Bangladesh Agron. J. 2022, 25(1): 75-82

EFFECT OF PLANTING SYSTEM ON PRODUCTIVITY OF HYBRID MAIZE-INDIAN SPINACH INTERCROPPING SYSTEM

A.A. Begum, M.H Rahman, J. Hossain, S.S. Kakon, M.Z. Ali and D.A. Choudhury

Agronomy Division, Bangladesh Agricultural Research Institute, Gazipur 1701
Corresponding E-mail*:* luckyshamol6869@gmail.com

(**Received:** 15 May 2022, **Accepted:** 02 August 2022)

Keywords: PAR interception, LER, yield, equivalent yield and BCR

Abstract

A field experiment was undertaken at Joydebpur, Jashore and Ishurdi Farm of Bangladesh Agricultural Research Institute during *Kharif* seasons of 2016 and 2017 to find out suitable combination of hybrid maize and Indian spinach as intercropping system for higher productivity and monetary advantage. Treatments included in the experiment were: T_1 = Hybrid maize normal row (75 cm × 20 cm) + 1 row Indian spinach (plant to plant 25 cm), T_2 = Hybrid maize paired row (37.5 cm/150 cm × 20 cm) + 1 row Indian spinach (plant to plant 25 cm), T_3 = Hybrid maize paired row (37.5 cm/150 cm × 20 cm) + 2 rows Indian spinach (plant to plant 25 cm), T_4 = Hybrid maize paired row (37.5 cm/150 cm × 20 cm) + 3 rows Indian spinach (plant to plant 25 cm), T_5 = Sole maize (75 cm × 20 cm) and T_6 = Sole Indian spinach (40 cm × 25 cm). Grain yield of maize was the maximum in sole crop but it was decreased 1.0 to 12.6% at Joydebpur, 5.2 to 17.1% at Jashore and 13.4 to 22.2% at Ishurdi due to inter specific competition for growth resources among maize and Indian spinach due to intercropping. All intercropping treatments showed better performance than sole maize crop. The highest maize equivalent yield (19.22 and 18.80 t ha^{-1} at Joydebpur, 13.30 and 11.58 t ha^{-1} at Jashore and 11.23 and 11.10 t ha^{-1} at Ishurdi in 2016 and 2017, respectively), gross margin (Tk. 196300 and Tk. 192000 ha^{-1} at Joydebpur, Tk. 111130 and Tk. 85330 ha^{-1} at Jashore and Tk. 88450 and Tk. 86500 ha^{-1} at Ishurdi in 2016 and 2017, respectively) and benefit cost ratio (3.13 and 3.07 at Joydebpur, 2.26 and 1.97 at Jashore and 2.11 and 2.08 at Ishurdi in 2016 and 2017, respectively) were observed in hybrid maize paired row + 3 rows Indian spinach intercropping. The highest land equivalent ratio (1.32 and 1.39 at Joydebpur and 1.50 and 1.47 at Jashore in 2016 and 2017, respectively) was also found in the same treatment. On the other hand, at Ishurdi, the highest LER (1.34 and 1.35 in 2016 and 2017, respectively) was observed in MNR + 1 rows ISP treatment followed by MPR + 3 rows ISP treatment. The results revealed that hybrid maize paired row + 3 rows Indian spinach and Hybrid maize normal row + 1 row Indian spinach intercropping might be economically profitable for hybrid maize + Indian spinach intercropping system at Joydebpur, Jashore and Ishurdi.

