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EFFECT OF NUTRIENT MANAGEMENT ON GROWTH AND YIELD PERFORMANCE OF CABBAGE GROWN IN CALCAREOUS SOIL OF BANGLADESH

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Abstract

The study was conducted in rabi season of 2012-13 and 2013-14 at the farmer's field of FSRD site, Hatgobindapur, Faridpur to evaluate the performance of nutrient management on economic yield of cabbage. The experiment was set up in Randomized Complete Block Design with eight different nutrient management treatments having five dispersed replications. The treatments were viz., $T_1= N_{242}P_{120}K_{33}S_{19}Zn_{1.4}B_{0.6}$ kg ha^{-1} (100% NPKSZnB from STB dose), $T_2= N_{302}P_{120}K_{33}S_{19}Zn_{1.4}B_{0.6}$ kg ha^{-1} (T_1+ 25% N), $T_3= N_{302}P_{150}K_{33}S_{19}Zn_{1.4}B_{0.6}$ kg ha^{-1} (T_1+ 25% NP), $T_4= N_{302}P_{120}K_{41}S_{19}Zn_{1.4}B_{0.6}$ kg ha^{-1} (T_1+ 25% NK), $T_5= N_{242}P_{150}K_{41}S_{19}Zn_{1.4}B_{0.6}$ kg ha^{-1} (T_1+ 25% PK), $T_6= N_{302}P_{150}K_{41}S_{19}Zn_{1.4}B_{0.6}$ kg ha^{-1} (T_1+ 25% NPK), $T_7= N_{182}P_{90}K_{25}S_{14}Zn_{1.05}B_{0.45}$ kg ha^{-1} (75% of T_1) and T_8= Native nutrient (control). The treatment 100 % N-P-K-S-Zn-B (STB) and additional 25% N-P-K (T_6) treatment produced maximum head yield (78.89 t ha^{-1}) which was statistically identical with other studied treatments. The lowest head yield (40.92 t ha^{-1}) was obtained from native fertility (control). According to economic performance, the highest gross return Tk. 473340 ha^{-1} and gross margin Tk. 440533 ha^{-1} was received from 100% soil test based fertilizer dose along with additional 25% NPK (T_6) treatment. While dominance and marginal analysis also showed that 100% STB fertilizer dose (T_1) dominated over control (T_8) revealed that application of 100% STB chemical fertilizers (T_1) would be economical for cabbage production in calcareous soil under AEZ- 12.

Keywords: Cabbage, Soil test based fertilizer, Gross return, Marginal rate of return, Yield.

Introduction

Cabbage (*Brassica oleracea* var. *capitata* L.) is an important, high nutritive and delicious leafy vegetables widely cultivated in Bangladesh. It is a rich source of protein, minerals and vitamin A (Uddin *et al*. 2009). It has some medicinal value as it prevents constipation, increases appetite, speeds up digestion and is very useful for cardiovascular diseases, diabetes, cancer and obesity. According to the USDA National Nutrient Database 75 g of frayed cabbage contains 17 calories, 4 g of carbohydrate, 1 g of protein, 81.5 µg of vitamin K, 11 mg of Mg, 22 µg of folate and lesser amounts of vitamin B-6, calcium, potassium and thiamin (Nahar *et al*. 2014) .

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Cabbage is growing throughout the world and China is the leading cabbage producer (32,800,000 tons) which is about 46% and India 12% of the total world production (FAO 2014). Bangladesh produces 2,58,608 metric tons fresh cabbage from 17,720 hectares of land (BBS 2015). It indicates a very poor yield (14.59 t ha^{-1}) per unit area. Per capita consumption of vegetables in Bangladesh is very low (166 g $head^{-1}day^{-1}$) compared to that in neighboring countries (Nahar *et al*. 2014). Total area, production and yield of cabbage in Faridpur was 254 ha, 3207 ton and 12.62 t ha^{-1}, respectively (BBS 2015). The requirement of vegetables will be much higher in coming years in view of ever increasing population. Bangladesh would need 51140 metric tons of vegetables per day by 2020 for maintaining minimum requirement. In this context vegetables production must be increased to meet the food supply and dietary standard. To produce an additional quantity of vegetables, the only option is to enhance productivity under the limited land resource condition. The inadequate supply of inputs often leads to limit the yield potential of vegetables. Identification of critical inputs to enhance the vegetables production is the need of hour. Apart from improved varieties, irrigation and balanced fertilization is critical for realizing higher head yield. Bangladesh soils are becoming highly deficient in nitrogen (N), medium in phosphorus (P) and low in potassium (K) due to intensive cultivation.

