Response of Seed Yield Contributing Characters and Seed Quality of Rapeseed (*Brassica campestris L.*) to Nitrogen and Zinc

T.A. Rimi[1], M. M. Islam[1], M. A. Siddik[1], S. Islam[1], S.C.Shovon[1] , S. Parvin[2]

[1]Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka-1207
[2]IAPP, Ministry of Agriculture, Dhaka-1000

Abstract- The experiment was conducted at the experimental Field of Sher-e-Bangla Agricultural University, Dhaka during the rabi season from November 2011 to February 2012 to investigate the role of nitrogen (N) and zinc (Zn) on seed yield contributing characters and seed quality of rapeseed (*Brassica campestris* L.). The experiment was factorial with two factors, factor A consisted of four different N levels *viz.* 0, 60, 120, 180 (kg/ha) and factor B consisted of three different levels of Zn *viz.* 0, 1, 2 (kg/ha). Randomized Complete Block Design (RCBD) with three replications was used in this experiment. Nitrogen significantly increased number of siliquae plant^{-1}, thousand seed weight and oil content percent up to 120 kg N/ha but the highest dose 180 kg N/ha failed to produce better results as other doses. The number of siliquae plant^{-1} and oil content percent was increased significantly with the increment of Zn up to 2 kg /ha. Interestingly, seed weight of 100 siliquae, 1000 seed weight did not show any statistical differences with the increment of Zn. The interaction between N and Zn significantly influenced seed weight plant^{-1}, seed weight of 100 siliquae, 1000 seed weight and oil content of seed. The maximum value of seed yield contributing characters and oil content of rapeseed was observed with thecombined dose of 120 kg N/ha and 2 Kg Zn/ha whereas the lowest values were obtained from control. . The maximum oil content (43.29%) was obtained from 120 kg N/ha with 2 Kg Zn/ha treatment combination. Separately, the combined use of N and Zn did not show any significant differences on regulation germination rate of rapeseed. Based on the present results, it can be suggested that the combined doses of 120 kg N/ha with 2 kg Zn/ha is appropriate for higher yield and quality seed production of rapeseed using cv. BARI Sarisha 15.

Index Terms- Rapeseed, Nitrogen, Zinc, Yield, Oil content, Germination (%)

I. Introduction

Rapeseed (*Brassica campestris* L.) is a bright yellow flowering member of the family Brassicaceae, which also includes cabbage, broccoli, cauliflower etc. It has been also reported that 100 g of mustards provide 4.733 mg of niacin, vitamin B 3 which is a part of nicotinamide co-enzymes; helps regulate blood cholesterol and triglyceride levels in human body. Oil cake is a nutritious food item for cattle and fish and also used as a good organic fertilizer. Dry mustard plants may be used as fuel. These are suggesting that mustard has diversified functions in a both agriculture and human physiology. It is well known that rapeseed is one the major oilseed crop in Bangladesh and covering about 70% of the total production. The area and production of mustard in this country was about 0.481 million hectares and 0.536 million tons, respectively with an average yield of 1.11 t ha^{-1} during 2010-2011 (AIS, 2012). The present domestic edible oilseed production is 267 thousand tons, which meets only one third of national oil demand. So, Bangladesh had to import a large quantity of edible oil every year at the cost of huge amount of foreign exchange worth BDT 11000 million during 2005-2006 fiscal years (BBS, 2006). The seed yield contributing charaters and seed yield of rapeseed is not to desired levels due to the imbalance use of nutrients, inefficiency to select a suitable variety, lack of high yielding (HYV) seed, lack of knowledge on climate change and lack of suitable approaches. 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 seed yield and oil content of rapeseed with several crop management practices along with proper combination of macro and micro nutrients. It has been reported that nitrogen (N) showed 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 (Allen and Morgan 2009). Mondal and Gaffer (1983) reported that N has significant effect on, siliquae plant^{-1} and other growth factors and yield of mustard. Many authors showed that the use of N @ 250 kg/ha and @180 kg/ha produced higher seed yield (Hossain and Gaffer 1997 and Singh and Prosad 2003). High yielding varieties of rapeseed are very responsive to fertilizers especially N (Ali and Rahman, 1986; Sharawat *et al*., 2002 and Patel *et al*., 2004). Separately, N increases the vegetative growth but delayed maturity of seed yielding plants and excessive use of this element may produce too much of vegetative growth, thus food production may be impaired and suggesting that N management is crucial in cropping system and for normal plant growth and development (Maini*et al*., 1959 and Singh *et al*., 1972). These results suggest that the optimum doses of N/ha for rapeseed seed yield is needed to verify. Zinc (Zn) is essential trace element for proteins synthesis and amino acids accumulation in plant tissues, protein synthesis decline by Zn deficit in plants indicates that Zn is the main composition of ribosome. One of the sites of protein synthesis is pollen tube that amount of Zn in there tip is 150 µgg^{-1} of dry matter and this Zn will contribute on the pollination by impact on pollen tube formation (Marschner, 1995; Outten *et al*., 2001 and Pandey *et al*., 2006). 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 (Arvind and Prasad, 2005). Furthermore, Zn may be required for chlorophyll production, pollen function and fertilization and zinc deficiency also affects carbohydrate metabolism, damages pollen structure, and decreases the yield (Pandey *et al*., 2006). However, little is known whether Zn regulates seed yield, oil content, and germination percent of rapeseed.

