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GROWTH AND YIELD RESPONSES OF SESAME AND SORGHUM IN SESAME/SORGHUM INTERCROPPING.

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ABSTRACT

A field trial was carried out at the Kwara State University Teaching and Research Farm in the 2019 cropping season. The study aimed to investigate the growth and yield responses of sesame and sorghum as affected by varying population density of both crops. Seven population densities viz: 100%SE:100%SH,100%SE:75%SH, 100%SE:50%SH, 100%SE:25%SH, 75%SE:100%SH, 50%SE:100%SH, and 25%SE:100%SH plant population per hectare where SE and SH represented sesame and sorghum respectively were combined in a Randomized Complete Block Design (RCBD) and replicated three times. The full population of each crop 111,111 and 55,555 plants per hectare respectively for sesame and sorghum were also included in the treatment as a control. The height and grain yield of sorghum were significantly influenced by population density of component sesame. The height decreased as the population density of component sesame decreased.The seed yield of sesame was affected by population density of component sorghum with the lowest yield (115.19 kg/ha) obtained at 100SH:25SE population ratio. Reasonable intercropping advantage was observed at the treatments where 55,555 and 41,250 population density of sorghum was intercropped with 111,111 plant population of sesame as measured by the Land equivalent ratios (LER) and Land equivalent coefficient (LEC) indices.Intercropping sorghum at population density of 27,777 and 13,750 with sesame at population density of 111,111 plants per hectare was disadvantageous. Aggressivity (A) values were positive for sorghum and negative for sesame in all the population ratios tested except, 50SH:100SE and 25SH:100SE population ratios. The competitive ratios (CR) values followed a similar trend to the A values. The highest A value, 0.70 and -0.86, and CR, 18.2 and 4.20 respectively for sorghum and sesame were recorded at 100SH:25SE population ratios. A reasonable intercropping advantage was obtained at the treatment where the full population ratio of both was intercropped and hence, recommended for adoption.

Keywords: Sorghum, sesame, intercropping, population ratios, intercropping advantage.

INTRODUCTION

Intercropping is a traditional farming system in Nigeria to increase yield per limited area of land as well as reduce crop failure that is often associated with sole cropping. The productivity can, however, be increased if the appropriate plant population is determined. Population density is essential to achieve maximum yields in modern cropping systems (Yang *et al.*, 2017) and plays an important role in determining seed yield (Malik *et al*., 2003).

The effect of plant population on yield and yield components of sesame has been reported by several workers. Seyede *et al.* (2015) reported that plant density significantly affects plant height, seed yield per plant, and the number of seeds per plant of sesame. In another study, in maize sesame mixture, a 36-52 % yield reduction was observed in maize compared to the sole crop (Kolawole, 2015). The dominance of maize over sesame was also reported in the same study. Bathi *et al*. (2013) also reported a more aggressive behavior of cowpea over sesame which ultimately led to about 26.0% yield reduction of sesame. In contrast, the growth and yield of sesame were found not to be affected in sesame/ cowpea intercropping (Afe, 2017) because sesame was planted earlier than cowpea and hence, was able to utilize the resources better than cowpea which was sown in the latter days.Sorghum and sesame are moderately tolerant to drought and are usually grown towards the end of the rainy season in the study area to take advantage of the moisture content that may not support other crops. While considerable information is available on sesame intercropping with other crops and has demonstrated growth and yield advantages over the sole crops (Ijoya, 2016; Afe, 2017; Ajibola and kolawole, 2019) information on sorghum/sesame

intercropping is scanty. This study was, therefore, carried out to evaluate the growth and yield responses of both sesame and sorghumat different population density and also access their competitive behavior at the intercrop.

