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Effect of plant spacing of different sweet gourd cultivars on potato yield in intercropping system

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ABSTRACT

A field experiment on intercropping of different varieties of sweet gourd with potato was conducted at farmer's field of Mymensingh, Bangladesh during Robi season of 2015-2016 to evaluate the performance of potato production in intercropping system and to increase crop productivity. Five crop combinations viz., Sole potato, 100% potato + 1.5 m distance from plant to plant of sweet gourd, 100% potato + 2 m distance from plant to plant of sweet gourd, 100% potato + 2.5 m distance from plant to plant of sweet gourd, 100% potato + 3 m distance from plant to plant of sweet gourd and three sweet gourd varieties viz. BARI Mistikumra 2, BARI Hybrid Mistikumra 1, and local variety were used in this experiment. Result revealed that among the treatment combinations, sole potato performed better and yielded the highest (22.73 t ha^{-1}). The lowest tuber yield (19.31 t ha^{-1}) was recorded with 100% potato + 1.5 m distance from plant to plant of sweet gourd treatment combination. Potato yield was higher (22.14 t ha^{-1}) with local cultivar of sweet gourd, while potato with BARI Hybrid Mistikumra 1 gave the lowest yield (20.14 t ha^{-1}). Potato yield was reduced 2.33 to 28.89% due to cultivation of sweet gourd with different plant spacing but total productivity increased (9 - 106%) due to the contribution of companion crop. The highest potato equivalent yield (42.6 t ha^{-1}) was recorded in 100% potato + 2 m distance from plant to plant of sweet gourd crop combination. It also gave the highest gross margin (3, 93,550 Tk. ha^{-1}). Intercropping of BARI Hybrid Mistikumra 1 maintaining 2 m distance from plant to plant with potato, can be recommended to achieve higher productivity and profitability.

Introduction

Intercropping is a way of increasing crop production per unit land area by intensifying the use of land in many countries like Bangladesh, India, Sri Lanka, China and Africa. It increases total productivity through efficient utilization of land, labour and growth resources (Ahmed et al., 2006). Greater productivity in intercropping system is commonly achieved by minimizing inter-specific competition and maximizing complementary use of growth resources (Islam, 2002). Inter-specific competition may be minimized through judicious choice of crops (Santalla et al., 2001). Usually plants differing in growth duration, height, rooting systems and nutrient requirements are considered to growth together in intercropping systems (Reddy & Willey, 1981). It also increase land equivalent ratio (LER) of varying degrees (Mehta & Dey, 1980; Hashem et al., 1990).

Potato (*Solanum tuberosum*) is the major tuber crops in Bangladesh ranked 7th in the world in terms of production in 2011. In Bangladesh it is the 3rd most important crop next to rice and wheat which occupies only 3.13% of total cultivated area of Bangladesh (FAOSTAT, 2013; MOA, 2013). It has the capacity of producing more calories and protein per unit land area with minimum time and water than most other major food crops (Upadhaya, 1995). The area and production of potatoes are increasing day by day due to its higher demand and profitability. The annual growth rates of area, production and yield of potato were estimated at 7.14, 9.90 and 2.76% during 1989-1990 to 2008-2009, respectively (Miah et al., 2011). Among the 67 HYV potato varieties released by Tuber Crop Research Center of BARI, BARI Alu 7 (Diamant) has popularity because of its high yield potential and tolerant to insect pest and diseases.

Intercropping is a common practice among the farmers' of Bangladesh. Crop productivity may increase by cultivating vegetable crops like sweet gourd with potato. Sweet gourd (*Cucurbita moschata*) is a promising horticultural crop in Bangladesh as it fulfills a major portion of vegetable demand of the peoples of our country. The main nutrients of sweet gourd are lutein and both alpha and beta carotene, the latter of which generates vitamin A in the body. Sweet gourd is very versatile in their uses for cooking. Most parts of this vegetable are edible, including the green fleshy fruit, the seeds, the leaves, twigs and even the flowers. It was observed that if seeds of sweet gourd sown after 20 days of potato germination, the canopy of the sweet gourd cover the whole plot after potato harvest. However, in this case spacing of the sweet gourd should be maintained, without hampering the main crop potato. Therefore, to utilize the land sweet gourd can be grown easily. Most of the intercropping system researches have concentrated on field crops, like Soya bean, maize, Negro bean which are searched by Galal (1998), Santalla et al. (2001), Kunchinda et al. (2003) and Ghosh et al. (2006).

