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INTERCROPPING ONION AND GARLIC WITH BRINJAL UNDER DIFFERENT PLANTING SYSTEM

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Abstract

The experiment was conducted at the Agronomy Research Field of Bangladesh Agricultural Research Institute, Gazipur during *rabi* season of 2019-2020 and 2020-21 to find out the suitable crop combination of onion and garlic with brinjal for increasing total productivity, economic return and maximize land utilization through intercropping system. Seven treatments viz., T_1= Brinjal (80 cm × 60 cm) 100% + 4 row onion (15 cm × 10 cm) 57%, T_2= Brinjal (80 cm × 60 cm) 100% + 3 row onion (15 cm × 10 cm) 43%, T_3= Brinjal (80 cm × 60 cm) 100% + 4 row garlic (15 cm × 10 cm) 57%, T_4= Brinjal (80 cm × 60 cm) 100% + 3 row garlic (15 cm × 10 cm) 43%, T_5= Sole brinjal (80 cm × 60 cm) 100%, T_6= Sole onion (15 cm × 10 cm) 100%, T_7= Sole garlic (15 cm × 10 cm) 100% were used in the study. Results showed that light availability on onion and garlic decreased with the increased of shade produced by brinjal canopy over the time up to 95 days after transplanting of onion seedling and planting of garlic cloves. In both the years, throughout the growing period of onion and garlic the maximum light availability was observed in T_6 (sole onion) and T_7 (sole garlic) treatments followed by T_4 treatment (3 row garlic 43% in between two row of brinjal 100%) and T_3 treatments (4 row garlic 57% in between two row of brinjal 100%) and the minimum light availability was observed in T_1 treatment (4 row onion 57% in between two row of brinjal 100%) followed by T_2 treatment (3 row onion 43% in between two row of brinjal 100%). Light availability was more in brinjal + garlic intercropping system than brinjal + onion intercropping system throughout the growing period. All the intercropping combinations showed better performance in terms of brinjal equivalent yield, gross return, gross margin and benefit cost ratio (BCR) over sole crops. Among the intercropping combination, 4 row garlic (15 cm × 10 cm) 57% in between two row of brinjal (80 cm × 60 cm) 100% was the agronomically most feasible and profitable intercropping system in respect of brinjal equivalent yield (36.42 t ha^{-1}), land equivalent ratio (LER)1.29, gross return (Tk.7,28,333 ha^{-1}), gross margin (Tk.4,76,596 ha^{-1}) and benefit cost ratio (2.89).

Introduction

Bangladesh is a densely populated country. Day by day its total cropped area is declining due to urbanization, increase of population and industrialization. As a result, our total food demands are increasing. Intercropping is a traditional practice in Bangladesh and it increases total productivity per unit area through maximum utilization of land, labour and growth resources (Ahmed *et al.*, 2013). By judicious choice of compatible crops and adopting appropriate planting geometry, inter/intra specific competition may be minimized resulting higher total productivity (Alom *et al.*, 2013). Canopy architecture of tall stature crop regulates the availability of light on under storied crop (Faruque *et al.*, 2006). In Bangladesh small farmers constitute 79.4% of our farming community and their cultivated lands are shrinking day by day (MOA, 2014). In that context, intercropping is one of the viable technology to ensure efficient utilization of their resources for increased production and family income. Intercropping offers the possibility of yield

advantage relative to sole cropping through yield stability and improved yield in tropical and sub-tropical areas (Nazir *et al.*, 2002; Malik *et al.*, 2002; Bhatti *et al.*, 2005). Brinjal is a long duration (160-180 days) and wide spaced (80 cm × 60 cm) crop. So, there is a great possibility to cultivate minimum canopy spread herbaceous plant like onion and garlic in the inter row space of brinjal. Onion or garlic can be cultivated together with brinjal as they have different growth habit and duration. Productivity can be increased through intercropping of these two crops. Farmers can be benefited economically by proper utilization of the resources as well as contributing to food security and nutritional aspect. On the other hand, onion and garlic is the high value spices crop that market value always remains high (Onion around 40 to 50 Tk kg^{-1} and garlic around 100 to 120 Tk kg^{-1}) and they have also repellent character which may help in control brinjal shoot and fruit borer. So, there is a great possibility to cultivate minimum canopy spread herbaceous plant like onion and garlic in the inter row space of brinjal. Productivity can be increased through intercropping of these crops. However, the literature regarding onion-brinjal and garlic-brinjal intercropping is very scarce. Keeping this view in mind, the experiment was undertaken to find out suitable intercrop combination of onion and garlic with brinjal for increasing total productivity, economic return and maximize land utilization through intercropping system.

