Combined Effect of Different Micronutrients and Spacing on the Growth and Yield of Garlic (*Allium sativum L.*)

Sumaiya Afrin Jhuma[1], Dr. Tahmina Mostarin[1], Dr. Khaleda khatun[1], Israt Jahan[1], Prince Biswas[2], Mohammad Abu Bakar Siddik[3]

[1] Department of Horticulture, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh
[2] Department of Bichemistry, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh
[3] Depertment of Agroecology and Farming System, Institute of Crop Science, CAAS, China

Abstract- The experiment was conducted at Horticultural Farm, Sher-e-Bangla Agricultural University, during the period from November 2013 to April 2014 to find out the response of different micronutrients and spacing on the growth and yield of garlic. The experiment consists of two factors. Factor A: four levels of plant nutrients T_0: $S_0B_0Zn_0$ (control), T_1: $S_{15}B_2Zn_5$, T_2: $S_{20}B_4Zn_{10}$ and T_3: $S_{25}B_6Zn_{15}$ (kg/ha) respectively. Factor B: three levels of spacing S_1 = 10 cm × 10 cm, S_2 = 15 cm × 10 cm and S_3 = 15 cm × 15 cm were used for the present study. The experiment was laid out in RCBD with three replications. Results showed that T_3S_1 treatment combination was found highest yield (6.57 t) and lowest yield (3.36 t) was found fromT_0S_3 treatment combination. Calculating the benefit cost ratio T_3S_1 gave the highest economic return (2.52) compared with rest of the treatment combinations. So $S_{25}B_6Zn_{15}$ with 10 cm × 10 cm spacing gave highest yield of garlic.

Index Terms- Garlic; Micronutrients; Spacing; Growth; Yield

I. Introduction

Garlic *(Allium sativum* L.) is well known as a spice crop in Bangladesh as well as in the world. It is an aromatic herbaceous annual spice and one of the most important bulb crops belonging to the family Alliaceae (Kurian, 1995). It is the second most widely used Alliums after onion (Bose and Som, 1990) with the characteristics of pungent smell. The major garlic producing countries of the world are China, South Korea, Spain, India, USA, Egypt, Thailand and Turkey (FAO, 2000).

Garlic has been considered as a rich source of carbohydrates, proteins and phosphorus. It is popular all over the world as a valuable spice for different dishes. It is also used as a popular remedy for various diseases. According to the Unani and Ayurvedic medicines in treatments of diseases like chronic infection of stomach and intestine, dysentery, typhoid, cholera and diseases of lungs garlic is successfully used (Chopra *et al*, 1958). In recent, oil, powder are prepared from it for adding flavor to the curries (Pruthi, 1976). The average yield of garlic in Bangladesh is only 4.40 t/ha (BBS, 2010), which is very low as compared to that of other countries. In Bangladesh about 164,000 metric tons of garlic was produced from approximately 92000 hectares of land in 2009-2010 (BBS, 2010). The requirement of garlic in Bangladesh is about 85,000 metric tons (Rahim, 1992). The crop is extensively cultivated during the winter season of Bangladesh. Garlic ranks second in world production among the Alliums after onion (Purseglove, 1975).

Judicious application of fertilizer may enhance bulb yield significantly. Nitrogen is required for cell division and vital for plant growth. It directly involved in photosynthesis. Potassium helps in the root development and increase the efficiency of leaf in the manufacture of sugar and starch. Phosphorus promotes early root formation and growth. It also involved cell division, cell enlargement and increase water use efficiency. The sulphur compounds in garlic have received a lot of attention because of it potential antibiotics and flavor properties. Boron is essential for promotes maturity. Zinc is necessary for chlorophyll production and necessary for starch formation. So different plant nutrients are physiologically important element and it has a miscellaneous effect on vegetative and reproductive stages in plant body. Plant spacing influences the growth and yield of garlic.

Yield of garlic is dependent on the number of plants accommodated per unit area of land. Planting of garlic at proper spacing also increases the yield and improves the grade of bulbs. Wider spacing increased number of leaves and greater plant height of garlic has been reported by several authors (Om and Srivastava, 1977). Increased bulb size in garlic with wider spacing has been noted by a number of authors (Menezes *et al*. 1974). Accommodation of reduced number of plants per unit area involves wider spacing is directly reduces the yield (Rahim *et al*., 1984). Thus the increased number of plant per unit area in closer spacing compensates the loss of reduced bulb sizes and ultimately increases the yield. Reports generally agree that higher plant spacing gave higher yield, but lower bulb weight of garlic (Duranti and Cuocolo, 1984).