Introduction

Intercropping is an important tool for getting higher productivity per unit area of land (Mahfuza *et al*., 2012). Maize is ideal for intercropping and mixed cropping, especially with legumes, potato, onion, groundnuts and vegetables. Maize based intercropping is found profitable and suitable in many countries like Bangladesh. Hybrid maize is a unique crop because of its versatile use and low cost $unit^{-1}$ production. Maize grains and cobs can be used as food for human, poultry, livestock and fish. It can also be used as raw materials of varieties of industrial products (corn starch). So, there is ample scope for expansion of maize in Bangladesh (Islam and Kaul, 1986). On the other hand, Indian spinach *(Basella alba)* is one of the important summer leafy vegetables in Bangladesh. It is a popular and high

nutritious leafy vegetable during *kharif* season. 100 g basella leaves contain 0.12 mg calcium, 1.2 mg iron, 0.08 mg thiamine and 1686 IU carotene *(Anon,* 2000). It demands and popularity is rising due to its nutrient content. Higher productivity from intercropping depends on judicious choice of component crops, suitable planting system or proportion of component crops (Islam *et al*., 2006). Maize is a C_4 crop; its roots enter more than one meter in to the soil and can absorb nutrients from deeper layer. Hybrid maize is an unbranched and erect cereal crop grown with wide spacing. Several short duration and short stature vegetable like Indian spinach may be grown in association with hybrid maize. Indian spinach is the most compatible with maize for their contrasting phenology such as different growth habits, growth duration and demand for growth resources. Maize takes longer time and offers an opportunity for intercropping. Some vegetable crops might be a good intercrop with maize (Uddin *et al*., 2009) and the practice also offers considerable yield advantage and higher economic return over sole cropping (Singh *et al*., 2010; Singh *et al*., 2002; Kheroarand Patra, 2013). However, literature is meagre regarding hybrid maize Indian spinach intercropping under different planting systems. Hence, this experiment was undertaken to find out suitable planting systems of hybrid maize and Indian spinach intercropping system for higher productivity, economic return and food security.

Materials and Methods

A field experiment was undertaken at the Agronomy Research Field, BARI, Joydebpur, Gazipur (23°53′-24°21′N latitudes and 90°09′-92°39′E longitudes), Regional Agricultural Research Station (RARS), Jashore (22°48′-23°22′N latitudes and 88°51′-89°34′ E longitudes) and RARS, Ishurdi, Pabna (24°03'-24°15' N latitudes and 89°00'-89°11' E longitudes) during *Kharif* season of 2016 and 2017. Treatments included in the experiment were: T_1 = Hybrid maize normal row (75 cm × 20 cm) + 1 row Indian spinach (plant to plant 25 cm), T_2 = Hybrid maize paired row (37.5 cm/150 cm/37.5cm × 25 cm) + 1 row Indian spinach (plant to plant 25 cm), T_3 = Hybrid maize paired row (37.5 cm/150 cm × 20 cm) + 2 rows Indian spinach (plant to plant 25 cm), T_4 = Hybrid maize paired row (37.5 cm/150 cm × 20 cm) + 3 rows Indian spinach (plant to plant 25 cm), T_5 = Sole maize (75 cm × 25 cm) and T_6 = Sole Indian spinach (40 cm × 25 cm). The experiment was laid out in randomized complete block design with three replications and the unit plot size was 6m × 5m. Hybrid maize var. BARI Hybrid maize-9 in all locations and Indian spinach var. BARI Indian Spinach-2 at Joydebpur and Ishurdi but local Indian spinach was used at Jashorein both years. Hybrid maize seeds were sown on 15 March, 2016 and 12 March, 2017 and Indian spinach seedlings (25 days old) were transplanted on 13 March, 2016 and 10 March, 2017 at Joydebpur, at Jashore hybrid maize seeds were sown on 10 April, 2016 and 11 April, 2017 and Indian spinach seedlings (20-25 days old) were transplanted on 8 April, 2016 and 9 April, 2017. But at Ishurdi, maize seeds were sown and Indian spinach seedlings were transplanted on the same day (4 April, 2016 and 23 March, 2017). The seeds of BARI Hybrid maize-9 were treated with provex at the rate of 3 g per one kg of seed in all locations. Fertilizers were applied at the rate of 250-76-121-72-5-1 kg ha^{-1} of N, P, K, S, Zn, B (FRG, 2012) as urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum, zinc sulphate and boric acid for sole maize and intercrop. One third of N, whole amount of TSP, MoP, gypsum, zinc sulphate and boric acid were applied as basal. Remaining 2/3 N was top dressed at 20 and 40 days after sowing (DAS) of maize. In intercrop, extra N (40 kg/ ha) was applied in 2 splits at 20 and 40 DAT as ring method to Indian spinach. Sole Indian spinach was fertilized at the rate of 70-15-45-15 kg/ ha of N, P, K, S. One third of N and all other fertilizers were applied as basal. Rest N was applied in 2 splits at 20 and 40 DAT as ring method in all locations. Light availability was measured by PAR Ceptometer (Model – LP-80, Accu PAR, Decagon, USA) in only Joydebpur location. Photo synthetically active radiation (PAR) was measured at 15-day intervals from 30 to 105 DAT at around 11:30 am to 13:00 pm. The PAR was measured by PAR Ceptometer (Model – LP-80, Accu PAR, Decagon, USA). LP-80 has an 80 cm long sensor, which is usually used for below canopy measurement. Another optional quantum sensor can be used for above canopy measurement through a cable connection. So, simultaneous measurement of PAR at above and below canopy is possible with this instrument. The respective sensors were simultaneously installed above and below of