Cabbage requires relatively large amount of these nutrients for realization of yield potential but inadequate supply often leads to low productivity. The importance of nitrogen, phosphorus, potassium and sulphur on the growth and yield of vegetable crops is well established. Ullah *et al*. (1999) reported the significant influence of combined application of N, P, K and S on the yield of cabbage. Among the nutrients, nitrogen plays the most important role for vegetative growth of the crop. Phosphorus is also an essential nutrient which helps in the good growth of the roots of vegetable crops. Potassium exerts balancing role on the effects of both nitrogen and phosphorus (Brady 1990). The requirement of these plants nutrients can be provided by applying inorganic fertilizer or organic manure or both. But, excessive fertilizer was applied by farmers and contributed to a higher production cost and worse soil structure such as physical, chemical and biological degradation (Li 2007). The supply of proper nutrient must be ensured during its cultivation, which is related to the judicious application of fertilizer. The crop production system with high yield targets cannot be sustainable unless nutrient inputs to soil are at least balanced against nutrient removal by crops (Jahiruddin and Rijpma 2004). The farmers of Bangladesh use only about 172 kg nutrients ha^{-1} annually (132 kg N, 17 kg P, 17 kg K, 4 kg S and 2 kg Zn plus B and others), while the crop removal is about 250 kg ha^{-1} (Islam 2002). As a result other nutrients such as Mo, Mn, Mg etc. are being observed as deficient in many parts of Bangladesh. Some researchers investigated the effect of macro and micronutrients for cabbage production and recommended organic manure with macro and micronutrients to be added to the soil for increased head of cabbage (Farid *et al*. 1998). Boron is a very sensitive micronutrient and the range of deficiency and toxicity are narrow. However, in cole crops like cabbage boron requirement is very high (Tisdale *et al*. 1995).

The average yield of cabbage is very low in Bangladesh compared to other developed countries due to imbalanced application of fertilizers and no consideration of micronutrients (Islam 2002). Therefore, it is necessary to improve the yield of cabbage through judicious application of fertilizers. Therefore, the present study was carried out to find out with the aim of improving the performance of cabbage in terms of yield and quality through the combination of chemical fertilizers in calcareous soil of Bangladesh.

Materials and Methods

The study was conducted in the farmer's field of Farming systems Research and Development (FSRD) site Hatgobindapur, Faridpur of On-Farm Research Division (OFRD), Bangladesh Agricultural Research Institute to evaluate the performance of nutrient level on maximum yield and economics of cabbage during *rabi* seasons of 2012-2013 and 2013-2014. The geographical position of the experimental area is between 23º35' N latitude and 89º45' E Longitude. The topography of the study area was mainly high land having irrigated facilities with moderately well drained Calcareous soil under agro-ecological zone-12 (AEZ-12). The soil belongs to the Gopalpur series having loamy textural class. Maximum and minimum air temperature (ºC), relative humidity (%) and monthly rainfall (mm) of the experimental site during the growing season of cabbage are presented in Table 1.

Table 1. Maximum and minimum air temperature (ºC), relative humidity (%) and monthly rainfall (mm) of the Sadar Faridpur during 2012-13 and 2013-14.