II. Materials and Methods

The present study was carried out to study the response of different micronutrients and spacing on the growth and yield of garlic (*Allium sativum L.*) during the period from November 2013 to April 2014. The experiment was conducted at Horticultural Farm in Sher-e-Bangla Agricultural University, Dhaka-1207.

The climate of the experimental field was sub-tropical and was characterized by high temperature, heavy rainfall during Kharif-1 season (March-June) and scanty rainfall during Rabi

season (October-March) associated with moderately low temperature. The physical and chemical properties of soil of the experimental site sandy loam in texture and having soil p^H varied from 5.45-5.61. Organic matter content ware very low (0.83). The physical composition such as sand, silt, clay content were 40%, 40% and 20% respectively. Urea, Triple Super Phosphate (TSP) and Murate of Potash (MP) were used as the fertilizer source of the nutrient elements N, P and K respectively. A standard dose of NPK @ 100, 55,160 kg /ha was used in all treatments. The following doses of manure and fertilizer were used for the present study.

Fertilizer		**Doses/ha**	**Nutrients**	**Sources**
Cow dung-		15 t	-	Nature
Mustard oil cake		2 t	-	Nature
Urea		218 kg	100 kg N	$CO(NH_2)_2$
TSP		275 kg	55 kg P	$Ca(H_2PO4)_2$
MP		320 kg	160 kg k	KCl
Gypsum	T_1	84 kg	15 kg S	$CaSO_4.H_2O$
	T_2	112 kg	20 kg S	
	T_3	139 kg	25 kg S	
Boric acid	T_1	12 kg	2 kg B	H_3BO_3
	T_2	24 kg	4 kg B	
	T_3	36 kg	6 kg B	
Zinc Sulphate	T_1	15 kg	5 kg Zn	$ZnSO_4.H_2O$
	T_2	29 kg	10 kg Zn	
	T_3	43 kg	15 kg Zn	

The two factors experiments having 12 different treatment combinations were laid out in a Randomized Complete Block Design (RCBD) with three replications. The whole experimental area was divided into three blocks and each of which was then divided into 12 unit plots. The twelve treatment combinations were then distributed randomly among the unit plots of each block so as to all of treatments were placed once in each block. The size of each unit plot was 0.6 m × 0.9 m. The space between the blocks and plots were 50cm and 30cm respectively. Two factors were used in the experiment viz. four levels of nutrients (T) and three levels of spacing (S).

Factor- A: Four levels of micronutrients

T_0 = $S_0B_0Zn_0$ (Kg/ha) (Control) , T_1 = $S_{15}B_2Zn_5$ (Kg/ha), T_2 = $S_{20}B_4Zn_{10}$ (Kg/ha)

T_3 = $S_{25}B_6Zn_{15}$ (Kg/ha).

Factor –B: Three levels of spacing

S_1 = 10 cm × 10 cm, S_2 =15 cm × 10 cm, S_3 = 15 cm × 15 cm.

Treatment combinations (Micronutrients × spacing)

T_0S_1, T_0S_2, T_0S_3, T_1S_1, T_1S_2, T_1S_3, T_2S_1, T_2S_2, T_2S_3, T_3S_1, T_3S_2, T_3S_3

The collected data from the experiment on yield and yield components were statistically analyzed following experiment in RCBD wherever necessary. The mean for all treatments were calculated and analyses of variance of the parameters under study were performed by F variance test. The significance of the difference among the means of treatment combinations was estimated by Dunean's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez,1984).The means of the parameters were separated by least significant difference (LSD).

III. Results and Discussion

Combined effect of different nutrient and spacing on plant height of garlic was statistically significant at different days after sowing (DAS) (Table 1). At 75DAS, the highest plant height (47.93cm) was found in T_3S_1 ($S_{25}B_6Zn_{15}$ with 10cm×10cm) treatment combination. On the contrary the lowest plant height (36.37cm) at 75 DAS was recorded from T_0S_3 ($S_0B_0Zn_0$ with 15cm×15cm) treatment combination. Similar result was also found by Sing *et al*. (2004) and they observed that different plant nutrients with different spacing and planting dates had significant influence on plant height.

