

# Response Agronomic Traits of Lentil Varieties to Zinc Fertilization in Calcareous and Terrace Soils of Bangladesh

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**Abstract:** Zinc (Zn) fertilization is reflected a significant agronomic strategy for global food security. Deficiency of zinc in soils could be caused to decrease the crop yield. Hence an experiment was made over two years at the research farm of Pulses Research Sub-Station of Bangladesh Agricultural Research Institute (BARI), Gazipur and in the research farm of Regional Agricultural Research Station (RARS), Ishwardi and Jessore, during Rabi season to assess the sensitivity of different varieties of lentil to Zn fertilization and evaluate the Zn in terms of yield and Zn mineral content in seed. There were 12 treatment combinations comprising six lentil varieties ( $V_1 = \text{BARI Masur-2}$ ,  $V_2 = \text{BARI Masur-3}$ ,  $V_3 = \text{BARI Masur-4}$ ,  $V_4 = \text{BARI Masur-5}$ ,  $V_5 = \text{BARI Masur-6}$  and  $V_6 = \text{BARI Masur-7}$ ) and two levels of zinc (0 and 2 kg ha<sup>-1</sup>). The experiment was laid out in split-plot design with three replications. Results reveal that growth, yield attributes and yield varied positively by zinc level and variety. Among the varieties, BARI Masur-7 followed by BARI Masur-6 gave the highest seed yield. Interaction of variety and zinc the highest mean seed yield (1568 kg ha<sup>-1</sup> at Gazipur, 2396 kg ha<sup>-1</sup> at Ishurdy and 1639 kg ha<sup>-1</sup> at Jashore) produced by the treatment  $V_6\text{Zn}_2$ . The improved protein content (28.5% at Gazipur, 28.9% at Ishurdy and 29% at Jashore) and zinc content (70.2 ppm at Gazipur, 73.6 ppm at Ishurdy and 69.9 ppm at Jashore) was achieved in  $V_6\text{Zn}_2$  treatment. The result, suggest that 2 kg Zn ha<sup>-1</sup> could be applied in any lentil variety for quality improvement and yield maximization in terrace and calcareous soils of Bangladesh. The current study recommended conducting another experiment for further monitoring and determining the appropriate Zn dose for lentil production through application of different zinc rates in Zn- deficient soils.

**Keywords:** Lentil Varieties, Zinc, Yield, Quality, Calcareous and Terrace Soil

## 1. Introduction

Lentil (*Lens culinaris*) is an edible pulse which belongs to sub-family *Faboideae* under the family *Fabaceae*. It is one of the popular food legumes in Bangladesh and rank first in respect of consumer's preference and second in terms of area

(154000 ha) and production (116000 mt) [1]. Lentil is considered a relatively affordable, high protein, fibers, antioxidants and micronutrients including iron, zinc, selenium and vitamin (A and B complex), folate and  $\beta$ -carotene [2, 3]. Furthermore, lentil enhances of soil fertility by biologically nitrogen fixation (BNF) and can fix 8-14 kg

N ha<sup>-1</sup> [4]. The agronomic significance of lentil is related to high protein content and micronutrients like Zn. Insufficiency of Zn nutrient has been documented in terrace and calcareous soils of Bangladesh [5]. This element is less available for plant uptake in high pH soils (e.g. calcareous soils) mainly due to their retention by soils and soil constituents [6]. The terrace soil is acidic in reaction with low organic matter and mainly phosphate fixing, and low in P, K, S, Zn and B levels [7, 8]. Zinc deficiency has occurred mainly due to continuous mining of this nutrient from soil and to increase cropping intensity [9]. Zinc deficiency is the most widespread micronutrient deficiency in the world [10].

However, the present dietary value and reflecting an increasing beneficial effect of lentil in human body and soil fertility, the effort should be taken to increase productivity through using high yielding variety of lentil and appropriate nutrient management. Several works have been done globally regarding the rate determination of micronutrient fertilizer in micronutrient deficient condition [11-13]. Sommer and Lipman [14] were the first to prove the essentiality of Zn as a nutrient requirement for higher plants. Plants emerged from seeds with low concentration of Zn could be highly sensitive to biotic and abiotic stress [15]. Zinc requirement of pulses might be higher than cereals. In the country like Bangladesh, the farmers have been taken less attention on proper nutrient management practices for legume cultivation especially micronutrient like Zn. Keeping the above points of view, the present study was undertaken to assess the sensitivity of different varieties of lentil to Zn fertilization and to evaluate the Zn in terms of yield and Zn mineral content in seed.

## 2. Materials and Methods

Field experiments were conducted in three locations for two consecutive years (winter season of 2012-13 and 2013-

14). Three locations were viz. (i) at the research farm of Pulses Research Sub-Station, Bangladesh Agricultural Research Institute (BARI), Gazipur, (ii) at the research field of Regional Agricultural Research Station, BARI, Ishurdu and (iii) at the research field of Regional Agricultural Research Station, BARI, Jashore, Bangladesh. The terrace soils of Gazipur farm was medium high land with fine-textured (clay loam) belongs to Chhiata series under the agro ecological zone - Madhupur Tract (AEZ-28). The experimental field of Ishurdu was medium high land, calcareous in nature and the soil was clay loam in texture. The land of Jashore belongs to Gopalpur soil series and calcareous in nature having silt loam texture. The soils of both Ishurdu and Jashore are under High Ganges River Floodplain agroecological zone-11. The all experimental sites have subtropical humid climatic conditions which are characterized by relatively high monsoon rainfall, high humidity, and high temperature. Long day with less clear sunshine, sometimes the sky remains cloudy for heavy rainfall during April to September. The scanty rainfall, low humidity and low temperature, short day and more clear sunshine during October to March. During experimental period in Gazipur, two years average total rainfall was received from 130 mm. The mean minimum air temperatures of 10 to 12°C and maximum air temperatures 25 to 33.5 °C during growing period. In Ishurdu, two years average total rainfall got 70.5 mm during growing period. The average minimum temperatures of 7 to 11°C and average maximum temperatures were of 22 to 33°C in experimental period. The Jashore area got average total rainfall 88.8 mm, average minimum temperatures of 8.9 to 13.5°C and average maximum temperatures were of 20 to 33.8°C in experimental period. Before starting the experiment initial soil (0-15 cm) samples of three locations have been analyzed and chemical properties are presented in the Table 1.