Materials and Methods

A field experiment was conducted at Agronomy Research Field of Bangladesh Agricultural Research Institute, Gazipur during *rabi* season of 2019-20 and 2020-21. The soil was silty clay loam with pH 6.3 belonging to Agro Ecological Zone (AEZ) 28. The treatments were: T_1= Brinjal normal row (80 cm × 60 cm) 100% + 4 row onion (15 cm × 10 cm) 57%, T_2= Brinjal normal row (80 cm × 60 cm) 100% + 3 row onion (15 cm × 10 cm) 43%, T_3= Brinjal normal row (80 cm × 60 cm) 100% + 4 row garlic (15 cm × 10 cm) 57%, T_4= Brinjal normal row (80 cm × 60 cm) 100% + 3 row garlic (15 cm × 10 cm) 43%, T_5= Sole brinjal (80 cm × 60 cm) 100%, T_6= Sole onion (15 cm × 10 cm) 100%, T_7= Sole garlic (15 cm × 10 cm) 100%. The trial was set up in randomized complete block design with three replications. The unit plot size was 3.2 m × 4.2 m. The sole crop of brinjal and intercropped treatments were fertilized with cowdung 5 t ha^{-1} and 140-41-120-18-3-1.5 kg ha^{-1} of N-P-K-S-Zn-B in the form of urea, triple super phosphate, murate of potash, gypsum, zinc sulphate and boric acid, respectively. For sole brinjal and intercrop, except N and K, full amount of all other fertilizer were applied in pit before 1 week of transplanting brinjal seedling. N and K were applied in three equal splits at 21, 40 and 60 days after transplanting (DAT) of brinjal seedling as ring method followed by irrigation. Sole onion and garlic were fertilized with 105-60-144-32-3.5-2.1 kg ha^{-1} of N-P-K-S-Zn-B and 135-57-105-50-4.0-4 kg ha^{-1} N-P-K-S-Zn-B in the form of urea, triple super phosphate, murate of potash, gypsum, zinc sulphate and boric acid, respectively. For onion and garlic half N, K and all other fertilizers were applied at the time of final land preparation. Rest N and K were applied in two equal splits at 25 DAT and 50 DAT under moist soil condition and mixed thoroughly with the soil as soon as possible for better utilization (FRG, 2018). Brinjal (var. BARI Begun-8) as base crop and onion (var. BARI Piaz-4) and garlic (var. BARI Roshun-4) were used as intercrops in this study. The sole crop of brinjal was planted at a spacing of 80 cm × 60 cm. In intercropping system four rows of onion, three rows of onion, four rows of garlic and three rows of garlic were intercropped in between two rows of brinjal. After establishment of brinjal seedling (12 DAT) onion seedling and garlic cloves were transplanted/planted as per treatments. Brinjal (thirty days old seedling) was transplanted on 29 November, 2019 and 10 December, 2020. Onion seedling and cloves of garlic was transplanted/planted on 11 December, 2019 and 23 December, 2020, respectively. Brinjal was harvested four times and it was harvested in 2020 on 12 March, 23 March, 18 April, 7 May and in 2021 harvested on 25 March, 7 April, 21 April, and 12 May. Both Onion and garlic were harvested on 16 April, 2020 and 21 April, 2021, respectively. Five irrigations were done in the

experimental field. First was applied at just after brinjal transplanting. Second, third, fourth and fifth irrigation were applied at 10, 45, 60 and 90 DAT of brinjal seedling. Weeding was done as per requirement. Sex pheromone trap were used for controlling of brinjal shoot and fruit borer at active vegetative, fruit setting and fruit developing stage. Light availability or photo synthetically active radiation (PAR) was measured by PAR Ceptometer (Model – LP-80, Accu PAR, Decagon, USA). The PAR was measured at 5-day intervals from 25 to 90 DAT of onion seedling/ DAP of garlic cloves 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:

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

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

The yield component data of brinjal was taken from 10 randomly selected plants prior to harvest from each plot. Yield data of brinjal, onion and garlic were recorded plot wise. Yield and yield contributing characters were recorded and pooled data analyzed statistically and mean separations were done by LSD test at 5% level of significance.

