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RESEARCH ARTICLE

FIELD ASSESSMENT OF YIELD PERFORMANCE OF MAIZE AND OKRA INTERCROPPING SYSTEM IN BANGLADESH

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ABSTRACT

Maize (*Zea mays* L.) is an important cereal crop and okra (*Abelmoschus esculentus* L. Moench) is one of the most nutritious vegetable crops. People of Bangladesh have taken nutrients from these crops. A field experiment was conducted from October 2022 to March 2023 cropping season, at Field Laboratory, Bangladesh Agricultural University (BAU), Mymensingh, to evaluate the effects of different cropping patterns on performance of maize-okra mixture and to find out the suitable cropping system. The experiment has consisted of four cropping systems, which consisted of one row of maize alternated with one row of okra (1M:1Ok), one row of maize alternated with two rows of okra (1M:2Ok), one stand of maize alternated with one stand of okra (1sM: 1sOk) and one stand of maize alternated with two stands of okra (1sM: 2sOk), while the sole crops of maize and okra constituted the fifth and sixth cropping pattern. The experiment was laid out in Randomized Complete Block Design (RCBD) and three replicates of each treatment. The results of the present study showed that alternating intercropping pattern 1M:1Ok produced the highest yield of maize & okra and the highest land equivalent ratio (LER) value of 1.96 as well as saved the maximum percentage of land (49.14%) compared to other tested intercropping patterns. While, the intercropping system, 1sM: 2sOk explored the lowest in all characters. It may be concluded, therefore, 1M:1Ok could be used as an alternative intercropping pattern in cropping system in Bangladesh. And it is also recommended that further investigation be done to assess the effect of maize and okra intercropping patterns widely in different locations of Bangladesh.

KEYWORDS

Intercropping, cropping pattern, maize, okra, and yield

1. INTRODUCTION

Maize (*Zea mays* L.) is an important grain crop in the Poaceae family. It is grown in Bangladesh ranks as the second after rice and white (Alam et al., 2020c, d). Bhutta is the Bengali name for what is commonly known as corn. It is a high-potential crop that's why it is known as "King of grain crops"(Alam et al., a, b & e). It features prominently in intercropping systems involving different types of crops such as okra, soybean, cassava, cowpea, amarnth, peanuts etc (Ijoyah et al., 2012). Various types of food namely human food, poultry & fish feed are produced from maize. It is used to make different industrial materials *viz.,* oil, alcohol and starch (Ijooyah and Dzer, 2012). Besides, Okra (*Abelmoschus esculentus* L. Moehch) is a significant vegetable crop in Bangladesh and around the world. The pods are used as delicious vegetable in all over the world, but it used specially to make soup in temperate zoon of world. The green pod is a good source of vitamin, calcium, potassium, and other minerals (Ijoyah and Jimba, 2012).

Intercropping is a system of agricultural cultivation where two or more crops are grown together in same place at the same time. It is one kind of mixed cropping system (Ijoyah and Jimba, 2012). In Bangladesh, vegetable-cereal crop mixes are a popular cropping pattern among small-scale farmers and home gardeners. Maize-based mixes in approximately thirty Agro-ecological zones include maize-okra, maize-amaranth, maize-radish, maize-latus, and maize-soybean (Alam et al., 2020b, c). There have been several single or small experiments conducted on monocultures maize and okra as influenced by cropping patterns; however, this research did not reveal the optimal cropping pattern, particularly in a maize-okra mixture. From the impact of the above-mentioned issues, we will try to find out the effect and evaluate the pattern of cropping on intercropped yields of maize and okra, to identify the appropriate cropping pattern that will maximize yields of both crops in combination and assess the advantage of the intercropping system.