**Table 1.** Fertility status of initial soils of experimental field at Gazipur, Ishurdu and Jashore.

Location	pH	OM (%)	Total N (%)	Ca	K	P	S	Zn	B
				meq. 100 g <sup>-1</sup>	meq. 100 g <sup>-1</sup>	μg g <sup>-1</sup>	μg g <sup>-1</sup>	μg g <sup>-1</sup>	μg g <sup>-1</sup>
Gazipur (result)	6.1	1.30	0.063	7.2	0.11	12	14.2	0.86	0.16
Critical level	-	-	0.12	2.0	0.12	7	10	0.60	0.20
Interpretation*	acidic	low	very low	high	low	medium	medium	low	low
Ishurdu (result)	7.6	1.42	0.069	13.2	0.17	14	15	0.90	0.19
Jashore (result)	8.1	1.44	0.078	20.0	0.18	13	14.5	0.89	0.18
Critical level	-	-	0.12	2.0	0.12	10	10	0.60	0.20
Interpretation*	slightly alkaline	low	very low	high	low	medium	medium	low	low

(\*FRG, 2012)

There were 12 treatment combinations containing six lentil varieties (V<sub>1</sub> = BARI Masur-2, V<sub>2</sub> = BARI Masur-3, V<sub>3</sub> = BARI Masur-4, V<sub>4</sub> = BARI Masur-5, V<sub>5</sub> = BARI Masur-6 and V<sub>6</sub> = BARI Masur-7) and two levels of zinc (0 and 2 kg ha<sup>-1</sup>). The 12 treatment combinations were as V<sub>1</sub>Zn<sub>0</sub>; V<sub>1</sub>Zn<sub>2</sub>; V<sub>2</sub>Zn<sub>0</sub>; V<sub>2</sub>Zn<sub>2</sub>; V<sub>3</sub>Zn<sub>0</sub>; V<sub>3</sub>Zn<sub>2</sub>; V<sub>4</sub>Zn<sub>0</sub>; V<sub>4</sub>Zn<sub>2</sub>; V<sub>5</sub>Zn<sub>0</sub>; V<sub>5</sub>Zn<sub>2</sub>; V<sub>6</sub>Zn<sub>0</sub>; and V<sub>6</sub>Zn<sub>2</sub> following main plot and sub-plot system. The experiment was laid out in split-plot design with three replications. The main plot was considered as variety factor and sub-plot was as Zn factor. The unit sub-plot size was 4 m

× 3 m. The blanket fertilizers dose of N, P, K, S and B @ 20, 20, 40, 10 and 1 kg ha<sup>-1</sup>, respectively used in all treatment plots as urea, TSP, MoP, gypsum and boric acid at the time of final plot preparation. Zinc was applied treatments basis as ZnSO<sub>4</sub> (36%Zn). Seeds of lentil varieties were treated using the fungicide Provex 200 (at 2.5 g kg<sup>-1</sup> seeds) before sowing to control of root rot disease. Treated seeds of all varieties were sown @ 35 kg ha<sup>-1</sup> with a spacing of 30 cm × continuous on 4 November, 2012 & 23 November, 2013 at Gazipur, on 15 November, 2012 & 10 November, 2013 at Ishurdu and on 1

November, 2012 & 24 November, 2013 at Jashore. Manually weeding as well as thinning of seedlings was done at 25 days after sowing (DAS). Again hand weeding was done at 50 days after sowing. The disease of *stemphylium* blight was control by three times spraying of Rovral fungicide @ 2 g L<sup>-1</sup> of water at interval of 10 days, first start at flowering stage and two times insecticide (Karate @ 2 ml L<sup>-1</sup> of water) sprayed at 10 days interval starting from 60 DAS to overcome insect infestation. Crop was harvested at maturity.

Data on seed yield (kg ha<sup>-1</sup>) at around 10% moisture basis were recorded from the whole plot technique.

The growth and yield attributes namely: plant height, number of branch per plant and number of pods per plant were recorded from ten plants selected randomly from each unit plot. Pods were detached from every plant and the number of pods per plant was counted and averaged. Hundred seed weight (g) was determined by the counting of 100 seeds randomly from each plot and weighing through electronic balance. The data of nodule per plant was recorded at 55 days after sowing in each plot by selecting of 5 plants randomly. The plants of lentil were smoothly uprooted and carefully removed the soil from roots by water. Then washed the roots with water, blotted with tissue paper and counted the number of nodules. Percentage of harvest index (HI) was determined by the formula-

$$HI = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100 \quad (1)$$

Initial soil sample (0-15 cm depth) of three locations were collected and brought to the laboratory and spread on a brown paper for air drying. The air-dried soil samples were ground and passed through a 2-mm sieve. The sieving soil samples were kept into plastic container with proper label for chemical analysis.

Soil pH was measured by glass electrode pH meter using soil: water ratio of 1:2.5 [16]. Organic carbon was determined following the wet oxidation method as described by Page et al. [16] and the organic matter content was calculated by multiplying the % organic carbon with the Van Bemmelen factor 1.73. Total N by Microkjeldahl method [17]; available P was determined following Olsen method for calcareous soil as described by Page et al. [16] and Bray and Kurtz [18] method for terrace soil; exchangeable K by 1N NH<sub>4</sub>OAc method [19]; exchangeable Ca by 1N NH<sub>4</sub>OAc method [20]; available S by turbidity method using BaCl<sub>2</sub> [21]; available Zn by DTPA method [22]; available B by azomethine-H method [16].

Ground seed samples were digested with di-acid mixture

(HNO<sub>3</sub>-HClO<sub>4</sub>) (5: 1) as described by Piper [23] for the determination- concentration of N (Micro-Kjeldahl method) and Zn (atomic absorption spectrophotometer method, VARIAN SpectraAA 55B, Australia). Protein content was measured by estimating the N concentration and then multiplying the N value by 6.25 [24].

Data of growth and yield attributes, nodules per plant, N and protein content were statistical analyzed through ANOVA procedure using a split-plot design with three replications considering main-plot factor variety and sub-plot factor Zn. Then multiple comparisons like all-pairwise comparisons i.e. the means of treatment tested by LSD method at 5% (LSD 0.05) level of significance [25].

### 3. Result

#### 3.1. Varietal Performance

In case of lentil variety, the growth and yield parameters exhibited significant variation among themselves (Table 2). In Gazipur, the plant height of lentil varied across the varieties from 27.5 to 32.8 cm. The highest plant height (32.8 cm) was recorded from the variety V<sub>6</sub> (BARI Masur-7) which was significantly different over the other variety but statistically identical with V<sub>5</sub> and V<sub>2</sub> variety. The lowest plant height (27.5 cm) was found in V<sub>4</sub> variety. In Ishurdi, the plant height was ranged from 31.8 to 37.2 cm across the varieties where, the significantly highest plant height was obtained from V<sub>6</sub> variety followed by V<sub>5</sub>, V<sub>2</sub> and V<sub>1</sub> variety. In case of plant height in Jashore, varied among the variety from 32.3 to 37.7 cm. The tall plant also documented in V<sub>6</sub> which was statistically similar to V<sub>5</sub>, V<sub>2</sub> and V<sub>1</sub> variety and dwarf plant was found in V<sub>4</sub> variety (Table 2). Number of branches per plant varied among the lentil varieties from 3.91 to 5.44 at Gazipur, 4.54 to 6.04 at Ishurdi and 5.06 to 6.44 at Jashore. The maximum number of branches per plant (5.44) was recorded in V<sub>5</sub> variety at Gazipur which was significantly different over the others varieties but statistically alike with V<sub>6</sub> variety. Significantly highest number of branches per plant was achieved in the variety V<sub>6</sub> in both the location of Ishurdi and Jashore and lowest was in V<sub>1</sub> variety (Table 2). The maximum number of pods per plant was produced (65.3 at Gazipur, 82.4 at Ishurdi and 101 at Jashore) by V<sub>6</sub> (BARI Masur-7) which was showed significantly variation among the others varieties at Gazipur but statistically similar to V<sub>2</sub> at Ishurdi and similar to V<sub>5</sub>, V<sub>2</sub> & V<sub>1</sub> at Jashore. The minimum number of pods per plant was noted from V<sub>3</sub> variety at Gazipur and Jashore while it was found minimum in V<sub>1</sub> variety at Ishurdi (Table 2).

