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RESEARCH PAPER

Effects of Varieties and Zinc on Physico-Chemical Quality of Chilli

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ABSTRACT

This study was undertaken to investigate the effect of variety and different levels of zinc (Zn) on physico-chemical quality of chilli (*Capsicum frutescens* L.). Treatments for this study comprised of (i) three chilli varieties (MS-217, Premium-F_1 and Hot Master-F_1) and (ii) five levels of zinc (0, 1.5, 3.0, 4.5 and 6.0 kg Zn ha^{-1}) in all combinations. The pot (0.79 ft^3) experiment was laid out in a randomized complete block design (RCBD) with three replications. The result exhibited that physico-chemical quality characters of chilli fruit were significantly influenced (p<0.05) by the variety and zinc application. In varieties, maximum fruit firmness (3.74 lbs), pH (4.31), calcium (2.493%), magnesium (0.414%) and phosphorus (0.139%) were recorded in Hot Master-F_1; maximum potassium (2.827%), sodium (3.587%), sulphur (0.05%) and total soluble solids (TSS) (11.92%) were recorded in MS-217; the highest titrable acidity **(**TA) (1.14%) and vitamin C (83.05 mg/100g) were found in Premium-F_1. At the same time in zinc levels, maximum TA (1.55%) was obtained at 6 kg Zn ha^{-1}; maximum TSS (12.04%), calcium (2.611%) and sulphur (0.051%) were obtained at 3 kg Zn ha^{-1}; the highest fruit firmness (3.91 lbs), vitamin C (86.97 mg/100 g), potassium (2.867%), magnesium (0.431%) and phosphorus (0.134%) were found at 4.5 kg Zn ha^{-1} treated plants; and the highest sodium (4.289%) was found at 1.5 kg Zn ha^{-1} treated plants. However, the lowest values of those parameters, except minimum pH (3.95) at 6 kg Zn ha^{-1} and sodium (2.478%) at 4.5 kg Zn ha^{-1}, were observed at control (0 kg Zn ha^{-1}) treated plants. Therefore, the optimum dose of zinc was appeared to be 4.5 kg ha^{-1} followed by 3 kg ha^{-1} which may be recommended to obtain improved quality chilli fruit.

Key words: Chilli, Mineral contents, Postharvest quality, Variety, Zinc.

Introduction

Chilli (*Capsicum frutescens* L.) commonly known as hot pepper, belongs to the family Solanaceae, and is consumed and cultivated as an annual spice crop worldwide including Bangladesh. It is an indispensable spice, which is liked for pungency, spicy taste and its appealing color adds to the curry. Chilli fruits are highly nutritious and contains large amounts of vitamin C, small amounts of carotene, vitamin B, vitamin B6, calcium, phosphorus, potassium, magnesium, and iron (Howard *et al.* 2000; Pawar *et al.* 2011; Ganguly *et al.* 2017).

Nutrition plays an important role in successful production. Like macronutrients, soil addition of micronutrients has a pronounced effect on the production and quality of various crops (Ali *et al.* 2013). Application of micronutrients gave higher fruit weight, yield and maximum ascorbic acid content of pepper (Malawadi *et al.* 2010) and tomato (Batra *et al.* 2006; Savitha 2008) fruits. Tamilselvi *et al.* (2005) observed maximum total soluble solids, titrable acidity, ascorbic acid and lycopene contents with the application of micronutrients. Among the micronutrients, zinc (Zn) plays an important role in synthesis of proteins, enzyme activating, oxidation, revival reactions and metabolism of carbohydrates and hormones, stabilization of ribosomal fractions, increasing the rate of chlorophyll (Tisdale *et al*. 1997; Obata *et al.* 1999; Ali *et al.* 2013). Zinc played significant role in augmenting growth, yield, and physico-chemical properties of many crops (Hatwar *et al.* 2003; Tamilselvi *et al.* 2005; Shaheen *et al.* 2007; Savitha 2008; Shil *et al.* 2013). Increases in Zn application from 2 to 10 mg/kg soil significantly increased chlorophyll, soluble protein, K concentration, and reduced shoot content of Na (Aktas *et al.* 2007). Zinc application improved growth and yield of tomato plants cultivated under saline conditions (Gurmani *et al.* 2012). Application of Fe and Zn in different forms and rates gave significantly increases in total yield and Fe, Zn and K uptake of different plants (Negm *et al.* 2004; Hassan *et al.* 2011). Zinc application also raised the concentration of Zn, Ca, Mg, K, and P in plant tissues (Singh and Singh 2004).