Combined effect of different micronutrient and spacing was statistically significant in respect of number of leaves per plant at different days after sowing (DAS) (Table 2). Gradually increased number of leaves per plant was observed till 75 DAS. At 75 DAS, the maximum (6.77) number of leaves per plant was found in T_3S_3 ($S_{25}B_6Zn_{15}$ with 15cm×15cm) treatment combination which was statistically identical with T_2S_3 treatment combination and the minimum (5.87) number of leaves per plant was found in T_0S_1 ($S_0B_0Zn_0$ with 10cm×0cm) treatment combination which was statistically similar to T_1S_1, T_2S_1 and T_3S_1 treatment combinations. Such results obtained from the present study might be due to cause of nutritional factors in soil and different spacing. Generally more nutrients and higher spacing plant get more food and space for vigorous growth and produce more leaves compared to lower nutrients and spacing.

Combined effect of different plant nutrients and spacing on neck diameter per plant of garlic at different days after sowing (DAS) had considerable variation among the treatments (Table 3). At 75 DAS, the maximum neck diameter per plant (0.65cm) was found in T_3S_3 ($S_{25}B_6Zn_{15}$ with 15cm ×15cm) treatment combination and the minimum neck diameter per plant (0.46cm) was found in T_0S_1 ($S_0B_0Zn_0$ with 10cm×10cm) treatment combination which was statistically similar T_0S_2 ($S_0B_0Zn_0$ with 15 cm × 10 cm) treatment combination.

Bulb length of garlic varied significantly by combined effect of different levels of micronutrient and spacing (Table 4). The highest bulb length (3.62 cm) was obtained from T_3S_3 ($S_{25}B_6Zn_{15}$ with 15cm×15cm) Treatment combination, which was statistically similar with T_2S_3 treatment combination. The lowest bulb height (2.81 cm) was recorded from T_0S_1 ($S_0B_0Zn_0$ with 10cm×10cm) treatment combination, which was statistically similar with T_0S_2 treatment combination. Intermediate results were found from the rest of the treatment combinations.

Combined effect of different levels of micronutrient and spacing proved significant differences on bulb weight per plant of garlic (Table 5). Results revealed that the highest bulb weight per plant (18.20 g) was obtained from T_3S_3 ($S_{25}B_6Zn_{15}$ with 15cm×15cm) treatment combination, which was statistically similar with T_2S_3 treatment combination. The lowest bulb weight per plant (10.50 g) was recorded from T_0S_1 ($S_0B_0Zn_0$ with 10cm×10cm) treatment combination. Rest of the treatment combination performed intermediate results in terms of fresh bulb weight per plant compared to all other treatments.

Combined effect of different micronutrient and spacing had significant effect on number of cloves per bulb of garlic (Table 5). Results demonstrated that the highest number of cloves per bulb (23.99) was obtained from T_3S_3 treatment combination. The lowest number of cloves per bulb of garlic (16.80) was from

T_0S_1 treatment combination which was statistically similar to T_0S_2 treatment combination. The results obtained from all other combined effect gave intermediate results.

Yield per plot of garlic was significantly affected by combined effect of different levels of micronutrient and spacing (Table 5). It was observed that the highest yield per plot (354.78 g) was obtained from T_3S_1 ($S_{25}B_6Zn_{15}$ with10cm×1ocm) treatment combination. Results also revealed that the lowest yield per plot of garlic (181.44 g) was recorded from T_0S_3 ($S_0B_0Zn_0$ with 15cm×15cm) treatment combination ,which was statistically similar to T_0S_2 treatment combination. The results obtained from all other treatment combination gave intermediate results compared to highest and lowest results. Higher number of plant population need higher amount of nutrients. Under the present study, closer spacing with higher nutrient doses gave the higher yield and this type of achievement might be due to higher plant population.

Yield of garlic was significantly affected by combined effect of different micronutrient and spacing (Table 5). Results identified that the highest yield of garlic (6.57 t ha^{-1}) was obtained from T_3S_1 ($S_{25}B_6Zn_{15}$ with 10cm×10cm) treatment combination. The lowest yield of garlic (3.36 t ha^{-1}) was recorded from T_0S_3 ($S_0B_0Zn_0$ with 15cm×15cm) treatment combination. This result might be due to presence of favorable nutrient present in soil and higher population also contributed in the formation of the height yield of garlic. Similar results were observed by Sing *et al*. (2004).

