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Research Article

Evaluation of Different Levels of Nitrogen and Zinc Fertilizer on Morphological Characters and Yield of Rapeseed

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Abstract: The experiment was undertaken during rabiseason, November 2011 to February 2012 to examine the effects of different levels of nitrogen and zinc fertilizer on morphology and yield of rapeseed *Brassica campestris*L. variety BARI sarisha 15. In this experiment, the treatment consisted of four different N levels *viz.* (N_0: 0, N_1: 60, N_2:120, and N_3:180 Kg N/ha) and three different levels of Zn *viz.* (Zn_0:0, Zn_1:1 and, Zn_2:2 Kg/ha) using randomized complete block (RCBD) with three replications. Nitrogen showed significant variations on both morphological characters, yield contributing parameters and yield of rapeseed such as plant height, number of leaves, number of primary branches, length of inflorescence, seed yield and harvest index. Zinc did not show significant difference on morphological characters as nitrogen. But the significant differences were found on yield contributing characters and yield of rapeseed with zinc fertilization. The interaction between nitrogen and zinc showed statistical variations on all characters including morphological and yield contributing parameters and yield of rapeseed. The treatment combination, N_2Zn_2 (120 Kg N/ha along with 2 Kg Zn/ha) produced the highest seed yield (4.22 t/ha)whereas the lowest seed yield (0.37 t/ha) recorded from N_0Zn_0treatment combination with nitrogen and zinc fertigation. Therefore, the experimental results suggested that both nitrogen and zinc have contribution to improve seed yield of rapeseed by altering reproductive characters.

Keywords:*Brassica campestris*; Growth; Yield; N and Zn
Received: November 17, 2019 **Accepted**: January 24, 2020 **Published**: May 16, 2020
Competing Interests: The authors have declared that no competing interests exist.

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1. Introduction

Rapeseed (*Brassica campestris* L.) is a bright-yellow flowering member of the family Brassicaceaeand one of the major oilseed crops in Bangladesh and covering about 70% of the total production. Rapeseed contains more phenolic compounds, sinapic acid and its derivatives, most notable sinapine than any other oilseed plant[1] which has potential value in the regulation of low density lipoprotein (LDL), cholesterol oxidation as a biomarker for cardiovascular diseases[2,3] and suggesting that phenolics are functional food element that intended for health benefit. The aroma and pungent flavor of mustard comes from secondary metabolite, glucosinolate which is hydrolyzed by myrosinase to produce isothiocyanate that can inhibit weed seed germination during crop production.

The growth and seed yield of rapeseed is not to desired levels due to deficiency of suitable variety/ies, the imbalance use of nutrients or fertilizers,lack of knowledge on climate smart agriculture with the changing environment. In the meantime, the scientists have developed some varieties to increase the yield and quality of rapeseed. In addition, several researchers are still working for improving the morphological characters, seed yield and oil content of rapeseed with several crop management practices along with proper combination of macro and micro nutrients. Many previous reports showed that fertilization is the depending source of nutrient that can be used to boost up growth and yield of crops [4-7]. Nitrogen (N) has an important role in seed protein and physiological functions of the plant and supports the plant with rapid growth, increasing seed and fruit production and enhancing quality of leaf and oil seed yield [8]. N has significant effect on plant height, branches plant^{-1}, siliquae plant^{-1} and other growth factors and yield of mustard [9]. In addition, N significantly increased morpho-physiological parameters such as leaf area and rate of photosynthesis etc. It is essential for carbohydrate use within plants and stimulates root growth and development as well as uptake of other nutrients. It is essential constituent of protein or chlorophyll, so it is a great physiological important in plant metabolism. Many authors showed that the use of N @ 250 kg/ha and @180 kg/ha produced higher seed yield. [10-11]. High yielding varieties of rapeseed are very responsive to fertilizers especially N [12-14]. Separately, the deficiency of N causes stunted or slow plant growth, drying of lower or older leaves, pre matures leaf shedding, slender fibrous stems and the yellowing or chlorosis of leaves due to a drop in chlorophyll content. Excessive use of N may produce too much of vegetative growth, weakening of the stem and delay maturity of seed yield. So that N management is crucial in cropping system and for normal plant growth and development [15,16]. Therefore, it is necessary to find the suitable dose of N fertilizer for getting higher yield of rapeseed with the changing environment under the edaphic and climatic conditions of Sher-e-Bangla Agricultural University.

Not only nitrogen as a macronutrient but also zinc as a micro nutrient contributed to enhance the growth and yield of numerous crops. Zinc (Zn) is essential trace element for proteins synthesis and amino acids accumulation in plant tissues, protein synthesis. Zinc have better ability to withstand adverse environmental conditions. It was also reported that Zn is the active element in biochemical processes and has a chemical and biological interaction with some other elements. Micronutrient, zinc (Zn) increased mustard seed yield and oil content by developing root system and increasing leaf area to stimulate tryptophan, precursor of Indole acetic acid (IAA), promoting photosynthesis. It has been also reported that pollen sterility was recorded in low Zn condition thus reduces the seed yield. In addition, Zn has a protective role against oxidative damage [17]. Furthermore, zinc may be required for chlorophyll production, pollen function and fertilization and zinc deficiency also affect carbohydrate metabolism, damages pollen structure, and decreases the seed yield [18]. Application of proper amount of both macro and micro nutrients is essential to maximize crop production in soil or without soil. The N and Zn fertilizer play a vital role in enhancing the production of mustard. Zhu et al. [19] reported that Zn increased the mustard seed yield 18% over NPK alone. Both Zn deficiency and excessive N decreased the oil content in mustard. It is become evident that without the use of micronutrient, it is not possible to get the maximum benefits of NPK fertilizers and high yielding varieties of seed plants. Therefore, it has scope to conduct experiment to improve the seed yield of rapeseed with zinc fertilizer under the edaphic and climatic conditions of Sher-e-Bangla Agricultural University.