2. MATERIALS AND METHODS

2.1 The study location and period

The Study was carried out at the Entomology Field Laboratory of the Department of Entomology, Bangladesh Agricultural University (BAU), Mymensingh, during the cropping season of October 2022 to March 2023, to assess the effect of various cropping patterns on the field performance of maize and okra mixture cropping. The study site was situated at 24.75 N latitude and 0.50 E longitude, with an average elevation of 18m above mean sea level. It is located in the Sonatola series of the dark grey floodplain soil, which is part of the Old Brahmaputra Floodplain Agro-Ecological Zone 9 (Alam et al., 2020a, b & e).

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2.2 Experimental design, cropping materials and planting

In this study, the experimental crops were okra from BARI derosh 1 and maize from the BARI Hybrid Butta-09 variety. Each plot measured 10 m^2 (4 m × 2.5 m). There were four ridges in the plots. The size of a 10 m^2 (4 m × 2.5 m) plot in solitary maize had a 60 × 30 cm spacing between row to row and plant to plant, respectively, and the two plots were separated by 70 cm. The size of a 10 m^2 (4 m × 2.5 m) plot in sole okra had a 45 × 30 cm spacing between row to row and plant to plant, respectively, and the two plots were separated by 70 cm. The study area comprised of six treatments and the experiment was designed in a randomized complete block design (RCBD) with three replicates. A total of four treatments were implemented: one row of maize alternated with one row of okra (1M:1Ok), one row of maize alternated with two rows of okra (1M:2Ok), one stand of maize alternated with one stand of okra (1sM: 1sOk) and one stand of maize alternated with two stands of okra (1sM: 2sOk). Maize and okra were sowed in the intercrop at different cropping patterns, 2-3 cm deep.

2.3 Crop development

Using a power tiller, the soil was ploughed and cross-ploughed six times to attain good tilth. Laddering and spading were then done. The stubble was totally removed from the field before the seeds were sown. Except for urea and potash muriate, all recommended fertilizers were applied during field preparation before final plowing. During the last stages of land preparation, one-fourth of the urea and MOP were applied. Triple super phosphate, urea, potash muriate, gypsum, zinc sulphate, and boric acid were applied in the required amounts of N-P-K-S-Zn and B (250, 80, 120, 45, 3, and 2.4 kg/ha) (FRG, 2012). In two equal applications, during the vegetative and early stages of corn development, the leftover urea and MOP were sprayed. The application of maize seed rates was 20 kg/ha. On November 1st, 2022, the seed of BARI Hybride Butta-09 maize and BARI dherosh 1 were planted. As necessary, appropriate intercultural activities were conducted to support the development and expansion of maize plants. Harvesting occurred when the cobs were ready, and data was collected based on treatment. Furthermore, okra was collected after the fruit had fully developed.

2.4 Data collection and calculation procedure

In case of okra crop, plant height (cm), fruit diameter and length (cm), quantity of fruits per plant, and yield (t/ha) were all measured for obtaining data. Plant height (cm), cob length and diameter (cm), number of grains per cob (g), grain weight per cob (g), and yield (t/ha) were among the data obtained for maize. Approximately ten maize or okra plants were randomly picked from each experiment. In terms of yield, the grain or okra was collected from each treated plot after the cobs or fruits had been harvested. The grains or fruits were then weighed and recorded, with yield statistics translated to tons per hectare. According to Willey (1985), the land equivalent ratio (LER) was calculated using the following formula:

$$LER=\frac{\text{Intercrop yield of crop A}}{\text{Sole crop yield of A}}+\frac{\text{Intercrop yield of crop B}}{\text{Sole crop yield of B}}$$

The competitive ration was calculated according to the formula of Willey and Rao (1980). The formula is $CR=\frac{\text{Partial LER for relay crop (Lok)}}{\text{Partial LER for main crop (Lm)}}$

Where, Lok=Partial LER for okra and Lm= Partial LER for maize

On the contrary, Lok and Lm were calculated by the following formula:

$$Lok=\frac{\text{Intercrop yield of sole crop A (okra)}}{\text{yield of sole crop A (okra)}} \quad \text{and} \quad Lm=\frac{\text{Intercrop yield of sole crop B (maize)}}{\text{yield of sole crop B (maize)}}$$