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 and thereby reducing the oil deficit in the country. The deficiency of N is widespread in Bangladesh due to high cropping intensity, lack of use of organic matter into soil, reduction of livestock production, use of hybrid varieties for increasing yield etc. Zhu *et al.* (1996) 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. 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 variety of BARI Sarisha 15.

Materials and Methods

The experiment was conducted at the Sher-e-Bangla Agricultural University Farm, Dhaka, under the agro-ecological zone of Modhupur Tract, AEZ-28 during rabi season, November to February of 2011-12 to examine the response of nitrogen (N) and Zinc (Zn) on yield attributes and seed quality of rapeseed cv. BARI Sarisha-15. The seed was collected from the Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur. The experiment was laid out in randomized complete block design with three replications. Treatments of the experiment was four doses of nitrogen viz. N_0 = without nitrogen, N_1 = 60 kg N/ha, N_2 = 120 kg N/ha, N_3 = 180 kg N/ha and three doses of Zinc viz. Zn_0 = 0 kg Zn/ha, Zn_1 = 1 kg Zn/ha, Zn_2 = 2 kg Zn/ha. There were 12 treatment combinations of different N doses and mulch materialswhich were used in the experiment are as N_0 Zn_0, N_0 Zn_1, N0 Zn_2, N_1 Zn_0, N_1 Zn_1, N_1 Zn_2, N_2 Zn_0, N_2 Zn_1, N_2 Zn_2, N_3 Zn_0, N_3 Zn_1, N_3 Zn_2. The total plot number was 12 x 3 = 36. The unit plot size was 3 m x 1.5 m = 4.5 m^2. The land was ploughed with a rotary plough and power tiller for four times. Ploughed soil was then brought into desirable fine tilth and leveled by laddering. The weeds were cleaned properly. The final ploughing and land preparation were done on 15 November 2011. In this experiment, manures and fertilizers were used according to BARI. Sowing was done on 17 November 2011 in rows 30 cm apart. Seeds were sown continuously in rows at a rate of 8 kg/ha. After sowing, the seeds were covered with the soil and slightly pressed by hand. The optimum plant population, 60 plants/ m^2 was maintained by thinning excess plant at 15 days after sowing (DAS). The plant to plant distance was maintained as 5 cm. One weeding with khurpi was given on 25 DAS. Different intercultural operations and protection measures were done when necessary. Previous randomly selected ten plants were collected from each plot to analyze number of siliquae $plant^{-1}$, 1000 seed weight (g), seed oil content (%) and germination percentage. The oil content of seed was determined from Oil Seed Research Centre, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur- 1701. Oil content of seeds was determined by the following methods of Mehlenbacher (1960). The germination percentage of seed was analyzed from Seed Certification Agency (SCA), Joydebpur, Gazipur. The data obtained from the experiment were subjected to statistical analysis following analysis of variance technique (Russell, 1986). The mean differences were tested through least significant difference (LSD) method.

