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PLANTING SYSTEM EFFECTS ON INTERCROPPING OF GARDENPEA AND SORGHUM

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Abstract

The field experiment was conducted at Agronomy Research Field, Joydebpur and RARS, Burirhat, Rangpur, BARI during *Rabi* season of 2018-2019 and 2019-2020 to find out suitable combination of sorghum and gardenpea intercropping for higher productivity and monetary advantage. Treatments included in the experiment were: T_1 = Sorghum normal row (SNR) + 1 row gardenpea (GP), T_2 = SNR + 2 rows GP, T_3 = Sorghum paired row (SPR) + 2 rows GP, T_4 = SPR + 3 rows GP, T_5 = SPR + 4 rows GP, T_6 = Sole sorghum (60 cm × 10 cm) and T_7 = Sole GP (30 cm × 10 cm). Light availability on gardenpea decreased with the increase of shade produced by sorghum canopy over the time up to 60 DAS. The lowest light availability on gardenpea was observed in T_2 treatment and the highest was observed in sole gardenpea (T_7) followed by T_3 treatment in both the years. The maximum grain yield of sorghum was observed in T_6 and it was decreased (6-10% in 2018-2019 and 1-12% in 2019-2020) at Joydebpur and (5-11% in 2018-2019 and 6-14% in 2019-2020) at Burirhat. The highest sorghum equivalent yield (SEY) of 10.93 t ha^{-1} in 2018-2019 and 12.02 t ha^{-1} in 2019-2020 at Joydebpur and 12.06 t ha^{-1} in 2018-2019 and 11.77 t ha^{-1} in 2019-2020 at Burirhat and also the highest land equivalent ratio (LER) of 1.77 in 2018-2019 and 1.93 in 2019-2020 at Joydebpur and 1.79 in 2018-2019 and 1.81 in 2019-2020 at Burirhatwere observed in T_5 treatment. The highest gross margin of Tk.146600 ha^{-1} in 2018-2019 and Tk.168400 ha^{-1} in 2019-2020 at Joydebpur and Tk. 169200 ha^{-1} in 2018-2019 and Tk.163400 ha^{-1} in 2019-2020 at Burirhat and also the benefit cost ratio (BCR) of 3.04 in 2018-2019 and 3.34 in 2019-2020 at Joydebpur and 3.35 in 2018-2019 and 3.27 in 2019-2020 at Burirhat were also found in the same treatment. The results revealed that sorghum paired row + 4 rows gardenpea might be agronomically feasible and economically profitable for sorghum + gardenpea intercropping system at Joydebpur and Burirhat region.

Introduction

Intercropping is an important tool for getting higher productivity per unit area of land (Mahfuza *et al*., 2012). Higher productivity from intercropping depends on judicious choice of component crops, suitable planting system or proportion of component crops (Islam *et al*., 2006). Sorghum is an unbranched and erect cereal crop grown with a wide spacing. Several short duration and short stature vegetable like garden pea may be grown in association with sorghum. Sorghum grain is as nutritious as other cereal grains; contains about 11% water, 340 k.cal of energy, 11.6% protein, 73% carbohydrate and 3% fat by weight (Thimmaiah, 2002; Taylor *et al*., 2006; Yan *et al*., 2012). It is used as food, feed, fodder and fuel. Sorghum's health benefits include more antioxidants, high protein, fiber and gluten - free which make it a perfect dietary grain for all people, especially celiac patients. Certain sorghum

varieties are more easily digestible. On a field basis, sorghum yields have exceeded 11 t ha^{-1} with above average yields ranging from 7-9 t ha^{-1} where moisture is not a limiting factor.

Gardenpea is a very popular vegetable with rich in different nutrients. It contains about 68g water, 127 k.cal of energy, 7.4g protein, 24g carbohydrate and 26g calcium per 100 grams edible portion. Generally legumes in association with non-legumes helps not only in utilization of the nitrogen being fixed in the current growing season, but also helps in residual nutrients build up of the soil (Kakraliya *et al*., 2018). Legumes enrich the soil with N and thus facilitate a better environment to subsequent crops for better growth and productivity (Meena *et al.,* 2015). Legume cultivation releases up to seven times less GHGs per unit area than non-legume crops. Legumes allow the sequestration of carbon (1.42 Mg C ha^{-1} $year^{-1}$) in soils and induce the conservation of fossil energy inputs in the system (Kakraliya *et al*., 2018).