The formula of Willey (1985) was used to calculate the percentage (%) of land conserved.

$$\%\ \text{Land saved}=\frac{LER-1}{LER}\times 100$$

2.5 Data analysis

All experimental data was recorded, tabulated, processed, and compiled using Microsoft Excel 2010 in order to get ready for statistical analysis. The collected data was statistically analyzed to assess the significance of differences between treatments. The mean values of all the characters were evaluated, and the treatment effect was calculated using analysis of variance (ANOVA) in R statistical software version 3.5.3. Mean differences were assessed using Duncan's Multiple Range (DMRT) Test (Gomez and Gomez, 1984).

3. Results and Discussions

3.1 Yield and yield attributes of okra

All cropping systems differed significantly, and the results are reported in Table 1. The results of present study revealed that monocrop okra gave the highest results in all characters *namely* plant height (241.26cm), fruit length (15.10cm) & diameters (1.28cm), fruits number per plant (25.41) and yield (14.48 t/ha) compared to other tested cropping systems. Among the other intercropping patterns, the highest plant height (236.44cm) was found alternating 1M:1Ok. In the case of fruit length and diameter, intercropping pattern 1M:1Ok showed the maximum length (14.69cm) and diameter (1.23cm) compared to other tested intercropping patterns. In the 1M:1Ok intercropping system, the greatest number of fruits per plant (25.02) was produced which was followed by 21.56 and 18.34 in intercropping pattern 1sM: 1sOk and 1M:2Ok, respectively. And Intercropping pattern 1sM: 2sOk produced the minimum number of fruits per plant (14.75) that's why the minimum yield (6.49 t/ha) was product from that intercropping system (1sM: 2sOk) but 1M:1Ok intercropping system yielded okra 14.27 t/ha compared to other tested intercropping patterns (Table 1).

This view of the results agreed with Jiao et al., 2008 who reported that intercropping reduced vegetative growth of okra crop. But the plant height, fruit length & diameter have increased through proper maintaining of intercrop. A group researcher also reported that sole cropping produces higher yield compared to intercropping (Hossain et al., 2001). The present result also proved by this principle which was reported by (Muneer et al., 2004). This view agreed with Oyolu who said that crops planted as a sole usually produced higher yield due to higher used of light, air, and nutrient of soil (Oyolu, 2002). Generally, the number of fruits, fruit length and weight depend on the intensity of growth of plants, but optimum utilization of light, air and soil nutrient enhance the growth of plant which is maintained by proper intercropping system (Ijooyah and Dzer, 2012).

Table 1: Impact assessment of different cropping patterns on yield and yield attributes of okra at BAU campus during the period of 2022 to 2023.

Treatments	Plant height (cm)	Length of fruit (cm)	Diameter of fruit (cm)	Fruits No./plant	Yield (t/ha)
Sole okra	241.26a	15.10a	1.28a	25.41a	14.48a
1M:1Ok	236.44ab	14.69ab	1.23a	25.02ab	14.27ab
1sM: 1sOk	210.63c	12.08bc	1.06b	21.56abc	10.25b
1M:2Ok	183.67d	11.12c	0.80c	18.34bc	7.45c
1sM: 2sOk	175.75d	8.45d	0.68d	14.75c	6.49c
Level of sig.	*	**	**	***	*
CV (%)	7.46	5.48	8.17	6.93	7.12
SE (±)	1.25	1.17	0.89	0.96	0.76

The means in the column that are indicated by different letters differ significantly at 5%, 1% & 0.1% level. Here, Sole okra; 1M:1Ok (1 row of maize alternated with 1 row of okra); 1M:2Ok (1 row of maize alternated with 2 rows of okra); 1sM: 1sOk (1 stand of maize alternated with 1 stand of okra) and 1sM: 2sOk (1 stand of maize alternated with 2 stands of okra).