In Bangladesh, there is limited information on the combined use of N and Zn on growth and yield of oil producing *Brassica* spp. However, to my knowledge little is known whether different doses of N along with different doses of Zn regulate the growth, yield and oil content of rapeseed using new variety of BARI Sarisha 15 which is moderately salinity resistant. In view of above points current study has been undertaken to investigate the growth and yield of rapeseed variety BARI sarisha15 with different levels of nitrogen and zinc.

2. Materials and methods

The experiment was carried out at Sher-e-Bangla Agricultural University Farm, Dhaka-1207, Bangladesh during rabi season, November 2011 to February 2012 to examine the response to different levels of nitrogen (N) and zinc (Zn) on morphology, yield, yield attributes and seed quality of rapeseed variety BARI Sarisha 15. The seed was collected from the Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur. Before sowing of the seed in the experimental plot, germination test was done in the laboratory and results of percentage of germination was over 95%. The recommended doses of Triple super phosphate (TSP) as a source of Phosphorus (P), Muriate of Potash (MP) as a source of Potash (K), Gypsum as a source of Sulphur (S) and Boric acid as a source of Boron (B) were added to the soil of experimental field along with different levels of Nitrogen (N) in the form of Urea and Zinc (Zn) in the form of Zinc Oxide (ZnO). However, any N or Zn fertilizers were not applied to control plot. Experiment consisted four levels of nitrogen viz. N_0 = 0 Kg N/ha, N_1= 60 Kg N/ha, N_2= 120 Kg N/ha, N_3 =180 Kg N/ha and three levels of Zinc viz. Zn_0=0 Kg Zn/ha, Zn_1= 1Kg Zn/ha and Zn_2= 2Kg Zn/ha using Randomized Complete Block Design with 3 replications. The unit plot size was 3 m × 1.5 m = 4.5 m^2. The distance between blocks was 1 m and distance between plots was 0.5 m and plant spacing was 30 cm × 5 cm. TSP (160 Kg/ha), MP (110 Kg/ha), Gypsum(160 kg/ha) and Boric acid (7.5 kg/ha) were applied. Half of urea and total amount of all other fertilizers of each plot were applied and incorporated into soil during final land preparation. Rest of the urea was top dressed after 30 days of sowing (DAS). Seed sowing was done in rows 30 cm apart @8 kg/ha. Two irrigations were given as plants required. First irrigation was given immediate after topdressing and second irrigation were applied 60 DAS with watering can. After irrigation when the plots were in *zoe* condition, spading was done uniformly and carefully to conserve the soil moisture for proper growth and development of plants. As a preventive measure of aphid infestation, Malathion 57 EC @ 2 ml $litre^{-1}$ of water was applied twice first at 25 DAS and second at 50 DAS. The seeds were separated from the plants by beating the bundles with bamboo sticks on the threshing floor. Seeds and Stovers thus collected were dried in the sun for couple of days. Dried seeds and stovers of each plot was weighted and subsequently converted into yield kg/ha. Ten (10) plants from each plot were selected as random and were tagged for the data collection. The sample plants were uprooted prior to harvest and dried properly in the sun. The seed yield and stover yield per plot were recorded after cleaning and drying those properly in the sun. Data were collected on Plant height (cm), no. of leaves $plant^{-1}$,no. of primary branches $plant^{-1}$, Length of main inflorescence (cm), Yield (t/ha) and Harvest index (%). Collected data were statistically analyzed using MSTAT-C computer package programme and difference between treatments was assessed by Least Significant Difference LSD test at 5% level of significance [20].

3. Results and discussion

3.1Plant Height

Nitrogen (N) levels showed significant effect on rapeseed plant height as dose dependent manner at different days after sowing (DAS). The plant height increased with increasing the age of the plants. The tallest plant height was recorded with N_2(95.8 cm) while shortest from N_0 (86.2 cm) at 60 DAS (Fig. 1a). These findings are in agreement with those of Singh et al. [21], Tripathi and Tripathi [22]. Similar findings were reported by Tomar et al. [23], Ali and Ullah [24], Shamsuddin et al. [25], Ali and Rahman [12] and Hassan and Rahman [26]. Plant height was not significantly affected by different doses of Zn at DAS. However, plant height increased with increasing levels of Zn up to higher level. The tallest plant was found from Zn_2 (83.6 cm) while the shortest plant from Zn_0 (91.2cm) at 60 DAS (Fig 1b). These results suggest that Zn has no contribution to elongate of the axis of the plant during growth period. The combined use of N and Zn had significant effect on plant height. The tallest plant was found in N_2Zn_2 (98.5 cm) whereas the shortest plant from N_0Zn_0 (84.3cm) at 60 DAS (Table 1). Plant height increased significantly with successive increase in nitrogen up to 120 kg/ha [27]. The N increased plant height but Zn could not show any effect on plant height of rapeseed separately. All together these results indicate that plant height of rapeseed increases with combined use of N and Zn.

