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INTERCROPPING MAIZE WITH HIGH YIELDING UPLAND SUMMER RICE: A POTENTIAL PRACTICE FOR BANGLADESH

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In field trials, conducted at the Regional Research Station, Bangladesh Agricultural Research Institute (BARI), Ishurdi, Pabna during the crop seasons of 1989 and 1990, maize *(Zea mays)* inter-cropped with high yielding variety (HYV) upland summer (aus) rice *(Oryza sativa)* (cv. BR 21). The treatments included were varying levels of plant populations; sole rice (broadcast) at 100 kg seed/ha; 100% rice + 50% maize (line sowing); 100% rice + 33% maize; 75% rice + 33% maize; 50% rice + 50% maize; 100% rice + paired row maize (100%) and sole maize at 53,333 plants/ha. Highest maize yield (4.37 t/ha) was obtained from sole maize and it was followed by 100% rice + paired row maize intercrop (4.26 t/ha). This intercrop combination also produced an additional rice yield of 1 t/ha which was nearly 50% of the yield obtained from sole rice crop (2.05 t/ha). The treatment gave each of the highest rice equivalent yield (4), Land equivalent ratio (1.47), net return (US$ 412/ha) and benefit-cost ratio (2.50).

Key words: Intercropping, Maize, Land equivalent ratio.

Introduction

Intercropping [1], is an important cropping system widely practiced in many countries over the world. It leads to intensive crop production and exploit more efficiently the environments with limiting growth resources [1,2]. The most common form of intercropping is cereal-legume one which provides with additional advantages of fixation of atmospheric nitrogen into the soil and utilizes soil moisture from deeper soil layer [3,4]. However, cereal-cereal intercropping with a particular planting geometry has also been more productive and economic than sole cropping [5-7].

Recently, maize has become a potential crop for growing both as food and fodder in Bangladesh due to its high yielding ability in all seasons and diversified utilization of byproducts [4,8]. But the competition of maize with other crops both in summer (kharif) and winter (rabi) seasons is posing threats to increasing the cropping area for maize cultivation in the country. The problem can be solved to a great extent if the crop is included in the cropping system as an intercrop. Intercropping of maize with different legumes [9-11] and that of rice with legume [12] are feasible in Bangladesh. But sufficient data on the relative contribution of rice-maize intercropping system for grain yield and economic returns are not available.

An investigation was, therefore, carried out for two consecutive years to see the effect of intercropping maize with HYV aus rice on grain yield productivity, to select a suitable intercrop combination with appropriate planting geometry and to find out the economic benefits to be derived from the rice-maize intercropping system over their sole crops.

Experimental

The experiment was conducted in medium high land under the calcareous grey floodplain soils of the Regional Agricultural Research Station, BARI, Ishurdi, Pabna during kharif seasons of 1989 and 1990 under rainfed condition. The soil of the experimental site was silty loam with pH value of 7.3. Sole crop of aus rice (at 100 kg seed/ha), sole crop of maize (at 53,333 plant/ha) and five intercrop combinations were tested in a randomised complete block design with three replications. The unit plot size was 4.5 x 5.0 m. Treatment details are given in Table 1. The varieties BR 21 for aus rice and Barnali for maize were used in the experiment. These are newly released high yielding varieties of aus rice and maize respectively, which are recommended for cultivation in Bangladesh. The sole rice crop received 60 kg N, 40 kg P_2O_5 and 20 kg K_2O in the forms of urea, triple super phosphate and muriate of potash, respectively. The sole maize and intercrop treatments received 120 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha in the same forms as above. All the fertilizers were applied as basal dose in sole rice, but in sole maize and intercrop treatments half of nitrogen full doses of phosphate and potash were given as basal application. The other half of the nitrogen was side dressed in the maize rows in two instalments at 35 and 60 days after sowing (DAS). Seeds were sown on 20 and 28 April of 1989 and 1990, respectively. Maize seeds were sown as per schedule of the treatments using two seeds per hill which was later thinned to one plant per hill at 20 DAS. Rice was harvested at 115 DAS and maize at 120 DAS. Data on grain yields were recorded after drying the seeds thoroughly in the

sun and were statistically analysed following the "analysis of variance" technique and the mean differences were compared by LSD values [13]. Land equivalent ratio (LER), rice equivalent yield (REY) and benefit-cost ratio were computed. LER values were computed from grain yield data of the crops according to the formula as [14].

$$LER = \frac{\text{Yield of maize intercrop/unit area}}{\text{Yield of maize sole crop/unit area}} + \frac{\text{Yield of rice intercrop/unit area}}{\text{Yield of rice sole crop/unit area}}$$

and REYs were computed by converting the yields of intercrop maize into the yields of rice on the basis of market prices of individual crops using the following formula [15].

$$REY = Y_a + \frac{Y_m \times P_m}{P_a}$$

where, Y_a = yield of aus rice intercrop; Y_m = yield of intercrop maize; P_a = price of rice; P_m = price of maize

The cost of production and net returns were determined using the existing market prices of various inputs and that of individual crops. The variable costs included the costs for land tillage, seeds, fertilizers, irrigation and harvesting.