MATERIALS AND METHODS

Study location and experimental design. The experiment was carried out in 2019 cropping seasons at the Teaching and Research Farm of Kwara State University, Malete, (Latitude 080˚ 71N; Longitude 040˚ 44E) in the Southern Guinea Savannah Ecological Zone of Nigeria. Sorghum cultivar (CSR-01) and sesame (E-8) obtained from National Cereal Research Institutes, Badeji, Nigeria were used for the trial. Seven population densities:100%SE:100%SH,100%SE:75%SH,100 %SE:50%SH,100%SE:25%SH,75%SE:100%SH, 50%SE:100%SH, and 25%SE:100%SH where SE and SH represented sesame and sorghum respectively were combined in a Randomized Complete Block Design (RCBD) and replicated three times (Table 1). The full population of each crop 55,555 and 111,111 plants per hectare respectively for sorghum and sesame was also included in the treatment as a control.

Cultural practices

The land was plowed and harrowed twice for proper seed germination. For sorghum, 4 to 5 seeds were planted at their respective plant population but were thinned to two plants per stand two weeks after planting. Sesame was introduced to sorghum in a single alternate row at two weeks after planting. That is one row of sorghum followed by one row of sesame. Pendimethalin mixed with paraquat was applied as pre-emergence immediately after sorghum was planted. This was followed by manual weeding with hoe such that the experimental field was weedfree during the period of the experiment. NPK (20:10:10) was applied to sorghum and sesame respectively at the rate of 400 and 300 kg/ha four weeks after planting. Cyalothrin was applied to sesame and sorghum at the rate of 20ml/20liters of water to control insect pests at 5 WAP for sesame and 6 and 10 WAP for sorghum. Sorghum was harvested at 12 WAP. At this period, the leaves turn yellow with a brown colour, and dried-up appearance. The grains were hard and firm to the kernel. Ten tagged plants at the inner rows were harvested by cutting the ear-head with a knife. The cut ear head was later dried and threshed manually. Sesame was harvested at 8WAP when 75% of the fruit capsules were ripened, that is, they have turned brown. At this period also, many leaves have withered and the remaining leaves turned brown and yellow with the lowest capsule about to split open. The crops were manually harvested from the two inner rows by cutting with a sharp knife The harvested crops were tied together and made to stand erect for 7 days for proper drying after which they were threshed and winnowed.

Yba = Intercrop yield of crop b

Data collection and analysis

The following data were collected. Sorghum: Plant height at 4, 6, 8, and 10 weeks after planting, stem girth, days to 50% panicle initiation/ flowering, number of leaves per plant, and grain yield/ha. Sesame: Plant height at 4, 6, 8, and 10 WAP, days to 50% flowering**,** and seed yield. Efficiency of intercropping and competitive behavior The efficiency of intercropping was evaluated using the following indices: **Land equivalent ratio index (LER)**, is defined as the relative land area under sole crops that is required to produce the yield achieved in intercrops (Willey, 1985). LER was determined as described by Willey (1985) using the equation: LER = Intercrop yield of crop a / Sole crop yield of crop a + Intercrop yield of crop b / Sole crop yield of crop b

Land Equivalent Coefficient (LEC). This is a measure of the level of interaction and productive potential at the intercrop. It was estimated as proposed by Adetiloye *et al*. (1983). LEC = (Lso x Lsh). Where Lso and Lsh are partial LER for sorghum and sesame respectively. LEC greater than 0.25 was considered advantageous. Competitive ratio (CR) The CR was calculated using the formula proposed by Willey and Rao (1980). The CR describes the degree of competition among component crops in the mixture. A higher CR value indicates higher competitive ability.

CR (sesame) = Lso x Zsosh/Lsh x Zshso

CR (sorghum = Lsh x Zshso/Lso x Zsosh

Where: Lso and Lsh are partial LER for sorghum and sesame respectively Zso and Zsh =proportions of sorghum and sesame respectively at the intercrop

Aggressively (A).