Month	Maximum air temperature (ºC)		Minimum air temperature (ºC)		Relative Humidity (%)		Rainfall (mm)	
	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14
October	33.44	32.19	24.72	23.58	78.94	80.48	1.8	83.4
November	30.00	28.59	19.08	18.22	77.87	78.06	0	111.5
December	24.60	24.00	14.07	13.28	81.61	83.77	0	7.2
January	23.95	23.94	13.24	10.44	77.42	72.38	30	2
February	28.91	28.60	14.13	15.08	67.07	70.42	1.7	11.4

The initial soil samples of the experimental site were collected and analyzed. Results of soil samples are presented in Table 2. Soil was loamy having pH 7.7, low in organic matter and the fertility status of N, P and B was below the critical level and S, Zn and K was above the critical level.

Table 2. Initial soil properties of farmer's field at FSRD site, Hatgobindapur, Faridpur.

Items	pH	OM	Total N	Available P (Olsen method)	S	Zn	B	K
		(%)		µg g^{-1}				meq$100g^{-1}$ soil
Average	7.7	1.73	0.087	8.46	22.11	1.07	0.24	0.21
Interpretation	Slightly Alkaline	L	VL	L	M	M	L	M
Critical level	--	--	0.12	10	10	0.6	0.2	0.12

OM=Organic matter, M=Medium, L=Low and VL=Very low

The trial was laid out in a randomized complete block design (RCBD) with six dispersed replications having eight treatments. The tested cabbage variety was Atlas 70. The unit plot size was 8 m x 5 m. The treatment T_1 comprises with soil test based fertilizer dose for high yield goal *viz.,* $T_1= N_{242}P_{120}K_{33}S_{19}Zn_{1.4}B_{0.6}$ kg ha^{-1} (100% NPKSZnB from STB dose); $T_2= N_{302}P_{120}K_{33}S_{19}Zn_{1.4}B_{0.6}$ kg ha^{-1} (T_1+ 25% N); $T_3= N_{302}P_{150}K_{33}S_{19}Zn_{1.4}B_{0.6}$ kg ha^{-1} (T_1+ 25% NP); $T_4= N_{302}P_{120}K_{41}S_{19}Zn_{1.4}B_{0.6}$ kg ha^{-1} (T_1+ 25% NK); $T_5= N_{242}P_{150}K_{41}S_{19}Zn_{1.4}B_{0.6}$ kg ha^{-1} (T_1+ 25% PK); $T_6= N_{302}P_{150}K_{41}S_{19}Zn_{1.4}B_{0.6}$ kg ha^{-1} (T_1+ 25% NPK); $T_7= N_{182}P_{90}K_{25}S_{14}Zn_{1.05}B_{0.45}$ kg ha^{-1} (75% of T_1) and T_8= Absolute control (native fertility without addition of fertilizers). Urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate monohydrate and boric acid were used as the source of N, P, K, S, Zn and B. Full doses of P, S, Zn and B was broadcasted and incorporated during final land preparation. Nitrogen and K were applied in two equal splits at 15 and 35 days after transplanting of seedlings followed by irrigation. Thirty days old healthy seedlings of cabbage was transplanted on 12 to 15 November, 2012 and 15 to 22 November, 2013 maintaining a spacing of 60 cm from row to row and 45 cm from plant to plant.

Fertilizer management and intercultural operations like weeding, mulching and irrigation were accordingly to

support the normal growth of the crop. Nitro/Symbosh @ 1ml/L water was sprayed two times at 10 days interval to control cutworm and cabbage caterpillar and Bavistin @ 2g/L water was sprayed two times at 10 days interval to control alternaria leaf spot. Cabbage was harvested plot wise at different dates after attaining maturity. The crop was harvested from 05-20 February 2013 and 10-25 February 2014 in two consecutive years. At maturity, ten sample plants were harvested at first from each plot and yield components data were recorded. The harvest index (%) was calculated according to the following formula:

$$\text{Harvest Index (HI)} = \left[\frac{\text{Economic yield}}{\text{Biological yield}}\right]\times 100$$

Percent dry matter was calculated by using the following formula:

$$\text{Dry matter (\%)} = \frac{\text{Dry weight of heads}}{\text{Fresh weight of heads}}\times 100$$

The data were analyzed statistically using MSTAT-C, a statistical computer package programme. Mean comparison among the treatments were made by Least Significant Difference (LSD) test at 5% level of probability (Gomez and Gomez 1984) and pooled analysis was done as because there was no significant variation in yield and yield parameters between the years. Finally, benefit-cost and marginal analysis was done based on prevailing market price.