There are a number of studies done on intercropping system of potatoes and maize (Saddam, 2009). Sweet gourd intercrop with potato, as a new one will be successful if the spacing of sweet gourd can maintain properly and suitable

variety can be selected. Therefore, this experiment was conducted to find out suitable spacing and variety of sweet gourd with potato crop combination in intercropping system with proportion for higher productivity and a maximum economic return.

Materials and methods

The experiment was conducted at Muktagacha, Mymensingh during Rabi 2015-2016. It was laid out in randomized complete block design with three replications. Five treatment combinations viz., sole potato, 100% potato + 1.5 m distance from plant to plant of sweet gourd, 100% potato + 2 m distance from plant to plant of sweet gourd, 100% potato + 2.5 m distance from plant to plant of sweet gourd, 100% potato + 3 m distance from plant to plant of sweet gourd and three sweet gourd varieties viz. BARI Mistikumra 2, BARI Hybrid Mistikumra 1, and local variety were used in this experiment. BARI Alu 7 (Diamant) was used as potato cultivar. The unit plot size was 6 m × 3 m. The soil of the experimental site belongs to AEZ- 9. The soil was acidic in nature and sandy loam in texture. Soil sample were collected and analyzed following standard method in the laboratory of Soil Science Division of BARI (Table 1).

Table 1. Chemical properties of initial soil (0-15 cm depth) of the experimental field.

Location and status	p^H	Organic matter (%)	Total N (%)	K (meq/ 100 g soil)	P	S	Zn	B
					Microgram/ g soil			
Muktagacha	6.0	1.56	0.07	0.14	11.20	18.55	1.09	0.29
Status	Acidic	low	Very low	low	optimum	optimum	medium	medium

Manures and fertilizers were applied at the rate of 10 t ha^{-1} cowdung and 115-30-110-21-3.5 Kg of NPKSZnB ha^{-1}, respectively in the form of urea, TSP, MOP, gypsum, zinc sulphate and boric acid as per recommendation of TCRC. Half amount of N and full dose of other fertilizers were applied during final land preparation. The rest amount of N fertilizer was applied at 35 DAS. Whole tuber seeds of potato (var. BARI Alu 7) were sown on 22 November 2015 maintaining 60 cm × 20 cm spacing. Before sowing, seed tubers were treated with 3% Boric acid solution. Seeds of sweet gourd varieties were sown after every 3 rows of potato following the spacing of the treatments and after fully earthing up, on 15 December, 2015. Three times irrigation was given up to 56 days of plant age of potato. Indofil and Secure were sprayed at 10 days interval up to 65 days after sowing of potato. Potato was harvested on 17 to 22 February, 2016. After harvesting of potato two times irrigation and fertilizer (urea and MoP) were applied to ensure quick growth of sweet gourd. Pheromone trap was used for controlling of insect pest of sweet gourd. Sweet gourd was harvested from 25 March to 30 April, 2016. Data on yield and yield contributing characters were recorded plot wise and converted it to t ha^{-1}. Collected data were analyzed statistically with the help of MSTAT-C program and mean separation was done as per least significant difference (LSD) test at 5% level of significance. Potato equivalent yield (PEY) was calculated according to Prasad and Srivastava (1991). Economic analyses were done to assess the economic productivity of the intercropping systems.

$$\text{PEY (t/ha)} = \text{Yield of potato} + \frac{\text{Yield of intercrop sweet gourd} \times \text{market price of sweet gourd}}{\text{Market price of Potato}}$$