Brinjal equivalent yield (BEY) was converted by converting yield of intercrops on the basis of present market price of individual crop following the formula:

$$\text{BEY} = \text{Yield of intercrop brinjal} + \frac{\text{Yi} \times \text{Pi}}{\text{Price of brinjal}}$$

Where, Yi = yield of intercrops (Onion/Garlic) and Pi = Price of intercrop (Onion/Garlic). Land equivalent ratio (LER) was determined from the yield data of the crops according to Mian (2008).

$$\text{LER} = \frac{\text{BIYB}}{\text{BSY}} + \frac{\text{RIYC}}{\text{RSYC}}$$

B_{IYB} = Intercrop yield of brinjal

B_{SY} = Sole crop yield of brinjal

R_{IYC} = Intercrop yield of component crops (Onion/ Garlic).

R_{SYC} = Sole crop yield of component crops (Onion/ Garlic).

Results and Discussion

Light availability

In both the year (2019-20 and 2020-21), irrespective of treatments, availability of light on onion and garlic canopy was almost 100% at earlier growth stage 30 DAT of onion seedling and 30 days after planting of garlic cloves and it decrease with the increase of shade produced by brinjal canopy over the time up to onion and garlic harvest (Fig. 1). In both the years, throughout the growing period of onion and garlic the maximum light availability was observed in T_6 (sole onion) and T_7 (sole garlic) treatments. However, among the intercropping treatments the maximum light availability was observed in T_4 treatment (3 row garlic 43% in between two row of brinjal 100%) followed by T_3 treatment (4 row garlic 57% in between two row of brinjal 100%). The minimum light availability was observed in T_1 treatment (4 row onion 57% in between two row of brinjal 100%) followed by T_2 treatment (3 row onion 43% in between two row of brinjal 100%) up to onion and garlic harvest. Among all treatments, the maximum light availability was observed in T_6 (sole onion) and T_7 treatments (sole garlic) treatment (Fig.1). Light availability was more in brinjal + garlic intercropping system than brinjal + onion intercropping system throughout the growing period.

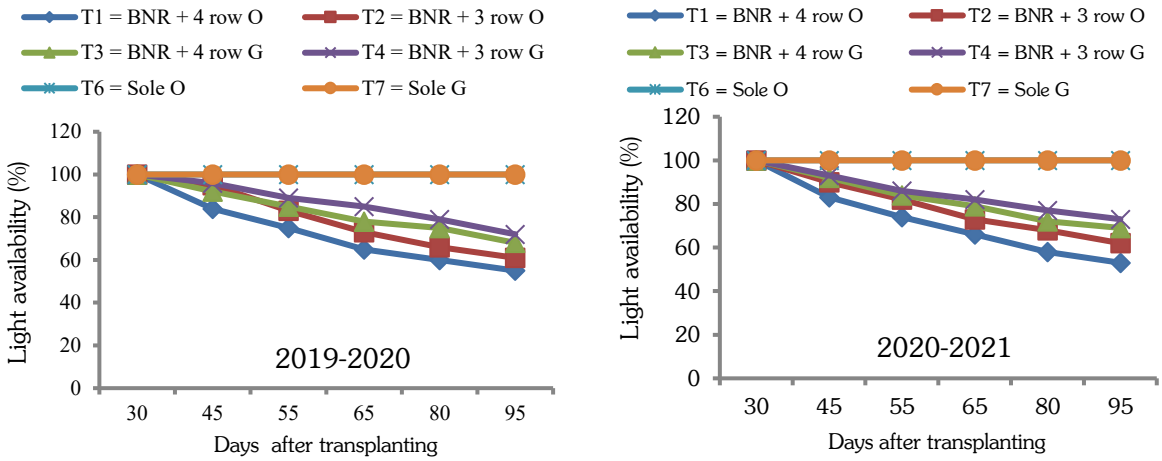

Fig.1. Light availability on onion and garlic in brinjal + onion/ garlic intercropping system (2019-20 and 2020-21)

Yield and yield contributing characters of brinjal

Number of fruits plant^{-1}, single fruit weight, fruit length, fruit diameter and yield of brinjal was significantly varied due to intercropping of onion and garlic with brinjal and sole crop of brinjal except plant height (Table 1).