Results and Discussion

Plant height of cabbage

The height of cabbage plant was significantly influenced by different fertilizer management (Table 3). The tallest plant height (37.98 cm) was obtained from 100% STB fertilizers dose which was statistically similar with 100% STB fertilizer dose and 25% additional NPK (T_6), 100% STB fertilizer dose and 25% additional N and P (T_3) and 100% STB fertilizer dose and 25% additional P and K (T_5). The treatment comprised of T_1 with 25% N K (T_4) and reduced 25% of T_1 (T_7) showed lower plant height than other treatments except T_8. The lowest plant height (27.32 cm) was observed from T_8 treatment. The results are in agreement with the observation of Naher *et al*. (2014) who reported that N, P, and K had significant effect on plant height of cabbage when added with boron. Inorganic fertilizer combination helps to grow plant vigorously and it facilitates plant growth. As a result plant height increased day by day at different treatment combinations.

Days required for 80% head formation

The use of different doses of inorganic fertilizers and their combinations exhibited significant influence of days required for 80% head formation. The control plots (T_8) required the longest period of time (58.62 days) for head formation while T_3 required only 56.26 days although it was statistically similar to T_2, T_4, T_5 and T_7 (Table 3). It appears that application of 100% STB (T_1) took only 50.98 days for head formation. It might be due to the fact that application of 100% STB (T_1) fertilizers makes soil more friendly and probably supplied adequate plant nutrients due to higher microbial activities in the soil resulting in earlier head formation. This indicates that early head formation of cabbage was significantly influenced by the application of balanced fertilizer in calcareous soils of Bangladesh. Naher *et al*. (2014) reported that early head formation of cabbage was significantly influenced by the application of boron fertilizer in calcareous soils of Bangladesh. This indicates that head formation of cabbage is responsive to boron but has reverse relation with sulphur.

Days required for head maturity

The use of different inorganic fertilizer combinations had significant effect on days required for head maturity of cabbage (Table 3). The cabbage grown in the plot receiving 100% STB fertilizer dose (T_1) required minimum days (92.10 days) for maturity although it was statistically similar with the treatments T_2, T_4, T_5 and T_6. Maturity of head was delayed by 12 days due to unfertilized plots (T_8). This indicates that early head formation of cabbage was significantly influenced by the application of balanced fertilizer in calcareous soils of Bangladesh. Naher *et al*. (2014) reported that early head formation of cabbage was significantly influenced by the application of boron fertilizer in calcareous soils of Bangladesh. These results are in partial agreement with the findings of Wang-Xiude *et al*. (1996) who reported that minimum days required for head maturity were obtained from the plot receiving N, P, K and B at the rate of 150, 50, 100 and 3 kg ha^{-1}, respectively.

Number of unfolded leaves plant^{-1}

There was no statistically significant effect of different fertilizer packages on the number of unfolded leaves $plant^{-1}$ (Table 3). However, number of unfolded leaves $plant^{-1}$ varied from 12.66 to 13.85 due to the effect of

different inorganic fertilizers. It was increased with the advancement of time and reached the highest at 70 days after transplanting. The higher number of unfold leaves per plant was recorded in STB fertilizer dose (T_1). This might be due to the fact that STB fertilizer probably supplied adequate available plant nutrients for proper vegetative growth of cabbage plants which ultimately showed the highest performance. Hossain *et al*. (2015) was also found the similar type of result in their research work.

Table 3. Effect of fertilizer doses on different agronomic parameters of cabbage at Faridpur (pooled of 2012-13 and 2013-14).