Results and discussion

Yield and yield components of Potato

Effect of plant spacing

The yield and yield contributing characteristics of potato influenced by treatments are presented in Table 2. Results revealed that plant height, diameter of tuber, weight of tuber per plant and yield (ton per hectare) were statistically significant except number of tuber per plant and tuber length. The longest plant was found in sole cropping and it was 55.53 cm. Uddin et al. (2009) found the highest plant height from sole cropping in maize and potato per vegetables intercropping. Tuber diameter ranges from 4.18 to 4.42 cm. The highest tuber weight per plant was recorded in sole cropping (378.94 g) and the lowest was obtained from T_2 treatment combination (321.85 g). Sole potato yielded the highest (22.73 t ha^{-1}), while the treatment T_2 gave the lowest tuber yield (19.31 t ha^{-1}). Higher tuber yield in T_1 (sole cropping) was attributed due to large size, higher tuber weight and also for no companion crop. Potato 100% + 3 m distance from plant to plant of sweet gourd (T_5) treatment gave the second highest yield and it was 21.61 t ha^{-1} followed by T_4 (21.08 t ha^{-1}). This result is attributed to the lowest plant density of sweet gourd plants, which reduced the competition between the plants and helped potato plants to benefit more from light radiation. Therefore, a positive increase in the fresh weight of potato plants was possible. Saddam (2009) also reported the same result in maize and potato intercropping system.

Table 2. Effect of spacing and cultivar on yield and yield contributing characters of potato in intercropping system at Muktagacha, Mymensingh during 2015-16.

Spacing of potato and sweet potato cultivar	Plant height (cm)	Tubers plant^{-1}	Length of tuber (cm)	Diameter of tuber (cm)	Tuber weight plant^{-1} (g)	Yield (t ha^{-1})
T_1	55.53	8.83	6.21	4.40	378.94	22.73
T_2	47.93	8.46	5.84	4.18	321.85	19.31
T_3	49.62	8.59	5.88	4.24	347.41	20.84
T_4	50.95	8.63	5.93	4.34	351.20	21.08
T_5	54.36	8.91	6.09	4.42	360.19	21.61
LSD (0.05)	1.51	NS	NS	0.19	30.86	1.85
CV(%)	3.03	7.82	5.27	4.45	9.08	9.09

NS= Not significant; T_1: Sole potato, T_2: 100% potato + 1.5 m distance from plant to plant of sweet gourd, T_3: 100% potato + 2 m distance from plant to plant of sweet gourd, T_4: 100% potato + 2.5 m distance from plant to plant of sweet gourd, T_5: 100% potato + 3 m distance from plant to plant of sweet gourd.

Table 3. Effect of varieties of sweet gourd on yield and yield contributing characters of potato in intercropping system at Muktagacha, Mymensingh during 2015-16.

Varieties	Plant height (cm)	Tubers plant^{-1}	Length of tuber (cm)	Diameter of tuber (cm)	Tuber weight plant^{-1} (g)	Yield (t ha^{-1})
V_1	52.83	8.40	6.09	4.31	350.87	21.05
V_2	50.45	8.67	5.85	4.34	335.77	20.14
V_3	51.76	8.99	6.03	4.31	369.11	22.14
LSD (0.05)	1.17	0.51	NS	NS	23.91	1.44
CV (%)	3.03	7.82	5.72	4.45	9.08	9.09

NS= Not significant; V_1: BARI Mistikumra 2, V_2: BARI Hybrid Mistikumra 1, V_3: local variety

Effect of sweet gourd varieties

Yield components and tuber yield of potato influenced by sweet gourd varieties are presented in Table 3. All the parameters except tuber length and diameter show significant difference. The highest no of tuber per plant (8.99) was found from potato with local cultivar and the lowest number (8.40) from potato with BARI Mistikumra 2. The highest tuber weight per plant (369.11 g) and tuber yield (22.14 t ha^{-1}) was recorded in potato with local sweet gourd variety. Whereas the lowest (335.77 g tuber weight and 20.14 t ha^{-1} tuber yield) found from potato with BARI Hybrid Mistikumra 1. This is because of canopy structure and high yielding potentiality of BARI Hybrid Mistikumra 1. Competition for light between main crop and intercrop depends upon vegetative characteristics, nutrient uptake and yielding behavior of the two crops. Monteith (1977) insures that the total biological yield of plants depends directly on the quantum of light intercepted by green foliage of plants.