Table 2. Main effects of lentil varieties on growth and yield attribute (Pooled data of two years).

Varieties	Plant height (cm)			No. of branches plant <sup>-1</sup>			No. of pods plant <sup>-1</sup>		
	Gazipur	Ishurdi	Jashore	Gazipur	Ishurdi	Jashore	Gazipur	Ishurdi	Jashore
V <sub>1</sub>	29.0bc	34.4ab	35.3abc	3.92b	4.54b	5.06b	56.1bc	74.5c	93.6ab
V <sub>2</sub>	30.5ab	34.9ab	35.4ab	3.91b	4.59b	5.39b	58.8b	79.5ab	95.5ab
V <sub>3</sub>	27.8c	32.4b	33.0bc	4.33b	5.05ab	5.71ab	52.7c	76.4bc	82.5c
V <sub>4</sub>	27.5c	31.8b	32.3c	4.37b	4.87b	5.66ab	59.0b	77.7bc	92.4b
V <sub>5</sub>	30.7ab	36.1a	36.8a	5.44a	5.93a	6.30a	58.1b	77.1bc	99.0ab
V <sub>6</sub>	32.8a	37.2a	37.7a	5.34a	6.04a	6.44a	65.3a	82.4a	101a
CV (%)	6.52	7.42	6.70	11.7	15.7	11.3	5.41	4.66	7.0

Varieties	Plant height (cm)			No. of branches plant <sup>-1</sup>			No. of pods plant <sup>-1</sup>		
	Gazipur	Ishurdy	Jashore	Gazipur	Ishurdy	Jashore	Gazipur	Ishurdy	Jashore
LSD (0.05)	2.49	3.29	3.02	0.69	1.05	0.84	4.05	4.67	8.46

In a column, the values having common letter do not differ significantly ( $P \leq 0.05$ )

Note: V<sub>1</sub> = BARI Masur-2, V<sub>2</sub> = BARI Masur-3, V<sub>3</sub> = BARI Masur-4, V<sub>4</sub> = BARI Masur-5, V<sub>5</sub> = BARI Masur-6 and V<sub>6</sub> = BARI Masur-7

In case of seed weight, the heaviest seed (2.29 g at Gazipur and 2.28 g at Ishurdi) was obtained from V<sub>2</sub> variety which was significantly different with the others variety at Gazipur but it was showed non-significant at Ishurdi. In Jashore, the highest seed weight (2.41 g) was recorded from V<sub>6</sub> variety that was showed significant variation among the other varieties. The lowest seed weight was noted in V<sub>1</sub> variety in all the locations. Nodulation showed significantly variation among the different lentil varieties in all the locations (Table 3). The highest number of nodules per plant (36.7) at Gazipur

was noted in the variety V<sub>3</sub> that was statistically alike to V<sub>6</sub>, V<sub>5</sub> and V<sub>4</sub> variety. The lowest nodulation (27.6) was found in V<sub>2</sub> variety. In the locations of Ishurdi and Jashore, the maximum number of nodules per plant (35.9 at Ishurdi and 38.0 at Jashore) was counted in the variety V<sub>6</sub> which was statistically similar with V<sub>5</sub>, V<sub>4</sub> and V<sub>3</sub> at Ishurdi and V<sub>5</sub>, V<sub>4</sub>, V<sub>3</sub> and V<sub>2</sub> at Jashore. The lowest nodulation was observed in V<sub>2</sub> (27.6) at Ishurdi and V<sub>1</sub> (29.6) at Jashore which was statistically inferior with the other varieties (Table 3).

Table 3. Main effects of lentil varieties on yield attribute (Pooled data of two years).

Varieties	100 seed wt. (g)			No. of nodules plant <sup>-1</sup>		
	Gazipur	Ishurdy	Jashore	Gazipur	Ishurdy	Jashore
V <sub>1</sub>	1.78c	2.13	1.84e	29.1bc	27.8b	29.6b
V <sub>2</sub>	2.29a	2.28	2.26c	27.6c	27.6b	35.0ab
V <sub>3</sub>	2.06b	2.27	2.31b	36.7a	34.7a	35.3ab
V <sub>4</sub>	2.00b	2.20	2.23d	32.5abc	34.5a	34.3ab
V <sub>5</sub>	1.98b	2.19	2.21d	33.8ab	31.8ab	33.2ab
V <sub>6</sub>	2.02b	2.17	2.41a	34.5ab	35.9a	38.0a
CV (%)	4.79	9.81	0.77	14.3	14.8	16.2
LSD (0.05)	0.13	ns	0.023	5.98	6.13	7.13

In a column, the values having common letter do not differ significantly ( $P \leq 0.05$ )

Note: V<sub>1</sub> = BARI Masur-2, V<sub>2</sub> = BARI Masur-3, V<sub>3</sub> = BARI Masur-4, V<sub>4</sub> = BARI Masur-5, V<sub>5</sub> = BARI Masur-6, and V<sub>6</sub> = BARI Masur-7

In case of seed yield of lentil, significantly the highest yield (1471 kg ha<sup>-1</sup> in 1<sup>st</sup> year and 1302 kg ha<sup>-1</sup>) was produced by V<sub>6</sub> = BARI Masur 7 at Gazipur but it was statistically identical by V<sub>5</sub>, V<sub>4</sub>, V<sub>3</sub> and V<sub>2</sub> variety in 1<sup>st</sup> year. The lowest seed yield was produced by V<sub>1</sub> = BARI Masur-2 in both the years. In Ishurdy, the greatest seed yield (2030 kg ha<sup>-1</sup>) was achieved in V<sub>5</sub> = BARI Masur-6 in 1<sup>st</sup> year showed non-significant with other varieties but in 2<sup>nd</sup> year it was obtained highest (2314 kg ha<sup>-1</sup>) from V<sub>6</sub> = BARI Masur-7 followed by V<sub>5</sub>, V<sub>4</sub>, V<sub>3</sub> and V<sub>2</sub> variety. The lowest seed yield produced by BARI Masur-2 in both the years. In Jashore, the highest seed yield (1599 kg ha<sup>-1</sup>) got from V<sub>6</sub> = BARI Masur-7 in 1<sup>st</sup> year which statistically resemble with most of the

varieties although highest yield (1599 kg ha<sup>-1</sup>) acquired by V<sub>5</sub> = BARI Masur-6 in 2<sup>nd</sup> year which was significantly different over other varieties but statistically at par V<sub>6</sub> and V<sub>2</sub> variety (Table 4). In the experiment, harvest index (HI) of lentil was ranged across the varieties from 41.2 to 44.4% at Gazipur, 45.6 to 46.5% at Ishurdy and 42.8 to 45.6% at Jashore, respectively, where the significantly highest HI (44.4%) was recorded from V<sub>6</sub> variety and lowest HI was found in V<sub>1</sub> variety for Gazipur. The highest harvest index was recorded at Ishurdy from V<sub>2</sub> variety which showed non-significant. The highest HI was found in V<sub>1</sub> variety for Jashore that was statistically similar with most of the varieties (Table 4).

Table 4. Main effects of lentil varieties on yield and harvest index.