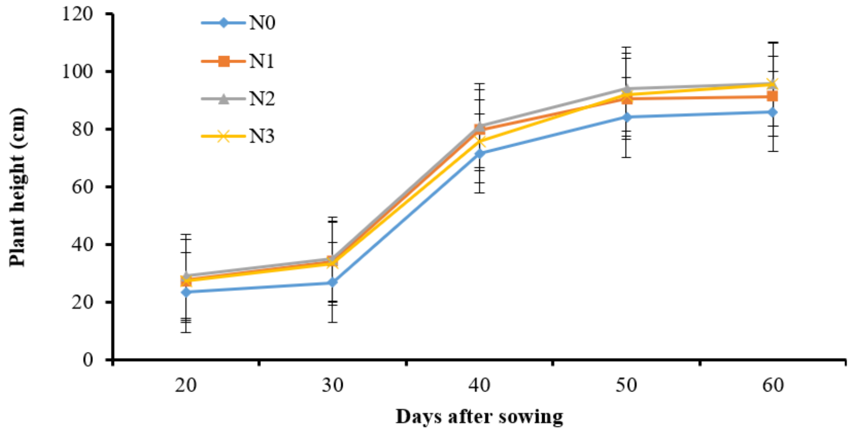

Fig. 1a: Effect of different levels of nitrogen at different DAS on the height of rapeseed plant (DAS = Days after sowing, N_0 = without nitrogen, N_1 = 60 kg N /ha, N_2 = 120 kg N/ha, N_3 = 180 kg N/ha, Error bars represent standard error).

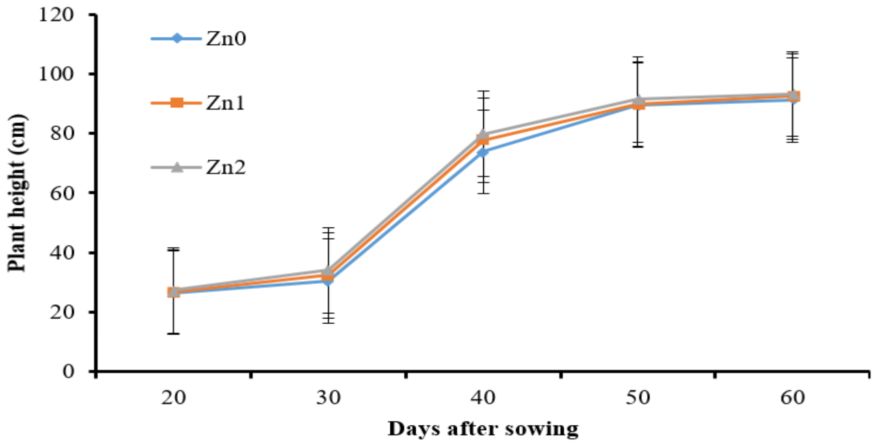

Fig. 1b: Effect of different levels of zinc at different DAS on the height of rapeseed plant (DAS = Days after sowing, Zn_0 = without zinc, Zn_1 = 1 kg Zn/ha, Zn_2 = 2 kg Zn/ha, Error bars represent standard error).

Table 1 Interaction effect of nitrogen (N) and zinc (Zn) on the height of rapeseed plant at different days after sowing (DAS)

Treatments	Plant height (cm)									
	20 DAS		30 DAS		40 DAS		50 DAS		60 DAS	
N_0Zn_0	22.7	e	25.4	f	68.7	g	82.9	f	84.3	c
N_0Zn_1	23.4	de	25.5	f	69.4	g	85.1	ef	87.9	abc
N_0Zn_2	24.4	d	29.6	e	74.6	ef	84.5	ef	85.9	abc
N_1Zn_0	27.7	bc	36.5	ab	82.1	abc	93.1	abc	94.8	abc
N_1Zn_1	27.7	bc	32.3	d	78.3	b-e	91.6	bcd	93.6	abc
N_1Zn_2	27.5	bc	36.1	ab	83.1	ab	94.4	ab	95.3	abc
N_2Zn_0	28.0	bc	32.4	d	76.3	de	88.1	de	84.7	bc
N_2Zn_1	28.9	ab	32.4	d	78.9	bcde	91.1	bcd	95.4	abc
N_2Zn_2	30.1	a	37.3	a	84.3	a	96.1	a	98.5	a
N_3Zn_0	27.9	bc	35.1	bc	81.3	abcd	92.4	abc	97.2	ab
N_3Zn_1	26.9	c	31.7	d	70.9	fg	89.7	cd	92.6	abc
N_3Zn_2	27.2	bc	33.6	cd	77.4	cde	93.7	abc	96.8	abc
$LSD_{(0.05)}$	1.57		1.94		4.84		3.66		11.0	
Significant level	*		*		*		*		*	
CV (%)	3.45		13.2		9.00		7.41		7.05	

In a column treatments having similar letter(s) do not differ significantly as per LSD

N_0 = without nitrogen, N_1 = 60 kg N/ha , N_2 = 120 kg N/ha , N_3 = 180 kg N/ha

Zn_0 = without zinc, Zn_1 = 1 kg Zn/ha, Zn_2 = 2 kg Zn/ha

CV = Co-efficient of Variation

LSD = Least Significant Difference

* = Significant at 5 % level

3.2Number of leaves plant^{-1}

It is reported that better growth and development of crop depend on a good number of leaves and producing more foliage related to the yield of rapeseed. The greater number of leaves, the greater the photosynthetic area which may result higher seed yield. The maximum number of leaves were found from N_2 (30.2/plant) while the minimum from N_0 (19.2 /plant) at 60 DAS (Fig 2a). These indicate number of leaves per plant increased with increasing N levels; those are consistent with Patil*et al.* [28] findings. With the 2 kg Zn/ha had the highest number of leaves (26.6/plant) while the lowest from Zn_0 (25.8/plant) at 60 DAS (Fig. 2b). So, Zn has important role on increasing number of rapeseed leaves. Significant variation in the number of leaves per plant was found among the different combination of the N and Zn levels. The maximum number of leaves was found from N_2Zn_2 (32.7/plant), while the minimum from N_0Zn_0 (18.7/plant) at 60 DAS (Table 2). These results indicated that combined use of N along with Zn can increase leaf number as well as leaf area of rapeseed plant.