In the combination of different micronutrients spacing showed various gross return under different treatment combination (Table 6). The height gross return (TK. 262800/ha) was obtained from the T_3S_1 ($S_{25}B_6Zn_{15}$ with 10cm×10cm) treatment combination and the second height gross return (TK.221200/ha) was obtained in T_2S_1 treatment combination. The lowest gross return (TK.134400/ha) was obtained from the T_0S_3 ($S_0B_0Zn_0$ with 15cm×15cm) treatment combination.

In case of net return, different treatment combination showed different type of net return. The height net return (TK.158392/ha) was obtained from the T_3S_1($S_{25}B_6Zn_{15}$ with 10cmx10cm) treatment combination and the second height net return (TK.1209211/ha) was obtained in T_3S_2 treatment combination. The lowest net return (TK.40551/ha) was obtained from the T_0S_1($S_0B_0Zn_0$ with 10cm×10cm) treatment combination.(Table 6).

The combination of different nutrient and spacing for benefit cost ratio was different in all treatment combination (Table 6). The height benefit cost ratio (2.52) was obtained from the T_3S_1($S_{25}B_6Zn_{15}$ with 10cm×10cm) treatment combination and the second height benefit cost ratio (2.27) was obtained from T_2S_2 and T_3S_2 treatment combination. The lowest benefit cost ratio (1.41) was obtained from the T_0S_1 ($S_0B_0Zn_0$ with 10cm×10cm) treatment combination. From the economic point of view, it was apparent form the above results that the treatment combination of T_3S_1 was more profitable than rest of treatment combinations.

Market price of garlic @ TK.40000 /ton ; Gross return = Total yield (t/ha) × TK.40000
Net return = Gross return- Total cost of production
Benefit Cost Ratio (BCR) = Gross return/ Total cost of production

IV. Conclusion

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In the experiment higher dose of nutrient $T_3(S_{25}B_6Zn_{15})$ was more effective than lower dose of nutrient $T_0(S_0B_0Zn_O)$. The spacing S_3 (15cm× 15cm) gave higher cloves per bulb but the spacing S_1(10cm ×10cm) gave maximum yield per hectare. During the investigation, the best treatment combination was obtained from T_3S_1 ($S_{25}B_6Zn_{15}$ with 10 cm × 10 cm) having yield potentiality of 6.57 t/ha^{-1} and BCR 2.52 .

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AUTHORS

First Author – Sumaiya Afrin Jhuma, Department of Horticulture, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh
Second Author – Dr. Tahmina Mostarin, Department of Horticulture, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh
Third Author – Dr. Khaleda khatun, Department of Horticulture, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh
Fourth Author – Israt Jahan , Department of Horticulture, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh
Fifth Author – Prince Biswas, Department of Bichemistry, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh
Sixth Author – Mohammad Abu Bakar Siddik, Depertment of Agroecology and Farming System, Institute of Crop Science, CAAS, China

Table 1. Combined effect of different micronutrients and spacing on plant height at different days after sowing of garlic

Treatments	Plant height (cm)			
	30 DAS	**45 DAS**	**60 DAS**	**75 DAS**
T_0S_1	25.43 c	32.03 cd	37.03 c	44.63 c
T_0S_2	24.10 d	30.57 f	35.48 d	41.40 e
T_0S_3	22.80 f	28.57 h	33.10 e	36.37 h
T_1S_1	26.10 b	32.40 bc	38.00 b	44.07 c
T_1S_2	24.27 d	30.73 f	35.37 d	42.70 d
T_1S_3	23.43 e	28.93 gh	33.42 e	38.57 g
T_2S_1	27.87 a	32.87 b	38.43 b	46.73 b
T_2S_2	24.87 c	30.93 ef	35.53 d	42.80 d
T_2S_3	24.03 d	29.13 gh	34.03 e	40.20 f
T_3S_1	28.33 a	35.53 a	40.60 a	47.93 a
T_3S_2	25.03 c	31.57 de	36.83 c	44.53 c
T_3S_3	24.03 d	29.57 g	35.23 d	41.70 e
$LSD_{0.05}$	**0.5487**	**0.7164**	**0.9087**	**0.5792**
CV(%)	**9.38**	**8.80**	**7.98**	**7.82**