Results and Discussion

Number of siliquae $plant^{-1}$

The number of siliquae per plant of rapeseed/mustard was highly affected nitrogen rates and their interaction. The N showed significant variation in the number of siliquae per plant (Table-1). The maximum number siliquae per plant (38.3) was obtained in plots which received 120 kg N ha^{-1} which was statistically similar with 60 kg N/ha and 180 kg N/ha. The minimum number of siliquae per plant (32.6) produced with no nitrogen application. Similar results also obtained by Shukla et al. (2002) and Singh et al. (2003) in rapeseed. These are consistent with the length of inflorescence of rapeseed of this study (data not shown).

There was a significant difference among the Zn in the number of siliquae per plant (Table-2). The maximum number of siliquae per plant (38.4) was produced with Zn_2 or 2 kg Zn/ha and the minimum number of siliquae per plant (33.5) was produced in Zn_0 or control condition.

The analysis of variance (Table 3) showed a significant variation among the treatment combinations of N and Zn in number of siliquae per plant. The maximum number of siliquae per plant (42.0) was found in N_2Zn_2, whereas the minimum number of siliquae per plant (26.80) was found in N_0Zn_0 treatment combination. These results are consistent with the results of length of inflorescence up to 80 DAS (Table 4).

Seed weight of hundred siliquae

Seed weight of hundred siliquae showed significant difference due to variation of doses of nitrogen (Table 1). The highest seed weight of hundred siliquae (0.76 g) was obtained from N_2 treatment. The lowest seed weight of hundred siliquae (0.55 g) was recorded in control treatment. These results are in agreement with the findings of Deekshitulaet al. (1997) in Indian mustard, Bhagwanet al. (1996) and Patilet al. (1997) in mustard. They reported that seed weight of hundred siliquae in mustard increased with the application of nitrogen.

The Zn showed insignificant variation in the seed weight of hundred siliquae(Table 6 and Appendix VII). The highestseed weight of hundred siliquae (0.69 g) was obtained from Zn_2

treatment. The lowest seed weight of hundred siliquae (0.65 g) was obtained from control treatment.

The interaction effect of N and Zn was significant on seed weight of hundred siliquae(Table 7). The highest seed weight of hundred siliquae (0.83 g) was produced in N_2Zn_2. The lowest (0.52 g) was recorded in the treatment combination of N_0Zn_0.

Thousand seed weight

The application of nitrogen influenced significantly on the thousand seed weight (Table 1). The maximum thousand seed weight (7.63 g) was produced by N_2, which was statistically similar with N_1 andN_3 treatment and N_0 produced the lowest thousand seed weight (5.53 g). Ozer (2003), Singh, P.C. (2002) and Shamsuddin et al. (1987) also obtained highest 1000 seed weight with 120 kg N/ha.

The weight of thousand seed was significantly influenced by Zn (Table 2). The highest thousand seed weight (6.91 g) was obtained from Zn_2 treatment. The lowest thousand seed weight (6.52 g) was obtained from without Zn.

Thousand seed weight was significantly affected by both N and Zn (Table 3). The highest thousand seed weight (8.29 g) was found in N_2Zn_2 treatment combination, 120 kg N/ha and 2 kg Zn/ha whereas the lowest thousand seed weight (5.21 g) was found in N_0Zn_0 treatment (Table 3). These results suggest that combined use of appropriate doses of N and Zn produced maximum thousand seed weight than the use of same dose of N or Z along.

Oil content show significant influence by different N levels (Fig. 1). Fig. 1 revealed that application of N at 120 kg/ha (N_2) gave the maximum oil content (43.09 %), which was statistically similar with N_3 (180 kg N/ha) treatment and the minimum oil content (41.60 %) was obtained from N_0 levels. Singh et al. (2004) also reported that N application did not affect the oil content of rapeseed. The present results of oil content of rapeseed suggest that N improve the oil percent up to 120 kg N /ha but not 180 kg /ha.