Table 1. Fruit yield and yield attributes of brinjal under sole and intercropping system

Treatment	Plant height (cm)	Fruit plant^{-1} (no.)	Single fruit weight (g)	Length of fruit (cm)	Fruit diameter (cm)	Fruit yield (t ha^{-1})
T_1	90.95	19.85	72.17	19.47	3.48	14.75
T_2	93.82	22.67	78.64	21.98	4.03	16.12
T_3	96.37	23.12	82.65	20.88	3.84	16.83
T_4	99.39	25.84	86.99	23.38	4.19	19.94
T_5	104.01	28.08	94.74	25.27	4.33	22.48
LSD (0.05)	NS	2.89	9.87	2.64	0.17	2.99
CV (%)	5.69	6.42	6.32	6.31	7.37	8.82

Note: T_1= Brinjal normal row (80 cm × 60 cm) 100% + 4 row onion (15 cm × 10 cm) 57%, T_2= Brinjal normal row (80 cm × 60 cm) 100% + 3 row onion (15 cm × 10 cm) 43%, T_3= Brinjal normal row (80 cm × 60 cm) 100% + 4 row garlic (15 cm × 10 cm) 57%, T_4= Brinjal normal row (80 cm × 60 cm) 100% + 3 row garlic (15 cm × 10 cm) 43%, T_5= Sole brinjal normal row (80 cm × 60 cm) 100%, T_6= Sole onion (15 cm × 10 cm) 100%, T_7= Sole garlic (15 cm × 10 cm) 100%.

Significantly the maximum number of fruits plant^{-1} (28.08), single fruit weight plant^{-1} (94.74 g), highest fruit length (25.27 cm) and fruit diameter (4.33 cm) and fruit yield (22.48 t ha^{-1}) were recorded in sole planting of brinjal. In case of intercropping combination, the maximum number of fruits plant^{-1} (25.84), single fruit weight plant^{-1} (86.99 g), highest fruit length (23.38 cm), fruit diameter (4.19 cm) and fruit yield (16.83 t ha^{-1}) was recorded in T_4 treatment (Brinjal normal row 100% + 3 row garlic 43%). Similar trend was found in case of onion with brinjal intercropping combination the maximum number of fruits plant^{-1} (22.67), single fruit weight plant^{-1} (78.64 g), highest fruit length (21.98 cm), fruit diameter (4.03 cm) and fruit yield (16.12 t ha^{-1}) was recorded in T_2 treatment (Brinjal normal row 100% + 3 row onion 43%). The lowest number of fruit plant^{-1} (19.85 in onion and 23.12 in garlic), single fruit weight (72.17 g in onion

and 82.65 cm in garlic), fruit length (19.47 cm in onion and 20.88 cm in garlic), fruit diameter (3.48 cm in onion and 3.84 cm in garlic) and fruit yield (14.75 t ha^{-1} in onion and 16.83 t ha^{-1} in garlic) were obtained from T_1 and T_3 treatments (Brinjal normal row (80 cm × 60 cm) 100% + 4 row onion/garlic (15 cm × 10 cm) 57%). It was apparent that all the yield contributing characters and yields in the intercrops increased gradually with the decreased of garlic population. This might be due to competition between brinjal and garlic crop for moisture, light and nutrients. Islam *et al.*, (2014) also not find any significant difference in yield and yield attributes of brinjal due to intercropping of leafy vegetables/legumes i.e. growing of the intercrops in interspaces between brinjal rows did not affect the base crop.

