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Improving growth and yield of cabbage (*Brassica oleracea* var. *capitata*) by applying nitrogen and zinc

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ABSTRACT

The experiment was carried out at the Horticulture Farm of the Bangladesh Agricultural University during the period from October 2021 to February 2022 to study the effects of nitrogen and zinc on growth and yield of cabbage. The experiment consisted of two-factors viz. Factor A: four doses of nitrogen- (kg/ha) such as N_0: 0, no nitrogen (control), N_1: 100 kg N/ ha, N_2: 150 kg N/ ha, N_3: 200 kg N/ ha and Factor B: four doses of zinc- (kg/ha), Zn_0: 0 no zinc (control), Zn_1: 1.5 kg Zn/ ha, Zn_2: 2.0 kg Zn/ ha, Zn_3: 2.5 kg Zn/ ha. The two-factor experiment was laid out in Randomized Complete Block Design with three replications. The N_3: 200 kg N/ ha showed best performance with respect to plant height (32.72 cm), number of leaves per plant (21.65) gross yield N_3 (79.42 ton/ ha) marketable yield per hectare (55.09 t/ha). Application of zinc at Zn_3: 2.5 kg Zn/ ha was initiated to be excellent for plant height (32.30 cm), number of leaves (21.15), gross yield per hectare (75.39 ton), marketable yield per hectare (54.59 ton). Regarding the combined effect the treatment, N_3Zn_3 (200 kg N/ ha with 2.5 kg Zn/ ha) gave the maximum plant height (33.32 cm), number of leaves (22.33) per plant, gross yield per hectare (82.24 t/ha) and marketable yield per hectare (65.91 t/ha). Considering the above findings, it was concluded that the combination of N_3Zn_3 (200 kg N/ ha with 2.5 kg Zn/ ha) was found to be better for growth and yield of cabbage.

INTRODUCTION

Cabbage (*Brassica oleracea* var. *capitata* L.) is one the most important leafy vegetables of Bangladesh. It is an important part of Cole crops belongs to the Brassicaceae family. In Bangladesh, cabbage is mainly grown in the rabi season, which constitute the months from October to February. The maximum production of cabbage is attached with the proper doses of nitrogen and zinc (Yadav et al., 2012).

Among all the vegetables production in Bangladesh, cabbage ranks 2nd in respect of area under production. It is cultured in an area of 22.35 thousand hectare with the total production of 380 thousand tons (BBS, 2021). Compared to the production of cabbage in exhibited countries of the world, the mean yield of cabbage in Bangladesh is very low (FAO, 2015). The main cause for such yield of cabbage is poor growth due to lack of new technology, suitable application of fertilizer and proper take care.

Nitrogen can play important role on the vegetative growth of the plant. A plant lack in the nitrogen will oversee to make small growth having usually is little leaves of thin and yellowish in habit. A plant is supplied suitable amount of N, there is an enlargement to rise cell size and cell number with a total rise in leaf outturn (Bhagavantagoudra and Rokhade, 2001; Wang-zhaottui and Li-shenkiu, 2004). Nitrogen plays a serious induction in the making up of protein and protoplasm which conduce cell elongation and begin meristemetic activities when applied in optimum quantity of fertilizer (Jamre et al., 2010).

Zinc is vital element of many enzymes like alcohol dehydrogenase, RNA polymerase and carbonic anhydrase etc. Micronutrient lack of general. It was indicated that about 2.0 million hectares of

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agricultural land are Zinc deficient under different AEZ in Bangladesh. Zinc has high exploit to many physiological operation of plants. Zinc lack of affecting Protein synthesis activities and stem tension and Due to deficiency of zinc, plant shows many unusual reason and malformations causing a decreased new vegetative growth and improvement of smaller and parochial leaves (Ghuge et al., 2007; Hajiboland and Amirazad, 2010).

So, there is a huge opportunity to rise the growth and yield of cabbage by the application of N and Zn to increment of maximum grown in our country. Regarding the above facts undertaken with the following objectives to effect of nitrogen and zinc on growth and yield contributing behavior of cabbage and proper combination of nitrogen and zinc for assuring the better growth and yield of cabbage.

MATERIALS AND METHODS

Soil and climate of experimental site

The experiment was seen at the Horticulture Farm of the Department of Horticulture, BAU, Mymensingh. The mean land belonging to the old Brahmaputra flood plain as AEZ-9 having non calcareous dark grey flood plain soil (Hajiboland and Amirazad, 2010). It was acidic soil P^H ranging from 6.68 - 6.92 which is suitable for cabbage production.

Land preparation and planting materials used for the experiment

The land was made few deep and cross ploughing tiller pursued by laddering to derive a better tilth. The seedlings were raised in the seedbed. The intercultural management like as irrigation, gap filling, weeding, earthing up, and plant protection were done at a time.