3.2 Impact assessment of different intercropping patterns on growth and yield attributes of maize

3.2.1 Plant height (cm)

Table 2 demonstrates a substantial variation ($P<0.05$) in maize plant height between 2022 and 2023 cropping seasons due to maize-okra intercropping. Planting maize in solitary cropping resulted in significantly higher plant height (210.36cm) than other studied intercropping systems. However, in the case of intercropping pattern, one row of maize alternated with one row of okra (1M:1Ok) significantly produced higher plant height

(202.14cm), which was followed by 1sM: 1s0k (182.63cm) and 1M:20k (174.76cm). The plant height with the minimum value, 166.78cm, came from 1sM: 2s0k.

3.2.2 Cob length (cm) and diameter (cm)

The results of Table 2 demonstrate a significant difference (P<0.0) in length and diameter of cob without husk as affected by different maize-okra intercropping pattern during the cropping season of 2022 to 2023. Monocropping pattern of maize significantly generated the maximum length (17.49cm) and diameter (15.23cm) of cob without husk compared to other tested intercropping systems. However, in the case of intercropping pattern, one row of maize alternated with one row of okra (1M:10k) significantly explored the maximum length (17.16cm) and diameter (14.98cm) which was followed by 15.32 & 13.27cm, and 12.45 & 10.33cm in length and diameter of intercropping pattern of 1sM: 1s0k and 1M:20k, respectively, whereas the minimum length (11.47cm) and diameter (9.21cm) was found from intercropping system of 1sM: 2s0k.

3.2.3 Number of grains and grain weight per cob

The results from the Table 2 revealed that sole maize recorded significantly higher number (415.14) of grains and grain weight (156.34g) per cob as compared to other tested intercropping pattern. One row of maize alternated with one row of okra (1M:10k) recorded higher number of grains (401.29) and grain weight (150.18g) per cob than other tested intercropping patterns, whereas the minimum number of grains (272.24) and grain weight (72.46g) was found from 1sM: 2s0k.

3.2.4 Yield (t/ha)

Significant differences were produced among various intercropping systems which impacted on yield therefore, sole maize showed the significantly higher yield (7.13 t/ha) compared to others. Interestingly, one row of maize alternated with one row of okra (1M:10k) produced the maximum yield (6.97 t/ha) among all tested intercropping patterns followed by 5.03 & 4.39 t/ha in 1sM: 1s0k and 1M:20k, respectively whereas the minimum yield (4.02 t/ha) was found from intercropping pattern of 1sM: 2s0k. The present study revealed that intercropping between maize and okra produced higher agronomic traits as well as yield than other tested intercropping system (Susan and Mini, 2005). Interesting, some researcher experimented on cereal-based intercropping (maize-okra, maize-soybean, maize-potato, maize-groundnut and maize-bean) and they got similar results. Some researchers assessed the yield of maize in a maize-okra mixture, as affected by the planting method of solo or intercropping and they said that one row of maize and one row of okra produced higher yield compared other intercropping systems (Usman, 2001; Jiao et al., 2008). This view also agreed with the result of present study (Ijoyah and Jimba, 2012). Oyolu similarly reported that the light and other resources of nature was used and utilized properly by intercropping system, and thereby the maize-okra intercropping system provided the maximum yield (Oyolu, 2002).

Table 2: Impact assessment of different cropping patterns on yield and yield attributes of maize at BAU campus during the period of 2022 to 2023.