Farmers in the developing countries often demand for quick return from their crops, so they can get quick return by growing short duration vegetable crops with long duration crop like maize, sorghum *etc*. However, suitable intercrops, local food habit and market demands are important factors for getting higher benefit from intercropping. However, findings on profitability of sorghum + gardenpea intercropping under different planting systems are meagre in Bangladesh. So, this experiment was conducted to find out suitable intercrop combination and planting system of sorghum and gardenpea intercropping for higher productivity and economic return.

Materials and Methods

The field experiment was conducted at the Agronomy Research Field, Joydebpur, Gazipur and RARS, Burirhat, Rangpur, BARI during *Rabi* season of 2018-2019 and 2019-2020. The soil was silty clay in texture at Joydebpur (AEZ-28) and sandy loam at Burirhat, Rangpur (AEZ-3). Treatments included in the experiment were: T_1 = Sorghum normal row (SNR) + 1 row gardenpea (GP), T_2 = SNR + 2 rows GP, T_3 = Sorghum paired row (SPR) + 2 rows GP, T_4 = SPR + 3 rows GP, T_5 = SPR + 4 rows GP, T_6 = Sole sorghum (60 cm × 10 cm) and T_7 = Sole GP (30 cm × 10 cm). The experiment was laid out in a randomized complete block design with three replications and the unit plot size was 4.8m × 5m in both locations in both years. Local sorghum variety (BSL-20) and BARI Sorghum-1 was used in 1st and 2nd year, respectively, and BARI Motorshuti-3 were used in the experiment for both locations in both years. Seeds of sorghum and gardenpea were sown on same day. In 1st year, seeds were sown on 22 November 2018 at Joydebpur and 15 November 2018 at Burirhat and in 2nd year, seeds were sown on 24 November 2019 at Joydebpur and 17 November 2019 at Burirhat. Seeds of both crops were treated with provax @ 3g kg^{-1} of seed in both locations. Fertilizers were applied at the rate of 120-48-75-30-3-1 kg ha^{-1} of N, P, K, S, Zn, B 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 25 and 45 days after sowing (DAS) of sorghum. In intercrop, extra N (40 kg ha^{-1}) was applied in 2 splits at 20 and 35 DAS to gardenpea. Sole gardenpea was fertilized at the rate of 46- 25-31-13-2.1 kg ha^{-1} of N, P, K, S and Zn (FRG, 2018). One third of N and all other fertilizers were applied as basal. Rest N was applied in 2 splits at 20 and 35 DAS in both locations in both years. Light availability or Photosynthetically active radiation (PAR) was measured only at Joydebpur location by PAR Ceptometer (Model – LP-80, Accu PAR, Decagon, USA). The PAR was measured at 5-day intervals from 25 to 60 DAS at around 11:30 am to 13:00 pm. Four readings each of PARinc and PARt were recorded at different spots of each plot. The proportion of intercepted PAR (PARint) was calculated using the following equation and expressed in percentage (Ahmed *et al.,* 2010):

$$\text{Light availability } \{\text{PARint (\%)}\} = \frac{\text{PARinc} - \text{PARt}}{\text{PARinc}} \quad 100$$

Whrer, PARinc = Incident PAR, PARt = Transmitted PAR, PARint = Intercepted PAR.

There was no facility to measure light availability in Burirhat, Rangpur. Data on yield contributing characters of sorghum were taken from randomly selected 5 plants from each plot. Yields of both the crops were taken from whole plot area in both locations. In 1st year, sorghum was harvested on 4 April, 2019 and gardenpea was harvested 2 times on 20 and 28 January, 2019 and in 2nd year, gardenpea was harvested 2 times on 25 and 31 January, 2020 and sorghum was harvested on 14 April, 2020 at Joydebpur. On the other hand, in 1st year, sorghum was harvested on 5 April, 2019 and gardenpea was harvested 2 times on 25 January and 2 February, 2019 and in 2nd year, gardenpea was harvested 2 times on 2 and 10 February, 2019 and sorghum was harvested on 15 April, 2020 at Burirhat. In both locations, SEY was computed by converting yield of intercrops on the basis of prevailing market price of individual crop following the formula by Bandyopadhyay (1984) as given below:

Sorghum equivalent yield = Yis + (Yigp×Pgp)/ Ps

Where, Yis = Yield of intercropped sorghum, Yigp = Yield of intercropped gardenpea,
Ps = Market price of sorghum and Pgp = Market price of gardenpea.
Land equivalent ratio (LER) was obtained according to Willey (1979) as follows:

$$LER = \frac{\text{Yield of sorghum as intercrop}}{\text{Yield of sorghum as sole crop}} + \frac{\text{ld of gardenpea as intercrop}}{\text{ld of gardenpea as sole crop}}$$

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.