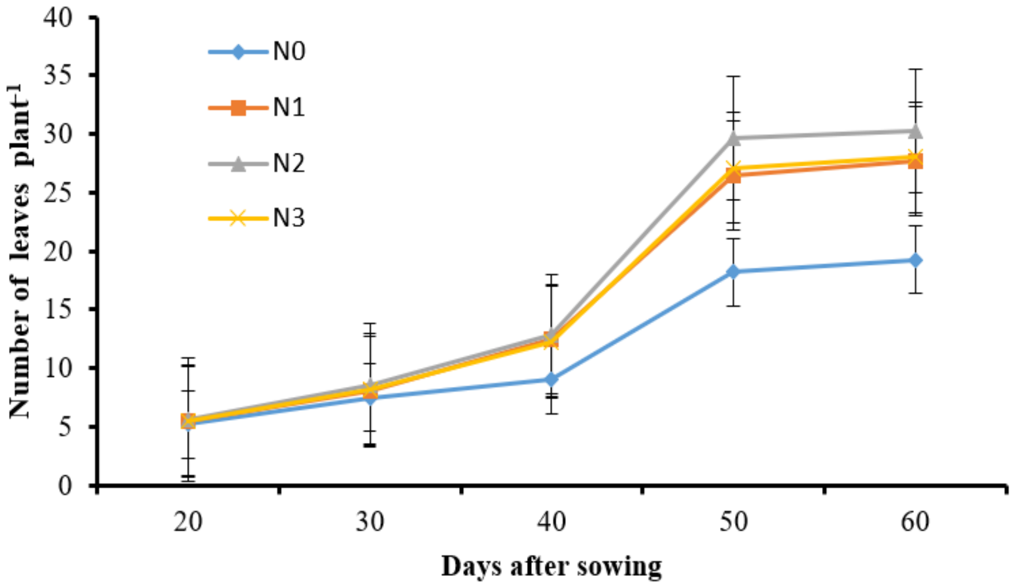

Fig. 2a: Effect of nitrogen at different DAS on the number of leaves plant^{-1} of rapeseed (DAS = Days after sowing, N_0 = without nitrogen, N_1 = 60 kg N/ha, N_2 = 120 kg N/ha, N_3 = 180 kg N/ha, Error bars represent standard error).

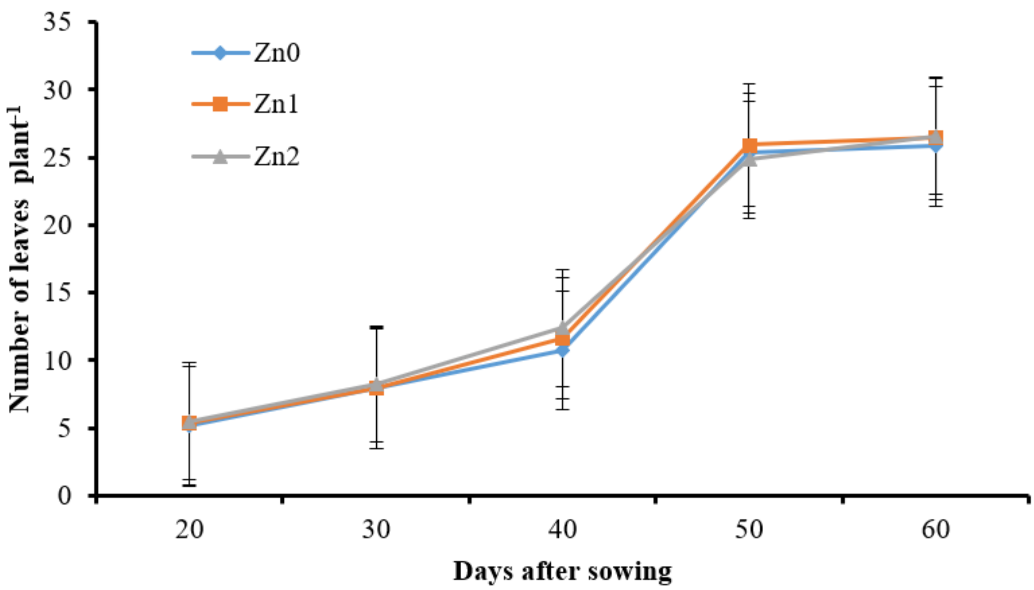

Fig. 2b: Effect of different doses of zinc at different DAS on the number of leaves per plant of rapeseed (DAS = Days after sowing, Zn_0 = without zinc, Zn_1 = 1 kg Zn/ha, Zn_2 = 2 kg Zn/ha, Error bars represent standard error).

