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EFFECTS OF SPATIAL ARRANGEMENT AND POPULATION DENSITY ON THE GROWTH AND YIELD OF SESAME (*SESAMUM INDICUM* L.) IN A SESAME/MAIZE INTERCROP

Afe A. Isaac[1*], Alabi K. Oyebisi[1],
Ogundare S. Kayode[2] and Adeniji S. Mojisola[1]

[1]Department of Crop Production, Kwara State University, Malete, Nigeria
[2]Division of Agricultural Colleges, Ahmadu Bello University, Kabba, Nigeria

Abstract: A field experiment was carried out at the Teaching and Research Farm, Kwara State University, Malete, Nigeria. The aim of the experiment was to investigate the growth and yield of sesame (*Sesamum indicum* L.) as affected by the row arrangement and population density of maize (*Zea mays* L.). The full population of sesame in two-row arrangements (1:1) and (2:2) was combined with four population densities of maize viz: 100S:100M; 100S:75M; 100S:50M and 100S:25M (where S and M represented sesame and maize, respectively). Sole crops of sesame and maize at full population were included in the treatments as control. The number of pods per plant (NPP), length of fruit zone (LFZ), and yield of sesame were significantly ($P \leq 0.5$) influenced by the interactive effect of population ratios and row arrangements. These variables increased as the population of associated maize decreased. All variables measured in maize were influenced by population density and row arrangement except for the number of cobs per plant (NCP), cob length (CL), and cob circumference (CC). Regardless of spatial arrangement and population density, the aggressivity (A) value was positive for sesame and negative for maize. The competitive ratio (CR) values were also higher in sesame than in maize. Land equivalent ratio (LER) and land equivalent coefficient (LEC) values, for all population ratios tested, indicated the intercropping advantage with the highest value recorded at a full population of sesame mixed with fifty percent population of maize in a 2:2-row arrangement and hence, recommended for adoption.

Key words: competitive ratio, grain yield, intercropping efficiency, intercropping, row arrangement.

[*]Corresponding author: e-mail: adeafe22@yahoo.com

Introduction

The simultaneous growing of two or more crops on the same piece of land to produce greater yield is common in the tropical farming system. In the crop mixture, each component crop must have adequate space to maximize cooperation and reduce competition for optimum yield. This makes spatial arrangement and population density an important factor to achieve optimum yield. Plant density manipulates the microenvironments and could affect the growth, development, and yield due to the interception of available photosynthetic active radiation. Exceeding the plant population above the optimum gave did not increase the yield due to a decrease in radiation use efficiency (Purcell et al., 2002), competitive shading within the leaf canopy architecture (Hiyane et al., 2010) with a consequent reduction of intercepted radiation by the middle and lower stem leaves particularly during the silking stage in maize (Chistopher et al., 2009; Li and Wang, 2010).

Seran and Brintha (2010) opined that the full population of each crop at the intercrop would significantly reduce yield due to overcrowding. Muoneke et al. (2007) reported a reduction in soybean seed yield with increasing maize plant density. In intercropping involving sesame and grain legumes, Iftikhar et al. (2006) reported that sesame appeared to be a dominant crop and hence utilized the resources more aggressively than the dominated legumes at the intercrop. In another study, Tamiru et al. (2019) reported that population density and spatial arrangement significantly influenced the yield of sesame when intercropped with maize. This study did take into consideration the varying population of maize for optimum yield in the mixture.

According to Sevgi et al. (2004), the population density was reported to influence the growth and yield component of sesame significantly. Similarly, Ijoyah et al. (2016) reported that the yield and yield components of both maize and sesame decreased with increasing plant density of sesame. In another study, Kolawole et al. (2015) observed that the growth and yield of maize were not affected when the two crops were simultaneously planted but the yield of sesame, being a weak competitor, decreased, particularly, when introduced two weeks after maize.

