in Zimbabwe that the number of seeds per pod in cowpea were significantly affected by intercropping. 100 seed weight of cowpea was not significantly affected by row arrangement, the medium values found in this work were superior to those obtained by Nuhu (2023. Similarly, undies et al. (2012) have reported that intercropping and crop management had no significant effect on 100-grain weight.

CONCLUSION

At both locations, cowpea variety did not affect maize yield and yield attribute of maize while higher values for number of pods per plant, pod weight per hectare, grain yield per hectare, 100 seed weight were recorded by SAMPEA 21 over SAMPEA 19. Row arrangement significantly affected maize grain yield per hectare with 1M:1C arrangement recording the highest than other arrangements in both locations. In the case of cowpea, pod weight per hectare, grain yield per hectare were significantly affected by row arrangement with 1M:1C recording higher yield than other arrangement. In conclusion, the present study has shown the possibility of achieving a productive maize/cowpea intercrop with the combination of SAMPEA 21 and 1M:1C row arrangement in both Buk and Minjibir as all the LER values where greater than one.

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Table 1: Effect of Row Arrangement and Cowpea Varieties on Number of Cobs per Plant, Cob Weight per Plant, Grain Yield per Hectare and 100 Seed Weight of Maize in a Maize-Cowpea Intercrop during the 2023 Rainy Season at BUK and Minjibir

	Number of Cobs per Plant		**Cob Weight per Plant**		**Grain Yield (kg/ha)**		**100 Seed Weight (g)**	
Treatments	BUK	Minjibir	BUK	Minjibir	BUK	Minjibir	BUK	Minjibir
Variety (V)								
SAMPEA 19	1.1	1.1	89.4	87.5	1922.1	1109.5	17.5	17.0
SAMPEA 21	1.1	1.1	82.4	77.5	1895.8	1095.3	16.8	16.8
SE±	0.02	1.00	6.25	5.56	30.37	14.91	0.30	0.41
Row Arrangement (R)								
1M:1C	1.2	1.1	93.0	86.0	2286.8a	1211.2a	17.3	16.9
1M:2C	1.1	1.1	81.7	84.5	1594.3c	951.2b	16.6	16.5
2M:1C	1.0	1.0	72.8	73.2	2006.7b	1127.8a	16.9	17.0
2M:2C	1.1	1.1	87.2	77.7	1747.8c	1119.5a	17.8	17.1
SE±	0.05	0.03	7.96	5.40	61.07	34.10	0.24	0.31
Interactions								
V X R	0.91	0.77	0.35	0.48	0.19	0.18	0.45	0.31

Means in the same column followed by the same letter(s) are not significantly different at 5% level of probability using Student-Neuman Keuls Test, 1M:1C= 1 row of maize to1 row of cowpea, 1M:2C= 1 row of maize to 2 row of cowpea, 2M:1C= 2 rows of maize to 1 row of cowpea, 2M:2C= 2 rows of maize to 2 rows of cowpea.

Table 2: Effect of Cowpea Varieties and Row Arrangement on Number of Pods Per Plant, Pod Weight Per hectare, 100 Seed Weight, Number of Seed per Pod and Yield per Hectare of Cowpea in a Maize-Cowpea Intercrop during the 2023 Rainy Season at BUK and Minjibir

	Number of Pods Per Plant		**Pod Weight Per Hectare (Kg/ha)**		**100 Seed Weight (g)**		**Number of Seed per Pod**		**Yield Per Hectare (kg/ha)**	
Treatments	BUK	Minjibir	BUK	Minjibir	BUK	Minjibir	BUK	Minjibir	BUK	Minjibir
Variety (V)										
SAMPEA 19	31.7b	35.3b	1665.3b	1513.3b	25.2b	17.8b	8.2	8.2	1390.6b	1281.1b
SAMPEA 21	41.1a	39.8a	1841.4a	1615.2a	28.6a	19.7a	8.3	8.3	1589.2a	1417.4a
SE±	1.38	0.82	29.07	26.49	0.65	0.47	0.26	0.31	35.55	33.04
Row Arrangement (R)										
1M:1C	38.4	33.7	2034.2a	1801.2a	27.8	19.4	8.0	7.6	1717.7a	1596.3a
1M:2C	35.6	33.0	1555.7c	1510.5b	26.0	19.3	7.7	7.1	1292.0c	1316.8b
2M:1C	38.0	32.9	1624.2bc	1323.0c	25.6	18.2	7.2	7.4	1401.2b	1082.0c
2M:2C	37.9	30.4	1799.5b	1622.2b	28.3	18.6	8.6	8.8	1548.7ab	1420.3c
SE±	2.76	2.04	58.76	32.79	1.30	0.62	0.52	0.40	71.10	35.01
Interactions										
V X R	0.32	0.94	0.64	0.56	0.09	0.36	0.28	0.27	0.67	0.004

Means in the same column followed by the same letter(s) are not significantly different at 5% level of probability using Student-Neuman Keuls Test, 1M:1C= 1 row of maize to1 row of cowpea, 1M:2C= 1 row of maize to 2 rows of cowpea, 2M:1C= 2 rows of maize to 1 row of cowpea, 2M:2C= 2 rows of maize to 2 rows of cowpea.

Table 3: Interaction between Cowpea Varieties and Row Arrangement on Grain Yield (kg/ha) of Cowpea in a Maize-Cowpea intercrop in Minjibir during 2023 Rainy season

	Row Arrangement			
Treatment	1M:1C	1M:2C	2M:1C	2M:2C
Variety				
SAMPEA 19	1432.3b	1259.3cd	1044.3de	1331.3bc
SAMPEA 21	1667.3a	1256.7cd	1119.7d	1397.7bc
SE±		62.53		

Means in the same column followed by the same letter(s) are not significantly different at 5% level of probability using Student-Newman Keuls Test, WAS=Weeks after sowing, 1M:1C= 1 row of maize to1 row of cowpea, 1M:2C= 1 row of maize to 2 row of cowpea, 2M:1C= 2 rows of maize to 1 row of cowpea, 2M:2C= 2 rows of maize to 2 rows of cowpea

Table 4: Land Equivalent Ratio (LER) of Maize/Cowpea intercrop as affected by Cowpea Varieties and Row Arrangement at BUK and Minjibir during 2023 Rainy Season

	Land Equivalent Ratio (LER)					
	BUK			Minjibir		
	Partial		Total	Partial		Total
Treatments	Maize	Cowpea		Maize	Cowpea	
SAMPEA19+ 1M:1C	0.72	0.76	1.48	0.63	0.71	1.34
SAMPEA19+ 1M:2C	0.51	0.59	1.10	0.50	0.62	1.12
SAMPEA19+ 2M:1C	0.66	0.65	1.31	0.60	0.52	1.12
SAMPEA19+ 2M:2C	0.58	0.68	1.26	0.57	0.66	1.23
SAMPEA21+ 1M:1C	0.79	0.79	1.58	0.62	0.78	1.40
SAMPEA21+ 1M:2C	0.55	0.61	1.16	0.49	0.58	1.07
SAMPEA21+ 2M:1C	0.66	0.65	1.31	0.57	0.52	1.09
SAMPEA21+ 2M:2C	0.57	0.73	1.30	0.60	0.65	1.25

1M:1C= 1 row of maize to1 row of cowpea, 1M:2C= 1 row of maize to 2 rows of cowpea, 2M:1C= 2 rows of maize to 1 row of cowpea, 2M:2C= 2 rows of maize to 2 rows of cowpea