Yield of onion and garlic

The number of plant m^{-2}, plant height, single bulb weight and bulb yield of onion and garlic was markedly differed by intercrop combination (Table 2). The highest number of plant m^{-2} of onion (69.59 m^{-2}) was obtained from T_6 treatment (Sole onion). Among the intercropping situation in case of onion, the highest number of plant m^{-2} (38.59 m^{-2}) of onion was obtained from T_1 treatment (Brinjal 100% + 4 row onion 57%) and the lowest number of plant m^{-2} (27.59 m^2) was recorded in T_4 treatment (Brinjal 100% + 3 row garlic 43%). The highest plant height (50.45 cm) and single bulb weight (60.90 g) was recorded in T_2 treatment (Brinjal 100% + 3 row onion 43%) and the lowest plant height (46.42 cm) and single bulb weight (55.08 g) was obtained from T_1 treatment (Brinjal 100% + 4 row onion 57%). On the other hand, in case of garlic the similar trend also was observed. The highest number of plant m^{-2} of garlic (36.26 m^{-2}) was obtained from T_3 treatment (Brinjal 100% + 4 row garlic 57%) and the lowest number of plant m^{-2} (27.59 m^{-2}) was recorded in T_4 treatment (Brinjal 100% + 3 row garlic 43%). The highest plant height (43.65 cm) and single bulb weight (12.96 g) was recorded in T_4 treatment (Brinjal 100% + 3 row garlic 43%) and the lowest plant height (41.82 cm) and single bulb weight (10.16 g) was obtained from T_3 treatment (Brinjal 100% + 4 row garlic 57%). The highest bulb yield of onion (15.68 t ha^{-1}) was obtained from T_6 treatment (Sole onion) and the highest bulb yield of garlic (7.25 t ha^{-1}) was obtained from T_7 treatment (Sole garlic). Among the intercropping situation the maximum bulb yield of onion (8.66 t ha^{-1}) was recorded in T_1 treatment (Brinjal 100% + 4 row onion 57%) and the lowest bulb yield (6.23 t ha^{-1}) was obtained from T_2 treatment ((Brinjal 100% + 3 row onion 43%). Similar trend also was observed in case of garlic. The highest bulb yield of garlic (3.92 t ha^{-1}) was recorded in T_3 treatment (Brinjal 100% + 4 row garlic 57%) and the lowest bulb yield (2.91 t ha^{-1}) was obtained from T_4 treatment (Brinjal 100% + 3 row garlic 43%). The higher bulb yield in onion and garlic was attributed to maximum number of plant m^{-2}. Faruque *et al.* (2006) also reported similar result.

Table 2. Bulb yield and yield components of onion and garlic under sole and intercropping system

Treatments	Plant m^{-2}	Plant height (cm)	Single bulb weight (g)	Bulb Yield (t ha^{-1})
T_1	38.59	46.42	55.08	8.66
T_2	27.92	50.45	60.90	6.23
T_3	36.26	41.82	10.16	3.92
T_4	27.59	43.65	12.96	2.91
T_6	69.59	53.74	61.88	15.68
T_7	65.92	45.15	13.70	7.25b
LSD $_{(0.05)}$	4.60	4.86	5.01	1.55
CV (%)	5.70	5.70	7.69	11.42

Note: T_1= Brinjal normal row (80 cm × 60 cm) 100% + 4 row onion (15 cm × 10 cm) 57%, T_2= Brinjal normal row (80 cm × 60 cm) 100% + 3 row onion (15 cm × 10 cm) 43%, T_3= Brinjal normal row (80 cm × 60 cm) 100% + 4 row garlic (15 cm × 10 cm) 57%, T_4= Brinjal normal row (80 cm × 60 cm) 100% + 3 row garlic (15 cm × 10 cm) 43%, T_5= Sole brinjal normal row (80 cm × 60 cm) 100%, T_6= Sole onion ((15 cm × 10 cm) 100%, T_7= Sole garlic (15 cm × 10 cm) 100%.

Brinjal equivalent yield

Brinjal equivalent yield was expressed in total productivity. Brinjal equivalent yields were higher in all the intercrops (30.14 to 36.42 t ha^{-1}) than the sole crop of brinjal (22.48 t ha^{-1}) indicated higher productivity than sole cropping (Table 3). In intercrop combination the highest brinjal equivalent yield (36.42 t ha^{-1}) was recorded in T_3 treatment (4 row garlic 57% in between two row of brinjal 100%) which was followed by T_4 treatment (34.46 t ha^{-1}) (3 row garlic 43% in between two row of brinjal 100%) and T_1 treatment (34.22 t ha^{-1}) (4 row onion 57% in between two row of brinjal 100%). The total productivity were also increase of 34.05-62.00% over sole brinjal. Ahmed *et al.* (2013) also reported that intercrop combination always increase the equivalent yield.

Land equivalent ratio

The highest land equivalent ratio (1.29) was recorded in T_3 treatment (4 row garlic 57% in between two row of brinjal 100%) and T_4 treatment (3 row garlic 43% in between two row of brinjal 100%) intercropping system (Table 3). The land equivalent ratio (LER) of different crop combinations ranged from 1.11 to 1.29 indicating that land utilization was increased 11 to 29% through intercropping. The mean values of LER (more than one) in all intercropping treatments revealed that land was more efficiently utilized under intercropping than that of sole cropping of brinjal, onion and garlic. Nazir *et al.* (2002) also reported that intercrop combination always increase the land equivalent ratio (LER).