Treatments of the investigation and experimental design

The experiment consisted of two-factors viz. Factor A: four doses of nitrogen- (kg/ha) such as N_0: 0, no nitrogen (control), N_1: 100 kg N/ ha, N_2: 150 kg N/ ha, N_3: 200 kg N/ ha and Factor B: four doses of zinc- (kg/ha), Zn_0: 0 no zinc (control), Zn_1: 1.5 kg Zn/ ha, Zn_2: 2.0 kg Zn/ ha, Zn_3: 2.5 kg Zn/ ha. The two-factor experiment was laid out in Randomized Complete Block Design with three replications. The treatments were counted randomly. There were 48 (16 x 3) units plot in the research. The plot of 2.4 m x 2 m in size and block to block, plot to plot distances were 1m and 0.5m.

Collection of data

The plant height was measured from the ground level to the tip of the largest leaf. The total number of loose leaves per plant was counted from each of plots, the Length and breadth of the largest leaf was measured from selected plants by a meter scale and mean of each plants was recorded. The plant height, total number of loose leaves per plant. The length and breadth of the largest leaf was measured at 15, 30, 45, and 60 days after transplanting (DAT). The diameter and thickness of stem at harvest was recorded with a meter scale. The average gross weight of sample plants in kilogram (kg) was multiplied by the number of head developed plants in a plot (2.4m x 2m) and was converted to gain the yield per hectare. The weight of the compact head excluding the loose leaves were taken in kilogram (kg) and mean value was calculated as the fresh weight of marketable head to converted to per plot into yield per hectare basis and was expressed in ton (t) (Ghuge et al., 2007; Hajiboland and Amirazad, 2010; Jamre *et al.*, 2010).

Statistical analysis

The recorded data were statistically resolved by using MSTAT-C computer package program in various behavior. The mean for all the treatments was counted and the analysis of variance for each of the characters was edited by F test. The differences between the treatment means were appreciated by least significant difference (LSD) test at 1% or 5% probability wherever applicable (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Main Effect of N and Zn on plant height

The highest plant height (32.72, 32.30 cm) was recorded from the application of nitrogen and Zinc (200 kg/ha), Zn_2 *(*2.5 kg/ha) at 60 DAT and the

lowest (30.79, 31.18 cm) was recorded from the control treatments N_0, Zn_0 (0 kg/ha) at 60 DAT. The result of Nitrogen and zinc treatments showed highly significant effect on the height of cabbage plants at 15, 30, 45 and 60 DAT (Figure 1). Most of similar findings have been obtained from (Akand et al., 2015; Yadav et al., 2012).

Main effect of nitrogen and zinc on number of leaves per plant

At 60 DAT the highest number of leaves (21.65) was obtained from N_3 (200 kg/ ha) and the lowest number of leaves per plant (18.41) was obtained from the plant receiving N_0 (without nitrogen). The number of leaves per plant was increased mainly due to the increased vegetative growth of the plant. The maximum number of leaves per plant (21.15) was recorded in Zn_3 (2.5 kg/ ha) while the minimum (19.09) was observed under control in Zn_0 (without zinc) (Figure 2). Similar findings also have been obtained from (Chaudhary et al., 2018; Hajiboland and Amirazad, 2010; Singh et al., 2002).

Main effect of nitrogen and zinc on length of the largest leaf

The highest length of the largest leaf N_3 (33.17 cm) and Zn_3 (33.07 cm) at 60 DAT. whereas the lowest length of the largest leaf N_0 (28.91 cm) and Zn_0 (30.39 cm) was found at (without nitrogen) treatment at 60 DAT (Table 1). The present findings are similar to the results as replied (HOU and Shang ZN 2006; Hajiboland and Amirazad, 2010; Sharma et al., 2003).

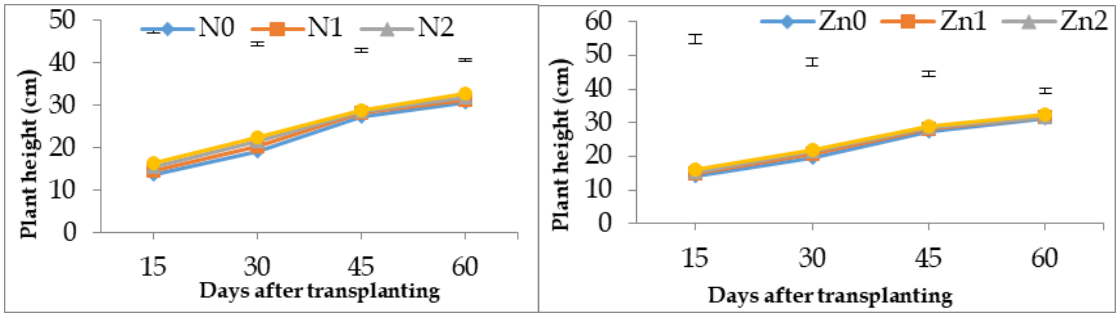

Figure 1: Main effects of nitrogen (left) and zinc (right) on plant height (cm) of cabbage. N_0 = 0 kg/ha, N_1 = 100 kg/ha, N_2 = 150 kg/ha, N_3 = 200 kg/ha. Zn0: 0 no zinc (control), Zn1: 1.5 kg Zn/ ha, Zn2: 2.0 kg Zn/ ha, Zn3: 2.5 kg Zn/ ha. Vertical bars indicate the LSD at 1% level of significance