Table 2 Combined effect of nitrogen and zinc on the number of leaves plant^{-1} of rapeseed at different days after sowing (DAS)

	Number of leaves plant^{-1}				
Treatments	**20 DAS**	**30 DAS**	**40 DAS**	**50 DAS**	**60 DAS**
N_0Zn_0	5.00 b	7.00 b	8.33 e	16.7 d	18.7 c
N_0Zn_1	5.33 ab	7.33 ab	8.67 de	18.7 d	19.0 bc
N_0Zn_2	5.33 ab	8.00 ab	10.0 cde	19.3 d	20.0 bc
N_1Zn_0	5.00 b	7.67 ab	14.0 ab	25.7 bc	28.3 ab
N_1Zn_1	5.00 b	8.00 ab	11.7 bcde	27.7 bc	28.0 abc
N_1Zn_2	5.67 a	8.33 ab	11.7 bcde	26.0 bc	26.7 abc
N_2Zn_0	5.67 a	7.67 ab	11.0 bcde	26.7 bc	28.3 ab
N_2Zn_1	5.67 a	8.67 ab	11.3 bcde	29.3 ab	29.7 a
N_2Zn_2	5.67 a	9.33 a	16.0 a	32.3 a	32.7 a
N_3Zn_0	5.33 ab	8.33 ab	13.3 abc	25.3 c	27.7 abc
N_3Zn_1	5.33 ab	8.00 ab	11.3 bcde	28.0 bc	26.3 abc
N_3Zn_2	5.67 a	8.33 ab	12.0 bcd	28.7 bc	30.0 a
LSD $_{(0.05)}$	0.45	1.76	3.15	3.35	8.24
Significant level	*	*	*	*	*
CV (%)	7.69	12.9	16.0	14.7	18.5

In a column treatments having similar letter(s) do not differ significantly as per LSD

N_0 = without nitrogen, N_1 = 60 kg N/ha , N_2 = 120 kg N/ha , N_3 = 180 kg N/ha

Zn_0 = without zinc, Zn_1 = 1 kg Zn/ha, Zn_2 = 2 kg Zn/ha

CV = Co-efficient of Variation

LSD = Least Significant Difference

* = Significant at 5 % level

3.3Number of Primary branches plant^{-1}

The maximum number of primary branches was found from N_2 (6.56/plant) while the minimum from N_0 (3.89/plant) at 60 DAS (Fig.3a). Tomar*et al.* [29], Ali and Ullah [24] also obtained highest number of branches per plant with 120 kg N ha^{-1}. In contrast, Mondal and Gaffer [9] also reported that N fertilizer application had no significant effect on number of primary branches per plant of rapeseed. Altogether, it suggests that N involve in initiating primary branches by sprouting lateral buds of rapeseed plants. Application of Zn had significant influence on number of primary branches/plant. The highest number of branches was obtained from Zn_2(6/plant) and the lowest from Zn_0(5.08/plant) at 60 DAS (Fig. 3b).It was observed that with the increase of Zn, number of primary branches/plant also increase at a certain level. Interaction effect between N and Zn was found significant on the number of primary branches/plant. The maximum number of branches was found in N_2Zn_2(7/plant) whereas the lowest in N_0Zn_0 (3.67/plant) at 60 DAS (Table 3). Murtaza and Paul [30] findings that there was a significant effect of nitrogen on number of primary branches/plant. Altogether, the result of this study suggests that N and Zn show synergistic effect on primary branches/plant of rapeseed plants

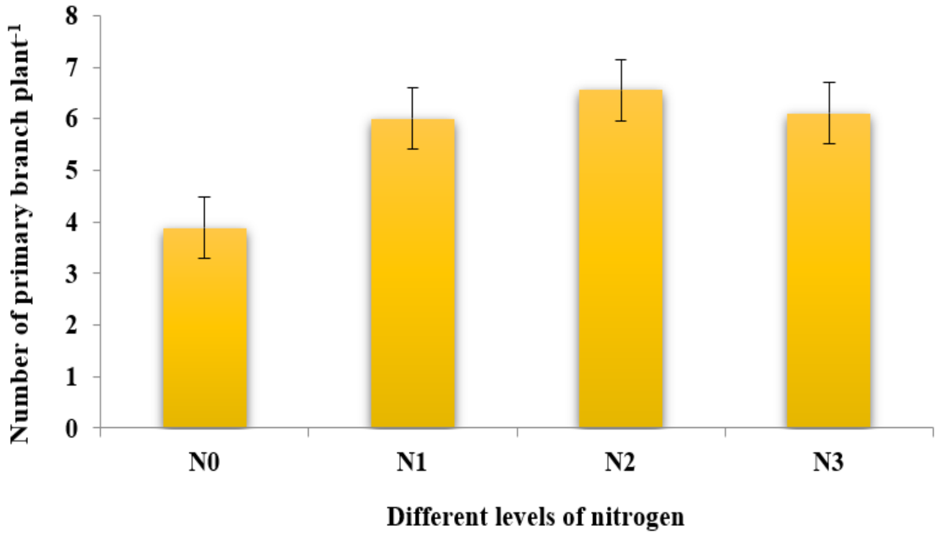

Fig. 3a: Effect of nitrogen on the number of primary branches plant^{-1} of rapeseed
(N_0 = without nitrogen, N_1 = 60 kg N /ha, N_2 = 120 kg N/ha, N_3 = 180 kg N/ha, Error bars represent standard error).