Intercropping sesame with maize is a common practice among smallholder farmers in the southern Guinea Savannah agro-ecological zone of Nigeria. Although several studies have been carried out on sesame/maize intercropping, reports from these studies were inconsistent and did not take into consideration the optimum plant population of maize to be intercropped with sesame at the appropriate spatial arrangement for optimum productivity. This research was therefore carried out to determine the suitable population density of maize and appropriate spatial arrangement for intercropping, and also examined the competitive behavior of the intercrop, considering sesame as the main crop.

Materials and Methods

Study location

The experiment was carried out between July to November of the 2017 cropping season at the Teaching and Research Farm of the Kwara State University, Malete, in the southern Guinea Savannah agro-ecological zone of Nigeria. Six composite soil samples at a depth of 0–20 cm were collected in a zigzag pattern with a soil auger to determine the physical and chemical properties. Soil particles were analysed using the hydrometer method (Bouyoucous, 1962 modified by Gee and Bauder, 1986). Total nitrogen was determined using the Kjeldahl digestion method as described by Bremner and Mulvaney (1982). Available P was determined by Bray 1 method (Anderson and Ingram, 1998). Soil pH was determined electrometrically in a 1:1 soil water suspension. Total soil organic carbon was determined using the acid dichromate wet-oxidation procedure of the Walkley and Black method (1934), and soil organic matter was determined by multiplying with a factor (1.72). Exchangeable bases (Ca, Mg, Na and K) were extracted with 1M ammonium acetate (1M NH4OAc) solution buffered at pH 7.0, as described by Anderson and Ingram (1998). The exchangeable sodium (Na^+) and potassium (K^+) contents of the filtrates were determined by the flame photometer while the exchangeable calcium (Ca^+) and magnesium (Mg^+) were determined by the EDTA titration method and were read using the atomic absorption spectrophotometer (AAS). The cation exchange capacity of the soil was determined with 1M NH4OAc (1M ammonium acetate), buffered at pH 7.0 (Rhoades, 1982).

The meteorological data during the period of the experiment were obtained at the Lower Niger River Basin Development Authority; Ilorin. The rainfall was measured using the rain gauge at regular intervals, usually in the morning by measuring the water collected in a graduated measuring jar of 0.1mm. The air temperature was measured using a maximum thermometer that was mounted at an angle of about 2^0 from a horizontal position such that the mercury column rested against the constriction without gravity.

Planting materials

Maize variety, ACR9931-DMSR-Y, and sesame X-Sudan were, respectively, obtained from the International Institute of Tropical Agriculture, Ibadan, and the National Cereal Research Institute, Badeji, Nigeria.

Experimental design

Full populations of sesame at two-row arrangements (1:1 and 2:2) were combined with four population densities of maize as 2 × 4 factorial combinations in a split-plot design and replicated three times. Sole crops each of sesame and maize were included in the treatments as the control. The treatments were: 100S: 100M; 100S: 75M; 100S: 50M; and 100S: 25M (where S and M represented sesame and maize respectively). Spatial arrangements with one row of sesame alternated with one row of maize (1:1) and two rows of sesame alternated with two rows of maize (2:2) constituted the main plots while population density was assigned to the sub-plot treatments. Plant population per hectare was determined as:

$$\text{Plant population} = \frac{\text{Area} \times \text{number of plants per stand}}{\text{Intra-row spacing} \times \text{inter-row spacing}}$$

Details of population ratios and the corresponding plant population are presented in Table 1.

Table 1. Component population ratios.

Population ratios	Spacing cm (+)		Plant	Population/ha	Total plant population/ha
S:M	S	M	S	M	
100:100	75 x 20	75 x 50	133,333	53,333	186,666
100:75	75 x 20	75 x 60	133,333	40,000	173,333
100:50	75 x 20	75 x 100	133,333	26,666	160,000
100:25	75 x 20	75 x 125	133,333	13,333	146,666
100:00	75 x 20	75 x 50	133,333	-	133,333
00:100	75 x 20	75 x 50	-	53,333	53,333

S = sesame; M = maize; + = two plants were maintained per stand.