Treatments	Plant height at harvest (cm)	Days required to head formation	Days required for head maturity	Number of unfold leaves $plant^{-1}$
T_1= 100% NPKSZnB (STB)	37. 98	50.98	92.10	13.85
T_2= T_1+25% N	34.05	55.65	93.57	13.34
T_3= T_1+25% NP	35.77	56.26	95.21	13.23
T_4= T_1+25% NK	33.90	53.98	92.88	13.25
T_5= T_1+25% PK	35.54	55.50	92.58	13.32
T_6= T_1+25% NPK	36.93	52.64	92.64	13.17
T_7= 75% of T_1	31.94	54.89	97.71	13.42
T_8=Native fertility	27.32	58.62	103.91	12.66
CV (%)	5.83	7.54	5.22	9.70
LSD (0.05)	1.22	1.57	1.41	ns

Whole head weight

The whole head weight of cabbage varied significantly among the treatments due to different doses of inorganic fertilizer packages (Table 4). Considering the whole head weight, it was evident that the treatment T_1 produced the highest individual whole head weight (3.42 kg) and the lowest whole head weight (1.85 kg) was obtained from T_8 (control). The STB fertilizer dose (T_1) was statistically at par with T_2, T_3, T_4 and T_6 treatments. This might be due to fact that inorganic fertilizers supplied adequate available plant nutrients for proper vegetable growth of cabbage plants and finally those plants produce good head. The lowest whole plant weight (1.85 kg) was recorded from unfertilized control plot. Sajib *et al*. (2015) was also found the similar type of result in their research work.

Head pericycle

The pericycle of cabbage head at harvest responded significantly to fertilizer application and varied from 46.22 to 78.09 cm (Table 4). The maximum (78.09 cm) pericycle of the head was recorded in the plot (T_6) where T_1+25% NPK fertilizer dose was used while the smallest (46.22 cm) was noted in control plot (T_8). This might be due to fact that inorganic fertilizers supplied adequate available plant nutrients for proper vegetable growth of cabbage plants which ultimately influenced the head pericycle. These findings are in agreement with the observation of Naher *at al. (*2014) who reported that NPKB significantly increased the head pericycle.

Biological yield

The biological yield of cabbage responded significantly due to nutrient management and it ranged from 64.81 to 119.86 t ha^{-1} (Table 4). The highest biological yield (119.86 t ha^{-1}) was obtained from T_6 which was statistically identical to T_1, T_2, T_3 and T_4 treatments. The lowest biological yield (64.81 t ha^{-1}) was recorded from T_8 for native fertility. This might be due to fact that inorganic fertilizers supplied adequate available plant nutrients for proper vegetable growth of cabbage plants which ultimately influenced the head pericycle, whole plant weight and marketable weight of head and finally produce good biological yield of cabbage. These results indicated that balanced fertilizer dose was better in producing higher biological yield. The present results are partially

supported by Hoque *et al*. (2002) who reported that higher biological yield was found when balanced fertilizer dose was applied together in organic and inorganic sources.

Harvest Index (HI)

Harvest index is the proportion of economic yield to the biomass yield of the crop. The harvest index of cabbage ranged from 63 to 68 % (Table 4). The highest harvest index (68 %) was obtained from T_1 and the lowest was 63%) was recorded from T_8 for native fertility. Harvest index decreased markedly in control plot. The decrease harvest index indicated that marketable head yield of cabbage was reduced more than total biomass under control condition**.** The ability of a crop to convert total dry matter into grain or economic yield is indicated by its harvest index value. It is important for harvesting of cabbage to ensure optimum yield. Low crop harvest index is the major cause of less crop yield. Therefore, harvest index could be used as a yardstick for determining the gap between potential and actual yields. Higher harvest index indicative of efficient utilization of photosynthesized products and also associated with high yield.

Table 4. Effect of fertilizer doses on different agronomic parameters of cabbage at Faridpur (pooled of 2012-13 and 2013-14).