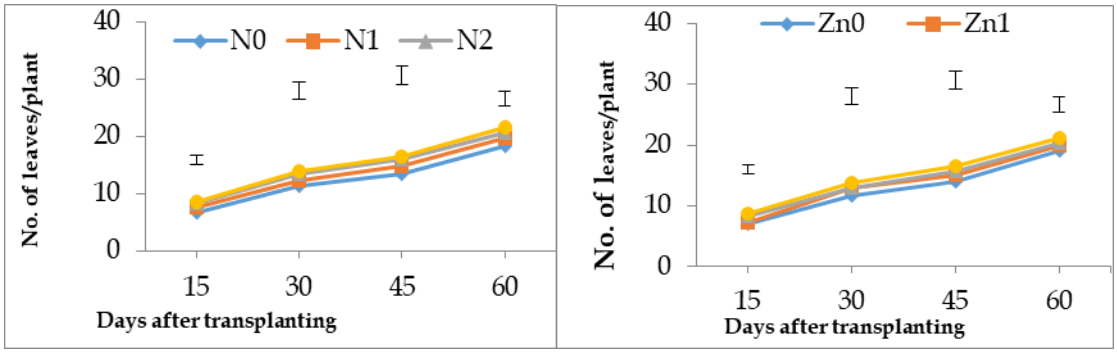

Figure 2: Main effects of nitrogen and Zinc on number of leaves per plant of cabbage. N_0 = 0 kg/ha, N_1 = 100 kg/ha, N_2 = 150 kg/ha, N_3 = 200 kg/ha, Zn_0 = 0 kg/ha, Zn_1 = 1.50 kg/ha, Zn_2 = 2.00 kg/ha, Zn_3 = 2.50 kg/ha. Vertical bars indicate the LSD at 1% level of significance

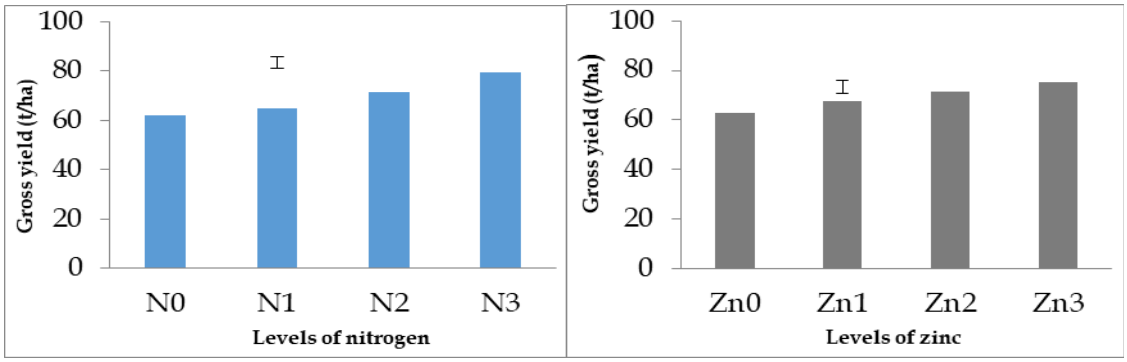

Figure 3: Main effects of different doses of nitrogen and Zinc on gross yield per hectare of cabbage. N_0 = 0 kg/ha, N_1 = 100 kg/ha, N_2 = 150 kg/ha, N_3 = 200 kg/ha, Zn_0 = 0 kg/ha, Zn_1 = 1.50 kg/ha, Zn_2 = 2.00 kg/ha, Zn_3 = 2.50 kg/ha. Vertical bar indicate the LSD at 1% level of significance

Table 1: Main effects of different doses of nitrogen and zinc on length of largest leaf at different days after transplanting of cabbage

Levels of nitrogen/Zinc	Length of largest leaf (cm) at different days after transplanting			
	15	**30**	**45**	**60**
N_0	15.09	21.30	27.27	28.91
N_1	15.96	22.89	27.53	31.05
N_2	17.63	23.97	29.02	33.00
N_3	17.85	25.10	28.54	33.17
$LSD_{0.01}$	0.22	0.22	0.17	0.20
Level of significance	**	**	**	**
Zn_0	15.10	22.17	27.53	30.39
Zn_1	16.29	22.88	27.38	30.71
Zn_2	17.04	23.70	28.30	31.97
Zn_3	18.10	29.15	29.15	33.07
$LSD_{0.01}$	0.22	0.17	0.17	0.20
Level of significance	**	**	**	**

** = Significant at 1% level of probability N_0 = 0 kg/ha, N_1 = 100 kg/ha, N_2 = 150 kg/ha, N_3 = 200 kg/ha, Zn_0 = 0 kg/ha, Zn_1 = 1.50 kg/ha, Zn_2 = 2.00 kg/ha, Zn_3 = 2.50 kg/ha.

