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FERTILIZER RECOMMENDATION FOR CHILLI-GARLIC INTERCROPPING SYSTEM

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Abstract

An experiment was conducted at Central Research Farm, BARI, Gazipur and On Farm Research Division, BARI, Noakhali during Rabi season of 2017-18, 2018-19 and 2019-20 to develop a fertilizer recommendation for chilli with garlic intercropping system. Six treatment combinations viz. T_1= 100% RDCF of chilli + 0% RDCF of garlic, T_2= 100% RDCF of chilli +10% RDCF of garlic, T_3= 100% RDCF of chilli + 20% RDCF of garlic, T_4= 100% RDCF of chilli +30% RDCF of garlic, T_5= 100% RDCF of chilli +40% RDCF of garlic and T_6= 100% RDCF of chilli +50% RDCF of garlic were tested. The experiment was laid out in randomized complete block design with 3 replications. Both chilli and garlic characters significantly influenced by different treatment combinations. The maximum yield of chilli (10.12 and 9.10 t ha^{-1} at Gazipur and Noakhali, respectively) and garlic (3.70 and 3.55 t ha^{-1} at Gazipur and Noakhali, respectively) were obtained from T_6 treatments which were statistically similar with T_5 treatment. Chilli equivalent yield progressively increased with the increase of inorganic fertilizers. The results showed that T_6 provided the highest CEY (17.52 and 16.18 t ha^{-1} at Gazipur and Noakhali, respectively) followed by T_5 (17.47 and 16.14 t ha^{-1} at Gazipur and Noakhali, respectively). The highest gross margin (Tk. 339755 ha^{-1} and Tk 310198. ha^{-1}at Gazipur and Noakhali, respectively) as well as BCR (4.50 and 4.32 at Gazipur and Noakhali, respectively) were obtained from T_5 treatment while the lowest net return (Tk. 266661 ha^{-1} and Tk. 242264 ha^{-1}at Gazipur and Noakhali, respectively) as well as BCR (3.92 and 3.76 at Gazipur and Noakhali, respectively) were observed from T_1 treatment. Though T_6 treatment gave higher yield over all the treatments but it showed lower BCR compared to T_5 treatment due to higher cost involvement for inorganic fertilizer.

Introduction

In Bangladesh, the majority of farmers are practicing monoculture rather than an intercropping system. However, intercropping use nutrients efficiently and gives greater yield stability over monoculture (Seran and Brintha, 2010). Moreover, mixed or intercropping can ensure maximum land utilization of the available resources and compared with each sole crop to increase productivity (Launay *et al*., 2009; Mucheru-Muna *et al*., 2010). Intercropping is an important tool for getting higher productivity per unit area by intensifying the use of land particularly densely populated countries which has limited per capita land for crop production. Chilli is one of the major spices cropin Bangladesh which generally grown in char land as a sole crop. Farmers of different region especially coastal and char areas grow chilli as a sole or sometimes intercropping with garlic and onion. From the previous research findings of Begum *et al*. (2015), chilli-garlic intercropping system was found very productive and profitable for the char land. Moreover, it is a promising practice in coastal saline area as both chilli and garlic can

tolerate salinity level up to 3 - 10 dS m^{-1} at fruiting stage (Amin *et al*., 2011). However, there is still no recommended fertilizer dose for chilli with garlic intercropping system. To get the maximum return and crop production, fertilizer management is the most logical way to raise total production. So, it is necessary to find out the optimum fertilizer dose for chilli-garlic intercropping system. Thus, this experiment was carried at Gazipur and Noakhali with the objective to develop a fertilizer recommendation for chilli with garlic intercropping system.

Materials and Methods

A field experiment was conducted at Central Research Farm, BARI, Gazipur (AEZ-28) and On Farm Research Division, BARI, Noakhali (AEZ-18) during Rabi season of 2017-2018, 2018-19 and 2019-20 to develop a fertilizer recommendation for chilli with garlic intercropping system. The experiment confined with intercropping where chilli was transplanted as main crop and garlic as companion crop. The variety of chilli was BARI Morich-3 and Local in Gazipur and Noakhali, respectively. The variety of garlic was BARI Garlic-2 in both the location. Before conducting the experiment, initial composite soil samples at a depth of 0-15 cm from the experimental plots were collected and analyzed following standard methods (Table 1).