The value of A was calculated by the formula proposed by McGilChrist (1965) and cited in Afe (2017). It is a measure of how much a relative yield increase in one species (dominant) is greater than the other species (dominated or recessive) in the mixture. The values of A for component crops a and b are usually the same but the dominant crop gives a positive value, while the dominated or recessive crops give a negative value. A high A value is an indication of the higher difference between the actual and expected yield.

$$Aab = \frac{Yab}{Yaa \times Zab} \quad \frac{Yba}{Ybb \times Zba}$$

Where:

Aab = Aggresivity value for a component crop a

Yab = Intercrop yield of crop a

Zab and Zba = Sown proportion of crop a and b at the intercrop

Data analysis

All data collected were subjected to analysis of variance (ANOVA) and treatment means where significant differences exist were separated using Duncan's Multiple Range Test at a 5% level of probability.

RESULTS

The height of sorghum, days to 50% heading, stem girth, and grain yield were significantly influenced by population density but the number of leaves per plant was not influenced (Table 2). The height decreased as the population density of component sesame decreased. At 6WAP and beyond, significantly taller plants were recorded where full populations of both crops were combined. There was no significant difference in plant height between 100SH:50SE and 100SH:25SE population ratios throughout the growing period. At 8 and 10 WAP, the height of sorghum at the intercrop was significantly reduced with the reduction in their population between 75% and 25% of their full population. Regardless of sampling periods, the shortest plants of sorghum were recorded in the 25SH:100SE population ratio. Intercropping sorghum and sesame at full population had reduced the stem girth compared to other population ratios including the sole stand but not significantly different except the 100SH:50SE population ratio. The yield of sorghum was significantly affected by the population density of associated sesame. The yield obtained at the sole was significantly higher than the intercrops. The yield increased as the population of sesame decreased, though not significantly different. Decreasing the population of sorghum at the intercrops also led to a further significant reduction in the grain yield. Compared to other population ratios, there was a significant reduction in the grain yield when 25% population of sorghum was intercropped with the full population of sesame.

The effect of population ratio on the height of sesame at 4, 6, 8, and 10 weeks after planting (WAP), days to 50% flowering, and seed yield is presented in Table 3. The effect of population density on the height of sesame was not significant until 6WAP and beyond. During these periods, significantly taller plants were recorded in 100SH:100SE population ratios compared to other population ratios. There was no significant difference in plant height between 100SH:75SE and 100SH:50SE population ratios at 6 and 8WAP. Except for the 25SH: 100 SE population ratio, the sole significantly took longer days to attain flowering compared to the intercrop. Generally, decreasing the population of sorghum was found to increase the seed yield of sesame at the intercropped. Intercropping involving full population of sorghum with 75%, 50%, and 25% full population of sesame had similar seed yield. The seed yield of sesame when 75% and 50% full population of sorghum was intercropped with the full population of sesame were also not significant. The sole sesame significantly out yielded the intercropped.

Table 1: Component population ratios and the corresponding plant population/hectare

Population ratios		Spacing	(cm)+	Plant population/ha		Total plants/ha
SH	: SE	SH	SE	SH	SE	
100	100	60 x 60	60 x 30	55,000	111,111	166,666
100	75	60 x 60	60 x 40	55,555	83,333	138,888
100	50	60 x 60	60 x 60	55,555	55,555	111,110
100	25	60 x 60	60 x 120	55,555	27,777	83,332
75	100	60 x 81	60 x 30	41,250	111,111	152,361
50	100	60 x 120	60 x 30	27,777	111,111	138,888
25	100	60 x 242	60 x 30	13,750	111,111	124,861
100	00	60 x 60	--------	55,555	---------	55,555
00	100	--------	60 x 30	---------	111,111	111,111

SH= Sorghum, SE= Sesame, += Two plants/stand

Table 2: Effect of population density on plant height of sorghum at 4, 6, 8 and 10 Weeks afterplanting, days of 50% heading, stem girth and grain yield of sorghum in sesame/sorghum intercropping.