Main effect of different doses of nitrogen and zinc on yield and yield contributing characters of cabbage

The stem length was found to be the highest (5.53 cm), fresh weight of roots (16.71 g), roots per plant (15.78), head diameter (17.41 cm), thickness of head (11.79 cm) lowest stem length (4.70 cm), roots per plant (13.36), diameter (16.29 cm), thickness of head (10.89 cm) was observed in control (N_0= 0 kg/ ha) treatment (Table 2). The maximum length of the stem (5.37 cm), number of roots per plant (15.24), head diameter (18.19 cm), thickness of head (12.31 cm) was obtained from zinc (Zn_3= 2.5 kg/ ha) treatment and minimum length of stem (5.12 cm), number of roots per plant (14.21), minimum head diameter (17.13 cm), thickness of head (10.72 cm) was obtained from control Zn_0 treatment (Table 2). These findings are in commensurate with the reports of in (HOU and Shang ZN 2006; Hajiboland and Amirazad, 2010) in cabbage.

Table 2: Main effects of different doses of nitrogen and Zinc on yield and yield contributing characters of cabbage

Levels of nitrogen/ Zinc	Length of the stem (cm)	Fresh weight of root (g)	No. of root /plant	Diameter of the cabbage head (cm)	% Dry matter content	Thickness of the cabbage head (cm)
N_0	4.70	9.98	13.36	16.29	5.85	10.89
N_1	5.26	11.65	14.19	17.18	5.96	11.19
N_2	5.50	15.58	15.33	18.88	6.35	12.09
N_3	5.53	16.71	15.78	17.41	6.84	11.79
$LSD_{0.01}$	0.05	0.20	0.14	0.12	0.15	0.15
Level of significance	**	**	**	**	**	**
Zn_0	5.12	11.93	14.21	17.13	4.99	10.72
Zn_1	5.19	13.85	14.32	17.29	5.73	11.16
Zn_2	5.31	13.77	14.90	17.15	6.85	11.77
Zn_3	5.37	14.36	15.24	18.19	7.43	12.31
$LSD_{0.01}$	0.05	0.20	0.14	0.12	0.15	0.15
Level of significance	**	**	**	**	**	**

** = Significant at 1% level of probability N_0 = 0 kg/ha, N_1 = 100 kg/ha, N_2 = 150 kg/ha, N_3 = 200 kg/ha, Zn_0 = 0 kg/ha, Zn_1 = 1.50 kg/ha, Zn_2 = 2.00 kg/ha, Zn_3 = 2.50 kg/ha.

Table 3: Main effects of different doses of nitrogen and Zinc on yield and yield contributing characters of cabbage

Levels of nitrogen	Gross weight of cabbage plant (kg)	Gross yield/plot (kg)	Weight of marketable head (kg)	Marketable yield/plot (kg)
N_0	1.20	22.01	0.96	18.68
N_1	1.40	23.67	1.04	19.81
N_2	1.51	26.82	1.12	21.52
N_3	1.60	29.25	1.16	21.35
$LSD_{0.01}$	0.08	0.17	0.07	0.45
Level of significance	**	**	**	**
Zn_0	1.38	23.22	0.75	15.47
Zn_1	1.42	25.27	1.06	20.57
Zn_2	1.41	25.93	1.19	22.10
Zn_3	1.50	27.33	1.28	23.21
$LSD_{0.01}$	0.08	0.17	0.07	0.45
Level of significance	**	**	**	**

** = Significant at 1% level of probability N_0 = 0 kg/ha, N_1 = 100 kg/ha, N_2 = 150 kg/ha, N_3 = 200 kg/ha, Zn_0 = 0 kg/ha, Zn_1 = 1.50 kg/ha, Zn_2 = 2.00 kg/ha, Zn_3 = 2.50 kg/ha.

Main effect of different doses of nitrogen and zinc on yield and yield contributing characters of cabbage

The gross weight of cabbage plant was found to be the highest (1.60 kg), gross yield per plot (29.25 kg), marketable head (1.16 kg/ ha), marketable yield per plot (21.35 kg) in N_3 (200 kg/ ha) treatment and the lowest gross weight of cabbage plant (1.20 kg), marketable yield (18.68 kg) was observed in control (N_0) treatment. The maximum gross weight of cabbage plant (1.50 kg), gross yield per plot (27.33 kg), marketable head (1.28

kg), was observed Zn_3 treatment and minimum gross weight of cabbage plant (1.38 kg), marketable yield per plot (15.47 kg) was observed in control (Zn_0) treatment (Table 3). Similar results were also observed by (Jamre et al., 2010; Amreesh and Atul, 2002).

Main effect of different doses of nitrogen and zinc on gross yield per hectare of cabbage

The highest gross yield N_3 (79.42 ton/ ha), Zn_3 (75.39 ton), was obtained from highest nitrogen treatment (N_3= 200 kg/ ha) and the lowest gross yield (62.18 ton/ ha), (63.07 ton) was recorded with control treatment (Figure 3). Similar findings have also been obtained from Krishi Projucti Hathboi (BARI, 2014).

Main effects of different doses of nitrogen and zinc on the marketable yield per hectare of cabbage

The highest marketable yield per hectare N_3 (55.09 ton), Zn_3 (55.09 ton) was obtained and the lowest marketable yield per hectare N_0 (34.73ton), marketable yield per hectare Zn_0 (34.14 ton) was obtained from the control treatment of zinc (Fig. 4). Similar findings have also been obtained from Krishi Projucti Hathboi ((BARI, 2014; Jamre et al., 2010; Hossain et al., 2023; Rashid, 2022).