Table 1. Chemical properties of initial soil (0-15 cm depth) of the experimental field at Central Research farm, BARI, Joydebpur, Gazipur and OFRD, BARI, Noakhali during *Rabi* season

	Sample	pH	EC	OM	Total N	K	Ca	Mg	P	S	Zn	B	Cu	Fe	Mn
			dSm^{-1}	(%)	meq/100 g soil						$\mu g\ g^{-1}$ soil				
At Gazipur	Average	6.1	-	1.36	0.08	0.18	3.8	2.2	12.0	16	1.6	0.17	4.0	72	8
	Critical level	-	-	-	0.12	0.12	2.0	0.5	7	10	0.6	0.2	0.2	4.0	1.0
	Interpretation	Slightly acidic	-	Low	Very Low	Low	Medium	Very high	Medium	Medium	Optimum	Low	Very high	Very high	Very high
At Noakhali	Average	6.9	0.85	1.23	0.07	0.11	5.0	2.3	9.5	28	1.9	0.49	1.2	17	7.6
	Critical level	-	-	-	0.12	0.12	2.0	0.5	10	10	0.6	0.2	0.2	4.0	1.0
	Interpretation	Neutral	Non Saline	Low	Very Low	Low	Optimum	Very high	Low	Optimum	High	Optimum	Very high	Very high	Very high

The experiment was laid out in a randomized complete block design with three replications. The unit plot size was 4.0 m × 3.0 m. Chilli transplantation and garlic cloves dibbling were done on last week of November at Gazipur and 2nd week of December at Noakhali in all the three consecutive years. One row of garlic was sown in between two rows of chilli. Line to line spacing of chilli was 40 cm and chilli to garlic spacing was 20 cm. Plant to plant spacing of chilli and garlic was 40 cm and 10 cm, respectively.

The experiment was set up with six treatments viz. T_1= 100% RDCF of chilli + 0% RDCF of garlic, T_2= 100% RDCF of chilli +10% RDCF of garlic, T_3= 100% RDCF of chilli + 20% RDCF of garlic, T_4= 100% RDCF of chilli +30% RDCF of garlic, T_5= 100% RDCF of chilli + 40% RDCF of garlic and T_6= 100% RDCF of chilli + 50% RDCF of garlic. Recommended fertilizer dose was estimated based on the soil test value. At Gazipur, recommended dose of chemical fertilizer (RDCF) for chilli was $N_{99.5}$ $P_{32.6}$ K_{64} $S_{9.5}$ $Zn_{0.2}$ $B_{0.9}$ kg $ha^{-1}$and garlic was N_{118} $P_{27.5}$ K_{60} S_{28} $Zn_{0.5}$ $B_{2.8}$ kg ha^{-1} where as the

recommended doses of chemical fertilizer for chilli and garlic were N_{104} P_{52} K_{89} $S_{1.4}$kg ha^{-1} and N_{127} P_{44} $K_{83.6}$ $S_4B_{0.7}$ kg ha^{-1}, respectively at Noakhali. The whole amounts of P, S, Zn, B and 1/4th of K were applied at the time of final land preparation. Remaining K and whole amounts of N were applied in three equal installments at 25, 50 and 75 days after transplantation from 10-12 cm away from the base of the plant which would be beneficial for the growth and yield of garlic. Cowdung (5 t ha^{-1}) were applied as a basal in all the plots. All the intercultural operations such as irrigation, weeding, insect control etc. were done as and when necessary.

At Noakhali, Soil salinity level was measured by using Electrical Conductivity meter Adwa (AD 310) at 15 days interval from emergence to maturity stages of the crop in all the three consecutive years and similar trends were observed. Salinity level was 1.18 to 10.41 dS m^{-1}, 1.12 to 9.75 dS m^{-1} and 1.15 to 8.19 dS m^{-1} in 2017-18, 2018-19 and 2019-20, respectively over the whole growing period. Soil salinity gradually increased up to 2nd week of April and then declined due to heavy rainfall at the later stages of the crop growing period.