the canopy (10 cm above the soil surface) for incident PAR (PARinc) and transmitted PAR (PARt), respectively. Four readings each of PARinc and PARt were recorded at different spots of each plot. PARt indicated the light availability above underneath crop (Indian spinach). The proportion of transmitted PAR (PARt) was expressed in percentage (Ahmed *et al.*, 2010):

$$\text{Light availability, PARt (\%)} = \frac{\text{PARt}}{\text{PARinc}} \times 100$$

where, PARinc = Incident PAR,
PARt = Transmitted PAR

Data on yield contributing characters of maize were taken from randomly selected 5 plants from each plot. Yields of both the crops were taken from whole plot area in all the locations. Maize was harvested on 7 July, 2016 and 28 June 2017 and Indian spinach was harvested 6 times in both the years (2 May, 12 May, 20 May, 30 May, 8 June and 18 June in 2016 and 29 April, 9 May, 17 May, 27 May, 5 June and 15 June in 2017) at Joydebpur. On the other hand, maize was harvested on 20 and 25 July in 2016 and 2017, respectively, at Jashore and at Ishurdi, 13 and 15 July in 2016 and 2017, respectively. Indian spinach was harvested only 3 times at Jashore (29 May, 14 and 30 June in 2016 and 29 May, 15 June, 30 June in 2017) and 3 times at Ishurdi (24 May, 10 and 26 June in 2016 and 4 June, 20 June, 10 July in 2017). In all locations, maize equivalent yield was computed by converting yield of intercrops on the basis of prevailing market price of individual crop following the formula of Bandyopadhyay (1984) as given below:

Maize equivalent yield = Yim + (Yiisp×Pisp)/ Pm
Where, Yim = Yield of intercropped maize, Yiisp = Yield of intercropped Indian spinach, Pm = Market price of maize and Pisp = Market price of Indian spinach.
Collected data of both the crops were analyzed statistically and the means were adjudged using $LSD_{(0.05)}$ test. Economic analysis was also done considering local market price of harvested crops.

Result and Discussion

Light availability

Irrespective of treatments, availability of light (Transmitted PAR) on Indian spinach canopy was almost 100% at earlier growth stage 30 DAT of Indian spinach and it decreased with the increase of shade produced by maize canopy over the time up to 105 DAT and then increased up to harvest due to leaf senescence of maize. The lowest light availability on Indian spinach was observed at 105 DAT in hybrid maize normal row (MNR) + 1 row Indian spinach (ISP) treatment and the highest was observed in sole ISP treatment and light availability on Indian spinach was more or less similar in MPR + 1 row ISP, MPR + 2 rows ISP and MPR + 3 rows ISP. Among the treatments, light availability on Indian spinach canopy was more in the paired row than normal row of maize throughout the growing period (Figure 1).