Treatments	Plant height (cm)	Length of cob without husk (cm)	Diameter of cob without husk (cm)	Grain No. /cob	Grain wt./cob (g)	Yield (t/ha)
Sole maize	210.36a	17.49a	15.23a	415.14a	156.34a	7.13a
1M:10k	202.14b	17.16ab	14.98abc	401.29b	150.18ab	6.97ab
1sM: 1s0k	182.63c	15.32bc	12.45bcd	345.16c	130.24c	5.03c
1M:20k	174.76cd	13.27c	10.33cd	303.13d	90.37d	4.39cd
1sM: 2s0k	166.78d	11.47d	9.21e	272.24e	72.46d	4.02d
Level of sig.	*	***	**	*	**	*
CV (%)	7.89	6.55	8.46	6.49	7.57	6.19
SE (±)	1.24	0.89	1.15	0.94	1.07	0.76

The means in the column that are indicated by different letters differ significantly at 5%, 1% & 0.1% level. Here, Sole maize; 1M:10k (1 row of maize alternated with 1 row of okra); 1M:20k (1 row of maize alternated with 2 rows of okra); 1sM: 1s0k (1 stand of maize alternated with 1 stand of okra) and 1sM: 2s0k (1 stand of maize alternated with 2 stands of okra).

Table 3: Effect of different cropping patterns on yield of Okra and maize, intercrop yields, total intercrop yield, partial land equivalent ratio, land equivalent ratio (LER), competitive ratio (CR) and percentage (%) land saved at BAU campus during the period of 2022 to 2023 cropping season.

Cropping pattern	Sole crop yield		Intercrop yield (t/ha)		Total intercrop yield (t/ha)	Lok	Lm	LER	CR	% Land saved
	Sole Okra	Sole maize	Okra	Maize						
Soles	14.48	7.13	----	----	----	----	----	----	----	----
1M:10k	----	----	14.27	6.97	21.24	0.98	0.97	1.96	1.01	49.14
1sM: 1s0k	----	----	10.25	5.03	15.28	0.70	0.71	1.41	0.98	29.07
1M:20k	----	----	7.45	4.39	11.84	0.51	0.62	1.13	0.82	11.50
1sM: 2s0k	----	----	6.49	4.02	10.51	0.45	0.56	1.01	0.80	0.99

Here, Lok=Partial land equivalent ratio of okra; Lm= Partial land equivalent ratio of maize

1M:10k (1 row of maize alternated with 1 row of okra)

1M:20k (1 row of maize alternated with 2 rows of okra)

1sM: 1s0k (1 stand of maize alternated with 1 stand of okra)

1sM: 2s0k (1 stand of maize alternated with 2 stands of okra)

3.3 Assessing intercropping advantages

The values of land equivalent ratio (LER) were all above 1.00, indicating that it is desirable to have both crops and intercropping at varied cropping patterns. This could be attributed to more efficient resource utilization in intercropping. Willey and Rao observed that intercropping boosted LER by up to 48.0% when compared to cereal solo crops (Willey and Rao, 1980). Intercropping maize with okra using the cropping pattern of 1M:10k gave the highest LER values of 1.96 in 2022-2023 season, indicating that the greatest productivity per unit area was achieved by growing the two crops together alternating 1M:10k than by growing them separately. These LER values allowed for the respective saving of 49.14% of land in 2022-2023 cropping season, which could have been put to better use in agriculture. The average of this season indicate that the lowest competitive pressure was recorded when planting was done alternating 1sM: 2s0k. A few researchers concur with the current findings. They stated that the aforementioned intercropping strategy also united and utilized land appropriately (Ijooyah and Dzer, 2012; Ijoyah and Jimba, 2012; Jiao et al., 2008).

4. Conclusion

The present study concluded that the 1M:10k alternating intercropping pattern provided the highest maize and okra production, the highest land equivalent ratio (LER), and saved the greatest percentage of land. It may be concluded, therefore, 1M:10k could be used as an alternative intercropping pattern in cropping system in Bangladesh. And it is also recommended that further investigation be done to evaluate the impact of maize and okra intercropping pattern largely in various places of Bangladesh.

Conflict of Interest

The authors declare no conflict of interest.

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