Table 4: Combined effects of different doses of nitrogen and zinc on plant height at different days after transplanting of cabbage

Treatment combination	Plant height (cm) at different days after transplanting			
	15	**30**	**45**	**60**
N_0Zn_0	12.51	18.29	26.32	30.18
N_0Zn_1	13.54	18.67	27.40	30.56
N_0Zn_2	13.91	19.22	27.84	31.01
N_0Zn_3	15.21	20.31	28.12	31.39
N_1Zn_0	13.32	19.42	27.09	30.80
N_1Zn_1	14.12	20.35	28.15	31.09
N_1Zn_2	14.93	20.83	28.50	31.15
N_1Zn_3	15.85	21.22	28.94	32.10
N_2Zn_0	14.50	20.23	27.69	31.47
N_2Zn_1	15.33	21.44	28.55	32.23
N_2Zn_2	15.86	22.12	29.04	32.16
N_2Zn_3	16.43	22.72	29.25	32.42
N_3Zn_0	15.65	21.17	28.25	32.27
N_3Zn_1	16.25	22.24	28.78	32.51
N_3Zn_2	17.02	23.28	28.96	32.78
N_3Zn_3	17.31	23.82	29.32	33.32
$LSD_{0.01}$	0.46	0.36	0.31	0.22
Level of significance	**	**	**	**

** = Significant at 1% level of probability. N_0 = 0 kg/ha, N_1 = 100 kg/ha, N_2 = 150 kg/ha, N_3 = 200 kg/ha, Zn_0 = 0 kg/ha, Zn_1 = 1.50 kg/ha, Zn_2 = 2.00 kg/ha, Zn_3 = 2.50 kg/ha. Zn_0 = 0 kg/ ha, Zn_1 = 1.50 kg/ ha, Zn_2 = 2.00 kg/ ha, Zn_3 = 2.50 kg/ ha.

Combined effects of different doses of nitrogen and zinc on plant height at different days after transplanting of cabbage

The combined effect of nitrogen and zinc influence the height of plant. The highest plant height (33.32 cm) was recorded with the application of 200 kg/ha of nitrogen and 2.5 kg/ha of zinc at 60 DAT while the lowest height of plant (30.18 cm) was with no application of nitrogen and zinc (Table 4). Most of the similar findings have been obtained from (Mahesh and Rawat, 2002; Yadav, 2012; Hajiboland and Amirazad, 2010).

Combined effects of different doses of nitrogen and zinc on number of leaves per plant at different days after transplanting of cabbage

The highest number of leaves per plant (22.33) was produced by the treatment combination of the highest dose of nitrogen (N_3= 200 kg/ ha) and zinc (Zn_3= 2.5 kg/ ha) and the lowest (17.36) was recorded from no application of nitrogen and zinc (Table 5). The present findings are similar to the results as replied by (HOU and Shang, 2006) indicated that foliar application of Zn could obviously increase yield and improve quality of cabbage (Jamre *et al.*, 2010; Gomez and Gomez, 1984; Akand *et al.*, 2015; Wang-zhaottui and Li-shenkiu, 2004).

Table 5: Combined effects of different doses of nitrogen and zinc on number of leaves per plant at different days after transplanting of cabbage

Treatment combination	No. of leaves/plant at different days after transplanting			
	15	**30**	**45**	**60**
N_0Zn_0	5.76	10.34	12.80	17.36
N_0Zn_1	6.32	11.53	13.61	18.27
N_0Zn_2	7.23	11.45	13.45	18.77
N_0Zn_3	7.73	12.26	14.46	19.25
N_1Zn_0	6.62	11.34	13.50	18.84
N_1Zn_1	6.89	12.51	14.66	19.40
N_1Zn_2	8.33	12.25	15.44	19.68
N_1Zn_3	8.75	13.37	15.78	21.18
N_2Zn_0	7.57	12.31	14.67	19.56
N_2Zn_1	7.88	13.54	15.68	20.40
N_2Zn_2	8.77	13.95	16.44	20.63
N_2Zn_3	9.24	14.29	17.35	21.85
N_3Zn_0	8.34	12.65	14.65	20.62
N_3Zn_1	8.27	14.16	15.94	21.51
N_3Zn_2	8.73	14.27	17.37	22.13
N_3Zn_3	9.18	15.04	18.40	22.33
$LSD_{0.01}$	0.33	0.56	0.62	0.55
Level of significance	**	NS	**	**

** = Significant at 1% level of probability, NS = Not significant. N_0 = 0 kg/ha, N_1 = 100 kg/ha, N_2 = 150 kg/ha, N_3 = 200 kg/ha Zn_0 = 0 kg/ha, Zn_1 = 1.50 kg/ha, Zn_2 = 2.00 kg/ha, Zn_3 = 2.50 kg/ha.