Chilli was harvested five times at 15 days interval starting from 3rd week of March, at Gazipur and last week of March at Noakhali. Garlic was harvested in its maturity on 1st week of April and 3rd week of April at Gazipur and Noakhali, respectively in all the three years. Ten plants from each plot were tagged at random to take records on different agronomic parameters of chilli and garlic. Data on yield and yield contributing parameters were recorded and statistically analyzed with the help of statistical package statistix 10 (Analytical Software. Tallahassee, Fla, USA) and mean separation was tested by Duncan's Multiple Range Test (DMRT) (Steel and Torrie, 1960). Chilli Equivalent Yield (CEY) was calculated after Bandyopadhyay (1984):

$$\text{Chilli Equivalent Yield (kg/ha)} = \frac{\text{Yield of garlic(kg/ha) x Price of garlic (Tk./kg)}}{\text{Price of chilli (Tk./kg)}}$$

Methods of chemical analysis

Soil pH was measured by a combined glass calomel electrode (Jackson, 1958). Organic carbon determination by wet oxidation method (Walkley and Black, 1934). Total N was determined by modified Kjeldahl method. Ca and Mg were determined by NH_4OAc extraction method. K, Cu, Fe, Mn and Zn were determined by DTP Aextraction followed by AAS reading. Boron was determined by $CaCl_2$ extraction method. Phosphorus was determined by Bray and Kurtz method (Acid soils) and Modified Olsen method (Neutral + Calcareous soils). S was determined by $CaH_4(PO_4)_2$. H_2O extraction followed by turbidimetric method with $BaCl_2$.

Results and Discussion

Chilli

The effect of chemical fertilizers on the yield and yield parameters of chilli are summarized in the Tables 2 & 3. Chilli yield and yield attributes like plant height, number of branches $plant^{-1}$, number of fruits $plant^{-1}$ and average fruit weight $plant^{-1}$ of chilli were significantly influenced by different nutrient packages. The maximum plant height (65.7 cm and 61.9 cm at Gazipur and Noakhali, respectively) was obtained from T_6 treatment (100% RDCF of chilli +50% RDCF of garlic) which was statistically similar with T_5 treatment whereas the lowest plant height (59.8 cm and 56.3 cm at Gazipur and Noakhali, respectively) was obtained from T_1 treatment (100% RDCF of chilli + 0% RDCF of garlic). No. of branches $plant^{-1}$ positively affected by different fertilizer treatment. Significantly highest number of branches $plant^{-1}$ (9.0 and 7.8 at Gazipur and Noakhali, respectively) was obtained from T_6 treatment whereas the lowest number of branches $plant^{-1}$ (7.3 and 6.1 at Gazipur and Noakhali, respectively) was recorded in T_1 treatment. Number of fruits $plant^{-1}$ progressively increases with the increase of inorganic fertilizers. The maximum number of fruits $plant^{-1}$ (156.5 and 133.1 at Gazipur and

Noakhali, respectively) was obtained from T_6 treatment which was statistically similar with T_5 treatment. While the minimum number of fruits plant^{-1} (127.1 and 101.5 at Gazipur and Noakhali, respectively) was obtained from T_1 treatment. The maximum average fruit weight plant^{-1} (232.1 g and 207.3 g at Gazipur and Noakhali, respectively) was obtained from T_6 treatment which was statistically similar with T_5 . The lowest average fruit weight plant^{-1} (177.6 g and 154.2 g at Gazipur and Noakhali, respectively) was recorded in T_1 treatment.

Table 2. Yield and yield components of chilli as influenced by different treatment combinations at Gazipur during Rabi season (Pooled data of 3-years)

Treatments	**Plant height (cm)**	**Number of branches plant^{-1}**	**Number of fruits plant^{-1}**	**Average fruit weight plant^{-1} (g)**	**Fruit yield (t ha^{-1})**
T_1	59.8d	7.3c	127.1d	177.6e	8.13e
T_2	60.7cd	8.1bc	131.7d	200.1d	8.40d
T_3	61.3cd	8.4ab	136.6c	207.3c	8.83c
T_4	62.5bc	8.4ab	142.4b	213.2b	9.19b
T_5	64.2ab	8.8ab	154.8a	229.5a	10.09a
T_6	65.7a	9.0a	156.5a	232.1a	10.12a
SE (±)	1.25	0.98	3.16	2.95	0.19
CV (%)	6.25	5.83	3.87	3.26	7.23

Means followed by same letter (s) do not differ significantly at 5% level of significance by Duncan's Multiple Range Test (DMRT)

Table 3. Yield and yield components of chilli as influenced by different treatment combinations at Noakhali during Rabi season (Pooled data of 3-years)

Treatments	Plant height (cm)	Number of branches plant^{-1}	Number of fruits plant^{-1}	Average fruit weight plant^{-1}(g)	Chilli yield (t ha^{-1})
T_1	56.3c	6.1d	101.5e	154.2e	7.26e
T_2	57.2c	6.5cd	106.3d	162.7d	7.58d
T_3	58.5bc	6.8bcd	114.8c	175.6c	7.99c
T_4	60.3ab	7.2abc	123.2b	193.4b	8.41b
T_5	61.7a	7.6ab	132.6a	205.5a	9.06a
T_6	61.9a	7.8a	133.1a	207.3a	9.10a
SE (±)	1.62	0.81	3.54	3.10	0.22
CV (%)	5.46	6.66	4.84	3.52	7.64