Cultural practices

The land was ploughed and harrowed twice. Each plot size measured 4.0 m × 4.0 m with 0.5m between plots and 1.0 m between blocks. Four seeds of sesame were planted on the 28th of July but thinned to two plants per stand at two weeks after planting. Component maize at its respective plant populations was introduced to sesame at two weeks after planting (Mkamilo, 2004). Pendimethalin [N-(ethyl propyl)-3,4 dimethyl-2,6 dinitrobenzene amine], a pre-emergence herbicide, was applied at the rate of 1.5 litres/ha using a knapsack sprayer. The herbicide was applied immediately after the sesame crop was planted. This was followed by hoe weeding at a three-week interval. N-P-K (20:10:10) fertiliser was applied to sesame at the rate of 150kg/ha (3 bags) at three weeks after planting while 400kg/hectare (8 bags) was applied to maize at 3 and 6 weeks after planting.

Harvesting

Sesame was harvested from the 2.0 m inner rows at physiological maturity before shattering of the seeds. At physiological maturity, 75% of the capsules on the main stem have white colour seeds, and dark brown at the tip of the capsule (Langham et al., 2008). The harvested crops were made to stand erect until properly dried and were thereafter manually threshed and winnowed. Maize was harvested at 12WAP, at this period, the leaves and the silk were dried, and the kernels became hard.

Sampling and data collection

The following variables were collected from five tagged plants at the inner rows for the two crops.

1. Maize: Days to 50% tasselling, plant height at maturity, number of cobs/pant, cob length and circumference, number of grains per cob, stem girth at 8 WAP, the weight of 100 grains and grain yield per hectare.

2. Sesame: plant height, number of pods per plant, number of branches per plant, length of fruit zone at maturity, stem girth, and seed yield per hectare.

Evaluating the efficiency of intercropping

The land equivalent ratio (LER) was determined as described by Willey (1985) using the equation:

$$\text{LER} = \frac{\text{Intercrop yield of crop a}}{\text{Sole crop yield of crop a}} + \frac{\text{Intercrop yield of crop b}}{\text{Sole crop yield of crop b}}$$

The land equivalent coefficient (LEC), a measure of the level of interaction and productive potential at the intercrop, was estimated as proposed by Adetiloye et al. (1983).

LEC = (Ls x Lm), where Ls and Lm are the partial LER for sesame and maize, respectively. The partial LER is the ratio of the intercrop yield to the sole crop yield.

The competitive ratio (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 a higher competitive ability.

CR (sesame) = Ls x Zsm/Lm x Zms,
CR (maize) = Lm x Zms/Ls x Zsm,
where: Ls and Lm are the partial LER for sesame and maize, respectively;
Zsm and Zms = proportions of sesame and maize, respectively.

Aggressivity (A)

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

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

where:
Aab = Aggresivity value for component crop a,
Yab = Intercrop yield of crop a,
Yba = Intercrop yield of crop b,
Zab and Zba = Sown proportions of crops a and b in the intercrop.

Statistical analysis

All data collected, analysed by the analysis of variance (ANOVA) using the SAS statistical model and treatment means where significant, were separated using the Duncan Multiple Range Test at the 5% probability level.

Results and Discussion

The textural class of soil at the experimental site is sandy loam with the soil reaction that is moderately acidic (Table 2).

The highest rainfall (302.7mm) during the experiment was during August with the temperature range between 33^0C and 25.5^0C. The mean rainfall and temperature during the period of the experiment were 155.82 mm and 27.90^0C, respectively (Table 3).

Table 2. Pre-planting physical and chemical properties of the soil.