The oil content varied significantly due to the application of different levels of zinc fertilizer (Fig. 2). The highest oil content (42.81 %) was obtained from Zn_2, 2 kg Zn/ha, which was statistically similar with Zn_1 (1 kg Zn/ha) while Zn_0 gave the lowest (42.13 %) oil content. These results suggest that Zn can synthesis oil in rapeseed and higher levels of Zn improve the percent of oil in rapeseed.

The combined effect of N and Zn fertilizer was significant on oil content of rapeseed (Table 4). The highest oil content (43.29 %) was obtained from N_2Zn_2 treatment combination, 120 kg N/ha and 2 kg Zn/ha whereas the lowest oil content (40.11 %) was obtained from N_0Zn_0 treatment combination, 0 kg N/ha and 0kg Zn /ha (Table 8). Present result of oil content of rapeseed indicate that the combined use of N and Zn can enhance the percent of rapeseed oil content as compared to N and Zn alone Therefore, it can be suggested that the 120 kg N/ha along with 2 kg Zn/ha is the best combination for containing higher amount of oil percent in rapeseed.

Oil content

Table 1. The main effect of nitrogen on yield contributing characters and seed yield of rapeseed

Treatments	No. of siliquae/plant	Seed weight of 100 siliquae (g)	1000 seed weight (g)
N_0	32.6 b	0.55 b	5.53 b
N_1	36.9 a	0.68 ab	6.84 ab
N_2	38.3a	0.76a	7.63 a
N_3	38.1 a	0.69ab	6.85 ab
$LSD_{(0.05)}$	3.74	0.16	1.88
Significant level	*	*	*
CV (%)	12.9	10.6	8.11

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 2. Effect of zinc on yield contributing characters and seed yield of rapeseed

Treatments	No. of siliquae/plant		Seed weight of 100 siliquae(g)	1000 seed weight (g)
Zn_0	33.5	b	0.65	6.52
Zn_1	37.6	a	0.67	6.71
Zn_2	38.4	a	0.69	6.91

$LSD_{(0.05)}$	3.63	0.54	2.54
Significant level	*	NS	NS
CV (%)	12.9	10.6	8.11

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

Treatments	No. of siliquae/plant		Seed weight of 100 siliquae (g)		1000 seed weight (g)	
N_0Zn_0	26.8	g	0.52	b	5.21	b
N_0Zn_1	36.0	cdef	0.55	ab	5.54	ab
N_0Zn_2	34.9	ef	0.58	ab	5.85	ab
N_1Zn_0	34.1	f	0.64	ab	6.41	ab
N_1Zn_1	38.6	bc	0.69	ab	6.87	ab
N_1Zn_2	38.1	bcd	0.72	ab	7.23	ab
N_2Zn_0	36.9	cde	0.73	ab	7.27	ab
N_2Zn_1	35.5	def	0.73	ab	7.34	ab
N_2Zn_2	42.0	a	0.83	a	8.29	a
N_3Zn_0	36.4	cdef	0.66	ab	6.55	ab
N_3Zn_1	40.1	ab	0.71	ab	7.09	ab
N_3Zn_2	38.4	bc	0.69	ab	6.91	ab
$LSD_{(0.05)}$	2.43		0.26		2.38	
Significant level	*		*		*	
CV (%)	8.85		10.6		14.3	