Varieties	Seed yield (kg ha <sup>-1</sup> )						HI (%)		
	Gazipur		Ishurdy		Jashore		Gazipur	Ishurdy	Jashore
	1 <sup>st</sup> Yr.	2 <sup>nd</sup> Yr.	1 <sup>st</sup> Yr.	2 <sup>nd</sup> Yr.	1 <sup>st</sup> Yr.	2 <sup>nd</sup> Yr.			
V <sub>1</sub>	1219b	923b	1930	1867b	1543a	1391bc	41.2c	45.6	45.6a
V <sub>2</sub>	1262ab	999b	2054	2209a	1482a	1608ab	41.6c	46.5	45.1a
V <sub>3</sub>	1323ab	1062b	1995	2199a	1415a	1520b	42.0bc	46.3	44.9a
V <sub>4</sub>	1286ab	1011b	1980	2272a	1171b	1267c	42.2bc	46.4	42.8b
V <sub>5</sub>	1333ab	1104b	2030	2214a	1578a	1755a	43.0b	45.9	45.5a
V <sub>6</sub>	1471a	1302a	2014	2314a	1599a	1584ab	44.4a	46.3	45.1a
CV (%)	14.5	14.2	10.4	9.66	9.86	11.5	1.87	5.85	3.41
LSD (0.05)	249	195	ns	270	186	227	1.02	ns	1.96

In a column, the values having common letter do not differ significantly ( $P \leq 0.05$ )

Note: V<sub>1</sub> = BARI Masur-2, V<sub>2</sub> = BARI Masur-3, V<sub>3</sub> = BARI Masur-4, V<sub>4</sub> = BARI Masur-5, V<sub>5</sub> = BARI Masur-6, and V<sub>6</sub> = BARI Masur-7

In the experiment, the highest protein content (27.9% in Gazipur, 28.3% in Ishurdy and 28.2% in Jashore) was estimated in the seed lentil variety  $V_6 = \text{BARI Masur-7}$  which was significantly variation among the other varieties at Gazipur but at Ishurdy and Jashore it was showed non-significant (Table 5). In case of zinc content in seed, the zinc

content varied across the varieties from 54.7 to 67.4 ppm at Gazipur, 57.0 to 71.1 ppm at Ishurdy and 54.2 to 67.8 ppm at Jashore, where the highest zinc content was recorded from the variety  $V_6 = \text{BARI Masur-7}$  that was significantly different with the other varieties but statistically identical at par  $V_5 = \text{BARI Masur-6}$  in all the locations (Table 5).

**Table 5.** Main effects of lentil varieties on protein and zinc content (Pooled data of two years).

Varieties	Protein content (%)			Zinc content (ppm)		
	Gazipur	Ishurdy	Jashore	Gazipur	Ishurdy	Jashore
V <sub>1</sub>	26.7b	27.1	26.9	58.6bc	60.0b	60.0b
V <sub>2</sub>	26.9b	27.2	27.3	59.9bc	57.0b	58.1bc
V <sub>3</sub>	26.7b	26.9	27.4	54.7c	57.5b	54.2c
V <sub>4</sub>	27.2b	27.3	26.8	61.5abc	61.2b	57.1bc
V <sub>5</sub>	26.8b	27.2	27.0	64.8ab	68.3a	65.9a
V <sub>6</sub>	27.9a	28.3	28.2	67.4a	71.1a	67.8a
CV (%)	1.82	6.66	7.13	8.90	6.94	6.64
LSD (0.05)	0.63	ns	ns	7.0	5.58	5.16

In a column, the values having common letter do not differ significantly ( $P \leq 0.05$ )

Note: V<sub>1</sub> = BARI Masur-2, V<sub>2</sub> = BARI Masur-3, V<sub>3</sub> = BARI Masur-4, V<sub>4</sub> = BARI Masur-5, V<sub>5</sub> = BARI Masur-6, and V<sub>6</sub> = BARI Masur-7

### 3.2. Effect of Zinc

In case of lentil varieties, application of zinc showed positive variation among the different yield parameters (Tables 6 & 7). The tallest plant of lentil (31.3 cm at Gazipur, 36.2 cm at Ishurdi and 36.7 cm at Jashore) was significantly found in the plot application of 2 kg Zn ha<sup>-1</sup>. The dwarf plant was observed in Zn control plot at all the locations (Table 6). The highest number of branches per plant (4.82 at Gazipur, 5.41 at Ishurdi and 6.06 at Jashore) and the maximum

number of pods per plant (62.8 at Gazipur, 80.9 at Ishurdi and 99.0 at Jashore) was recorded in the plot receiving of 2 kg Zn ha<sup>-1</sup>. The number of both branches and pods were recorded lowest in Zn control plot (Table 6). The highest seed weight (2.07 g at Gazipur, 2.31 g at Ishurdi and 2.23 g at Jashore) and maximum nodulation (34.5 at Gazipur, 35.2 at Ishurdi and 38.0 at Jashore) was obtained by the application of 2 kg Zn ha<sup>-1</sup> and both the parameters got lowest in Zn control plot (Table 7).

**Table 6.** Main effects of zinc on growth and yield attribute of lentil varieties.

Zn level (kg ha <sup>-1</sup> )	Plant height (cm)			No. of branches plant <sup>-1</sup>			No. of pods plant <sup>-1</sup>		
	Gazipur	Ishurdy	Jashore	Gazipur	Ishurdy	Jashore	Gazipur	Ishurdy	Jashore
0	28.1b	32.7b	33.5b	4.29b	4.92	5.46b	53.8b	74.9b	89.0b
2	31.3a	36.2a	36.7a	4.82a	5.41	6.06a	62.8a	80.9a	99.0a
CV (%)	6.52	7.42	6.70	11.7	15.7	11.3	5.41	4.66	7.0
LSD (0.05)	1.81	1.99	1.81	0.29	ns	0.41	0.31	4.02	2.73

In a column, the values having common letter do not differ significantly ( $P \leq 0.05$ )

**Table 7.** Main effects of zinc on yield attribute of lentil varieties.

Zn level (kg ha <sup>-1</sup> )	100 seed wt. (g)			No. of nodules plant <sup>-1</sup>		
	Gazipur	Ishurdy	Jashore	Gazipur	Ishurdy	Jashore
0	1.96b	2.10b	2.19b	30.2b	28.9b	30.4b
2	2.07a	2.31a	2.23a	34.5a	35.2a	38.0a
CV (%)	4.79	9.81	0.77	14.3	14.8	16.2
LSD (0.05)	0.02	0.05	0.01	0.88	0.97	0.96

In a column, the values having common letter do not differ significantly ( $P \leq 0.05$ )

The seed yield of lentil was exhibited significantly different between Zn<sub>0</sub> and 2 kg Zn ha<sup>-1</sup> during all the years and all the locations (Table 8). The highest seed yield (1480 kg ha<sup>-1</sup> in 1<sup>st</sup> year and 1193 kg ha<sup>-1</sup> in 2<sup>nd</sup> year) at Gazipur was produced by the application of 2 kg Zn ha<sup>-1</sup>. In Ishurdy, the highest seed yield (2166 kg ha<sup>-1</sup> in 1<sup>st</sup> year and 2333 kg ha<sup>-1</sup> in 2<sup>nd</sup> year) was achieved in the same Zn rate and it was produced highest (1544 kg ha<sup>-1</sup> in 1<sup>st</sup> year and 1653 kg ha<sup>-1</sup> in 2<sup>nd</sup> year) at Jashore in the plot receiving of 2 kg Zn ha<sup>-1</sup>. The

lowest yield was found in all the years and locations in Zn control plot (Table 8). In the present study, harvest index (HI) of lentil was showed significant at Gazipur and it was non-significant at Ishurdy and Jashore between Zn<sub>0</sub> and 2 kg Zn ha<sup>-1</sup> during all the years and all the locations (Table 8). The highest HI (42.9%) at Gazipur, (46.6%) at Ishurdy and (45.0%) at Jashore was documented by the application of 2 kg Zn ha<sup>-1</sup> and it was lowest at Zn control plot at all the locations (Table 7).