Results and Discussion

Light availability

Availability of light on sorghum and gardenpea in intercropping was not markedly affected with each other in both years. Because gardenpea was harvested at 55-60 DAS. At that time sorghum canopy could not produced much shade which might affect gardenpea. Irrespective of treatments, availability of light on gardenpea canopy was almost 100% at earlier growth stage, 30 DAS of gardenpea and it decreased with the increase of shade produced by sorghum canopy over the time up to 60 DAS or up to harvest of gardenpea. However, among the intercropping treatments, the higher light availability on gardenpea was observed in T_3 treatment followed by T_4 throughout the growing period in both the years. The lower light availability on gardenpea was observed in SNR + 2 rows gardenpea (T_2) followed by T_1 treatment and the lowest was observed at 60 DAS in the same treatment. Among all treatments, the highest light availability was observed in sole gardenpea (T_7) followed by T_3 treatment in both the years. Light availability on gardenpea canopy was more in the paired row than normal row of sorghum throughout the growing period and it was higher in 2019-2020 than that of 2018-2019 (Fig.1 a.2018-2019 and b. 2019-2020). It might be due to higher number of tillers hill^{-1} in local variety used in 1st year.

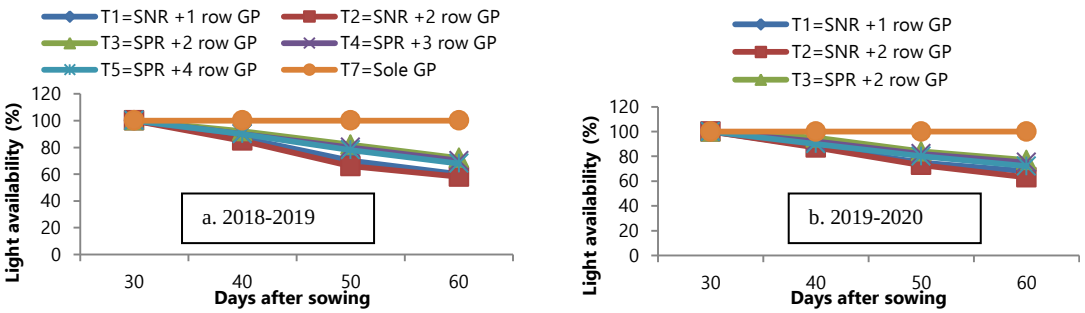

Fig. 1. Light availability on gardenpea canopy in sorghum + gardenpea intercropping systems at Joydebpur (a. 2018-2019 and b. 2019-2020).

Yield and yield components of sorghum

Grain yield and yield contributing characters of sorghum at both locations during *Rabi* of 2018-2019 and 2019-2020 have been presented in Table 1 and Table 2. Plant height, yield contributing characters (number of panicles hill^{-1}, panicle length, number of grains panicle^{-1}, 1000-grain weight) and grain yield of sorghum were not significantly differed among the treatments in both years in both locations.

At Joydebpur

The highest grain yield (3.87 t ha^{-1} in 1st year and 4.41 t ha^{-1} in 2nd year) were recorded in sole sorghum due to no intercrop competition for growth resources like light, nutrients, moisture and space in sole cropping.