Results and Discussion

Rice yield. The grain yield of aus rice decreased significantly when it was intercropped with maize ($P<0.05$). Rice yields, under intercropping situation, ranged from 35 to 78%of sole rice in 1989 and 33–71% in 1990. The significantly highest yields (2.00 t/ha in 1989 and 2.10 t/ha in 1990) were obtained from sole crop of rice compared to intercrops. The lowest rice yields were recorded from 50% rice + 50% maize treatment (0.73 t/ha in 1989 and 0.69 t/ha in 1990) and they were statistically equal to 100% rice + paired row maize in both the years (Table 2). The lower yields of rice grain in intercropping situation might be due to higher shoot competition (shading effect) of maize with rice. It was also observed that rice yields decreased proportionately with the increase of maize plants. Among the intercrops, the highest rice yield(1.52 t/ha) was found when 33% maize was intercropped with 100% rice. This result indicated that the lowest number of maize plants provided with the minimum competition pressure ultimately leading to the highest yield of rice. On the other hand, under constant number of maize plants, an increase in plant population of rice increased the grain yield of rice. Similar results were also reported by Qayyum and Jahiruddin [16].

TABLE 1. TREATMENT DETAILS OF MAIZE-HYV AUS RICE INTERCROPPING SYSTEM.

Treatments	Cropping geometry and seeding ratio	Maize spacing	Maize population/ha
T_1	Sole rice (broadcast)	–	–
T_2	Sole maize (line sowing)	75 x 25cm	53,333
T_3	100% rice (broadcast) + 50% maize (line sowing)	75 x 50cm	26,666
T_4	100% rice + 33% maize	112.5 x 50cm	17,777
T_5	75% rice + 33% maize	112.5 x 50cm	17,777
T_6	50% rice + 50% maize	75 x 50cm	26,666
T_7	100% rice + paired row maize	*	53,333

* In paired row system, two maize rows were placed at 37.5 cm apart and two such pairs were separated by 150 cm. Therefore, there were six rows of maize per plot. Individual plants within the row were spaced 25cm apart.

Maize yield. Grain yield of maize was significantly affected by different plant populations ($P<0.05$). Maximum grain yield of maize (4.37 t/ha) was obtained from sole maize which was followed by 100% rice + paired row maize intercrop (4.26 t/ha). The lowest grain yields of the crop were found from 100% rice + 33% maize which was again statistically equal to 75% rice + 33% maize combination (Table 2). There was a trend of increasing maize yields with the increase of maize plants intercropped. However, under the constant number of maize plants (e.g. 50% maize) when the number of rice plants increased from 50% to 100% no significant difference in maize yield was noticed which indicated a nonsignificant effect of number of rice plants on maize yield. The possible reason for this could have been due to higher competitive ability of the maize plants in rice-maize intercropping system. Similar insignificant effect of rice cultivars on maize yield was also observed when maize intercropped with upland rice [6]. Maize exploited the soil resources from different soil profiles than rice when it was intercropped with shallow rooted aus rice. Therefore, root competition (competition for water and nutrient) was not a great problem in this intercropping system [17]. However, the plants with vigorous and spreading leaves such as maize posed severe competition for light which rendered a considerable yield reduction of rice.

Rice equivalent yield (REY). Highest REY (4) was recorded in the treatment of 100% rice + paired row maize which means that by intercropping maize with HYV aus rice following the above mentioned planting geometry 100% more equivalent yield can be obtained than with the sole rice crop (Table 2). In the planting geometry of 100% rice + paired row maize, the maximum number of crop plants (rice + maize) were accommodated in the same area of land without much inter-plant competition. In this situation weed suppression was the greatest which probably resulted in the intercrop using

TABLE 2. GRAIN YIELDS, RICE EQUIVALENT YIELDS (REY) AND LAND EQUIVALENT RATIO (LER) OF MAIZE-HYV AUS RICE INTERCROPPING SYSTEM.