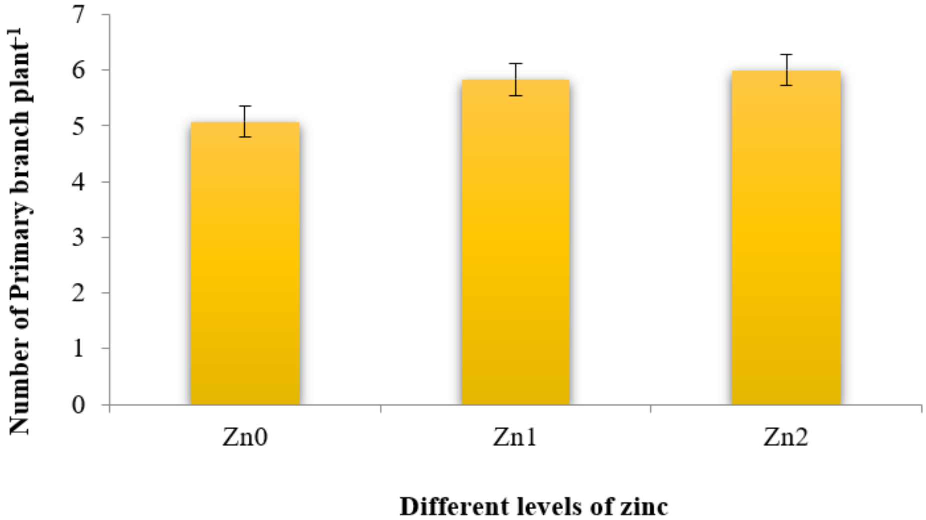

Fig. 3b: Effect of different levels of zinc on the number of primary branches plant^{-1} of rapeseed
(Zn_0= no zinc, Zn_1 = 1 kg Zn/ha, Zn_2 =2kg Zn/ha, Error bars represent standard error).

Table 3 Combined effect of nitrogen and zinc on the number of primary branches plant^{-1} of rapeseed

Treatments	**Number of Primary branches plant^{-1}**
N_0Zn_0	3.67 d
N_0Zn_1	3.67 d
N_0Zn_2	4.33 cd
N_1Zn_0	5.67 abc
N_1Zn_1	6.33 ab
N_1Zn_2	6.00 abc
N_2Zn_0	6.00 abc
N_2Zn_1	6.67 ab
N_2Zn_2	7.00 a
N_3Zn_0	5.00 bcd
N_3Zn_1	6.33 ab
N_3Zn_2	7.00 a
$LSD_{(0.05)}$	1.66
Significant level	*
CV (%)	7.30

In column, means containing same letter indicate significantly similar under LSD at 5% level of significance. Values are the means of three replications

N_0 = without nitrogen, N_1 = 60 kg N/ha , N_2 = 120 kg N/ha , N_3 = 180 kg N/ha

Zn_0= no zinc, Zn_1 = 1 kg Zn/ha, Zn_2 =2kg Zn/ha

CV = Co-efficient of Variation

LSD = Least Significant Difference

* = Significant at 5 % level

3.4Length of inflorescence

The longest inflorescence was found from N_2 (37.3 cm) while the shortest from N_0 (30.9 cm) at 80 DAS (Fig.4a). There was no significant difference among the Zn treatments in the length of inflorescence. However, the longest inflorescence was found from Zn_2 (36.2cm) whereas the shortest from Zn_0 (33.1cm) at 80 DAS. (Fig.4b). The longest inflorescence was found from N_2Zn_2 (39.6 cm) whereas the shortest from N_0Zn_0 (27 cm) at 80 DAS (Table 4).Proper combination of N and Zn is necessary for optimal growth and development in higher plants.

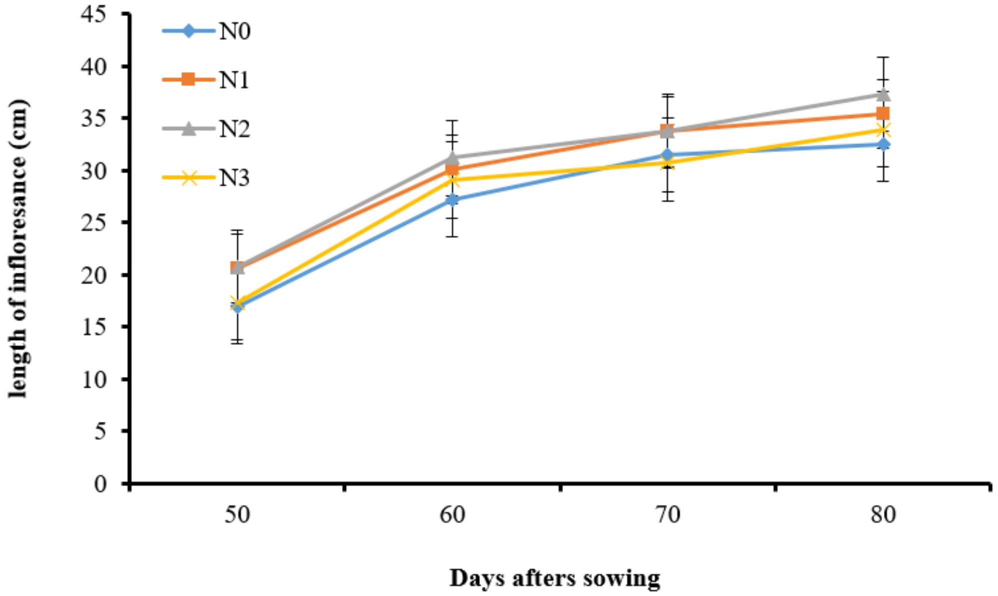

Fig. 4a: Effect of nitrogen at different DAS on length of inflorescence plant^{-1} of rapeseed (DAS = Days after sowing, N_0 = without nitrogen, N_1 = 60 kg N /ha, N_2 = 120 kg N/ha, N_3 = 180 kg N/ha, Error bars represent standard error).