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

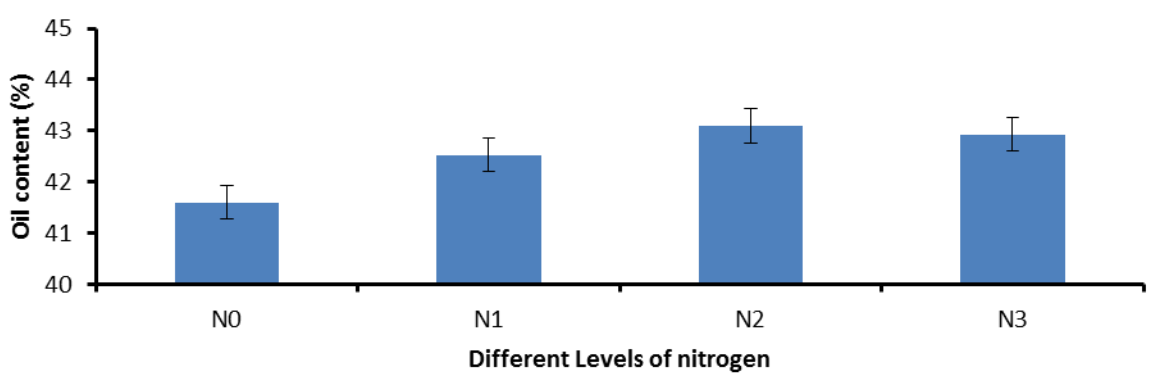

Fig. 1. The effect of nitrogen on oil content of rapeseed (N_0 = without nitrogen, N_1 = 60 kg N /ha, N_2 = 120 kg N/ha, N_3 = 180 kg N/ha, Error bars represent standard error).

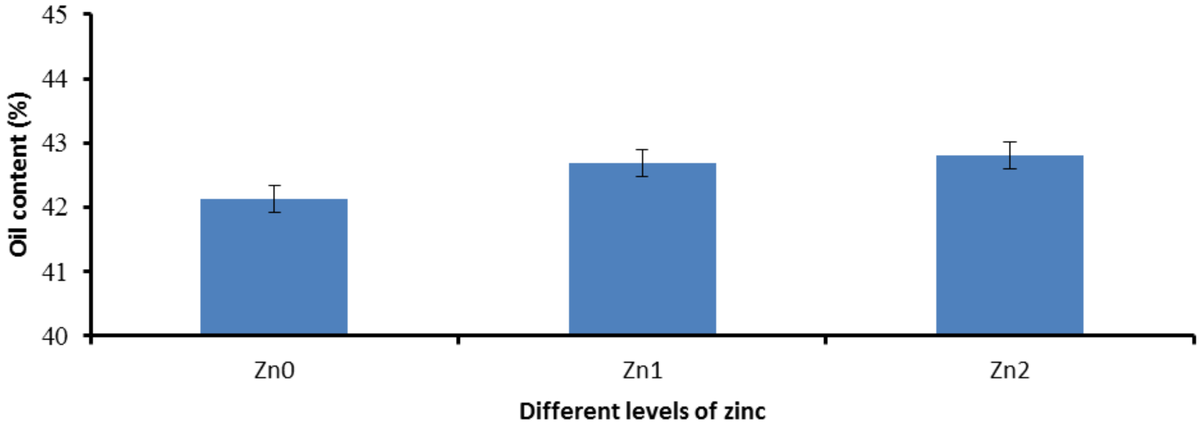

Fig. 2. The effect of zinc on oil content of rapeseed (Zn_0 = without zinc, Zn_1 = 1 kg Zn/ha, Zn_2 = 2 kg Zn /ha, Error bars represent standard error).

Table 4. Interaction effect of nitrogen and zinc on oil content and germination of rapeseed

Treatments	Oil content (%)		Percent of germination
N_0Zn_0	40.1	D	93.00
N_0Zn_1	41.8	c	96.00
N_0Zn_2	42.9	ab	93.67
N_1Zn_0	42.3	bc	94.00
N_1Zn_1	43.1	ab	97.00
N_1Zn_2	42.2	bc	98.00
N_2Zn_0	43.2	ab	93.00
N_2Zn_1	42.9	ab	92.00
N_2Zn_2	43.3	a	95.33
N_3Zn_0	43.0	ab	99.00
N_3Zn_1	43.0	ab	99.00
N_3Zn_2	42.8	ab	95.67
$LSD_{(0.05)}$	0.84		1.08
Significant level	*		NS
CV (%)	5.16		6.35

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

Germination percentage

The germination percentage of seed was not significantly affected of this rapeseed variety (Fig. 3). The maximum germination percentage of seed (97.89 %) was obtained from N_3 (170 kg N/ha) whereas the minimum germination percentage of seed (93.44 %) was obtained with N_2 (120 kg N/ha). Similarly, germination percentage of seed was not influenced by Zn (Fig. 4). The maximum germination percentage of seed (96.00 %) was obtained from Zn_1 (1 kg Zn/ha) and the minimum (94.75 %) from Zn_0 (control). Again, interaction effect of N and Zn also had significant variation on germination percentage of seed (Table 4). The maximum germination percentage of seed (99.00 %) was obtained from N_3Zn_0, while the shortest (92.00 %) was obtained from N_2Zn_1 (Table 8).