Particle size (%)	
Sand	87.60
Clay	5.22
Silt	7.18
Textural class	Sandy loam
pH (water)	5.48
Bulk density (g/cm^3)	1.63
Organic matter (%)	1.81
Total nitrogen (%)	0.14
Available P (mg/kg)	2.61
Exchangeable cation (Cmol/kg)	
Ca^+	0.32
Mg^{2+}	2.98
K^{2+}	0.92
Na^+ (mmol/L)	0.47

Table 3. Meteorological data for the experimental site (June–December 2017).

Months	Rainfall (mm)	Temperature (^{o}C)	Relative humidity (%)
June	184.90	33.00	74.50
July	42.80	26.50	74.50
August	302.70	26.00	51.00
September	215.90	25.50	52.00
October	38.20	28.50	75.00
Total	779.10	139.50	32.00
Mean	155.82	27.90	65.40

Source: Lower Niger River Basin Development Authority (Hydrology section) Ilorin, Nigeria.

The effect of spatial arrangement and population density on the growth and yield of sesame is presented in Table 4. The plant height, stem girth and the number of branches per plant of sesame were not influenced by spatial arrangement and population density of component maize but the length of fruit zone, the number of pods per plant and seed yield per hectare were significantly influenced. In the 1: 1row arrangement, the length of fruit zone in the sole stand was significantly higher than the intercrops, except in the 100: 75 population ratio, whereas in the 2: 2 row arrangement, there was no significant difference between the sole crop and the intercrops except where full populations of both crops were mixed. The number of pods per plant increased as the population of component maize decreased. Irrespective of the arrangement, the lowest numbers of pods were recorded where the full population of sesame was mixed with the full population of maize. The seed yield followed a similar trend. Regardless of the arrangements, significantly lower seed yield was recorded in the intercrops compared to their respective sole crop stand. There was no significant difference in the seed yield when the full population of sesame was mixed with the full population and 75% population of maize as well as 50% and 25% populations of maize in the 1:1 row arrangement. This observation is different in the 2:2 row arrangement, where the similarity in seed yield was observed where 75% and 50% populations of maize were combined with a full population of sesame.

Table 4. Effects of spatial arrangement and population density on the growth and yield of sesame.

Spatial arrangements	Population ratios S:M	Plant height (cm)	Stem girth (cm)	Length of fruit zone (cm)	Number of branches per plant	Number of pods per plant	Yield (Kg/ha)
1:1	100:100	106.64	7.40	66.29b	3.05	26.39c	404.49e
	100:75	105.59	7.53	66.97b	3.15	27.80c	417.56e
	100:50	105.91	7.49	75.95a	3.16	34.60ab	519.69c
	100:25	103.12	7.82	61.71c	3.28	34.73ab	521.64c
	100:00	101.38	7.89	74.43a	3.31	36.75ab	543.72b
2:2	100:100	106.66	7.40	65.63b	3.06	28.00c	402.56e
	100:75	105.64	7.72	74.43a	3.16	31.07bc	466.67d
	100:50	105.93	7.84	75.71a	3.25	31.67bc	475.68d
	100:25	106.97	7.87	74.43a	3.28	34.68ab	519.69c
	100:00	102.42	7.94	74.95a	3.32	40.34a	605.76a
SA × PD		Ns	Ns		Ns	*	*

Values with the same letter(s) in the same column are not significantly different at the p≤ 5% level of probability by the Duncan Multiple Range Test. Ns = non-significant; * = significant; S = sesame; M = maize.

The growth and yield of maize as influenced by spatial arrangement and population density are presented in Table 5. The number of cobs per plant, cob length, and circumference of maize were not significantly influenced by spatial arrangement and population density. Plant height, stem girth, number of grains per cob, weight of grains, and yield were significantly influenced by spatial arrangement and population density. In the intercrops, the tallest plants were observed where a full population of sesame was mixed with a full population of maize in the two spatial arrangements. This, however, is not superior to other population ratios, particularly in the 1:1 row arrangement. The girth of the stem increased as the population pressure decreased. In the 1:1 row arrangement, the girth of the stem in 100S: 100M was found to be significantly thinner compared to other population ratios, including the sole crop stand. The similar stem girth was recorded in the 2:2 row arrangements.