However, increased cropping intensity along with cultivation of modern crop varieties having high yield potential has resulted in deterioration of soil fertility with an emergence of micronutrient deficiency in Bangladesh. Among the micronutrients, zinc and boron deficiencies have widely been reported (Hossain *et al.* 2008; Jahiruddin 2011; Jahiruddin and Islam 2014). Currently, chilli yield and quality in Bangladesh including coastal regions is very low compared to cultivable land and other chilli growing countries of the world. Low yield may be attributed to a number of reasons such as lack of suitable high yielding variety (HYB) and their improvement through fertilizer management especially zinc (Zn) in the soil. Importantly, the soil of the coastal study area is more or less deficient in Zn. Moreover, increasing the pH in the coastal area decreases the solubility of Zn in soils, and hence, reduces the availability and uptake of Zn to plants (Lindsay 1972). Therefore, there is a great possibility to increase yield potential and improve quality of chilli by using suitable HYV with the application of balanced and optimum level of nutrients especially Zn in major chilli growing areas including coastal regions (Bose and Tripathi 1996). However, a few research works has been conducted so far to find out the influences of Zn level on the physico-chemical quality of chilli varieties in the coastal region of Bangladesh. Therefore, the aim of this work was to identify the suitable variety (s) with the optimum level of Zn for the improvement of physico-chemical quality of chilli. This information will contribute to increase the knowledge of the effect of Zn level on the physico-chemical quality attributes of chilli varieties in the study area.

Materials and Methods

The experiment was conducted in Germplams Centre and Postharvest Laboratory of the Department of Horticulture, and Central Laboratory of Patuakhali Science and Technology University, Dumki, Patuakhali during May 2018 to September 2018. The experimental materials were seeds of chilli (*Capsicum frutescens* L.) varieties *viz*., Hot Master-F_1 and MS-217 collected from Mallika Seed Company Limited, and Premium-F_1 collected from Lal Teer Seed Company Limited. They were high yielding variety (HYV). The experiment consisted of two factors with fifteen treatments comprising (i) three chili varieties (MS-217, Premium-F_1 and Hot Master- F_1) and (ii) five levels of zinc (Zn) (0, 1.5, 3.0, 4.5 and 6.0 kg Zn ha^{-1}) in all combinations. Zinc as $ZnSO_4.7H_2O$ was applied to the chilli crop. The available Zn content of the experimental untreated soil was below 2 ppm or mg kg^{-1} oven dried soil. The factorial experiment was laid out in a randomized complete block design (RCBD) with three replications. Thirty-day-old seedlings were transplanted in earthen pot (0.79 $feet^3$). The maturity of the crop was determined on the basis of deep green colouring of fruits. Harvesting of fruits was completed at 70 days after transplanting (DAT). Harvested treated and non-treated chilli fruits were brought to laboratories for physico-chemical analysis.

Firmness of chilli fruit was estimated by Force gauge (Yamagata Univ. Japan: FG–5000A) and was expressed in Neuton. Total soluble solid (TSS) content of chilli fruit was measured by digital refractometer (BOECO, Germany) and was expressed in per cent. pH of chilli fruit was determined by calibrated electric pH meter (model H 12211 pH/OPR meter of Hanna Company). Estimation of % titratable acidity (TA) was done by following the method of Ranganna (1977). Determination of vitamin C (Ascorbic acid) content was done by following the method of Ranganna (1979) and was expressed in mg per 100 g of fruit. The contents of minerals (Ca, Mg, S, Na, K and P) were determined by the methods Association of Official Analytical Chemist (AOAC) (2000) and were expressed in per cent. Contents of calcium (Ca) by complexometric method of titration using Na_2-EDTA as a complexing agent (Page *et al.* 1982), and magnesium (Mg) by titrimetrically (Page *et al*. 1982; APHA 2005) were determined. Determination of sulphur (S) was done by turbidimetric method (Tandon 1995). Estimation of sodium (Na) and potassium (K) in the fruit samples were done separately with the help of flame emission spectrophotometer (Spectrolab analytical, UK) using appropriate filters. After digestion, 0.5 ml sample was taken and it was diluted 200 times to take the flame emission spectrophotometer reading. Determination of phosphorus (P) was done using ascorbic acid as a reductant for color development and reading was recorded with the help of spectrophotometer (T60UV). Recorded data were analyzed using Minitab 17 statistical software program (Minitab Inc, State College, PS, USA) to determine the significance of variation resulting from the experimental treatments. General linear model (GLS) to perform analyses of variances (ANOVA) for different parameters and separation of means with Tukey at 5% level of probability were used.