Table 3. Brinjal equivalent yield (BEY), land equivalent ratio (LER) and % increase of BEY over sole brinjal in brinjal + onion/garlic intercropping system

Treatments	BEY (t ha^{-1})	% increase of BEY over sole brinjal	LER
T_1	34.22	52.23	1.21
T_2	30.14	34.05	1.11
T_3	36.42	62.00	1.29
T_4	34.46	53.31	1.29
T_5	22.48		1

Note: T_1= Brinjal normal row (80 cm × 60 cm) 100% + 4 row onion (15 cm × 10 cm) 57%, T_2= Brinjal normal row (80 cm × 60 cm) 100% + 3 row onion (15 cm × 10 cm) 43%, T_3= Brinjal normal row (80 cm × 60 cm) 100% + 4 row garlic (15 cm × 10 cm) 57%, T_4= Brinjal normal row (80 cm × 60 cm) 100% + 3 row garlic (15 cm × 10 cm) 43%, T_5= Sole brinjal normal row (80 cm × 60 cm) 100%, T_6= Sole onion (15 cm × 10 cm) 100%, T_7= Sole garlic (15 cm × 10 cm) 100%.

Cost benefit analysis

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 brinjal + onion/garlic intercropping system have been presented in Table 4. Intercropping combination of onion and garlic with brinjal showed higher monetary return than sole crop. Among the intercropping situation the maximum gross return (Tk.7,28,333 ha^{-1}) was recorded from T_3 treatment (4 row garlic 57% in between two row of brinjal 100%). This intercropping combination also gave the maximum gross margin (Tk. 4,76,596 ha^{-1}) and benefit cost ratio (2.89) followed by T_1 treatment (2.78) (4 row onion 57% in between two row of brinjal 100%) and T_4 treatment (2.75) (3 row garlic 43% in between two row of brinjal 100%). The minimum gross return (Tk. 6,02,708 ha^{-1}), gross margin (Tk.3,58,467 ha^{-1}) and BCR (2.47) were obtained from T_2 treatment (3 row onion 43% in between two row of brinjal 100%). The results revealed that intercropping increased productivity and returns were consistent with the earlier reports of yield advantage of crop mixture compared to monoculture (Akhteruzzaman *et al.*, 1991, Islam *et al.*, 2012 and Ahmed *et al.*, 2013).

Table 4. Cost and return analysis of sole brinjal and brinjal+ onion/ garlic intercropping system

Treatments	Gross return (Tk. ha^{-1})	Cost of production (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	Benefit cost ratio (BCR)
T_1	6,84,442	2,46,637	4,37,805	2.78
T_2	6,02,708	2,44,241	3,58,467	2.47
T_3	7,28,333	2,51,737	4,76,596	2.89
T_4	6,89,267	2,50,241	4,39,026	2.75
T_5	4,49,633	2,29,851	2,19,782	1.96

Price: Brinjal: Tk. 20 kg^{-1}, Onion: Tk. 45 kg^{-1}, Garlic: Tk. 100 kg^{-1}, Note: T_1= Brinjal normal row (80 cm × 60 cm) 100% + 4 row onion (15 cm × 10 cm) 57%, T_2= Brinjal normal row (80 cm × 60 cm) 100% + 3 row onion (15 cm × 10 cm) 43%, T_3= Brinjal normal row (80 cm × 60 cm) 100% + 4 row garlic (15 cm × 10 cm) 57%, T_4= Brinjal normal row (80 cm × 60 cm) 100% + 3 row garlic (15 cm × 10 cm) 43%, T_5= Sole brinjal normal row (80 cm × 60 cm) 100%, T_6= Sole onion (15 cm × 10 cm) 100%, T_7= Sole garlic (15 cm × 10 cm) 100%.

Conclusion

From two years results revealed that all intercropping combination showed higher productive and profitable than sole brinjal. 4 row garlic (15 cm × 10 cm) 57% in between two row of brinjal (80 cm × 60 cm) 100% intercropped combination was found agronomically feasible and economically profitable.

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