Combined effects of different doses of nitrogen and zinc on length of largest leaf at different days after transplanting of cabbage

The highest length of the largest leaf per plant (35.24 cm) was observed by the treatment combination of the highest doses of nitrogen (N_3 = 200 kg/ ha) and zinc (Zn_3 = 2.5 kg/ ha) and the lowest (27.54 cm) was recorded from no application of nitrogen and zinc (Table 6). These results are in agreement with the findings of (Haque et al., 2015; Mahesh and Rawat, 2002; Hajiboland and Amirazad, 2010; Jamre et al., 2015) in cabbage.

Table 6: Combined effects of different doses of nitrogen and zinc on length of largest leaf at different days after transplanting of cabbage

Treatment combination	Length of largest leaf (cm) at different days after transplanting			
	15	30	45	60
N_0Zn_0	13.78	20.44	26.44	27.54
N_0Zn_1	14.52	21.03	26.50	29.56
N_0Zn_2	15.32	21.52	27.49	28.33
N_0Zn_3	16.73	22.22	28.64	30.21
N_1Zn_0	14.75	21.50	27.65	29.80
N_1Zn_1	15.81	22.32	26.76	30.51
N_1Zn_2	15.86	23.48	27.21	31.40
N_1Zn_3	17.44	24.25	28.49	32.46

N_2Zn_0	15.64	22.54	28.41	31.55
N_2Zn_1	17.65	23.40	28.65	32.50
N_2Zn_2	18.38	24.55	29.19	33.61
N_2Zn_3	18.86	25.38	29.82	34.36
N_3Zn_0	16.23	24.20	27.60	32.65
N_3Zn_1	17.20	24.76	27.61	30.28
N_3Zn_2	18.61	25.25	29.30	34.53
N_3Zn_3	19.35	26.18	29.66	35.24
$LSD_{0.01}$	0.43	0.43	0.35	0.40
Level of significance	**	**	**	**

** = Significant at 1% level of probability. N_0 = 0 kg/ha, N_1 = 100 kg/ha, N_2 = 150 kg/ha, N_3 = 200 kg/ha Zn_0 = 0 kg/ha, Zn_1 = 1.50 kg/ha, Zn_2 = 2.00 kg/ha, Zn_3 = 2.50 kg/ha

Combined effects of different doses of nitrogen and zinc on yield and yield contributing characters of cabbage

Length of stem is highest (5.66 cm), roots fresh weight was varied from 8.73 g to 17.38 g, number of roots per plant (16.35), head diameter (18.87 cm), thickness of head is highest (12.95 cm) at the treatment combination N_3Zn_3 (200 kg/ ha nitrogen and 2.5 kg/ha zinc) while the lowest length of stem was (4.54 cm), roots per plant (13.18), head diameter (16.12 cm), (10.30 cm) thickness of head at the treatment combination of N_0Zn_0. (Table 7). The present findings are similar to the results as replied (HOU and Shang, 2006; Hajiboland and Amirazad, 2010; Sharma et al., 2003) indicated that foliar application of Zn could obviously increase yield and improve quality of cabbage.

Combined effects of different doses of nitrogen and zinc on yield and yield contributing characters of cabbage

The gross weight of cabbage plant is highest (1.63 kg), marketable head (1.32 kg), marketable yield per plot (24.71 kg) at the treatment combination of N_3Zn_3 (200 kg/ ha nitrogen and 2.5 kg/ ha zinc) and the lowest (1.14 kg), marketable yield per plot (14.61 kg), marketable head (0.71 kg) was recorded from no application of nitrogen and zinc (Table 8). Application of different level of nitrogen was shown different yield of cabbage. Highest yield is obtained the level of 150 kg nitrogen per hectare in spite of 100 kg nitrogen per hectare. The reason behind this yield performance in soil condition, excess nitrogen harmless of soil and environmental condition. But different AEZ yield performance is different in different level of nitrogen is shown which is reported by (Bhagavantagoudra and Rokhade, 2001; Mukhopadhay, 2002).

Table 7: Combined effects of different doses of nitrogen and zinc on yield and yield contributing characters of cabbage

Treatment combination	Length of the stem (cm)	Fresh weight of root (g)	No. of root /plant	Diameter of the cabbage head (cm)	% Dry matter content	Thickness of the cabbage head
N_0Zn_0	4.54	8.73	13.18	16.12	4.62	10.30
N_0Zn_1	4.61	9.98	13.26	16.28	5.09	10.53
N_0Zn_2	4.78	10.37	13.40	16.34	6.41	11.22
N_0Zn_3	4.88	10.83	13.62	16.40	7.28	11.50
N_1Zn_0	5.14	11.53	13.87	16.31	4.72	10.56
N_1Zn_1	5.26	11.46	14.05	17.43	5.43	10.84
N_1Zn_2	5.32	11.70	14.14	16.64	6.57	11.66
N_1Zn_3	5.33	11.91	14.70	18.36	7.12	11.69
N_2Zn_0	5.37	12.86	14.34	18.64	5.36	11.54
N_2Zn_1	5.45	15.63	14.94	18.82	5.67	11.11
N_2Zn_2	5.57	16.48	15.77	18.94	6.88	12.61
N_2Zn_3	5.61	17.33	16.29	19.11	7.49	13.10
N_3Zn_0	5.43	14.59	15.45	17.46	5.25	10.46
N_3Zn_1	5.45	18.33	15.03	16.64	6.75	12.15
N_3Zn_2	5.56	16.54	16.29	16.68	7.55	11.58