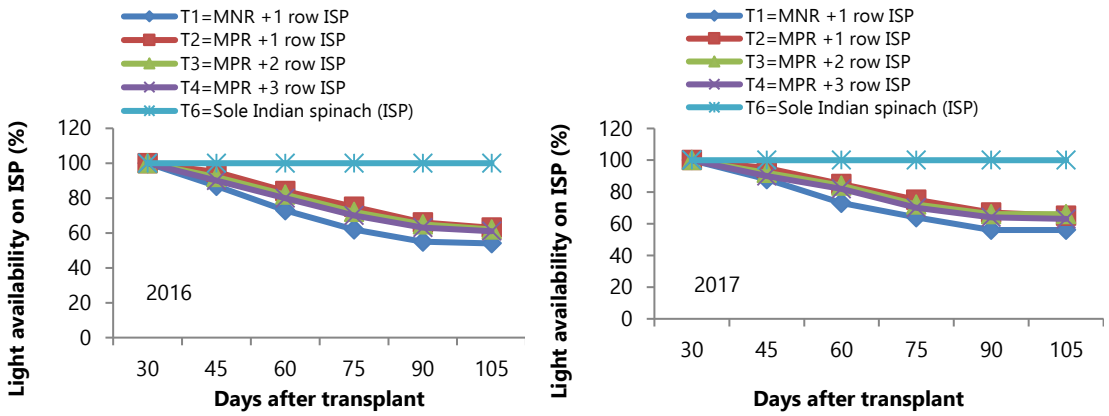

Fig. 1. Light availability on ISP canopy in hybrid maize + Indian spinach intercropping system.

Effect on yield and yield components of maize

Number of grainscob^{-1}, 1000- grain weight and grain yield of maize were not significantly differed in both years at all locations. Numerically the highest grain yield (8.03 and 8.01 t ha^{-1}at Joydebpur, 5.80 and6.07 t ha^{-1} at Jashore and 6.86 and 6.63 t ha^{-1} at Ishurdi during 2016 and 2017, respectively) were recorded in sole maize due to no intercrop competition for growth resources like light, nutrients, moisture and space in sole cropping (Table 1). This corroborates with the findings of Begum *et al.* (2016; 2020). The lowest grain yield were recorded in MPR + 3 rows ISP at all locations. Grain yield level at Jashore and Ishurdi was lower than Joydebpur. It might be due to delayed sown of crops where comparatively higher temperature prevailed in cropping period in other two locations than Joydebpur. Crop faced higher temperature and heavy rainfall at taselling and silking stage which was harmful to pollination resulting yield was decreased. Lizaso *et al.* (2018) reported that maize grain yield was reduced under heat stress mainly via pollen viability resulting in decreased the grain number and yield. The decrease in grain yield under intercrop situation varied from 1.0-12.6 % at Joydebpur, 5.2-17.1 % at Jashore and 13.4-22.2 % at Ishurdi due to inter specific competition for growth resources among maize and Indian spinach.

Table 1. Grain yield of hybrid maize as influenced by different planting systems in maize + Indian spinach intercropping during *kharif* 2016 and 2017

Treatments	**Grain yield (t ha^{-1})**					
	Joydebpur		**Jashore**		**Ishurdi**	
	2016	**2017**	**2016**	**2017**	**2016**	**2017**
T_1 = MNR + 1 row ISP	7.95	7.77	5.50	5.60	5.91	5.74
T_2 = MPR + 1 row ISP	7.47	7.35	5.40	5.23	5.53	5.44
T_3 = MPR + 2 rows ISP	7.35	7.26	5.37	5.07	5.41	5.24
T_4 = MPR + 3 rows ISP	7.02	7.22	5.30	5.03	5.38	5.16
T_5 = Sole maize	8.03	8.01	5.80	6.07	6.86	6.63
$LSD_{(0.05)}$	NS	NS	NS	NS	NS	NS
CV (%)	15.3	13.7	15.7	19.1	12.2	14.1