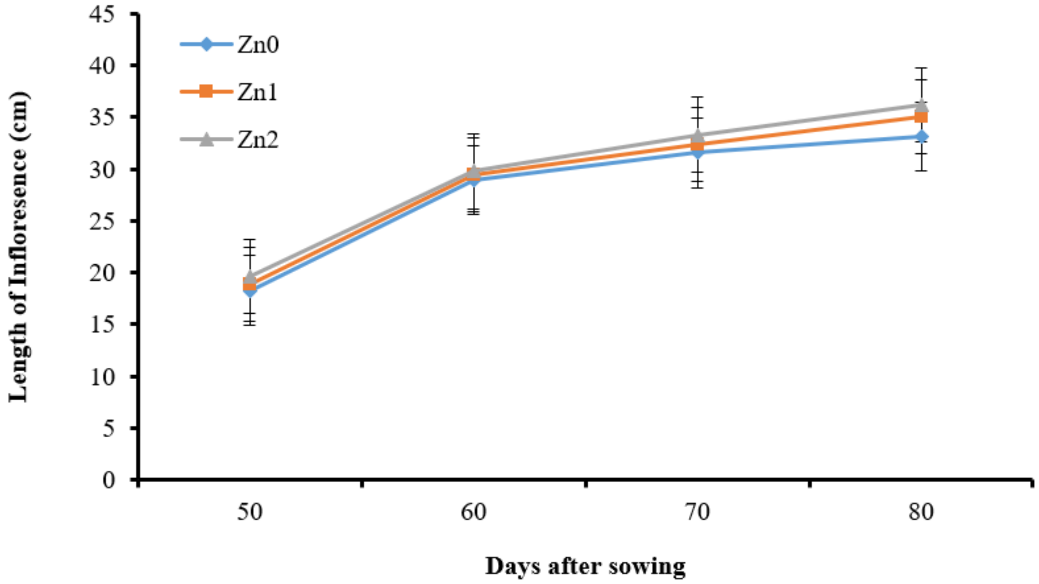

Fig. 4b: Effect of different levels of zinc at different DAS on the length of inflorescence plant^{-1} of rapeseed (DAS = Days after sowing, Zn_0 = without zinc, Zn_1 = 1 kg Zn/ha, Zn_2 =2kg Zn/ha, Error bars represent standard error).

Table 4 Interaction effect of nitrogen and zinc on length of inflorescence of rapeseed at different days after sowing (DAS)

	Length of inflorescence (cm)							
Treatments	**50 DAS**		**60 DAS**		**70 DAS**		**80 DAS**	
N_0Zn_0	12.7	c	23.1	c	28.1	c	27.0	d
N_0Zn_1	17.1	bc	31.6	a	32.5	abc	36.6	abc
N_0Zn_2	18.6	ab	28.6	ab	29.1	bc	32.7	bc
N_1Zn_0	21.3	ab	30.0	ab	34.3	abc	38.2	ab
N_1Zn_1	19.8	ab	30.8	a	33.8	abc	37.0	abc
N_1Zn_2	20.8	ab	31.0	a	33.3	abc	36.8	abc
N_2Zn_0	20.2	ab	30.0	ab	34.0	abc	34.5	abc
N_2Zn_1	18.7	ab	30.3	ab	34.7	ab	32.5	bc
N_2Zn_2	23.2	a	31.9	a	36.7	a	39.6	a
N_3Zn_0	20.7	ab	30.2	ab	32.8	abc	36.0	abc
N_3Zn_1	17.5	bc	27.1	b	28.5	bc	31.9	cd
N_3Zn_2	16.4	bc	28.2	ab	31.4	abc	34.8	abc
$LSD_{(0.05)}$	4.71		3.24		5.65		5.07	
Significant level	*		*		*		*	
CV (%)	22.25		12.57		10.29		20.11	

In column, means containing same letter indicate significantly similar under LSD at 5% level of significance. Values are the means of three replications