Table 1. Plant height, panicle hill^{-1}, panicle length and grains panicle^{-1} of sorghum in sorghum + gardenpea intercropping during *Rabi* of 2019-2020 (Joydebpur and Burirhat, Rangpur)

Treatments	Plant height (cm)		Panicles hill^{-1} (no.)		Panicle length (cm)		Grains panicle^{-1} (no.)	
	2018-2019	2019-2020	2018-2019	2019-2020	2018-2019	2019-2020	2018-2019	2019-2020
Joydebpur								
T_1	185.3	134	5.3	2.1	18.40	16.6	784	1541
T_2	184.0	136	5.3	2.1	18.87	16.5	756	1543
T_3	192.0	136	5.0	2.1	18.67	16.8	723	1591
T_4	186.7	137	5.3	2.1	19.13	16.6	794	1597
T_5	185.7	136	5.7	2.2	19.80	16.8	742	1604
T_6	193.0	137	5.3	2.3	19.60	17.4	814	1615
$LSD_{(0.05)}$	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	7.80	3.82	6.05	8.63	5.70	6.88	10.37	6.13
Burirhat, Rangpur								
T_1	185.3	132	6.0	1.5	18.40	17.97	788	1570
T_2	187.7	135	6.0	1.0	18.87	17.83	759	1530
T_3	184.0	137	5.7	1.8	18.67	17.85	766	1582
T_4	183.3	128	5.7	1.1	19.13	18.15	798	1564
T_5	187.0	129	6.3	1.3	19.80	18.39	758	1574
T_6	190.3	139	6.7	2.6	19.60	18.72	818	1602
$LSD_{(0.05)}$	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	5.93	5.18	7.90	8.63	6.30	5.41	8.63	5.94

This corroborates with the findings of Begum *et al*. (2016). Among the intercropping system, T_5 (SPR + 4 rows GP) gave the highest grain yield (3.64 t ha^{-1} in 1st year and 4.39 t ha^{-1} in 2nd year) followed by T_4. The lowest grain yield (3.47 t ha^{-1} in 1st year and 3.90 t ha^{-1} in 2nd year) was recorded in SNR + 2 rows GP (T_2). However, grain yield of sorghum in different treatments were attributed by the cumulative effect of yield components.

At Burirhat, Rangpur

The highest grain yield (3.92 t ha^{-1} in 1st year and 4.46 t ha^{-1} in 2nd year) were recorded in sole sorghum due to no intercrop competition for growth resources like light, nutrients, moisture and space in sole cropping. This corroborates with the findings of Begum *et al*. (2016). Among the intercropping system, T_5 (SPR + 4 rows GP) gave the highest grain yield (3.71 t ha^{-1} in 1st year and 4.20 t ha^{-1} in 2nd year) followed by T_4. The lowest grain yield (3.49 t ha^{-1} in 1st year and 3.83 t ha^{-1} in 2nd year) was recorded in SNR + 1 row GP (T_1). However, grain yield of sorghum in different treatments were attributed by the cumulative effect of yield components.

Grain yield of sorghum in 2nd year was higher than that of in 1st year in both locations. It might be due to local variety of sorghum was used in 1st year and in 2nd year, HYV BARI sorghum-1 was used in both locations.

Table 2. 1000-grain weight and grain yield of sorghum in sorghum + gardenpea intercropping during *Rabi* of 2019-2020 (Joydebpur and Burirhat, Rangpur)

Treatments	1000-grain wt. (g)		Grain yield (t ha^{-1})		Yield decrease over sole sorghum (%)	
	2018-2019	2019-2020	2018-2019	2019-2020	2018-2019	2019-2020
Joydebpur						
T_1	16.67	33.13	3.54	3.94	9	11
T_2	16.93	32.13	3.47	3.90	10	12
T_3	16.93	33.33	3.52	3.91	9	11
T_4	16.60	33.73	3.54	4.12	9	7
T_5	16.67	33.80	3.64	4.39	6	1
T_6	17.07	33.32	3.87	4.41	-	-
LSD $_{(0.05)}$	NS	NS	NS	NS	-	-
CV (%)	5.50	5.31	5.84	9.64	-	-
Burirhat, Rangpur						
T_1	16.80	32.02	3.49	3.83	11	14
T_2	17.07	32.35	3.65	3.98	7	11
T_3	16.07	31.93	3.58	4.03	9	10
T_4	16.73	32.47	3.65	4.01	7	10
T_5	16.93	32.56	3.71	4.20	5	6
T_6	17.73	33.03	3.92	4.46	-	-
LSD $_{(0.05)}$	NS	NS	NS	NS	-	-
CV (%)	4.57	6.22	5.77	7.13	-	-

T_1 = Sorghum normal row (SNR) + 1 row gardenpea (GP), T_2 = SNR + 2 rows GP, T_3 = Sorghum paired row (SPR) + 2 rows GP, T_4 = SPR + 3 rows GP, T_5 = SPR + 4 rows GP, T_6 = Sole sorghum (60 cm × 10 cm) and T_7 = Sole GP (30 cm × 10 cm)

Yield of gardenpea

Yield and yield components of gardenpea in different sorghum + gardenpea intercropping in both the locations (Joydebpur and Burirhat, Rangpur) during *Rabi* of 2018-2019 and 2019-2020 have been presented in (Table 3). Number of plants m^{-2} and green pod yield of gardenpea were significantly influenced by different planting systems in both year and in both locations.