NS= Not significant

Effect on yield of Indian spinach

Number of plants m^{-2} and leafy vegetable yield of Indian spinach were significantly influenced by different planting systems. The highest plants m^{-2} was observed in MPR + 3 rows ISP in all locations (7.5 and 7.1 at Joydebpur, 6.0 and 6.2 at Jashore and 6.6 and 6.5 at Ishurdi during 2016 and 2017, respectively) and the lowest in T_2 treatment in all locations due to planting system. The highest

biomass vegetable yield was found in sole Indian spinach due to higher plant population per unit area and there was no intercrop competition for growth resources (Table 2). Among the intercrop treatments, the highest vegetable yield (18.30 and 17.37 t ha^{-1} at Joydebpur, 12.00 and 9.83 t ha^{-1} at Jashore and 8.78 and 8.91 t ha^{-1} at Ishurdi during 2016 and 2017, respectively) were observed in MPR + 3 rows ISP treatment. The lowest vegetable yield were observed in MPR + 1 row ISP treatment due to variation of planting systems or number of plant population per unit area in both years at all locations.

Table 2. Leafy vegetable yield of Indian spinach as influenced by different planting systems in maize and Indian spinach intercropping during *kharif* 2016 and 2017

Treatments	**Leafy vegetable yield (t ha^{-1})**					
	Joydebpur		**Jashore**		**Ishurdi**	
	2016	**2017**	**2016**	**2017**	**2016**	**2017**
T_1 = MNR + 1 row ISP	12.02	11.70	9.9	8.50	7.93	7.86
T_2 = MPR + 1 row ISP	8.56	6.27	5.95	4.20	3.68	4.13
T_3 = MPR + 2 rows ISP	12.00	10.07	9.85	7.53	7.21	7.80
T_4 = MPR + 3 rows ISP	18.30	17.37	12.0	9.83	8.78	8.91
T_5 = Sole maize	-	-	-	-	-	-
T_6 = Sole Indian spinach	40.35	35.25	20.4	15.47	16.61	16.36
$LSD_{(0.05)}$	6.00	6.00	4.90	2.82	3.57	2.45
CV (%)	11.75	13.58	15.39	11.43	14.75	9.99

Vegetable yield of Indian spinach at Jashore and Ishurdi was lower than Joydebpur. It might be due to lower number of plant population per unit area and the number of plucking or cutting of Indian spinach at Jashore and Ishurdi were less (3 times) than that of Joydebpur (6 times).

Evaluation of intercrop productivity

Hybrid maize Indian spinach intercrop productivity was evaluated on the basis of Land equivalent ratio and maize equivalent yield (Bandyophadhyay, 1984). Land equivalent ratio (LER) and maize equivalent yield (MEY) of maize + Indian spinach intercropping in all locations are presented in Table 3 and Table 4. The LER values in the intercrops ranged from (1.14 to 1.32 and 1.10 to 1.39 at Joydebpur, 1.22 to 1.50 and 1.13 to 1.47 at Jashore and 1.03 to 1.34 and 1.07 to 1.35 at Ishurdi in 2016 and 1017, respectively) which indicated (14 to 32 % and 10 to 39% at Joydebpur, 22 to 50% and 13 to 47% at Jashore and 3 to 34% and 7 to 35% at Ishurdi in 2016 and 1017, respectively) land utilization increased by intercrop cultivation than growing maize and Indian spinach as sole crop.