N_0 = without nitrogen, N_1 = 60 kg N/ha , N_2 = 120 kg N/ha , N_3 = 180 kg N/ha

Zn_0 = without Zinc, Zn_1 = 1kg Zn/ha, Zn_2 =2kg Zn/ha

CV = Co-efficient of Variation

LSD = Least Significant Difference

* = Significant at 5 % level

3.5Seed yield

N levels, Zn levels and their combinations showed significant variation in the seed yield per plot. The maximum seed yield was produced from N_2 (1.61 kg/plot and 3.57t/ha) whereas N_0 produced the minimum (3.14 g/plot and 1.50t/ha) (Table 5). The higher seed yield/ha was also obtained with same N rate reported by Singh and Prasad [11], Singh *et al*. [21], Shukla *et al*. [5]. Therefore, N can enhance the seed yield (t/ha) of rapeseed variety BARI sarisha 15. Seed weight increased with the increasing rates of N fertilizer up to 120 kg/ha and then declined. Higher seed yield per plot was also obtained with same N rate as reported by Singh *et al.* [31], Tuteja*et al.* [32]. Further increase in N level beyond 120 kg/ha could not improve the seed yield.These results isconsistent with the N-induced increase of growth parameters (Fig. 1a, 2a, 3a, 4a) along with seed yield /plot, (Table 5). Total yield of rapeseed varied significantly due to the application of different levels of Zn fertilizer. The maximum seed yield was produced from Zn_2 (1.49 kg/plot and 3.31t/ha) whereas Zn_0 gave the lowest yield (0.84 kg/plot and 1.04t/ha) (Table 6). This result showed that the yield of mustard increased gradually with the higher doses of Zn fertilizer. Interestingly, this result is consistent with the Zn-induced yield components such as seed yield (Table 6) rather than growth parameters (Fig. 1b, 2b, 3b, 4b). Therefore, higher dose of Zn can increase seed yield of rapeseed. The maximum seed yield was found from N_2Zn_2 (1.90 kg/plot and 4.22t/ha), whereas minimum from N_0Zn_0(0.17 kg/plot and 0.37t/ha), (Table 7). Therefore, these results suggest that the combined use of 120 kg N/ha and 2 kg Zn/ha produce the highest seed yield of rapeseed.

Table 5 The main effect of nitrogen on yield contributing characters and seed yield of rapeseed

Treatments	Seedyield per plot (kg)	Seedyield (t/ha)	Harvest index (%)
N_0	0.68 d	1.50 d	48.1 c
N_1	1.18 b	2.61 b	50.1bc
N_2	1.61 a	3.57 a	54.6 a
N_3	1.12 c	2.50 c	52.0 b
$LSD_{(0.05)}$	0.03	0.08	2.6
Significant level	*	*	*
CV (%)	**6.22**	**7.23**	**8.15**

Table 6 Effect of zinc on yield contributing charactersand seed yield of rapeseed

Treatments	Seed yield per plot (kg)	Seed yield (t/ha)	Harvest index (%)
Zn_0	0.84 c	1.88 c	50.0 c
Zn_1	1.10 b	2.45 b	51.3 b
Zn_2	1.49 a	3.31 a	52.4 a
$LSD_{(0.05)}$	0.04	0.11	0.7
Significant level	*	*	*
CV (%)	**6.22**	**7.23**	**8.15**

In a column treatments having similar letter(s) do not differ significantly as per LSD

N_0 = without nitrogen, N_1 = 60 kg N/ha , N_2 = 120 kg N/ha , N_3 = 180 kg N/ha

Zn_0 = without zinc, Zn_1 = 1 kg Zn/ha, Zn_2 = 2 kg Zn/ha

CV = Co-efficient of Variation

LSD = Least Significant Difference

* = Significant at 5 % level

NS= Non significant

Table 7 Interaction effect of nitrogen and zinc on yield contributing characters and seed yield of rapeseed.

Treatments	**Seed yield per plot (kg)**		**Seed yield (t/ha)**		**Harvest index (%)**	
N_0Zn_0	0.17	j	0.37	j	45.7	d
N_0Zn_1	0.55	i	1.22	i	48.9	cd
N_0Zn_2	1.69	c	3.76	c	49.8	c
N_1Zn_0	0.18	j	0.41	j	50.7	bc
N_1Zn_1	1.34	e	2.98	e	50.0	bc
N_1Zn_2	1.79	b	3.98	b	49.7	c
N_2Zn_0	0.82	g	1.82	g	52.7	bc
N_2Zn_1	1.80	b	3.99	b	54.2	ab
N_2Zn_2	1.90	a	4.22	a	56.9	a
N_3Zn_0	0.66	h	1.47	h	50.9	bc
N_3Zn_1	1.30	f	2.89	f	51.9	bc
N_3Zn_2	1.55	d	3.44	d	53.0	abc
$LSD_{(0.05)}$	0.02		0.05		3.8	
Significant level	*		*		*	
CV (%)	**20. 1**		**15.7**		**8.16**	

In a column treatments having similar letter(s) do not differ significantly as per LSD

N_0 = without nitrogen, N_1 = 60 kg N/ha , N_2 = 120 kg N/ha , N_3 = 180 kg N/ha

Zn_0 = without zinc, Zn_1 = 1 kg Zn/ha, Zn_2 = 2 kg Zn/ha

CV = Co-efficient of Variation

LSD = Least Significant Difference

* = Significant at 5 % level

3.6Harvest index

Harvest index indicates the partitioning of dry matter between reproductive and vegetative part. The ratio of economic yield to biological yield is termed as harvest index. Higher HI might be beneficial in obtaining higher economic yield. N levels, Zn levels and their combinations had significant effect on the harvest index of mustard. Variation. The maximum HI was found N_2 54.6%) while the minimum from N_0(48.1%) Table 1). The highest HI was obtained from Zn_2 (52.4%) whereas the lowest from Zn_0 (50.0%) (Table 2). Combined effect of N and Zn had a significant variation on HI. The highest HI (56.9%) was obtained from N_2Zn_2 while the lowest (45.7%) from N_0Zn_0 (Table 3).

4. Conclusion

Growth and seed yield contributing parameters of rapeseed are related with N and Zn application. Therefore, these results suggest that the combined use of 120 kg N/ha and 2 kg Zn/ha along with recommended doses of other fertilizer would be beneficial to increase the seed yield and oil content of rapeseed variety BARI sarisha 15 under the climatic and edaphic condition of Sher-e-Bangla Agricultural University, Dhaka.

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