Means followed by same letter (s) do not differ significantly at 5% level of significanceby Duncan's Multiple Range Test (DMRT)

T_1= 100% RDCF of chilli + 0% RDCF of garlic, T_2= 100% RDCF of chilli +10% RDCF of garlic, T_3= 100% RDCF of chilli + 20% RDCF of garlic, T_4= 100% RDCF of chilli +30% RDCF of garlic, T_5= 100% RDCF of chilli +40% RDCF of garlic and T_6= 100% RDCF of chilli +50% RDCF of garlic.

Yield of chilli progressively increases with the increase of inorganic fertilizers. The maximum yield of chilli (10.12 and 9.10 t ha^{-1} at Gazipur and Noakhali, respectively) was obtained from T_6 treatment (100% RDCF of chilli +50% RDCF of garlic)which was statistically similar with T_5 treatment (100% RDCF of chilli +40% RDCF of garlic) and superior to all other treatments.The lowest yield of chilli (8.13 and 7.26 t ha^{-1} at Gazipur and Noakhali, respectively) was observed in T_1 treatment (100% RDCF of chilli + 0% RDCF of garlic).The result was similar to the findings of Jha *et al*. (2000) and Islam (2007) in maize + potato intercropping.

Garlic

The effect of chemical fertilizers on the yield and yield parameters of garlic are summarized in the Tables 4 and 5. The results indicated that most of the yield attributes of garlic were significantly

influenced by different treatment combinations except plants m^{-2}. The maximum plant height (52.4 cm and 51.2 cm at Gazipur and Noakhali, respectively) was obtained from T_6 treatment (100% RDCF of chilli +50% RDCF of garlic) which was statistically at par with T_4 and T_5 treatment whereas the lowest plant height (47.3 cm and 46.1 cm at Gazipur and Noakhali, respectively) from T_1 treatment (100% RDCF of chilli + 0% RDCF of garlic).

Table 4. Effect of different treatments on the yield and yield attributes of garlic at Gazipur during Rabi season (Pooled data of 3-years)

Treatments	Plant population m^{-2} (No.)	Plant height (cm)	Clove $bulb^{-1}$ (No.)	Bulb diameter (cm)	Individual bulb weight (g)	Bulb yield (t ha^{-1})
T_1	24.4	47.3b	19.4c	3.38d	12.6c	3.09d
T_2	24.5	48.5b	21.6bc	3.43cd	13.2bc	3.16d
T_3	24.8	49.1b	21.2bc	3.49bc	14.1abc	3.35c
T_4	24.7	51.4a	22.8ab	3.54b	14.8ab	3.51b
T_5	24.7	52.3a	24.1a	3.62a	15.7a	3.69a
T_6	24.8	52.4a	24.3a	3.64a	15.8a	3.71a
SE (±)	0.08	1.21	1.13	0.03	0.79	0.05
CV (%)	2.41	5.80	5.81	3.91	5.81	7.12

Means followed by same letter (s) do not differ significantly at 5% level of significance by Duncan's Multiple Range Test (DMRT)

T_1= 100% RDCF of chilli + 0% RDCF of garlic, T_2= 100% RDCF of chilli +10% RDCF of garlic, T_3= 100% RDCF of chilli + 20% RDCF of garlic, T_4= 100% RDCF of chilli +30% RDCF of garlic, T_5= 100% RDCF of chilli +40% RDCF of garlic and T_6= 100% RDCF of chilli +50% RDCF of garlic.

The maximum number of clove $bulb^{-1}$ (24.3 and 23.8 at Gazipur and Noakhali, respectively) was obtained from T_6 treatment which was statistically similar with T_4 and T_5 treatment whereas the minimum number of clove $bulb^{-1}$ (19.4 and 18.9 at Gazipur and Noakhali, respectively) from T_1 treatment (100% RDCF of chilli + 0% RDCF of garlic).