Population ratios	4 WAP	6WAP	8WAP	10WAP	Days to 50% heading	Number of leaves/plant	Stem girth (cm)	Grain yield (kg/ha)
100SH:100SE	25.5abc	53.2a	115.9a	163.7a	87b	9.5a	16.20b	2443.56b
100SH:75SE	25.6ab	37.8cd	101.9b	150bc	86c	9.0a	18.4ab	2302.22b
100SH:50SE	24.8abc	39.9bc	91.5c	139.4d	87b	9.2a	20.1a	2477.33b
100SH:25SE	20.8c	41.9b	96.00c	142.1cd	86c	8.8a	16.6ab	2502.22b
100SH:00SE	23.03bc	35.03de	94.3c	152.5b	86.33c	8.8a	16.63ab	2745.78a
75SH:100SE	26.2ab	37.9cd	81.4d	128.8e	88a	8.8a	16.90ab	2018.34c
50SH:100SE	23.39bc	34.3de	72.3e	124.7ef	86c	9.1a	16.5ab	1498.22d
25SH:100SE	22.7bc	33.1e	69.4e	116.2f	86c	8.8a	18.2ab	900.29e

Values with same letter under the same column are not significantly different at 5% level of probability by Duncan's Multiple Range Test.
SH= sorghum, SE= sesame, WAP= weeks after planting

Table 3: Effect of population density on plant height of sesame at 4, 6, 8 and 10 Weeks after planting, days to 50% flowering, and seed yield of sesame in sesame/sorghum intercropping.

Population ratios	4 WAP	6 WAP	8 WAP	10 WAP	Days to 50% flowering	Yield (kg/ha)
100SH:100SE	25.9a	61.2a	97.3a	109.09a	58.2C	271.83b
100SH:75SE	26.7a	55.8b	87.6bc	102.00b	58.67c	132.80e
100SH:50SE	24.4a	35.5c	85.7bc	94.3c	61.5b	115.20e
100SH:25SE	23.9a	28.9de	66.6e	107.3ab	61.43b	115.19e
75SH:100SE	25.1a	30.1de	84.8c	102.07b	58.57c	227.91d
50SH:100SE	23.4a	27.1e	76.1d	103.5ab	61.63b	229.80d
25SH:100SE	25.3a	27.4e	52.3f	104.1ab	64.47a	279.61c
00SH:100SE	25.3a	33.3cd	93.3ab	102.b	63.5ab	543.59a

Values with the same letter(s) in the same column are not significantly different at p≤ 5% level of probability by Duncan's multiple range test .SH= sorghum, SE = Sesame, WAP = weeks after planting, WAP=Weeks after planting

Table 4: Evaluating intercropping efficiency and competitive behavior in sesame/sorghum intercropping.

Population ratios	Sorghum Yield (Kg/ha)	Sesame Yield (kg/ha)	Partial LERSH	Partial LERSE	LER	LEC	A Sorghum	A Sesame	CR Sorghum	CR Sesame
100SH:100SE	2443.56b	271.83b	0.89	0.50	1.39	0.45	0.39	-0.39	1.78	0.56
100SH:75SE	2302.22b	132.80e	0.84	0.24	1.08	0.20	0.60	-0.74	8.4	0.12
100SH:50SE	2477.33b	115.19e	0.90	0.21	1.11	0.19	0.69	-0.79	8.18	0.12
100SH:25SE	2502.22b	115.88e	0.91	0.21	1.12	0.19	0.70	-0.86	18.2	4.20
75SH:100SE	2018.05c	227.91d	0.73	0.41	1.14	0.30	0.19	-0.32	1.31	0.75
50SH:100SE	1498.22d	229.80d	0.55	0.42	0.97	0.23	-0.14	0.13	0.67	1.50
25SH:100SE	900.29e	279.61c	0.33	0.51	0.84	0.17	-0.43	0.18	0.16	6.38
Sole	2745.78	543.59	0.50	0.50	1.00	0.25	0	0	0	0

LER=Land equivalent ratios, LEC= Land equivalent coefficient, A=Aggressivity, CR= Competitive ratios, SH=Sorghum, SE=Sesame.