The sole stand in the two-row arrangements had a significantly higher number of grains per cob and grain yield than their respective intercrops. In the two arrangements, where two rows of maize were followed by two rows of sorghum, similar numbers of grains per cob were produced except in a combination involving the full population of both crops where significantly fewer numbers of grains were recorded. The least grain weight of 140.33 gram was obtained where the full population of sesame was mixed with the full population of maize. Regardless of spatial arrangement, the component population ratio of 100S:25M recorded the lowest grain yield/ha. Irrespective of the arrangement, the sole stand was superior in grain yield compared to the intercrops. A significantly lower yield was recorded in 100S:25 M in the two-row arrangements. There was no significant difference in seed yield between 100S:75M and 100S:50M in the 1:1 row arrangement, but 100S:75M was superior to 100S:100M in the 2:2 row arrangement.

Table 5. The effect of spatial arrangement and population density on the growth and grain yield of maize.

Spatial arrangements	Population ratios S:M	Plant height (cm)	Stem girth (cm)	Number of cobs/ plant	Cob length (cm)	Cob circum-ference (cm)	Number of grains/ cob	Weight of 1000 grains (g)	Grain yield (kg/ha)
1:1	100:100	145.64bc	11.80c	1.67	9.87	10.13	328.81d	140.33e	1662.02d
	100:75	131.85c	13.44abc	1.68	9.89	10.16	370.00b	176.43cd	1830.83c
	100:50	136.90bc	14.17ab	1.68	10.00	10.19	357.60bc	162.75de	1745.76cd
	100:25	143.68b	14.23ab	1.69	10.20	10.22	366.29bc	157.40ef	985.31e
	00:100	140.74bc	14.45a	1.70	10.23	10.24	406.00a	183.70bc	2862.76a
2:2	100:100	145.10b	12.03bc	1.66	9.63	10.28	329.51d	146.66ef	1658.15d
	100:75	159.74a	12.20bc	1.69	10.18	10.40	369.91bc	199.49ab	1942.50b
	100:50	132.42c	12.68abc	1.69	10.19	10.15	369.53bc	199.46abc	1873.52c
	100:25	135.07bc	12.98abc	1.70	10.25	10.19	344.91cd	184.28bc	1008.68e
	00:100	142.71bc	14.18ab	1.71	10.28	10.68	414.40a	203.86a	2890.88a
SA x PD			*	Ns	Ns	Ns	*	*	*

Values with the same letter(s) in the same column are not significantly different at the p≤ 5% level of probability by the Duncan Multiple Range Test. Ns = non-significant; * = significant; M = maize; S = sesame.

The efficiency of intercropping as measured by land equivalent ratio (LER), land equivalent coefficient (LEC), aggressivity (A), and competitive ratio (CR) is presented in Table 6. Regardless of spatial arrangement and population density, all the intercrops demonstrated intercropping advantages over their respective sole crops. LER and LEC values increased as the population of component maize decreased from the full population to the 50% population and thereafter decreased. The highest LER and LEC values, 1.51 and 0.56, respectively were obtained when the 50% population of maize was intercropped with the full population of sesame in the treatment where two rows of sesame were followed by two rows of maize. The A values were positive for sesame and negative for maize, and they were found to be higher in the 1:1 row arrangement than in the 2:2 row arrangement except in the 100S:50M population ratio. The CR values for sesame were higher than for maize in all the mixtures with the highest value recorded in 100S:25M population ratios.

Table 6. Evaluation intercropping advantages as influenced by the spatial arrangement and population density in the sesame/maize system.