Treatments	Whole plant wt. (kg)	Head pericycle (cm)	Biological yield (t ha^{-1})	Harvest index (%)
T_1= 100% NPKSZnB (STB)	3.42	69.81	110.96	68
T_2= T_1+25% N	3.39	76.52	118.87	65
T_3= T_1+25% NP	3.28	74.14	115.24	64
T_4= T_1+25% NK	3.28	72.05	115.24	64
T_5= T_1+25% PK	2.98	68.89	108.34	66
T_6= T_1+25% NPK	3.12	78.09	119.86	66
T_7= 75% of T_1	2.83	68.29	98.16	65
T_8=Native fertility	1.85	46.22	64.81	63
CV (%)	8.91	5.15	7.19	6.21
LSD (0.05)	1.24	6.63	2.40	ns

Marketable head weight

The marketable head weight of cabbage varied significantly among the treatments due to different doses of inorganic fertilizer packages (Table 5). Considering the marketable head weight, it was evident that the treatment T_6 produced the highest individual marketable head weight (2.25 kg) and the lowest marketable head weight (1.17 kg) was obtained from unfertilized control (T_8) plot. Fertilizer treatment T_6 was statistically at par with T_1, T_2, T_3, T_4 and T_5 treatments. This might be due to fact that inorganic fertilizers supplied adequate available plant nutrients for proper vegetable growth of cabbage plants and finally those plants produce good head. The lowest marketable plant weight (1.17 kg) was recorded from unfertilized control plot. Sajib *et al*. (2015) were also found the similar type of result in their research work.

Marketable head yield

The marketable head yield of cabbage was significantly influenced due to the application of different doses of inorganic fertilizers and it ranges from 40.92 to 78.89 t ha^{-1} (Table 5). The highest marketable head yield of cabbage (78.89 t ha^{-1}) was obtained from the treatment T_6 followed by T_1, T_2, T_3, T_4 and T_5 and the lowest marketable head yield (40.92 t ha^{-1}) was obtained from the treatment T_8 which was statistically significant. It might be due to fact that inorganic fertilizers supplied sufficient plant nutrients readily for vigorous vegetative growth of cabbage plants as a result higher whole plant weight, head pericycle, and marketable head weight ultimately contributed higher marketable head yield. The results revealed that all the fertilizers contributed on the yield of cabbage while the effect of balanced fertilizer from

100% STB dose was more prominent than other treatments. It was observed that T_1+25% higher N alone could increase yields by 88.92% while T_1+ 25% higher NP, T_1+ 25 % higher NK and T_1+ 25% higher NPK increase yields by 81.52, 81.33 and 92.79%, respectively over control. These findings are in agreement with the observation of Naher e*t al. (*2014) who reported that the highest marketable head yield (76.53 t ha^{-1}) which was 191% increase over control was recorded from the plot receiving N, P, K and B at the rate of 150, 50, 100 and 3 kg ha^{-1}, respectively.

The higher dry matter of head (6.58%) was noted in T_1 (100% STB fertilizer dose) while the lowest (5.53%) was in control (T_8) treatment (Table 5). It might be due to fact that inorganic fertilizers supplied sufficient plant nutrients readily for vigorous vegetative growth of cabbage plants as a result higher dry matter was found in STB dose (T_1). The results revealed that all the fertilizers contributed on dry matter accumulation in head while the effect of balanced fertilizer from 100% STB dose was more prominent than other treatments. These findings are in agreement with the observation of Naher e*t al. (*2014) who reported that the highest dry matter (6.62%) of cabbage head was recorded from the plot receiving N, P, K, S and Zn at the rate of 150, 50, 100, 20 and 3 kg ha^{-1}, respectively whereas the lowest was recorded from the plot receiving N only at the rate 150 kg ha^{-1}.

Table 5. Effect of fertilizer doses on yield and dry matter of cabbage at Faridpur (pooled of 2012-13 and 2013-14).