Table 3. Land equivalent ratio as influenced by different planting systems in maize + Indian spinach intercropping during *kharif* 2016 and 2017

Treatments	**Land equivalent ratio**					
	Joydebpur		**Jashore**		**Ishurdi**	
	2016	**2017**	**2016**	**2017**	**2016**	**2017**
T_1 = MNR + 1 row ISP	1.29	1.30	1.44	1.47	1.34	1.35
T_2 = MPR + 1 row ISP	1.14	1.10	1.22	1.13	1.03	1.07
T_3 = MPR + 2 rows ISP	1.22	1.20	1.41	1.33	1.22	1.27
T_4 = MPR + 3 rows ISP	1.32	1.39	1.50	1.47	1.31	1.33
T_5 = Sole maize	1.00	1.00	1.00	1.00	1.00	1.00

The highest LER (1.32 and 1.39 at Joydebpur and 1.50 and 1.47 at Jashore in 2016 and 2017, respectively) was observed in MPR + 3 rows ISP treatment. On the other hand, at Ishurdi, the highest LER (1.34 and 1.35 in 2016 and 2017, respectively) was observed in MNR + 1 row ISP treatment followed by MPR + 3 rows ISP treatment. MEY of all the intercropping systems was higher than sole maize in all locations indicating higher productivity of intercropping than sole maize. Among the

intercropping, the highest maize equivalent yield (19.22 and 18.80 t ha^{-1} at Joydebpur, 13.30 and 11.58 t ha^{-1} at Jashore and 11.23 and 11.10 t ha^{-1} at Ishurdi in 2016 and 2017, respectively) was observed in T_4 treatment (MPR + 3 rows ISP) followed by T_1 (MNR + 1 row ISP). The lowest was observed in T_5 (sole maize) in all locations. Dhima *et al*. (2007) reported that intercropping maximizing land use and increasing crop yield.

Table 4. Maize equivalent yield as influenced by different planting systems in maize + Indian spinach intercropping during *kharif* 2016 and 2017

Treatments	Maize equivalent yield (t ha^{-1})					
	Joydebpur		Jashore		Ishurdi	
	2016	2017	2016	2017	2016	2017
T_1 = MNR + 1 row ISP	15.96	15.57	12.10	11.27	11.20	10.98
T_2 = MPR + 1 row ISP	13.18	11.53	9.47	8.03	7.98	8.19
T_3 = MPR + 2 rows ISP	15.35	13.97	11.94	10.09	10.22	10.44
T_4 = MPR + 3 rows ISP	19.22	18.80	13.30	11.58	11.23	11.10
T_5 = Sole maize	8.03	8.01	5.80	6.07	6.86	6.63

Market price (Tk kg^{-1}): Maize = 15, Indian spinach = 10 in all locations in both years

Economic performance

Economic analysis is an important tool to evaluate the economic feasibility of intercropping systems and monetary advantage was evaluated according to Shah *et al*. (1991). Benefit cost analysis of Maize + Indian spinach intercropping systems in 2016 and 2017 at all locations are presented in Table 5a to 5d. Among intercropping treatments, the highest gross return (Tk. 288300 and Tk. 282000 ha^{-1} at Joydebpur, Tk. 199500 and Tk. 173700 ha^{-1} at Jashore and Tk. 168450 and Tk. 166500 ha^{-1} in 2016 and 2017, respectively) was observed in T_4 treatment (hybrid maize paired row + 3 rows Indian spinach planting system) and it was close to T_1 owing to higher MEY in all locations. The gross margin followed the similar trend of gross return. The maximum cost of production was recorded in T_1 followed by T_4 treatments. Among intercropping treatments, the highest benefit cost ratio (3.13 and 3.07 at Joydebpur, 2.26 and 1.97 at Jashore and 2.11 and 2.08 at Ishurdi in 2016 and 2017, respectively) was obtained from T_4 (hybrid maize paired row + 3 rows Indian spinach planting system) followed by T_1 (hybrid maize normal row + 1 row Indian spinach planting system). This result has been supported by the findings of Islam *et al.* (2013) and Begum *et al.* (2020).