**Table 8.** Main effects of zinc on yield and harvest index of lentil varieties.

Zn level (kg ha <sup>-1</sup> )	Seed yield (kg ha <sup>-1</sup> )						HI (%)		
	Gazipur		Ishurdy		Jashore		Gazipur	Ishurdy	Jashore
	1 <sup>st</sup> Yr.	2 <sup>nd</sup> Yr.	1 <sup>st</sup> Yr.	2 <sup>nd</sup> Yr.	1 <sup>st</sup> Yr.	2 <sup>nd</sup> Yr.			
0	1184b	941b	1835b	2025b	1384b	1389b	41.8b	45.7	44.6
2	1480a	1193a	2166a	2333a	1544a	1653a	42.9a	46.6	45.0
CV (%)	14.5	14.2	10.4	9.66	9.86	11.5	1.87	5.85	3.41
LSD (0.05)	153	38.7	189	163	89	64	0.66	ns	ns

In a column, the values having common letter do not differ significantly ( $P \leq 0.05$ )

In the trial, zinc exhibited significantly positive effect on protein and zinc content in lentil seed at all the locations of Gazipur, Ishurdy and Jashore (Table 9). The highest protein content (27.6%) at Gazipur, (28.1%) at Ishurdy and (27.9%) at Jashore was estimated from the plot receiving of 2 kg Zn

ha<sup>-1</sup> and it was lowest at Zn control plot at all the locations (Table 9). Similarly the highest zinc content (64.6 ppm) at Gazipur, (65.5 ppm) at Ishurdy and (62.4 ppm) at Jashore was determined from the same dose of zinc (2 kg Zn ha<sup>-1</sup>) (Table 9).

**Table 9.** Main effects of zinc on protein and zinc content in lentil varieties.

Zn level (kg ha <sup>-1</sup> )	Protein content (%)			Zinc content (ppm)		
	Gazipur	Ishurdy	Jashore	Gazipur	Ishurdy	Jashore
0	26.4b	26.6b	26.6b	57.7b	59.5b	58.7b
2	27.6a	28.1a	27.9a	64.6a	65.5a	62.4a
CV (%)	1.82	6.66	7.13	8.90	6.94	6.64
LSD (0.05)	0.19	0.32	0.88	1.48	1.63	3.38

In a column, the values having common letter do not differ significantly ( $P \leq 0.05$ )

### 3.3. Interaction Effect of Variety and Zinc

The growth and yield attributes of lentil were positively influenced by the interaction of variety and zinc in all the locations (Tables 10 & 11). In the study, the tallest plant of lentil (34.9 cm at Gazipur, 38.7 cm at Ishurdy and 39.3 cm at Jashore) was recorded from the treatment combination of V<sub>6</sub>Zn<sub>2</sub> which was showed significantly difference in most of the cases. The dwarf plant (26.0 cm at Gazipur, 29.9 cm at Ishurdy and 30.2 cm at Jashore) was found in V<sub>4</sub>Zn<sub>0</sub> treatment (Table 10). In case of branches, the number of branches per plant was ranged across the combined variety and zinc treatments from 3.68 to 5.78 at Gazipur, 4.31 to 6.33 at Ishurdi and 5.00 to 6.88 at Jashore. The maximum number of branches per plant (5.78) was noted in V<sub>5</sub>Zn<sub>2</sub> treatment which was statistically identical to V<sub>5</sub>Zn<sub>0</sub>, V<sub>6</sub>Zn<sub>0</sub> and V<sub>6</sub>Zn<sub>2</sub> treatments at

Gazipur. The highest number of branches per plant (6.33 at Ishurdy and 6.88 at Jashore) was attained in the treatment V<sub>6</sub>Zn<sub>2</sub> followed by V<sub>6</sub>Zn<sub>0</sub>, V<sub>5</sub>Zn<sub>2</sub>, V<sub>4</sub>Zn<sub>2</sub> and V<sub>3</sub>Zn<sub>2</sub> at both the locations and the lowest was in V<sub>1</sub>Zn<sub>0</sub> treatment (Table 10). In Gazipur, BARI Masur-7 formed the highest number of pods per plant (70.3) in zinc treated plot which was significantly different over the other treatment of varieties and zinc treated or control. The lowest number of pods per plant (49.9) was recorded in V<sub>3</sub>Zn<sub>0</sub> treatment. The maximum number of pods per plant (88.3 at Ishurdi and 110 at Jashore) was achieved by the variety BARI Masur-7 in Zn treated plot (V<sub>6</sub>Zn<sub>2</sub>) which was statistically at par V<sub>2</sub>Zn<sub>2</sub> in both Ishurdi and Jashore and at par V<sub>5</sub>Zn<sub>2</sub> in Jashore. The lowest pods (72.0) was recorded at Ishurdi for V<sub>1</sub>Zn<sub>0</sub> and (81.0) was found in V<sub>3</sub>Zn<sub>0</sub> treatment at Jashore (Table 10).

**Table 10.** Interaction effects of lentil variety and zinc on growth and yield attribute of lentil.

Treatment combination	Plant height (cm)			No. of branches plant <sup>-1</sup>			No. of pods plant <sup>-1</sup>		
	Gazipur	Ishurdy	Jashore	Gazipur	Ishurdy	Jashore	Gazipur	Ishurdy	Jashore
V <sub>1</sub> Zn <sub>0</sub>	27.8cd	33.3bcd	34.3bcd	3.84ef	4.31c	5.00b	50.2e	72.0c	87.0def
V <sub>1</sub> Zn <sub>2</sub>	30.2bc	35.5abc	36.3ab	4.00def	4.77bc	5.12b	61.9bc	77.0bc	100bc
V <sub>2</sub> Zn <sub>0</sub>	28.6bcd	32.9cd	33.8bcd	3.68f	4.36c	5.23b	55.3d	76.0bc	88.0def
V <sub>2</sub> Zn <sub>2</sub>	32.4ab	36.9abc	37.1ab	4.15c-f	4.82abc	5.55b	62.3bc	82.9ab	103ab
V <sub>3</sub> Zn <sub>0</sub>	26.9cd	30.3d	31.1cd	4.10def	4.85abc	5.43b	49.9e	74.0c	81.0f
V <sub>3</sub> Zn <sub>2</sub>	28.7bcd	34.6a-d	34.9bc	4.56b-e	5.24abc	5.99ab	55.6d	78.7bc	84.0ef
V <sub>4</sub> Zn <sub>0</sub>	26.0d	29.9d	30.2d	4.01ef	4.57c	5.32b	52.6de	76.5bc	90.0def
V <sub>4</sub> Zn <sub>2</sub>	28.9bcd	33.8bcd	34.4bcd	4.74bcd	5.16abc	6.00ab	65.4b	78.9bc	95.0bcd
V <sub>5</sub> Zn <sub>0</sub>	28.8bcd	34.5a-d	35.5ab	5.10ab	5.67abc	5.77b	54.6d	74.4c	96.0bcd
V <sub>5</sub> Zn <sub>2</sub>	32.6ab	37.7ab	38.1ab	5.78a	6.19ab	6.82a	61.6bc	79.8bc	102ab
V <sub>6</sub> Zn <sub>0</sub>	30.7abc	35.7abc	36.0ab	5.00abc	5.74abc	6.00ab	60.4c	76.6bc	92.0cde
V <sub>6</sub> Zn <sub>2</sub>	34.9a	38.7a	39.3a	5.68a	6.33a	6.88a	70.3a	88.3a	110a
CV (%)	8.39	7.94	7.12	8.83	16.8	9.85	0.72	7.10	4.01
LSD (0.05)	4.43	4.87	4.44	0.72	1.55	1.01	0.75	9.84	6.71