Interaction effect of plant spacing and sweet gourd varieties

The yield and yield contributing characters except plant height of potato did not differ significantly in interaction effect of plant spicing and varieties of sweet gourd (Table 4). Similar result was found from the report of Detpiratmongkol et al. (2011). They found no interaction between plant spacing and variety of sweet potato. Highest plant height (57.53 cm) was found from sole potato and the lowest (46.93 cm) from T_2V_3 treatment combination. However, average tuber weight per plant in different interactions was statistically identical and it ranged from 315 to 406.11 g across the interactions. The highest tuber yield (24.36 t ha^{-1}) was obtained from T_1V_3 and it was statistically at par with T_1V_1. The lowest tuber yield (18.9 t ha^{-1}) was found in T_2V_3 treatment combination. Intercropping had a negative influence on the mean weight of potato tuber, which resulted in a lower weight and yield of tubers compared to sole potato (Saddam, 2009).

Potato yield was reduced 2.33 to 28.89% due to cultivation of sweet gourd with potato (Table 3). Sharaiha et al. (2004) reported that potato productivity have reduced up to 61%, when it was intercropped with maize crops, compared to the sole cropped potato and this reduction is related to low solar radiation intercepted by potato plants and its small leaf area.

Table 4. Combined effect of spacing and variety on yield and yield contributing characters and reduced yield (%) of potato for intercropping at Muktagacha, Mymensingh during 2015-16.

Interaction	Plant height (cm)	Tubers plant^{-1}	Length of tuber (cm)	Diameter of tuber (cm)	Tuber weight plant^{-1} (g)	Yield (t ha^{-1})	Yield reduction (%)
T_1V_1	56.0	8.50	6.36	4.43	386.28	23.16	-
T_1V_2	53.07	9.33	6.08	4.47	344.45	20.67	-
T_1V_3	57.53	8.67	6.19	4.30	406.11	24.36	-
T_2V_1	49.07	7.94	5.96	4.17	327.78	19.66	17.80
T_2V_2	47.8	8.67	5.58	4.17	322.78	19.37	6.71
T_2V_3	46.93	8.78	5.98	4.20	315.00	18.90	28.89
T_3V_1	50.93	8.00	5.96	4.17	338.89	20.30	14.09
T_3V_2	49.87	8.39	5.72	4.30	328.33	19.70	4.92
T_3V_3	48.07	9.38	5.97	4.27	375.00	22.50	8.27
T_4V_1	53.00	8.66	6.13	4.33	349.17	20.97	10.44
T_4V_2	50.00	8.39	5.81	4.33	330.00	19.80	4.39
T_4V_3	49.87	8.83	5.86	4.37	374.44	22.47	8.41
T_5V_1	55.13	8.89	6.06	4.43	352.22	21.13	9.61
T_5V_2	51.53	8.55	6.06	4.43	353.33	20.20	2.33
T_5V_3	56.40	9.28	6.15	4.40	375.00	22.50	8.27
LSD (0.05)	2.62	NS	NS	NS	NS	NS	-
CV (%)	3.03	7.82	5.27	4.45	9.08	9.09	-

NS= Not significant; T_1: Sole potato, T_2: 100% potato + 1.5 m distance from plant to plant of sweet gourd, T_3: 100% potato + 2 m distance from plant to plant of sweet gourd, T_4: 100% potato + 2.5 m distance from plant to plant of sweet gourd, T_5: 100% potato + 3 m distance from plant to plant of sweet gourd. V_1: BARI Mistikumra 2, V_2: BARI Hybrid Mistikumra 1, V_3: local variety.