N_3Zn_3	5.66	17.38	16.35	18.87	7.80	12.95
$LSD_{0.01}$	0.10	0.41	0.28	0.25	0.31	0.29
Level of significance	*	**	**	**	**	**

** = Significant at 1% level of probability, * = Significant at 5% level of probability. N_0 = 0 kg/ha, N_1 = 100 kg/ha, N_2 = 150 kg/ha, N_3 = 200 kg/ha Zn_0 = 0 kg/ha, Zn_1 = 1.50 kg/ha, Zn_2 = 2.00 kg/ha, Zn_3 = 2.50 kg/ha

Table 8: Combined effects of different doses of nitrogen and zinc on yield and yield contributing characters of cabbage

Treatment combination	Gross weight of cabbage plant (kg)	Gross yield/plot (kg)	Weight of marketable head (kg)	Marketable yield/plot (kg)
N_0Zn_0	1.14	20.06	0.71	14.61
N_0Zn_1	1.25	21.56	0.86	18.33
N_0Zn_2	1.13	22.29	1.10	20.42
N_0Zn_3	1.28	24.12	1.18	21.36
N_1Zn_0	1.32	21.24	0.74	14.74
N_1Zn_1	1.37	23.90	0.99	20.17
N_1Zn_2	1.41	23.82	1.13	21.80
N_1Zn_3	1.49	25.73	1.30	22.53
N_2Zn_0	1.44	25.28	0.82	16.41
N_2Zn_1	1.48	26.25	1.14	22.53
N_2Zn_2	1.55	27.27	1.20	22.87
N_2Zn_3	1.58	28.48	1.33	24.25
N_3Zn_0	1.61	26.29	0.75	16.11
N_3Zn_1	1.59	29.38	1.26	21.27
N_3Zn_2	1.56	30.31	1.31	23.31
N_3Zn_3	1.63	31.01	1.32	24.71
$LSD_{0.01}$	0.15	0.33	0.15	0.90
Level of significance	NS	**	**	**

** = Significant at 1% level of probability, * = Significant at 5% level of probability, NS = Not significant. N_0 = 0 kg/ha, N_1 = 100 kg/ha, N_2 = 150 kg/ha, N_3 = 200 kg/ha Zn_0 = 0 kg/ha, Zn_1 = 1.50 kg/ha, Zn_2 = 2.00 kg/ha, Zn_3 = 2.50 kg/ha

Combined effects of different doses of nitrogen and zinc on gross yield per hectare of cabbage

The doses of nitrogen (200 kg/ ha) and zinc (2.5 kg/ ha) produced the highest gross yield per hectare (82.24 ton). The lowest gross yield (54.66 ton) was recorded from without nitrogen and zinc treatment (Figure 5). This is inconformity with the work by (Hajiboland and Amirazad, 2010; Jamre et al., 2010).

Combined effects of different doses of nitrogen and zinc on marketable yield per hectare of cabbage

The doses of nitrogen (200 kg/ ha) and zinc (2.5 kg/ ha) produced the highest marketable yield per hectare (65.91 ton). The lowest marketable yield per hectare (26.53 ton) was recorded from without nitrogen and zinc treatment (Figure 6). Similar findings have also been obtained from Krishi Projucti Hathboi (BARI, 2014).

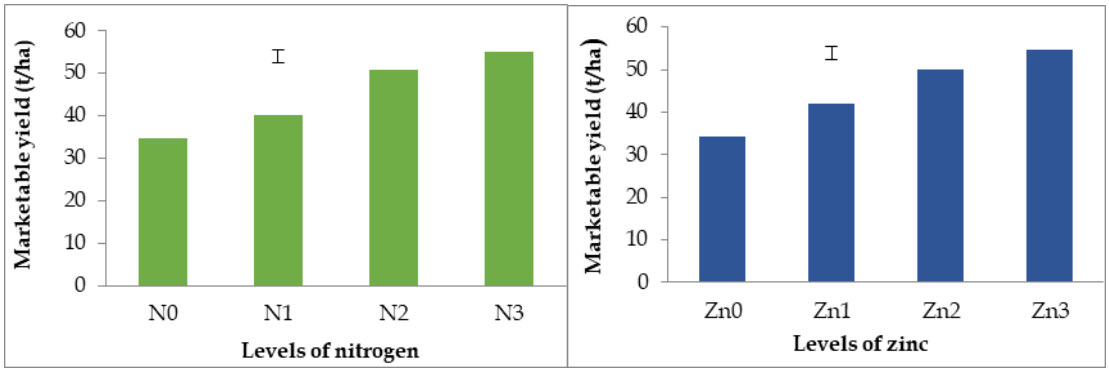

Figure 4: Main effects of different doses of nitrogen and Zinc on the marketable yield per hectare of cabbage. N_0 = 0 kg/ha, N_1 = 100 kg/ha, N_2 = 150 kg/ha, N_3 = 200 kg/ha, Zn_0 = 0 kg/ha, Zn_1 = 1.50 kg/ha, Zn_2 = 2.00 kg/ha, Zn_3 = 2.50 kg/ha. Vertical bar indicate the LSD at 1% level of significance