Spatial arrangement	Population ratios	Partial LER	Partial LER	LER	LEC	A		CR	
	S:M	Sesame	Maize	-	-	S	M	S	M
1:1	100:100	0.74	0.58	1.32	0.43	0.16	–0.16	1.28	0.78
	100:75	0.77	0.64	1.41	0.49	0.13	–0.13	1.60	0.62
	100:50	0.87	0.61	1.48	0.53	0.26	–0.26	2.80	0.36
	100:25	0.96	0.34	1.30	0.33	0.62	–0.62	10.67	0.09
	100:00	1.00	1.00	1.00	0.25			-	
	00:100	1.00	1.00	1.00	0.25				
2:2	100:100	0.66	0.57	1.23	0.38	0.09	–0.09	1.16	0.86
	100:75	0.77	0.67	1.44	0.52	0.10	–0.27	1.54	0.64
	100:50	0.86	0.65	1.51	0.56	0.21	–0.28	2.77	0.36
	100:25	0.86	0.34	1.20	0.29	0.52	–0.77	9.55	0.10
	100:00	1.00	1.00	1.00	0.25	-	-	-	-
	00:100	1.00	1.00	1.00	0.25	-		-	-

LER = land equivalent ratio; LEC = land equivalent coefficient; A= aggressivity; CR = competitive ratio; S = sesame; M = maize.

The overall results of the study showed the superiority of intercropping sesame with maize over their respective sole crops as measured by LER, LEC, A, and CR indices. The reduction in the number of pods per plant and seed yield of sesame as observed in this study agreed with the findings of earlier researchers on sesame/maize intercropping (Kolawole et al., 2015; Ijoyah et al., 2016; Ajibola and Kolawole, 2019; Tamiru et al., 2019). The extent of reduction varied significantly among the population ratios and spatial arrangements, possibly due to differences in competition for natural resources. This competition was found to be higher at high population densities of both crops. This is evident in the reduction in the number of pods and branches per plant of sesame, cob length, and circumference, number of grains per cob, weight of grains of maize, and consequent lower yield of both crops compared to their respective sole stands.

Generally, when plants compete for light, they tend to grow taller by producing more nodes for the light interception. High plant density, according to Huang (2008) and Feng et al. (2010), increases the length of the basal internodes and reduces mechanical tissue and cortical thickness in maize. In the present study, there was an increased plant height accompanied by thinner stem girth, low aggressivity, and competitive ratio values at higher population densities, which further lends credence to this observation. In a much earlier study, Seran and

Brintha (2010) had observed that a reduction in seed yield in the intercrops where the full population of both crops was combined was due to overcrowding. This overcrowding, according to Purcell et al. (2002) and Hiyane et al. (2010), could decrease radiation use efficiency and competitive shading within the leaf canopy architecture.

The non-significant effects of plant density on plant height and the number of branches per plant of sesame of the population ratio tested as observed in the present study did not conform to the earlier reported work involving sesame and cowpea (Iftikhar et al., 2006) and sesame and maize (Ijoyah et al., 2016). This non-significant effect could be attributed to the differences in the time of introduction of component crops, planting patterns, and varietal differences among sesame genotypes. In the earlier studies, sesame and the component crops were planted at the same time and with maize planted on the top of the ridge and sesame by the side of the ridge. This planting pattern and time of introduction had given maize an advantage over sesame to shade the sesame and maize was able to intercept more light in view of the fact that it is naturally taller than sesame, either sole or intercropped.

The intercropping advantages, as measured by LER and LEC and observed in this study, have been reported by other researchers (Ijoyah et al., 2016). The implication is that growing sesame and maize in the mixture enables them to utilize natural resources better than when grown alone. This complementarity could be due to differences in the growth habit of the two crops, time of introduction of maize, and spatial arrangement employed. The A value was positive for sesame and negative for maize in all population ratios tested regardless of the spatial arrangement. The CR values were also found to be higher in sesame than in maize irrespective of population ratios and spatial arrangements. This indicated that sesame was more competitive and dominated maize with the implication that maize yield was lower than the expected yield, possibly due to poor utilization of natural resources. This is in agreement with the work of Afe (2014) on the sesame/cowpea intercrop, but contrary to the finding of Kolawole et al. (2015), who reported that maize was more competitive than sesame in a sesame/maize system. The discrepancy could be due to the time of introduction of maize and population ratios employed. In the earlier study, sesame and maize were simultaneously sown on the same day, whereas, in the present study, sesame was sown two weeks before maize. Planting sesame two weeks ahead of maize and with the corresponding full population gave sesame early establishment and apparently sesame was able to utilize the natural resources at the early stage better than the component maize. This is corroborated by the non-significant difference in the height of sesame and a significant difference in the maize height. Earlier, Ofori and Stern (1987) have reported a significant decrease in the yield of the latter introduced crop in *Phaseolus* beans/millet and maize/cowpea mixtures.