Means in a column followed by the same letter do not differ significantly at 5% level

T_0 = $S_0B_0Zn_O$ (kg/ha) S_1 = 10 cm × 10 cm
T_1 = $S_{15}B_2Zn_5$ (kg/ha) S_2 = 15 cm × 10 cm
T_2 = $S_{20}B_4Zn_{10}$ (kg/ha) S_3 = 15 cm × 15 cm
T_3 = $S_{25}B_6Zn_{15}$ (kg/ha)

Table 2. Combined effect of different micro nutrients and spacing on leaves per plant at different days after sowing of garlic

Treatments	Number of leaves per plant			
	30 DAS	**45 DAS**	**60 DAS**	**75 DAS**
T_0S_1	3.60 f	4.47 e	4.80 e	5.87 f
T_0S_2	3.73 de	4.77 cd	5.23 d	6.10 de
T_0S_3	3.87 bc	4.93 bc	5.37 cd	6.33 bc

T_1S_1	3.60 f	4.50 e	5.17 d	5.93 ef
T_1S_2	3.73 de	4.77 cd	5.27 cd	6.17 cd
T_1S_3	3.90 ab	4.93 bc	5.50 bc	6.40 b
T_2S_1	3.63 ef	4.60 de	5.20 d	5.93 ef
T_2S_2	3.80 b-d	4.77 cd	5.27 cd	6.20 b-d
T_2S_3	3.90 ab	5.13 ab	5.63 ab	6.60 a
T_3S_1	3.77 cd	4.63 de	5.33 cd	5.97 ef
T_3S_2	3.80 b-d	4.93 bc	5.40 cd	6.20 b-d
T_3S_3	4.00 a	5.20 a	5.73 a	6.77 a
$LSD_{0.05}$	**0.1071**	**0.2074**	**0.2208**	**0.1855**
CV(%)	**6.72**	**7.06**	**6.87**	**5.93**

Means in a column followed by the same letter do not differ significantly at 5% level

$T_0 = S_0B_0Zn_O$ (Kg/ha) $S_1 = 10$ cm × 10 cm
$T_1 = S_{15}B_2Zn_5$ (Kg/ha) $S_2 = 15$ cm × 10 cm
$T_2 = S_{20}B_4Zn_{10}$ (Kg/ha) $S_3 = 15$ cm × 15 cm
$T_3 = S_{25}B_6Zn_{15}$ (Kg/ha)

Table 3. Combined effect of different micronutrients and spacing on neck diameter per plant at different days after sowing of garlic

Treatments	**Neck diameter per plant (cm)**			
	30 DAS	**45 DAS**	**60 DAS**	**75 DAS**
T_0S_1	0.27 e	0.32 e	0.44 e	0.46 f
T_0S_2	0.30 d	0.34 de	0.46 de	0.48 ef
T_0S_3	0.30 d	0.34 de	0.48 cd	0.51 de
T_1S_1	0.30 d	0.36 cd	0.49 cd	0.52 d
T_1S_2	0.30 d	0.36 cd	0.52 bc	0.56 bc
T_1S_3	0.33 b	0.40 b	0.51 c	0.58 b
T_2S_1	0.30 d	0.36 cd	0.49 cd	0.53 cd
T_2S_2	0.31 cd	0.36 cd	0.51 c	0.58 b
T_2S_3	0.33 b	0.39 b	0.54 b	0.59 d
T_3S_1	0.30 d	0.36 cd	0.50 c	0.53 cd
T_3S_2	0.32 bc	0.37 c	0.51 c	0.60 b
T_3S_3	0.37 a	0.45 a	0.61 a	0.65 a
$LSD_{0.05}$	**0.017**	**0.024**	**0.030**	**0.034**
CV(%)	**12.05**	**9.70**	**9.46**	**13.97**

Means in a column followed by the same letter do not differ significantly at 5% level

$T_0 = S_0B_0Zn_O$ (kg/ha) $S_1 = 10$ cm × 10 cm

$T_1 = S_{15}B_2Zn_5$ (kg/ha) $S_2 = 15$ cm × 10 cm
$T_2 = S_{20}B_4Zn_{10}$ (kg/ha) $S_3 = 15$ cm × 15 cm
$T_3 = S_{25}B_6Zn_{15}$ (kg/ha)