Treatments	Marketable head Wt. (kg $plant^{-1}$)	Marketable head yield (t ha^{-1})	Yield increase over T_8 (%)	% dry matter of head
T_1= 100% NPKSZnB (STB)	2.18	76.21	86.24	6.58
T_2= T_1+25% N	2.21	77.31	88.92	5.82
T_3= T_1+25% NP	2.12	74.28	81.52	6.18
T_4= T_1+25% NK	2.11	74.20	81.33	6.26
T_5= T_1+25% PK	2.04	71.54	74.83	6.30
T_6= T_1+25% NPK	2.25	78.89	92.79	6.42
T_7= 75% of T_1	1.82	63.84	56.01	6.49
T_8=Native fertility	1.17	40.92	-	5.53
CV (%)	10.10	6.03	-	0.66
LSD (0.05)	3.24	5. 52	-	6.48

Cost and return analysis

Cost and return analysis of fertilizer experiment has shown in Table 6. The highest gross return Tk. 473340 ha^{-1} and gross margin Tk. 440533 ha^{-1}) was received from 100% soil test based fertilizer dose along with additional 25% NPK (T_6) treatment. The lowest gross return Tk. 241920 ha^{-1} was obtained from control treatment. The highest variable cost was incurred Tk. 32807 ha^{-1} from T_6 due to additional 25% NPK fertilizers. The lowest cost was calculated Tk. 19975 ha^{-1} was obtained from T_7 treatment due to 75 % Soil test based fertilizer dose. Dominance and marginal analysis also showed that 100% soil test based fertilizer dose (T_1) dominated over control (T_8) and its marginal rate of return (MRR) was found 1015% which implies that additional Tk. 1015 ha^{-1} would be earned if additional investment at Tk. 100 ha^{-1} in respective treatment (Table 7). Application of 100% chemical fertilizers of N-P-K-S-Zn-B from soil test based (T_1) appeared as the best treatment combination for cabbage cultivation from economic point of view in respect of considering MRR.

Table 6. Cost and return analysis of cabbage production as influenced by different fertilizer doses at Faridpur (average of 2012-13 and 2013-14).

Treatments	Gross Return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})
T_1= 100% NPKSZnB (STB)	457260	26634	430626
T_2 = T_1+ 25% N	463860	29259	434601
T_3 = T_1+ 25% NP	445680	32559	413121
T_4 = T_1+ 25% NK	445200	29507	415693
T_5 = T_1+ 25% PK	429240	30182	399058
T_6 = T_1+ 25% NPK	473340	32807	440533
T_7 = 75% of T_1	383040	19975	363065
T_8 = (Native nutrient)	241920	00	241920

Price of input/output (Tk. kg^{-1}): Urea=16.00, TSP =22.00, MoP=16.00, Gypsum=8.00, Boric acid=. 160.00, Zinc sulphate monohydrate=150.00 and Cabbage= 6.00

Table 7. Marginal analysis of different fertilizer treatments applied in cabbage at Faridpur (average of 2012-13 and 2013-14).

Treatments	Gross margin (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Marginal gross margin (Tk. ha^{-1})	Marginal variable cost (Tk. ha^{-1})	MRR* (%)
T_6 = T_1+ 25% NPK	440533	32807	5932	3548	167
T_2 = T_1+ 25% N	434601	29259	3975	2625	151
T_1- 100% (STB) dose	430626	26634	67561	6659	1015
T_7 = 75% of T_1	363065	19975	121145	19975	606
T_8 = (Native nutrient)	241920	00	-	-	-

***MRR=** Marginal Rate of Return

Note: T_3, T_4 and T_5 were discarded due to irrational cost in respect of gross margin than other treatments by calculating dominance analysis.

Conclusion

Fertilizer application had a positive effect on growth and yield performance of cabbage. The highest profitable head yield and yield contributing parameters were detected in the STB fertilizer (N_{242} P_{120} K_{33} S_{19} $Zn_{1.4}$ $B_{0.6}$ kg ha^{-1} combination treatment. The study concluded that application of STB chemical fertilizer might be suitable and economically profitable for cabbage cultivation in the study area (AEZ-12).

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