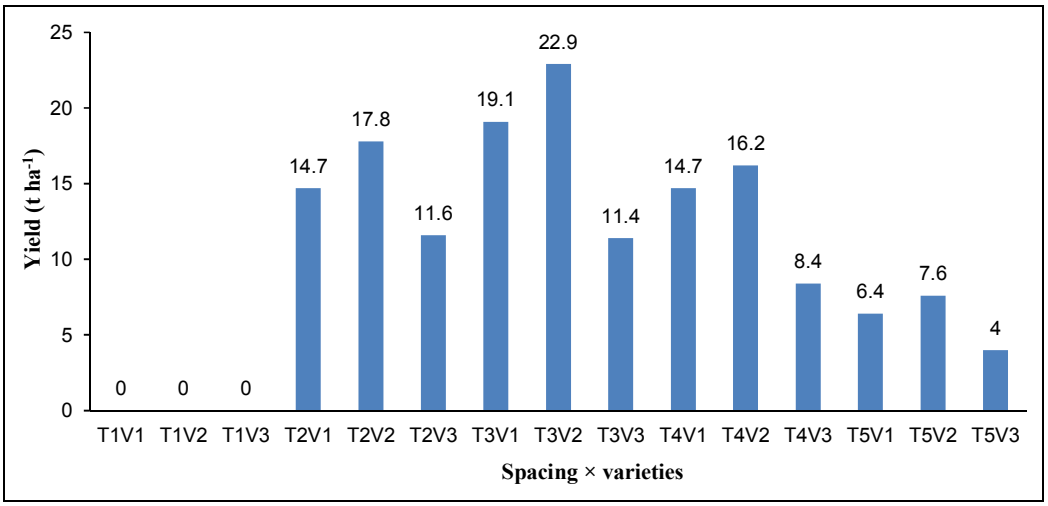

Fig.1. Sweet gourd yield (t ha^{-1}) in potato-sweet gourd intercropping system. T_1: Sole potato, T_2: 100% potato + 1.5 m distance from plant to plant of sweet gourd, T_3: 100% potato + 2 m distance from plant to plant of sweet gourd, T_4: 100% potato + 2.5 m distance from plant to plant of sweet gourd, T_5: 100% potato + 3 m distance from plant to plant of sweet gourd. V_1: BARI Mistikumra 2, V_2: BARI Hybrid Mistikumra 1, V_3: local variety.

Yield of companion crop

Sweet gourd varieties yield ranges from 4 t ha^{-1} to 22.9 t ha^{-1}. Among the varieties BARI Hybrid Mistikumra 1 gave highest yield in the combination effect of T_3V_2 and it was 22.9 t ha^{-1}. Sweet gourd varieties with 2 m spacing gave highest yield in all the treatment combinations. On the other hand, local variety gave the lowest yield and the lowest yield was recorded 4 t ha^{-1} in the combination effect of T_5V_3 (Fig. 1).

Potato equivalent yield

Total productivity was expressed in PEY. The highest potato equivalent yield (42.6 t ha^{-1}) was calculated from combination effect of BARI Hybrid Mistikumra 1 with 100% potato + 2 m distance from plant to plant of sweet gourd followed by BARI Mistikumra 2 with 100% potato + 2 m distance from plant to plant of sweet gourd (39.5 t ha^{-1}) and the lowest equivalent yield (20.7 t ha^{-1}) was obtained from sole potato (Fig. 2). Intercropping increased

productivity by 9-106% over each sole potato (Fig. 3). Among the treatment combinations, BARI Hybrid Mistikumra 1 with 100% potato + 2 m distance from plant to plant of sweet gourd (T_3V_2) increased 106% productivity over sole cropping. Saddam (2009) reported similar result and they found 1-24% increased ratio compared with the productivity of sole potato and 71-109% compared with the productivity of sole maize.