At Joydebpur

The highest number of plants m^{-2} was observed in sole gardenpea (28 m^{-2} in 1st year and 26 m^{-2} in 2nd year) and the lowest was observed in T_1 treatment (11 m^{-2} in 1st year and 10 m^{-2} in 2nd year) due to variation of planting system. The highest green pod yield (8.84 t ha^{-1} in 1st year and 8.18 t ha^{-1} in 2nd year) was found in sole gardenpea due to higher plant population per unit area. There was no intercrop competition for growth resources in sole cropping of gardenpea. Among the intercrop treatments, the highest green pod yield (7.29 t ha^{-1} in 1st year and 7.63 t ha^{-1} in 2nd year) was observed in T_5. The lowest green pod yield (3.89 t ha^{-1}) was observed in T_3 in 1st year and in T_1 in 2nd year (4.67 t ha^{-1}) due to the lowest number of plant population of gardenpea per unit area.

At Burirhat

More or less similar trend was observed in Burirhat. The highest number of plants m^{-2} was observed in sole gardenpea (30 m^{-2} in 1st year and 27 m^{-2} in 2nd year) and the lowest was observed in T_3 treatment (12 m^{-2} in both year) due to variation of planting system. The highest green pod yield (9.95 t ha^{-1} in 1st year and 8.68 t ha^{-1} in 2nd year) was found in sole gardenpea due to higher plant population per unit area. There was no intercrop competition for growth resources in sole cropping of gardenpea. Among

the intercrop treatments, the highest green pod yield (8.35 t ha^{-1} in 1st year and 7.57 t ha^{-1} in 2nd year) was observed in T_5. The lowest green pod yield (4.68 t ha^{-1}) was observed in T_3 in 1st year and in T_1 in 2nd year (5.02 t ha^{-1}) due to the lowest number of plant population of gardenpea per unit area.

Table 3. Plant height, yield and yield components of gardenpea in sorghum + gardenpea intercropping during *Rabi* of 2019-2020 (Joydebpur and Burirhat, Rangpur)

Treatments	Plant height (cm)		Plants m^{-2} (no.)		Pod $plant^{-1}$ (no.)		Seed pod^{-1} (no.)		Green pod yield (t ha^{-1})	
	2018-2019	2019-2020	2018-2019	2019-2020	2018-2019	2019-2020	2018-2019	2019-2020	2018-2019	2019-2020
Joydebpur										
T_1	50.33	48.5	12	10	6.33	6.4	5.07	5.07	4.76	4.67
T_2	51.40	51.4	21	23	6.27	6.4	5.13	5.13	6.44	7.62
T_3	50.87	48.5	11	13	7.13	7.2	5.07	5.07	3.89	4.72
T_4	51.87	50.5	14	15	6.73	6.8	5.13	5.13	6.25	6.92
T_5	52.67	51.3	21	23	6.53	6.6	5.20	5.20	7.29	7.63
T_7	49.47	48.4	28	26	7.33	7.4	6.87	6.87	8.84	8.18
$LSD_{(0.05)}$	NS	NS	4.06	5.54	NS	NS	NS	NS	1.05	2.47
CV (%)	10.20	5.94	8.35	12.20	13.30	8.77	6.67	6.67	6.60	14.42
Burirhat, Rangpur										
T_1	64.43	57.8	14	14	8.1	8.20	7.90	5.67	5.80	5.15
T_2	63.63	55.7	25	23	8.0	7.87	7.63	5.00	7.54	6.48
T_3	64.83	59.5	12	12	8.9	8.73	7.87	5.20	4.68	5.02
T_4	64.23	56.3	18	16	8.5	8.07	8.07	5.13	7.25	6.62
T_5	64.43	59.4	24	21	8.3	8.33	8.03	5.73	8.35	7.57
T_7	61.83	58.5	30	27	9.1	9.20	8.10	6.07	9.95	8.68
$LSD_{(0.05)}$	NS	NS	4.81	6.83	NS	NS	NS	NS	0.58	0.86
CV (%)	8.90	3.06	9.09	14.01	12.67	10.68	6.89	9.93	4.39	4.59