Treatment	1989				1990				Mean of two years			
	Grain yield(t/ha)		REY	LER	Grain yield(t/ha)		REY	LER	Grain yield(t/ha)		REY	LER
	Rice	Maiz			Rice	Maiz			Rice	Maiz		
T_1*	2.00	–	2.00	1.00	2.10	–	2.10	1.00	2.05	–	2.05	1.00
T_2	–	4.32	3.05	1.00	–	4.41	3.11	1.00	–	4.37	3.08	1.00
T_3	1.11	2.31	2.74	1.09	1.15	2.38	2.83	1.09	1.13	2.35	2.79	1.09
T_4	1.55	1.52	2.62	1.13	1.50	1.59	2.62	1.07	1.52	1.51	2.62	1.09
T_5	1.35	1.64	2.51	1.06	1.46	1.65	2.62	1.07	1.40	1.65	2.57	1.07
T_6	0.73	2.35	2.39	0.89	0.69	2.41	2.39	0.88	0.71	2.38	2.39	0.89
T_7	0.99	4.21	3.39	1.47	1.01	4.30	4.05	1.46	1.00	4.26	4.00	1.47
LSD (5%)	0.26	0.45	0.48	0.18	0.28	0.41	0.55	0.22	0.28	0.44	0.49	0.19
CV (%)	12.90	10.80	3.60	2.90	13.60	9.60	4.30	2.70	12.50	10.20	4.00	2.80

*T_1 = Sole rice, T_2 = Sole maize, T_3 = 100% rice+50% maize, T_4 = 100% rice + 33 maize, T_5 = 75% rice +33% maize, T_6 = 50% rice +50% maize and T_7 = 100% rice + paired row maize. Price: Rice= US $ 0.17/kg, Maize= US$ 0.12/kg.

TABLE 3. ECONOMIC ANALYSIS OF DIFFERENT INTERCROP COMBINATIONS OF MAIZE-HYV AUS RICE INTERCROPPING SYSTEM.

Treatment	1989				1990				Mean of two years	
	Gross return ($/ha)	Total variable cost ($/ha)	Netreturn ($/ha)	Benefit cost	Cross return ($/ha)	Total variable cost ($/ha)	Net return ($/ha)	Benefit cost	Net return ($/ha)	Benefit cost
T_1	340.0	244.6	95.4	1.39	357.0	247.9	110.0	1.44	102.7	1.42
T_2	518.4	268.6	249.8	1.93	529.2	271.4	257.8	1.95	253.8	1.94
T_3	465.9	269.3	196.6	1.73	481.1	273.4	207.7	1.76	202.2	1.75
T_4	445.9	265.4	180.5	1.68	445.8	265.3	180.6	1.68	180.5	1.69
T_5	426.3	256.8	169.5	1.66	446.2	275.9	170.3	1.73	169.9	1.70
T_6	406.1	257.0	149.1	1.58	406.5	258.9	147.6	1.57	148.4	1.58
T_7	673.5	270.5	403.0	2.49	687.7	272.8	414.9	2.52	412.0	2.51

*T_1 = Sole rice, T_2 = Sole maize, T_3 = 100% rice + 50% maize, T_4 = 100% rice + 33% maize, T_5 = 75% rice + 33% maize, T_6 = 50% rice + 50% maize and T_7 = 100% rice + paired row maize. Price: Rice = US $ 0.17/kg, Maize = US $0.12/kg.

the environmental resources more efficiently [18,19]. This paired row system of maize planting was also found to be the best performer in maize-groundnut and maize-potato intercropping systems in Bangladesh [11,20].

Land equivalent ratio (LER). Highest LER (1.47) was noted from 100% rice + paired row maize intercrop. The LER value of 1.47 for the treatment indicated that by intercropping maize at 53,333 plants/ha (100%) in paired row planting geometry a farmer could produce 1 ton of rice grain and 4.26 ton of maize grain from one hectare of land instead of growing them separately in 1.47 hectare of land to obtain the same yield. In other words, by intercropping maize at 53,333 plants/ha in paired row with 100% rice at 100 kg/ha the land use efficiency could be increased up to 47%.

Cost and return analysis. Highest net returns over variable costs in both the years (US$ 409/ha in 1989 and US$ 414.9/ha in 1990) (Table 3.) were obtained from 100% rice + paired row maize interrop combination which was about 38% more than sole maize and about 75% more than sole rice. The treatment also gave the highest benefit-cost ratio (2.50). In a study conducted at the multi-location testing site, BARI, Gabtoli, Bogra, intercropping of maize with broadcast rice was also found to produce an increase of about 50% profitability compared to the sole rice crop [21].

From the investigation it can be concluded that growing of maize at 53,333 plants/ha with broadcast HYV aus rice at 100 kg/ha of seed is a profitable cropping system and hence, a potential practice for Bangladesh.

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