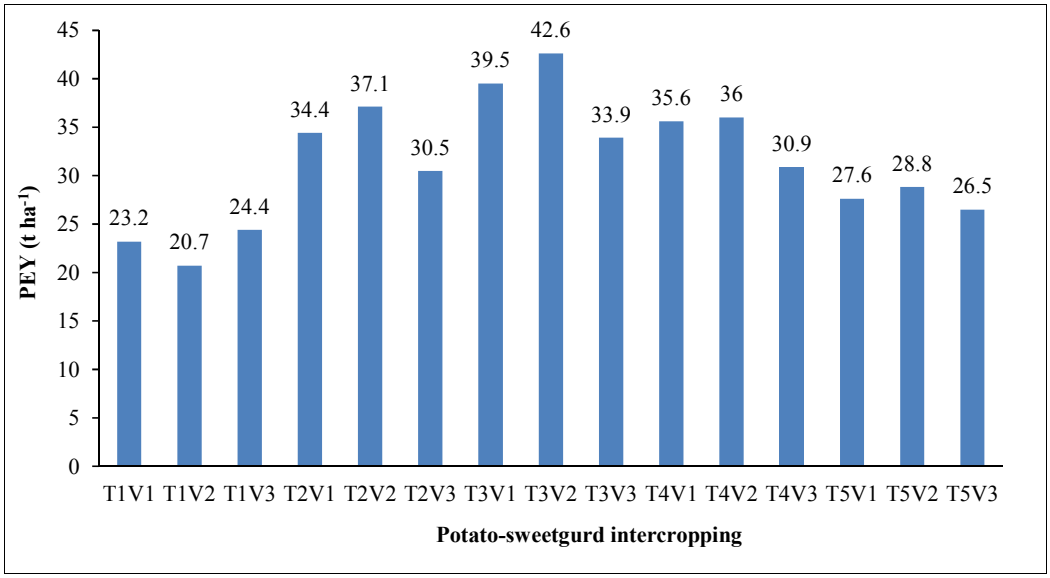

Fig. 2. Potato equivalent yield (t ha^{-1}) in potato- sweet gourd intercropping system. T_1: Sole potato, T_2:100% potato + 1.5 m distance from plant to plant of sweet gourd, T_3: 100% potato+ 2 m distance from plant to plant of sweet gourd, T_4: 100% potato + 2.5 m distance from plant to plant of sweet gourd, T_5: 100% potato + 3 m distance from plant to plant of sweet gourd. V_1: BARI Mistikumra 2, V_2: BARI Hybrid Mistikumra 1, V_3: local variety.