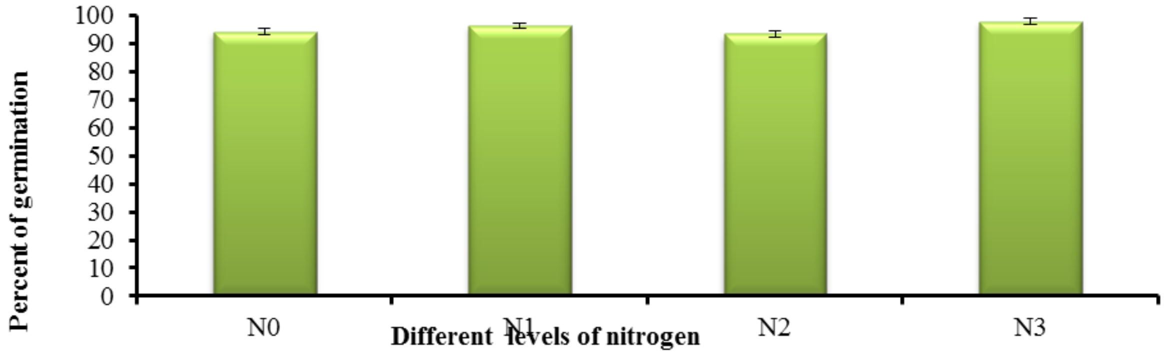

Fig. 3.The effect of nitrogen on germination percentage of rapeseed (N_0 = without nitrogen, N_1 = 60 kg N /ha, N_2 = 120 kg N/ha, N_3 = 180 kg N/ha, Error bars represent standard error).

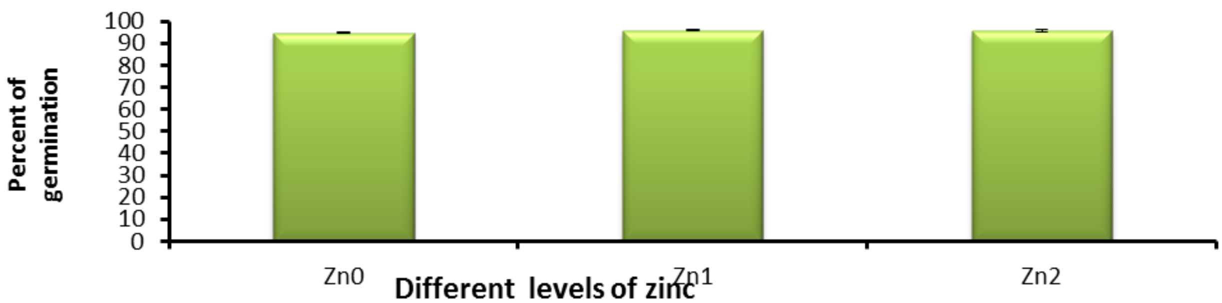

Fig. 4. The effect of zinc on germination percentage of rapeseed (Zn_0 = without zinc, Zn_1 = 1 kg Zn/ha, Zn_2 = 2 kg Zn /ha, Error bars represent standard error).

The number of siliquae plant^{-1},seed weight of 100siliquae, 1000 seed weight(g) and seed oil content(%) of rapeseed are positively correlated withnitrogen (N) and boron (Zn) application. Therefore, the present experimental 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 in rapeseed variety BARI sarisha 15 under the climatic and edaphic condition of Sher-e-Bangla Agricultural University, Dhaka.

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AUTHORS

First Author – Tahmina Akter Rimi, Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka-1207

Second Author – Mohammad Mahbub Islam, Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka-1207

Third Author – Md. Abubakar Siddik, Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka-1207

Fourth Author – Shahidul Islam, Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka-1207

Fifth Author – Sarkar Chandra Shovon, Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka-1207

Sixth Author – Suraya Parvin, IAPP, Ministry of Agriculture, Dhaka-1000