Both of bulb diameter and individual bulb weight are progressively increases with the increase of fertilizers. The maximum bulb diameter (3.64 cm and 3.60 cm at Gazipur and Noakhali, respectively) and individual bulb weight (15.8 cm and 15.6 cm at Gazipur and Noakhali, respectively) were obtained from T_6 treatment (100% RDCF of chilli + 50% RDCF of garlic) which was statistically significant with T_5 treatment (100% RDCF of chilli + 40% RDCF of garlic). The lowest bulb diameter (3.38 cm and 3.32 cm at Gazipur and Noakhali, respectively) and individual bulb weight (12.6 cm and 11.9 cm at Gazipur and Noakhali, respectively) were obtained from T_1 treatment (100% RDCF of chilli + 0% RDCF of garlic).Yield of garlic progressively increases with the increase of inorganic fertilizers.The maximum bulb yield of garlic (3.71 t ha^{-1} and 3.55 t ha^{-1} at Gazipur and Noakhali, respectively) was obtained from T_6 treatment (100% RDCF of chilli +50% RDCF of garlic)which was statistically similar with T_5 treatment (100% RDCF of chilli +40% RDCF of garlic) and superior to all other treatments.The lowest yield (3.09 and 2.97 t ha^{-1} at Gazipur and Noakhali, respectively) was obtained from T_1 treatment (100% RDCF of chilli + 0% RDCF of garlic).

Table 5. Effect of different treatments on the yield and yield attributes of garlic at Noakhali during Rabiseason (Pooled data of 3-years)

Treatments	Plant population m^{-2} (No.)	Plant height (cm)	Clove $bulb^{-1}$ (No.)	Bulb Diameter (cm)	Individual bulb weight (g)	Bulb yield (t ha^{-1})
T_1	24.0	46.1c	18.9c	3.32d	11.9d	2.97e
T_2	24.1	46.6c	20.8bc	3.41c	12.8cd	3.12d
T_3	24.1	47.7bc	21.2b	3.49b	13.5bc	3.28c

T_4	24.3	49.5ab	22.5ab	3.54ab	14.2b	3.37b
T_5	24.5	51.0a	23.6a	3.59a	15.4a	3.54a
T_6	24.5	51.2a	23.8a	3.60a	15.6a	3.55a
SE (±)	0.07	1.16	0.97	0.04	0.45	0.03
CV (%)	2.21	5.91	5.38	3.46	5.54	7.42

Means followed by same letter (s) do not differ significantly at 5% level of significance by Duncan's Multiple Range Test (DMRT)

T_1= 100% RDCF of chilli + 0% RDCF of garlic, T_2= 100% RDCF of chilli +10% RDCF of garlic, T_3= 100% RDCF of chilli + 20% RDCF of garlic, T_4= 100% RDCF of chilli +30% RDCF of garlic, T_5= 100% RDCF of chilli +40% RDCF of garlic and T_6= 100% RDCF of chilli +50% RDCF of garlic.

Chilli Equivalent Yield (CEY)

Chilli equivalent yield was progressively increases with the increase of inorganic fertilizers. The results showed that T_6 provided the highest CEY (17.52 and 16.18 t ha^{-1} at Gazipur and Noakhali, respectively) that was 22.43% and 22.57% higher over T_1 at Gazipur and Noakhali, respectively (Figure 1). The treatment T_5 also gave higher CEY (17.47 and 16.14 t ha^{-1} at Gazipur and Noakhali, respectively) followed by T_4, T_3 and T_2. The higher CEY was mainly attributed due to additional yield advantage resulted from fertilizer effect in chill-garlicinter cropping. The result was similar to the findings of Begum *et al*. (2016) who observed that there was a trend of increase in potato equivalent yield (PEY) with the increase of inorganic fertilizer level and decreased considerably towards lower fertilizer levels. Akhteruzzaman *et al*. (2008) also reported PEY increased towards higher fertilizer rates in potato hybrid maize intercropping.