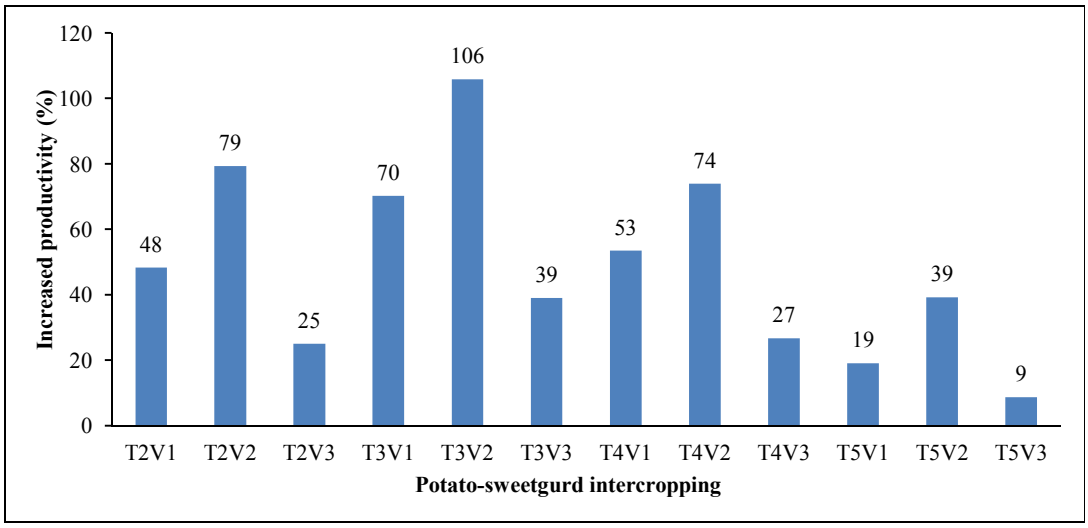

Fig. 3. Increased productivity (%) of potato- sweet gourd intercropping over sole cropping. T_1: Sole potato, T_2: 100% potato + 1.5 m distance from plant to plant of sweet gourd, T_3: 100% potato + 2 m distance from plant to plant of sweet gourd, T_4: 100% potato + 2.5 m distance from plant to plant of sweet gourd, T_5: 100% potato + 3 m distance from plant to plant of sweet gourd. V_1: BARI Mistikumra 2, V_2: BARI Hybrid Mistikumra 1, V_3: local variety.

Table 5. Economic performance of potato in intercropping system.

Interaction	Gross return (Tk. ha^{-1})	Variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	BCR
T_1V_1	278400	101975	176425	2.73
T_1V_2	248400	101975	146425	2.44
T_1V_3	292800	101975	190825	2.87
T_2V_1	412800	117650	295150	3.51
T_2V_2	445200	117650	327550	3.78
T_2V_3	366000	117650	248350	3.11
T_3V_1	474000	117650	356350	4.02
T_3V_2	511200	117650	393550	4.34
T_3V_3	406800	117650	289150	3.45
T_4V_1	427200	117650	309550	3.63
T_4V_2	432000	117650	314350	3.67
T_4V_3	370800	117650	253150	3.15
T_5V_1	331200	117650	213550	2.81
T_5V_2	345600	117650	227950	2.93
T_5V_3	318000	117650	200350	2.70

Price of input and output: Urea Tk. 20 kg^{-1}, TSP Tk. 22 kg^{-1}, MoP Tk. 15 kg^{-1}, Gypsum Tk. 10 kg^{-1}, Zinc sulphate Tk. 130 kg^{-1}, boric acid Tk. 130 kg^{-1}, Potato Tk. 12 kg^{-1}, and Sweet gourd Tk. 12 kg^{-1}. T_1: Sole potato, T_2: 100% potato + 1.5 m distance from plant to plant of sweet gourd, T_3: 100% potato + 2 m distance from plant to plant of sweet gourd, T_4: 100% potato + 2.5 m distance from plant to plant of sweet gourd, T_5: 100% potato + 3 m distance from plant to plant of sweet gourd. V_1: BARI Mistikumra 2, V_2: BARI Hybrid Mistikumra 1, V_3: local variety.

Economic performance

Cost and return analysis of intercropping sweet gourd with potato has been shown in Table 5. Result showed that the maximum gross return (Tk. 5,11,200 ha^{-1}) and gross margin (Tk. 3,93,522 ha^{-1} was recorded in combination effect of BARI Hybrid Mistikumra 1 with 100% potato + 2 m distance from plant to plant of sweet gourd. The minimum gross return (Tk. 248400 ha^{-1}) and gross margin (Tk. 146425 ha^{-1}) was calculated from sole potato. The highest benefit cost ratio (BCR) was obtained from T_3V_2 crop combination (4.34), whereas the lowest from sole potato (2.44). Additional yield of companion crops has contributed to increase the profitability over sole potato cropping. Ijoyah and Dzer (2012) also reported that intercropping gave greater combined yields and monetary returns than those obtained from sole cropping.

Conclusion

Farmers of Mymensingh region generally cultivate potato as a sole crop. But now they are interested to cultivate sweet gourd as intercrop with potato, because sweet gourd does not hamper potato yield as its vegetative structure starts developing after potato harvest. Intercropping increased total productivity as well as crop diversity and risk of cultivation of one crop can be reduced by intercropping. For intercropping, selection of suitable cultivar and proper spacing of intercrops are the important factors. From this study that performed at farmers' level concluded that intercropping of BARI Hybrid Mistikumra 1 maintaining 2 m distance from plant to plant with potato, can be recommended to achieve higher productivity and profitability.

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