Conclusion

Intercropping significantly influenced the number of pods produced per plant and the seed yield of sesame. The number of grains per cob and the grain yield of maize were also influenced. Sesame was found to be more competitive and it dominated maize, possibly due to better utilization of natural resources. Based on LER and LEC values, the full population of sesame mixed with 50% population of maize irrespective of the arrangement is most suitable for intercropping in southern Guinea savannah ecological zone of Nigeria.

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UTICAJ PROSTORNOG RASPOREDA I GUSTINE USEVA KUKURUZA NA RAST I PRINOS SUSAMA (*SESAMUM INDICUM* L.) GAJENOG U ZDRUŽENOM USEVU SA KUKURUZOM

Afe A. Isaac[1*], Alabi K. Oyebisi[1], Ogundare S. Kayode[2] i Adeniji S. Mojisola[1]

[1]Odsek za ratarstvo, Univerzitet u Državi Kvara, Malete, Nigerija
[2]Odeljenje poljoprivrednih koledža, Univerzitet Ahmadu Bello, Kaba, Nigerija

R e z i m e

Poljski ogled izveden je na imanju za nastavu i istraživanje Univerziteta u Državi Kvara, Malete, Nigerija. Cilj ovog ogleda bio je da se istraži rast i prinos susama (*Sesamum indicum* L.) na koje utiče raspored i broj biljaka kukuruza u redu kukuruza (*Zea mais* L.). Broj biljaka susama u čistom usevu u dvoredom rasporedu (1:1) i (2:2) kombinovan je sa četiri gustine populacija kukuruza, 100S:100K; 100S:75K; 100S:50K i 100S:25K (gde S i K predstavljaju susam, odnosno kukuruz). Čisti usevi susama i kukuruza u punoj gustini uključeni su u tretmane kao kontrola. Na broj mahuna po biljci (BMB), dužinu plodne zone (DPZ) i prinos susama značajno je uticala ($P \leq 0,5$) interakcija prostornog rasporeda i broja biljaka u redu. Ove promenljive su se povećavale kako se gustina kukuruza u združenom usevu smanjivala. Na sve parametre izmerene kod kukuruza uticali su gustina populacije i raspored redova, osim broja klipova po biljci (BKB), dužine klipa (DK) i prečnik klipa (PK). Bez obzira na prostorni raspored i broj biljaka, vrednost agresivnosti (A) bila je pozitivna za susam i negativna za kukuruz. Vrednosti indeksa kompetitivnosti (KO) takođe su bile veće kod susama nego kod kukuruza. Vrednosti indeksa efikasnosti korišćenja zemljišta (EKZ) i koeficijenta korišćenja zemljišta (KKZ) za sve ispitivane odnose populacija, ukazale su na prednost združivanja useva sa najvišom vrednošću zabeleženom pri punoj gustini susama pomešenog sa polovinom broja biljaka kukuruza u odnosu na čist usev u rasporedu redova 2:2. Zbog toga se ovaj tretman preporučuje za korišćenje u praksi.

Ključne reči: konkurentski odnos, prinos zrna, efikasnost združene setve, združena setva, prostorni raspored.

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[*]Autor za kontakt: e-mail: adeafe22@yahoo.com