Table 4.Combined effect of different micro nutrients and spacing on bulb length (cm), bulb diameter (cm) of garlic

Treatments	Bulb length (cm)	Bulb diameter (cm)
T_0S_1	2.81 g	2.72 f
T_0S_2	2.87 g	2.79 f
T_0S_3	3.08 f	3.00 de
T_1S_1	3.16 ef	2.92 e
T_1S_2	3.18 ef	3.02 de
T_1S_3	3.35 cd	3.16 bc
T_2S_1	3.20 ef	3.07 cd
T_2S_2	3.39 cd	3.22 b
T_2S_3	3.55 ab	3.26 ab
T_3S_1	3.27 de	3.23 b
T_3S_2	3.45 bc	3.25 ab
T_3S_3	3.62 a	3.34 a
$LSD_{0.05}$	**0.1417**	**0.0928**
CV(%)	**9.97**	**5.65**

Means in a column followed by the same letter do not differ significantly at 5% level

Table 5: Combined effect of different micronutrient and spacing on bulb weight plant^{-1}, number of cloves bulb^{-1}, yield plot^{-1}(g) and yield ton per hectare of garlic

Treatments	Bulb weight per plant (g)	Number of cloves bulb^{-1}	Yield plot^{-1} (g)	Yield (t ha^{-1})
T_0S_1	10.50 g	16.80 f	187.92h	3.48 h
T_0S_2	11.90 f	17.30 f	184.14 i	3.41 i
T_0S_3	13.10 e	18.57 e	181.44 *i*	3.36 j
T_1S_1	13.67 de	19.87 d	292.68 c	5.42 c
T_1S_2	13.93 d	20.97 c	272.70 e	5.05 e
T_1S_3	16.60 b	22.73 b	246.78 g	4.57 g
T_2S_1	14.23 d	20.23 d	298.62 b	5.53 b
T_2S_2	16.87b	22.83 b	286.20 d	5.30 d
T_2S_3	17.63 a	23.27 b	257.04 f	4.76 f
T_3S_1	15.73 c	21.57 c	354.78 a	6.57 a
T_3S_2	16.93 b	22.94 b	292.14 c	5.41 c

T_3S_3	18.20 a	23.99 a	270.54 e	5.01 e
$LSD_{0.05}$	**0.5987**	**0.6731**	**2.033**	**0.041**
CV (%)	**14.91**	**12.61**	**8.36**	**7.59**

Means in a column followed by the same letter do not differ significantly at 5% level

T_0 = $S_0B_0Zn_O$ (kg/ha) S_1 = 10 cm × 10 cm
T_1 = $S_{15}B_2Zn_5$ (kg/ha) S_2 = 15 cm × 10 cm
T_2 = $S_{20}B_4Zn_{10}$ (kg/ha) S_3 = 15 cm × 15 cm
T_3 = $S_{25}B_6Zn_{15}$ (kg/ha)

Table 6. Economic performances regarding gross return, net return and benefit cost ratio (BCR) of garlic

Treatment	Cost of production (Tk. ha^{-1})	Yield (t ha^{-1})	Gross return (Tk. ha^{-1})*	Net return (Tk. ha^{-1})	BCR
T_0S_1	98649	3.48	139200	40551	1.41
T_0S_2	89719	3.41	136400	46681	1.52
T_0S_3	83022	3.36	134400	51378	1.62
T_1S_1	100569	5.42	216800	116231	2.16
T_1S_2	91639	5.05	202000	110361	2.20
T_1S_3	84942	4.57	182800	97858	2.15
T_2S_1	102488	5.53	221200	118712	2.16
T_2S_2	93559	5.30	212000	118441	2.27
T_2S_3	86862	4.76	190400	103538	2.19
T_3S_1	104408	6.57	262800	158392	2.52
T_3S_2	95479	5.41	216400	120921	2.27
T_3S_3	88781	5.01	200400	111619	2.26

* Selling cost = 40.00 Tk.kg^{-1}

T_0 = $S_0B_0Zn_O$ (kg/ha) S_1 = 10 cm × 10 cm
T_1 = $S_{15}B_2Zn_5$ (kg/ha) S_2 = 15 cm × 10 cm
T_2 = $S_{20}B_4Zn_{10}$ (kg/ha) S_3 = 15 cm × 15 cm
T_3 = $S_{25}B_6Zn_{15}$ (kg/ha)