T_1= (SNR) +1 row GP, T_2=SNR +2 row GP, T_3= Sorghum paired row (SPR) +2 row GP, T_4=SPR +3 row GP, T_5= SPR +4 row GP, T_6=Sole sorghum (60 cm × 10 cm) and T_7= Sole GP (30 cm × 10 cm)

Evaluation of intercrop productivity

Sorghum and gardenpea intercrop productivity was evaluated on the basis of land equivalent ratio and sorghum equivalent yield (Bandyophadhyay, 1984). Land equivalent ratio (LER) and sorghum equivalent yield (SEY) of different treatment in both locations have been presented in Table 4. The LER values were found more than unity in all the intercropping systems indicated that land was more efficiently utilized under intercropping than sole cropping of sorghum and gardenpea.

At Joydebpur

The LER values in the intercrops ranged from 1.35 to 1.77 in 1st year and 1.46 to 1.93 in 2nd year which indicated that land utilization increased 35 to 77% in 1st year and 46 to 93% in 2nd year by intercropping. The highest LER (1.77 and 1.93 in 1st and 2nd year, respectively) was observed in SPR + 4 rows GP (T_5). SEY of all the intercropping systems was higher than sole sorghum indicating higher productivity of intercropping than sole sorghum. In intercropping, the highest sorghum equivalent yield (10.93 and 12.02 t ha^{-1} in 1st and 2nd year, respectively) was observed in T_5 treatment (SPR + 4 rows GP) which was 182 and 173% higher than sole sorghum in 1st and 2nd year, respectively. The lowest SEY was observed in T_6 (sole sorghum) in both years.

At Burirhat

Similar trend was observed in Burirhat. The LER values in the intercrops ranged from 1.38 to 1.79 in 1st year 1.43 to 1.80 in 2nd year and which indicated that land utilization increased 38 to 79% in 1st year and 43 to 80% in 2nd year by intercropping. The highest LER (1.79 and 1.80 in 1st and 2nd year,

respectively) was observed in SPR + 4 rows GP (T_5). SEY of all the intercropping systems was higher than sole sorghum indicating higher productivity of intercropping than sole sorghum. In intercropping, the highest sorghum equivalent yield (12.06 and 11.77 t ha^{-1} in 1st and 2nd year, respectively) was observed in T_5 treatment (SPR + 4 rows GP) which was 208 and 164% higher than sole sorghum in 1st and 2nd year, respectively. The lowest SEY was observed in T_6 (sole sorghum) in both years.

Table 4. Land equivalent ratio and sorghum equivalent yield as influenced by different planting systems in sorghum + gardenpea intercropping during *Rabi* of 2019-2020 (Joydebpur and Rangpur)

Treatments	LER		SEY (t ha^{-1})		% increased of SEY over sole sorghum	
	2018-2019	2019-2020	2018-2019	2019-2020	2018-2019	2019-2020
Joydebpur						
T_1	1.44	1.46	8.30	8.61	115	95
T_2	1.64	1.82	9.91	11.52	156	161
T_3	1.35	1.46	7.41	8.63	92	96
T_4	1.62	1.78	9.79	11.04	153	150
T_5	1.77	1.93	10.93	12.02	182	173
T_6	1.00	1.00	3.87	4.41	-	-
T_7	1.00	1.00	8.84	8.18	-	-
Burirhat						
T_1	1.47	1.45	9.29	8.98	137	101
T_2	1.69	1.64	11.19	10.46	186	135
T_3	1.38	1.48	8.26	9.05	111	103
T_4	1.66	1.66	10.90	10.63	178	138
T_5	1.79	1.81	12.06	11.77	208	164
T_6	1.00	1.00	3.92	4.46	-	-
T_7	1.00	1.00	9.95	8.68	-	-

T_1 = Sorghum normal row (SNR) + 1 row gardenpea (GP), T_2 = SNR + 2 rows GP, T_3 = Sorghum paired row (SPR) + 2 rows GP, T_4 = SPR + 3 rows GP, T_5 = SPR + 4 rows GP, T_6 = Sole sorghum (60 cm × 10 cm) and T_7 = Sole GP (30 cm × 10 cm)

Economic performance

Cost and return analysis is an important tool to evaluate the economic feasibility of intercropping system and monetary advantage was evaluated according to Shah *et al*. (1991). Benefit cost analysis of sorghum + gardenpea intercropping systems in both locations have been presented in Table 5. Gross return and BCR depends on equivalent yield.