The efficiency of intercropping as measured by LER, LEC, A, and CR is presented in Table 4. The LER was greater than unity where a full population of sorghum was mixed with the full population of sesame and when 75% population of sorghum was combined with the full population of sesame. A reduction in the population of sorghum from 50-25% recorded LER value less than unity. The efficiency of intercropping as measured by the LEC index was greater than 0.25 when the full population of both crops was combined. The values of A were positive for sorghum and negative for sesame in all the population ratios tested except, 50SH:100SE and 25SH:100SE population ratios where the values were negative for sorghum and positive for sesame. The CR follows a similar trend with the A values. The highest A value, 0.70 and -0.86 respectively for sorghum and sesame, and CR values 18.2 and 4.20 for sorghum and sesame respectively, were recorded at 100SH:25SE population ratios.

DISCUSSION

The overall results of the study showed that intercropping sesame with sorghum is better than planting either sesame or sorghum alone as measured by LER and LEC indices, particularly at the full population of both crops. The reduction in the population of both crops at the intercrop tends to reduce the height of both sorghum and sesame. The observed taller plants at high population density could be due to competition for natural resources especially light. This observation agreed with the findings of Ijoyah *et al.*(2016) and Afe(2017)).

Generally, when plant competes for the light they tend to grow taller by producing more nodes for light interception. According to Huang (2008) and Feng *et al*. (2010) high population increases the length of the basal internodes and reduces mechanical tissue and cortical thickness in maize. The yield reduction of both crops at the intercrop as observed in this study is supported by the finding of other researchers (Seran and Binta and 2010; Ijoya, 2016; Afe, 2017; Ajibola and Kolawole, 2019). This yield reduction was attributed to overcrowding. Overcrowding in crops according to Purcell *et al.* (2000) and Hiyane *et al.* (2010) could decrease radiation use efficiency and competitive shading within the leaf canopy architecture.

In the present study, there was no significant difference in the seed yield of sesame at 100SH:75SE, 100SH:50SE, and 100SH:25SE population ratios. This observation is expected in view of the domineering effect of sorghum over the associated sesame as indicated by positive aggressivity values for sorghum and with higher competitive ratios at these population ratios. The implication is that at these population ratios, sesame was suppressed and thus, given sorghum to efficiently utilize the natural resources better than sesame. The dominant effect of sesame over sorghum was only manifested when the population

of sorghum was reduced to 50% and 25% and intercropped with the full population of sesame, that is, 50SH:100SE and 25SH:100SE population ratios. At these population ratios, intercropping the two crops was disadvantageous as shown in the LER values less than unity and LEC value less than 0.25. The reduction in the seed yield of sesame at the intercrop as observed in this study is supported by the reports of earlier researchers on sesame/maize intercropping (Kolawole *et al.* 2015; Ajibola and Kolawole 2019; Tamiru *et al.*, 2019).

The dominant effect of sorghum over sesame in some of the population ratios tested did not agree with the findings of Iftikhar *et al.* (2006) who reported that sesame dominated cowpea in sesame/cowpea intercropping. The contrast could be due to the time of planting the two crops. In this study, sorghum was planted earlier and sesame was introduced to sorghum two weeks after planting. This early planting of sorghum in addition to being naturally taller than sesame had given sorghum the advantage over sesame to use natural resources better, especially at high population ratios.

In conclusion, the growth and yield of both crops were influenced by intercropping and increased as the population of component crops decreased. Sorghum was more competitive and dominated sesame at all population ratios except at the treatments where the population of sorghum was reduced between 25-50 %. The reasonable intercropping advantage was obtained at the combination of the full population of both crops and hence, recommended for adoption.

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