In a column, the values having common letter do not differ significantly ( $P \leq 0.05$ )

Note: V<sub>1</sub> = BARI Masur-2, V<sub>2</sub> = BARI Masur-3, V<sub>3</sub> = BARI Masur-4, V<sub>4</sub> = BARI Masur-5, V<sub>5</sub> = BARI Masur-6, and V<sub>6</sub> = BARI Masur-7

The heaviest seed (2.38 g at Gazipur and 2.44 g at Ishurdy) produced by the variety BARI Masur-3 in zinc treated plot ( $V_2Zn_2$ ) which was non-significant. Significantly the highest test seed weight (2.43 g) was obtained in the treatment  $V_6Zn_2$  at Jashore and the lowest was in  $V_1Zn_0$  treatment (Table 11). In the experiment, the nodulation per plant of lentil varied across the

combination of variety and zinc from 26 to 38.4 at Gazipur, 25 to 39.3 at Ishurdy and 26.4 to 43.4 at Jashore, however, the maximum number of nodules per plant was counted in the treatment  $V_3Zn_2$  at Gazipur which was non-significant. It was recorded highest in the treatment  $V_6Zn_2$  at Ishurdy and Jashore that was also showed non-significant (Table 11).

**Table 11.** Interaction effects of lentil variety and zinc on yield attribute of lentil.

Treatment combination	100 seed wt. (g)			No. of nodules plant <sup>-1</sup>		
	Gazipur	Ishurdy	Jashore	Gazipur	Ishurdy	Jashore
$V_1Zn_0$	1.73	2.05	1.83i	26.7	25.0	26.4
$V_1Zn_2$	1.83	2.20	1.84i	31.6	30.6	32.7
$V_2Zn_0$	2.20	2.13	2.25ef	26.0	25.5	31.1
$V_2Zn_2$	2.38	2.44	2.28de	29.2	30.0	38.9
$V_3Zn_0$	2.03	2.18	2.29cd	34.8	31.4	31.9
$V_3Zn_2$	2.08	2.36	2.32c	38.4	37.9	38.6
$V_4Zn_0$	1.90	2.16	2.21gh	30.7	31.2	31.1
$V_4Zn_2$	2.10	2.23	2.25ef	34.2	37.8	37.6
$V_5Zn_0$	1.93	2.03	2.18h	31.8	28.0	29.3
$V_5Zn_2$	2.03	2.34	2.24fg	35.7	35.6	37.0
$V_6Zn_0$	2.00	2.04	2.39b	31.3	32.6	32.6
$V_6Zn_2$	2.04	2.30	2.43a	37.7	39.3	43.4
CV (%)	1.34	3.13	0.79	3.74	4.17	3.9
LSD (0.05)	ns	ns	0.03	ns	ns	ns

In a column, the values having common letter do not differ significantly ( $P \leq 0.05$ )

Note:  $V_1$  = BARI Masur-2,  $V_2$  = BARI Masur-3,  $V_3$  = BARI Masur-4,  $V_4$  = BARI Masur-5,  $V_5$  = BARI Masur-6, and  $V_6$  = BARI Masur-7

Seed yield of lentil influenced significantly by the interaction of variety and zinc at three locations like Gazipur, Ishurdy and Jashore during two years but was non-significant in 2<sup>nd</sup> year at Jashore (Table 12). The highest seed yield (1664 kg ha<sup>-1</sup> in 1<sup>st</sup> year and 1471 kg ha<sup>-1</sup> in 2<sup>nd</sup> year) produced by the treatment  $V_6Zn_2$  which was statistically identical to  $V_5Zn_2$ ,  $V_4Zn_2$ ,  $V_3Zn_2$ ,  $V_2Zn_2$  and  $V_1Zn_2$  at Gazipur in 1<sup>st</sup> year but it was significantly different over the other treatment combinations in 2<sup>nd</sup> year. The lowest seed yield (1079 kg ha<sup>-1</sup> in 1<sup>st</sup> year and 832 kg ha<sup>-1</sup> in 2<sup>nd</sup> year) was recorded in the treatment combination of  $V_1Zn_0$  at Gazipur (Table 12). The average seed yield of lentil varied from 956 to 1568 kg ha<sup>-1</sup> across the treatments where the highest yield (1568 kg ha<sup>-1</sup>) was got from  $V_6Zn_2$  treatment at Gazipur (Figure 1). In Ishurdy, the highest seed yield (2268 kg ha<sup>-1</sup> in 1<sup>st</sup> year and 2523 kg ha<sup>-1</sup> in 2<sup>nd</sup> year) was obtained from  $V_6Zn_2$  treatment that statistically resembled in most of the treatment combinations. The lowest yield (1799 kg ha<sup>-1</sup> in 1<sup>st</sup> year and 1633 kg ha<sup>-1</sup> in 2<sup>nd</sup> year) was found in  $V_1Zn_0$  treatment (Table 12). The average seed yield (mean of two years) of lentil ranged across the treatment combinations at Ishurdy from 1716 to 2396 kg ha<sup>-1</sup> but the greatest yield was found in  $V_6Zn_2$  treatment (Figure 1). In Jashore, the highest seed yield (1669

kg ha<sup>-1</sup> in 1<sup>st</sup> year and 1608 kg ha<sup>-1</sup> in 2<sup>nd</sup> year) was achieved in  $V_6Zn_2$  treatment that was significantly different with other treatments but showed statistically alike in most the treatments in 1<sup>st</sup> year; however in 2<sup>nd</sup> year it was showed non-significant. The lowest yield was found in  $V_4Zn_0$  treatment in both the years (Table 12). The average seed yield (mean of two years) of lentil ranged among the different treatment combinations at Jashore from 1114 to 1639 kg ha<sup>-1</sup> but the highest yield was found in  $V_6Zn_2$  treatment (Figure 1). Comparison among the three locations on mean seed yield across the treatment combination of variety and zinc indicated that the highest yield was observed at Ishurdy followed by Jashore and the lowest in Gazipur (Figure 1). In the experiment, the harvest index (HI) of lentil varied among the treatments from 40.9 to 45.0% at Gazipur while the highest harvest index (45.0%) was calculated in the treatment  $V_6Zn_2$  that was statistically similar to  $V_6Zn_0$  and  $V_5Zn_2$  treatment. The lowest HI was in  $V_1Zn_0$  treatment (Table 12). In Ishurdy, the highest harvest index (46.9%) was computed in  $V_3Zn_2$  treatment which was showed non-significant. In Jashore, it was computed highest (45.8%) in  $V_5Zn_2$  treatment which was statistically at par most of the treatment combinations and the lowest HI (42.5%) was in  $V_4Zn_0$  treatment (Table 12).