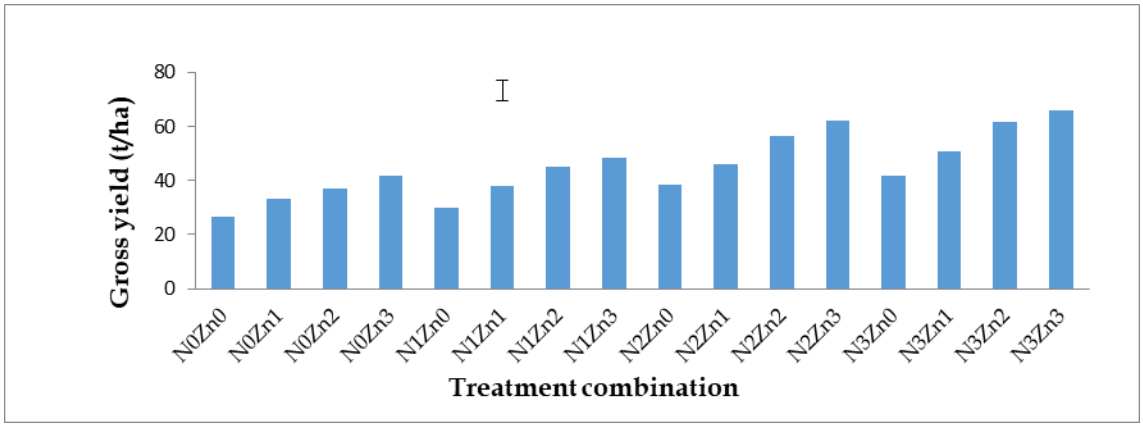

Figure 5: Combined effects of different doses of nitrogen and zinc on gross yield per hectare of cabbage. N_0 = 0 kg/ ha, N_1 = 100 kg/ ha, N_2 = 150 kg/ ha, N_3 = 200 kg/ ha. Zn_0= 0 kg/ha, Zn_1 = 1.5 kg/ha, Zn_2 = *2.0* kg/ha, Zn_3 = 2.5 kg/ha. Vertical bar indicate the LSD at 1% level of significance

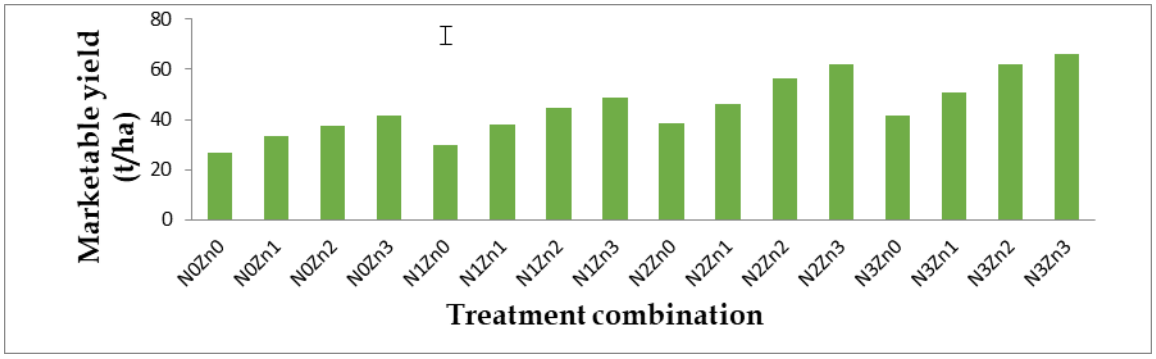

Figure 6: Combined effects of different doses of nitrogen and zinc on marketable yield per hectare of cabbage. N_0 = 0 kg/ ha, N_1 = 100 kg/ ha, N_2 = 150 kg/ ha, N_3 = 200 kg/ ha. Zn_0= 0 kg/ha, Zn_1 = 1.5 kg/ha, Zn_2 = *2.0* kg/ha, Zn_3 = 2.5 kg/ha. Vertical bar indicate the LSD at 1% level of significance

CONCLUSION

On the basis of above discussion it can be concluded that the application of nitrogen and zinc on plant height, length of the largest leaf, gross yield per hectare, marketable yield per hectare assigning role of cabbage. The application of N_3Zn_3 (200 kg nitrogen /ha and 2.5 kg zinc /ha) to the best height, number of leaves, gross yield per plot to per hectare of cabbage. In this test combination breadth of the largest leaf (29.71 cm) at 60 DAT, number of leaves per plant (22.33), diameter of head (18.87 cm), gross yield per plot (31.01 kg), gross yield per hectare (82.24 ton) marketable yield per plot (24.71 kg) and marketable yield per hectare (65.91 ton) were found in the treatment combination of N_3Zn_3 (200 kg nitrogen /ha and 2.5 kg zinc /ha.

Conflict of interest

All the authors do not have any possible conflicts of interest.

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