Table 5a. Gross return of maize + Indian spinach intercropping under different planting system

Treatments	Gross return (Tk. ha^{-1})					
	Joydebpur		Jashore		Ishurdi	
	2016	2017	2016	2017	2016	2017
T_1 = MNR + 1 row ISP	239400	233550	181500	169050	168000	164700
T_2 = MPR + 1 row ISP	197700	172950	142050	120450	119700	122850
T_3 = MPR + 2 rows ISP	230250	209550	179100	151350	153300	156600
T_4 = MPR + 3 rows ISP	288300	282000	199500	173700	168450	166500
T_5 = Sole maize	120450	120150	87000	91050	102900	99450

Table 5b. Cost of cultivation of maize + Indian spinach intercropping under different planting system

Treatments	Cost of cultivation (Tk. ha^{-1})					
	Joydebpur		Jashore		Ishurdi	
	2016	2017	2016	2017	2016	2017
T_1 = MNR + 1 row ISP	90000	90000	88370	88370	80000	80000
T_2 = MPR + 1 row ISP	84000	84000	86370	86370	79000	79000
T_3 = MPR + 2 rows ISP	87000	87000	87370	87370	79500	79500
T_4 = MPR + 3 rows ISP	92000	92000	88370	88370	80000	80000

T_5 = Sole maize	80000	80000	65370	65370	75000	75000

Table 5c. Gross margin of maize and Indian spinach intercropping under different planting system

Treatments	**Gross margin (Tk. ha^{-1})**					
	Joydebpur		**Jashore**		**Ishurdi**	
	2016	**2017**	**2016**	**2017**	**2016**	**2017**
T_1 = MNR + 1 row ISP	149400	143550	93130	80680	88000	84700
T_2 = MPR + 1 row ISP	113700	88950	55680	34080	40700	43850
T_3 = MPR + 2 rows ISP	143250	122550	91730	63980	73800	77100
T_4 = MPR + 3 rows ISP	196300	192000	111130	85330	88450	86500
T_5 = Sole maize	40450	40150	21630	25680	27900	24450

Table 5d. Benefit cost ratio of maize and Indian spinach intercropping under different planting system

Treatments	**Benefit cost ratio (BCR)**					
	Joydebpur		**Jashore**		**Ishurdi**	
	2016	**2017**	**2016**	**2017**	**2016**	**2017**
T_1 = MNR + 1 row ISP	2.66	2.60	2.05	1.91	2.10	2.06
T_2 = MPR + 1 row ISP	2.35	2.06	1.64	1.39	1.60	1.56
T_3 = MPR + 2 rows ISP	2.65	2.41	2.05	1.73	1.93	1.97
T_4 = MPR + 3 rows ISP	3.13	3.07	2.26	1.97	2.11	2.08
T_5 = Sole maize	1.51	1.50	1.33	1.39	1.32	1.33

Market price (Tk kg^{-1}): Maize = 15, Indian spinach = 10 in all locations in both years

Conclusion

Two years result revealed that all the intercropping systems showed better productivity than sole maize. Hybrid maize paired row (37.5 cm/150 cm/37.5 cm × 20 cm) + 3 rows Indian spinach intercropping and hybrid maize normal row (75 cm × 20 cm) + 1 row Indian spinach intercropping might be agronomically feasible and economically profitable in all locations (Joydebpur, Jashore and Ishurdi).

References

Anonymous. 2000. Puishaker utpadon projukti. *In:* Shabjir unnatojat o utpadon paddhoti (Bengali). S.M.M. Hossain. Ed. Horticulture Research Center, BARI, Gazipur. 46p.

Ahmed, F., M.N. Islam, M.T. Rahman, M.A. Jahan and M.S.A. Khan. 2010. Leaf area index, radiation interception, dry matter production and grain yield of hybrid maize as influenced by plant spacing. Bangladesh Agron. J. 13(1 & 2): 51-58.

Bandyopadhyay, S.N. 1984. Nitrogen and water relations in grain sorghum-legume intercropping systems. PhD. Dissertation, Indian Agril. Res. Inst., New Delhi.