**Table 12.** Interaction effects of lentil varieties and zinc on yield and harvest index (pooled data of two years) of lentil.

Treatment combination	Seed yield (kg ha <sup>-1</sup> )						HI (%)		
	Gazipur		Ishurdy		Jashore		Gazipur	Ishurdy	Jashore
	1 <sup>st</sup> Yr.	2 <sup>nd</sup> Yr.	1 <sup>st</sup> Yr.	2 <sup>nd</sup> Yr.	1 <sup>st</sup> Yr.	2 <sup>nd</sup> Yr.			
$V_1Zn_0$	1079b	832f	1799c	1633c	1526ab	1137	40.9d	45.0	45.7a
$V_1Zn_2$	1359ab	1013cde	2060abc	2100b	1559ab	1645	41.4cd	45.4	45.5a
$V_2Zn_0$	1146b	877ef	1930abc	2110b	1427bc	1528	41.2cd	46.1	45.2ab
$V_2Zn_2$	1378ab	1120bcd	2177abc	2307ab	1537ab	1688	42.0cd	46.8	45.0ab
$V_3Zn_0$	1202b	933def	1830bc	2100b	1210cd	1479	41.4cd	45.7	44.3abc

Treatment combination	Seed yield (kg ha <sup>-1</sup> )						HI (%)		
	Gazipur		Ishurdy		Jashore		Gazipur	Ishurdy	Jashore
	1 <sup>st</sup> Yr.	2 <sup>nd</sup> Yr.	1 <sup>st</sup> Yr.	2 <sup>nd</sup> Yr.	1 <sup>st</sup> Yr.	2 <sup>nd</sup> Yr.			
V <sub>3</sub> Zn <sub>2</sub>	1443ab	1191bc	2160abc	2298ab	1619ab	1560	42.6bc	46.9	45.6a
V <sub>4</sub> Zn <sub>0</sub>	1187b	903ef	1860abc	2187ab	1118d	1110	41.7cd	46.5	42.5c
V <sub>4</sub> Zn <sub>2</sub>	1384ab	1119bcd	2100abc	2356ab	1223cd	1423	42.6bc	46.3	43.2bc
V <sub>5</sub> Zn <sub>0</sub>	1212b	966def	1831bc	2014bc	1497ab	1520	41.9cd	45.2	45.1ab
V <sub>5</sub> Zn <sub>2</sub>	1653a	1242b	2230ab	2413ab	1658ab	1991	44.1ab	46.6	45.8a
V <sub>6</sub> Zn <sub>0</sub>	1277b	1132bcd	1760c	2105b	1528ab	1559	43.8ab	46.1	45.2ab
V <sub>6</sub> Zn <sub>2</sub>	1664a	1471a	2268a	2523a	1669a	1608	45.0a	46.4	44.9ab
CV (%)	15.8	5.0	13.1	10.3	8.35	5.74	2.15	5.47	1.77
LSD (0.05)	375	94.8	464	401	217	ns	1.62	ns	1.41

In a column, the values having common letter do not differ significantly ( $P \leq 0.05$ )

Note: V<sub>1</sub> = BARI Masur-2, V<sub>2</sub> = BARI Masur-3, V<sub>3</sub> = BARI Masur-4, V<sub>4</sub> = BARI Masur-5, V<sub>5</sub> = BARI Masur-6, and V<sub>6</sub> = BARI Masur-7

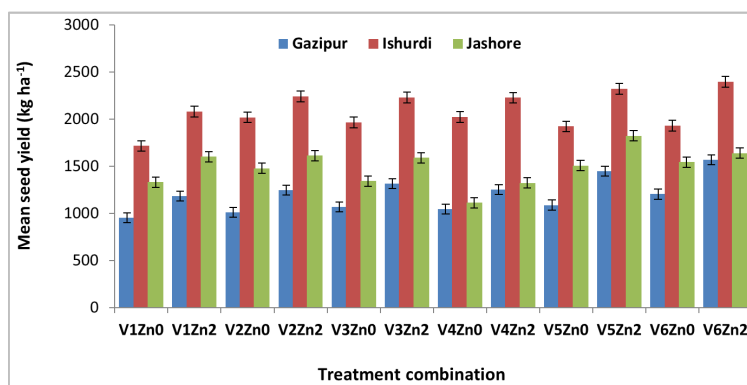


Figure 1. Seed yield variation among 3 locations due to different treatment combination.

Note: V<sub>1</sub>= BARI Masur-2, V<sub>2</sub>= BARI Masur-3, V<sub>3</sub>= BARI Masur-4, V<sub>4</sub>= BARI Masur-5, V<sub>5</sub>= BARI Masur-6 and V<sub>6</sub>= BARI Masur-7  
Error bar represent the SEM

Seed protein content of lentil affected positively by the interaction of variety and zinc at three locations like Gazipur, Ishurdy and Jashore but was showed non-significant at Ishurdy and Jashore (Table 13). The protein content ranged among the treatment combinations of variety and zinc from 25.9 to 28.5% at Gazipur, 26.2 to 28.9% at Ishurdy and 26.2 to 29.0% at Jashore, while the highest protein content was achieved in the treatment of V<sub>6</sub>Zn<sub>2</sub> in all the locations and lowest content was found in V<sub>1</sub>Zn<sub>0</sub> treatment at Gazipur and Jashore but it was lowest in V<sub>3</sub>Zn<sub>0</sub> at Ishurdy (Table 13). In

case of zinc content in seed, it was showed non-significant by the interaction of variety and zinc at Gazipur and Ishurdy. However, the zinc content of seed exhibited significant among the combination of different lentil varieties and 2 kg Zn ha<sup>-1</sup> at Jashore (Table 13). The highest zinc content (70.2 ppm at Gazipur and 73.6 ppm at Ishurdy) was recorded from V<sub>6</sub>Zn<sub>2</sub> treatment which was non-significant. In Jashore, the highest zinc content also recorded highest (69.9 ppm) in V<sub>6</sub>Zn<sub>2</sub> treatment that was statistically identical with V<sub>6</sub>Zn<sub>0</sub>, V<sub>5</sub>Zn<sub>2</sub>, V<sub>5</sub>Zn<sub>0</sub> and V<sub>1</sub>Zn<sub>2</sub> treatments (Table 13).

Table 13. Interaction effects of lentil variety and zinc on protein and zinc content in lentil seed.