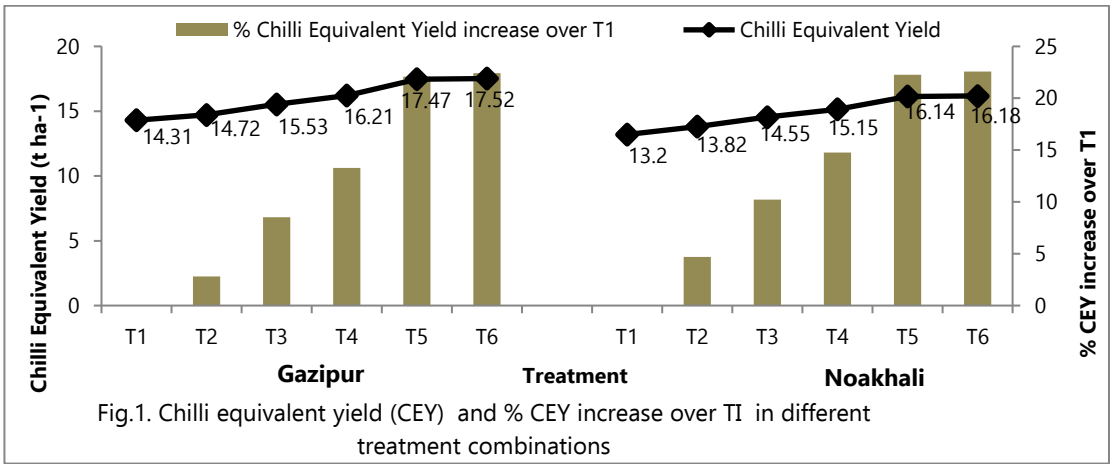

Fig.1. Chilli equivalent yield (CEY) and % CEY increase over TI in different treatment combinations

Cost and return analysis

Cost and return of chilli with garlic intercropping have been described in the Tables 6 & 7. Among the treatments, the highest gross margin (Tk. 339755ha^{-1} and Tk. 310198 ha^{-1}at Gazipur and Noakhali, respectively) as well as BCR (4.50 and 4.32 at Gazipur and Noakhali, respectively) were obtained from T_5 treatment (100% RDCF of chilli + 40% RDCF of garlic) whereas the lowest gross margin (Tk. 266661 ha^{-1} and Tk. 242264 ha^{-1}at Gazipur and Noakhali, respectively) as well as BCR (3.92 and 3.76 at Gazipur and Noakhali, respectively) were observed in T_1 treatment (100% RDCF of chilli + 0% RDCF of garlic). Though T_6 treatment gave higher yield over all the treatmentsbutt it showed lower BCR compared to T_5 treatment due to higher cost involvement for inorganic fertilizer.

Table 6. Cost and return analysis of chilli with garlic intercropping system as influenced by different fertilizer treatment combinations at Gazipur during Rabi season (Pooled data of 3-years)

Treatments	Yield (t ha^{-1})	Chilli equivalent	Gross	Total cost	Gross	Benefit

	Chilli	Garlic	yield (t ha^{-1})	return (Tk. ha^{-1})	(Tk. ha^{-1})	margin (Tk. ha^{-1})	cost ratio (BCR)
T_1	8.13	3.09	14.31	357750	91089	266661	3.92
T_2	8.40	3.16	14.72	368000	92566	275434	3.97
T_3	8.83	3.35	15.53	388250	94042	294208	4.12
T_4	9.19	3.51	16.21	405250	95520	309730	4.24
T_5	10.09	3.69	17.47	436750	96995	339755	4.50
T_6	10.12	3.71	17.52	438000	98472	339528	4.44

Input and output price per Kg: Urea = Tk. 16, TSP = Tk. 22, MoP = Tk. 15, Gypsum = Tk. 12, Zinc sulphate =Tk.150, Boric acid = Tk.220, Chilli selling price = Tk. 25 and Garlic selling price = Tk. 50

Table 7. Cost and return analysis of chilli with garlic intercropping system as influenced by different treatment combinations at Noakhali during *Rabi* season (Pooled data of 3-years)

Treatments	Yield (t ha^{-1})		Chilli equivalent yield (t ha^{-1})	Gross return (Tk. ha^{-1})	Total cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	Benefit cost ratio (BCR)
	Chilli	Garlic					
T_1	7.26	2.97	13.20	330000	87736	242264	3.76
T_2	7.58	3.12	13.82	345500	89028	256472	3.88
T_3	7.99	3.28	14.55	363750	90520	273230	4.01
T_4	8.41	3.37	15.15	378750	91910	286840	4.12
T_5	9.06	3.54	16.14	403500	93302	310198	4.32
T_6	9.08	3.55	16.18	404500	94694	309806	4.27

Input and output price per Kg: Urea = Tk. 16, TSP = Tk. 22, MoP = Tk. 15, Gypsum = Tk. 12, Zinc sulphate =Tk.150, Boric acid = Tk.220, Chilli selling price = Tk. 25 and Garlic selling price = Tk. 50

Conclusion

From the present study, it may be concluded that treatment package consists of 100% RDCF of chillialong with 40% RDCF of garlic is most profitablefor chilli with garlic intercropping systemin the study area (AEZ-28 and 18).

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