Begum, A.A, M.A.K. Mian, S.M.A.H.M. Kamal, M.R. Karim, R.R. Saha and M.A. Hossain. 2020. Planting System Effects on Intercropping of Gardenpea and Sorghum. Bangladesh Agron. J. 23(2): 59-68.

Begum, A.A., M.S.U. Bhuiya, S.M.A. Hossain, Amlna Khatun and S.K. Das. 2016. Effect of planting system of potato and plant density of maize on productivity of potato- hybrid maize intercropping system. Bangladesh J. Agril. Res. 41(3): 397-409.

Dhima, K.V., A.S. Lithourgidis, I.B. Vasilakoglou and C.A. Dordas. 2007. Competition indices of common vetch and cereal intercrops in two seeding ratio. Field Crops Res. 100(2-3): 249-256.

FRG. 2012. Fertilizer Recommendation Guide, Bangladesh Agricultural Research Council (BARC). Farmgate, Dhaka 1215. 274p.

Hossain, M. 2021. Why farmers in northern Bangladesh are turning to corn for food security. Online article published on 5 May 2021 in the daily Prothom

Alo.https://www.weforum.org/agenda/2021/05/why-farmers-in-northern-bangladesh-are-turning-to-corn-for-food-security.

Islam, M.N., M.M. Haque and A. Hamid. 2006. Planting arrangement and population density effects on the physiological attributes and productivity of maize-bushbean intercropping systems. Bangladesh J. Agril. Res. 31(3): 353-364.

Islam, M.N., M. Akhteruzzaman and M.S. Alom. 2013. Split application of inorganic fertilizers in potato (*Solanumtuberosum* L.)-hybrid maize (*Zea mays* L.) intercropping system. Bangladesh J. Agril. Res. 38(3): 447-453.

Islam, T.M.T. and A.K. Kaul. 1986. Prospects of Maize in Bangladesh. FAO/UNDP Publication, Dhaka, Bangladesh.

Kheroar, S. and B. Patra. 2013. Advantages of Maize-Legume Intercropping Systems. J. Agril. Sci. Tech. 3(3): 733-744.

Kumar, R., V. Rajasree, L. Sagar, U. Tripura, K. Karthick, R. Karthick and G. Prasath. 2018. Underutilized vegetables as rich source of medicinal value: A boon for the pharmaceutical industries and farmer income. Int. J. Chem. Stud. 6(4): 3320-3323.

Kumar, S.S., P. Manoj and P. Giridhar. 2015. Nutrition facts and functional attributes of foliage of *Basella* spp. LWT – Food Sci. Technol. 64(1): 468-474.

Lizaso, J.I., M.R. Ramos, L. Rodriguez and C.G. Leal. 2018. Impact of high temperatures in maize: Phenology and yield components. Field Crops Res. 216: 129-140.

Mahfuza, S.N., M.N. Islam, A. Hannan, M. Akhteruzzaman and S. Begum. 2012. Intercropping different vegetables and spices with pointed gourd. J. Expt. Biosci. 3(1): 77-82.

Shah, N.H., P.K. Koul, B.A. Khanday and D. Kachrov. 1991. Production potential and monetary advantage index of maize intercropped with different grain legumes. Indian J. Agron. 36(1): 23-28.

Singh, G., R.K. Mehta and R.V. Singh. 2002. Energetics, yield, water use and economics of rice-based cropping systems in flood- prone situation of eastern Uttar Pradesh. Indian J. Agric. Sci. 72(2): 63-66.

Singh, N.K., B. Rai and R. Kumar. 2010. Production potential of winter maize (*Zea mays* L.) based intercropping system. Environ. Ecol. 28(4A): 2449-2452.

Uddin, M.J., M.A. Quayyum and K.M.S. Alahuddin. 2009. Intercropping of hybrid maize with short duration vegetables at hill valleys of Bandarban. Bangladesh J. Agril. Res. 34(1): 51-57.