Treatment combination	Protein content (%)			Zinc content (ppm)		
	Gazipur	Ishurdy	Jashore	Gazipur	Ishurdy	Jashore
V <sub>1</sub> Zn <sub>0</sub>	25.9d	26.3	26.2	54.9	55.6	56.8cd
V <sub>1</sub> Zn <sub>2</sub>	27.4b	27.8	27.6	62.3	64.3	63.2abc
V <sub>2</sub> Zn <sub>0</sub>	26.3d	26.5	26.8	55.3	53.6	56.2cd
V <sub>2</sub> Zn <sub>2</sub>	27.4b	27.9	27.9	64.5	60.4	59.8bcd
V <sub>3</sub> Zn <sub>0</sub>	26.2d	26.2	26.6	52.6	55.5	53.7d
V <sub>3</sub> Zn <sub>2</sub>	27.2bc	27.7	28.3	56.8	59.5	54.7d
V <sub>4</sub> Zn <sub>0</sub>	26.6cd	26.6	26.4	57.6	58.4	55.9cd
V <sub>4</sub> Zn <sub>2</sub>	27.8ab	28.0	27.2	65.4	63.9	58.4bcd
V <sub>5</sub> Zn <sub>0</sub>	26.1d	26.4	26.3	61.2	65.3	63.5abc
V <sub>5</sub> Zn <sub>2</sub>	27.4b	28.1	27.8	68.4	71.4	68.2a
V <sub>6</sub> Zn <sub>0</sub>	27.3b	27.7	27.4	64.5	68.5	65.8ab
V <sub>6</sub> Zn <sub>2</sub>	28.5a	28.9	29.0	70.2	73.6	69.9a
CV (%)	0.99	1.60	4.43	3.33	3.58	7.71
LSD (0.05)	0.48	ns	ns	ns	ns	8.29

In a column, the values having common letter do not differ significantly ( $P \leq 0.05$ )

Note: V<sub>1</sub> = BARI Masur-2, V<sub>2</sub> = BARI Masur-3, V<sub>3</sub> = BARI Masur-4, V<sub>4</sub> = BARI Masur-5, V<sub>5</sub> = BARI Masur-6, and V<sub>6</sub> = BARI Masur-7



## 4. Discussion

Pulses crops are generally grown in Bangladesh under rain-fed condition without proper nutrient management particularly zinc (Zn) micronutrient [26]. For increasing the productivity of lentil appropriate variety need to be chosen and timely application of Zn micronutrient including other nutrients for plant growth and better performance of yield attributes, quality and high seed yield. Zinc application resulted to enhance the performance of growth, grain yield and quality [27]. Hafeez et al. [28] and Alloway [29] documented that zinc involved in many physiological functions of plant and its inadequate supply will be reduced crop yields. Experimental calcareous soil and other soil with high phosphorus are predictable to be Zn deficient which can be affected plant by growth stunting, decreasing number of pods, chlorosis and smaller leaves, sterility and inferior quality of harvested products. Hence, we compared the response of different lentil varieties to zinc fertilization in terrace and calcareous soils. Genetic variability responded to applied Zn has been noticed among different cultivars of pulses [27]. In the study, growth, yield attributes, quality and yield are influenced by different lentil varieties. Among the performance of varieties, BARI Masur-7 exhibited better followed by BARI Masur-6 over the other lentil varieties. Uddin et al. [26] corroborated that BARI Masur-6 and BARI masur-7 can be grown and better performed in medium and high medium topography areas of Jessore, Chauadanga, Magura, meherpur, Kustia, Rajshahi, Gazipur districts of Bangladesh. In case of harvest index, two varieties BARI Masur-6 and BARI Masur-7 had reasonable plant height with better biomass production ability and improved harvest index and increased yield. Mondal et al. [30] reported that among the five promising lentil mutants, two mutants (LM-507 and LM-1018) showed improved HI, thereby increased yield.

Fertilization of grain legumes with Zn can affect both marketable yield and Zn content of the grain, which is important in human nutrition [31]. In the experiment, Zn fertilization significantly contributed to achieve higher yield and found improved growth, quality and yield contributing characters of lentil. Farooq et al. [32] reported that Zn played an important role in growth and development of crop yield. Seed yield of lentil increased in terrace and calcareous soils of all locations about 14 to 20% increment in Zn fertilization plot over Zn control plot. Grain yield can increase with Zn applications, which enhances plant growth due to the effects of Zn on photosynthesis and enzyme activation [33]. Quddus et al. [34] corroborated in field pea that application of different levels of Zn contributed 11.3% to 29.2% yield increment over Zn control. Zinc might be activated of several enzymes, involved in metabolic activities, assist nodule formation, protein synthesis resulting better pod formation which ultimately increase the seed yield. The results are in agreement with the findings of Mevada et al. [35]; Klug and Rhodes [36]. We observed that improved harvest index documented in Zn fertilization plot in all the experimental

locations. This improved HI might be due to higher biomass accumulation. Harvest index showed statistically significant, some of them were showed non-significant across the treatments. Some researchers have outlined that the harvest index positively affected by Zn applications. Usman et al. [37] stated that the highest harvest index for green gram (*Vigna radiata* L.) obtained by the application of 20 kg ha<sup>-1</sup> zinc sulfate. Furthermore, Purushottam and Saren [38] emphasized that Zn fertilizer had a significant effect on the harvest index. Azad et al. [39] and Gangwar and Singh [40] found that applications of Zn increased the harvest index. But, some research report expressed that the application of Zn had no effect on the harvest index [41, 42].

In our study the effective nodulation was found highest in all the experimental locations in Zn fertilization plot of all varieties and lowest was in Zn control plot. The increasing rate of nodulation among the locations was about 14 to 25%. Patel et al. [43] noted that Zn is involved in N-fixation through nodule formation. The protein percentage in lentil affected significantly by the application of Zn including other (N, P, K, S and B) nutrients. In the experiment, the highest protein content was achieved in Zn fertilization plot in all the locations and lowest was in Zn control plot. Mali et al. [44] found that use of proper doses of zinc might be enhanced the synthesis of carbohydrates and protein and their transport to the site of seed formation. Oktem [45] reported that different levels of zinc fertilization increased protein content in seed of lentil varied from 24.9 to 29.8%. Zinc is a vital micro element in protein synthesis [46, 47]. Pandey and Gautam [48] reported that the protein content of seeds significantly increased with the application of Zn in lentils. Application of Zn fertilizer generally increased the grain Zn concentration. Maqsood et al. [31] reported that low containing organic matter soils increase of 20% in Zn concentration in seed over control was observed when 5 kg Zn ha<sup>-1</sup> was added to a loamy textured soil. In the experiment, the Zn concentration augmented 6.3 to 12% among the locations over Zn control treatment. Some researchers have reported that the application of Zn to the soil had a significant positive effect on seed Zn content [49, 50]. Comparison among three locations, the productivity and performance of lentil varieties found comparatively better in calcareous soil than that of terrace soil. These improved variation might be due to soil fertility of calcareous soils was better over terrace soils.

The above results and explanations advocated advance to the appropriate requirement of zinc dose for the targeted soil fertility in order to monitor the different Zn rates to achieve maximum lentil production.

## 5. Conclusion

Experimental results indicated that Zn fertilization increased the seed yield taken per unit area. Among the varieties, BARI Masur-7 followed by BARI Masur-6 produced the highest seed yield in most of the cases by the application of 2 kg Zn ha<sup>-1</sup>. Growth and yield contributing

characters responded positively to Zn application in the zinc deficient soils. Protein and Zn content in lentil seed also improved by the application of Zn fertilizer. The result, suggest that 2 kg Zn ha<sup>-1</sup> could be applied in any lentil variety for quality improvement and yield maximization in terrace and calcareous soils of Bangladesh. Recommendation has been made from the current study, another experiment should be carried out to monitor and determine the appropriate Zn dose and dynamic for lentil production through different zinc levels in Zn- deficient soils.

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