At Joydebpur

Among intercropping treatments, the highest gross return (Tk. 218600 ha^{-1} and Tk. 240400 ha^{-1} in 1st and 2nd year, respectively) was observed in T_5 treatment (sorghum paired row + 4 rows gardenpea) and it was close to T_2 owing to higher SEY in both years. The gross margin also followed the similar trend of gross return. Cost of production differed among the treatments. The highest cost of production was recorded in T_5 treatment which was close to T_2 (SNR + 2 rows GP) due to involvement of higher costs (higher amount of gardenpea seed and labor cost) in both years. Among intercropping treatments, the highest benefit cost ratio (3.04 and 3.34 in 1st and 2nd year, respectively) was obtained from T_5 (SNR + 4 rows GP) treatment. This result has been supported by the findings of Islam *et al.* (2013).

At Burirhat

Among intercropping treatments, the highest gross return (Tk. 241200 ha^{-1} and Tk. 235400 ha^{-1} in 1st and 2nd year, respectively) was observed in T_5 treatment (sorghum paired row + 4 rows gardenpea) and

it was close to T_2 owing to higher SEY in both years. The gross margin also followed the similar trend of gross return.

Table 5. Benefit cost analysis of sorghum + gardenpea intercropping under different planting system during *rabi* of 2018-2019 and 2019-2020 (Joydebpur and Burirhat, Rangpur)

	Gross return (Tk. ha^{-1})		Cost of cultivation (Tk. ha^{-1})		Gross margin (Tk. ha^{-1})		BCR	
	2018-2019	2019-2020	2018-2019	2019-2020	2018-2019	2019-2020	2018-2019	2019-2020
Joydebpur								
T_1	166000	172200	66000	66000	100000	106200	2.52	2.61
T_2	198200	230400	73500	73500	124700	156900	2.70	3.13
T_3	148200	172600	66000	66000	82200	106600	2.25	2.62
T_4	195800	220800	70500	70500	125300	150300	2.78	3.13
T_5	218600	240400	72000	72000	146600	168400	3.04	3.34
T_6	77400	88200	52500	52500	24900	35700	1.47	1.68
T_7	176800	163600	61500	61500	115300	102100	2.87	2.66
Burirhat								
T_1	185800	179600	66000	66000	119800	113600	2.82	2.72
T_2	223800	209200	73500	73500	150300	135700	3.04	2.85
T_3	165200	181000	66000	66000	99200	115000	2.50	2.74
T_4	218000	212600	70500	70500	147500	142100	3.09	3.02
T_5	241200	235400	72000	72000	169200	163400	3.35	3.27
T_6	78400	89200	52500	52500	25900	36700	1.49	1.70
T_7	199000	173600	61500	61500	137500	112100	3.24	2.82

T_1= (SNR) +1 row GP, T_2=SNR +2 rows GP, T_3= Sorghum paired row (SPR) +2 rows GP, T_4=SPR +3 rows GP, T_5= SPR +4 rows GP, T_6=Sole sorghum (60 cm × 10 cm) and T_7= Sole GP (30 cm × 10 cm) Market price (Tk kg^{-1}): Sorghum = 20, gardenpea = 20 in both locations

Cost of production differed among the treatments. The highest cost of production was recorded in T_5 treatment which was close to T_2 (SNR + 2 rows GP) due to involvement of higher costs (higher amount of gardenpea seed and labor cost) in both years. Among intercropping treatments, the highest benefit cost ratio (3.35 and 3.27 in 1st and 2nd year, respectively) was obtained from T_5 (SNR + 4 rows GP) treatment. This result has been supported by the findings of Islam *et al.* (2013).

Conclusion

Result revealed that all the intercropping showed better productivity and profitability than growing sole sorghum. Sorghum paired row + 4 rows gardenpea intercropping was found agronomically feasible and economically profitable in Joydebpur and Rangpur.

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