Results and Discussion

Fruit firmness

Significant variation (p<0.05) was observed in respect to fruit firmness of chilli varieties and different levels of zinc (Fig. 1a and 1b). In varieties, the highest (3.74 lbs) and lowest (3.13 lbs) fruit firmness were obtained from V_3 (Hot Master-F_1) and V_1 (MS-217), respectively (Fig. 1a). Genetical effects or varietal character might influence the variations of fruit firmness in chilli. In zinc levels, maximum (3.91 lbs) and minimum (3.06 lbs) fruit firmess were recorded from Zn_3 (4.5 kg Zn ha^{-1}) and Zn_0 control (0 kg Zn ha^{-1}), respectively (Fig. 1b). This finding indicates that fruit firmness of chilli increases with the increased level of zinc application up to a certain level and then it was declined. This finding was supported by the findings of García-López *et al.* (2019).

Total soluble solids

There was significant variation (p<0.05) in case of total soluble solids (TSS) of chilli varieties and different levels of zinc (Fig. 2a and 2b). In varieties, the highest (11.92%) and lowest (11.50%) TSS were noted from V_1 (MS-217) and V_3 (Hot Master-F_1), respectively (Fig. 2a). The differences of TSS might be due to the varietal character of the chilli. In zinc levels, maximum (12.04%) and minimum (11.13%) TSS were found from Zn_2 (3.0 kg Zn ha^{-1}) and Zn_0 control (0 kg Zn ha^{-1}), respectively (Fig. 2b). This finding proposes that after crossing the optimum dose of zinc application, per cent TSS of chilli was declined. This finding was supported by the findings of García-López *et al.* (2019).

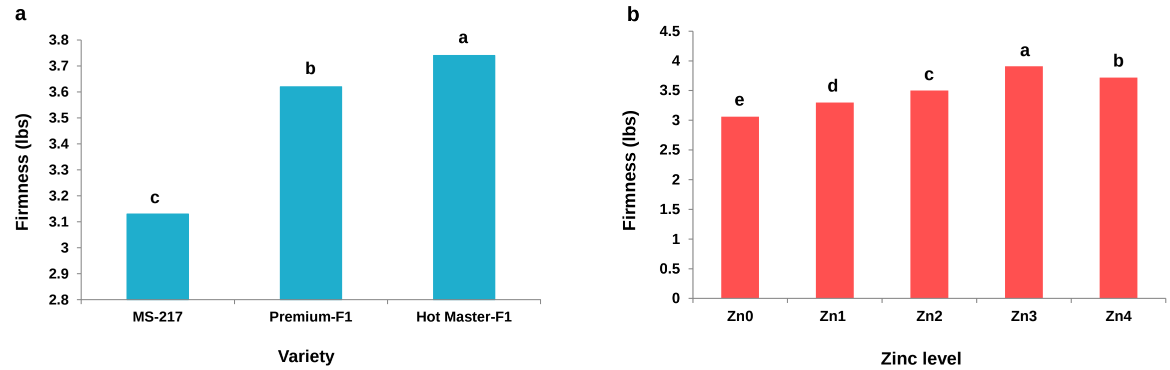

Fig. 1: Effect of varieties (a) and zinc levels (b) on firmness of chilli fruit
Zn_0= 0 kg Zn ha^{-1}, Zn_1= 1.5 kg Zn ha^{-1}, Zn_2= 3 kg Zn ha^{-1}, Zn_3= 4.5 kg Zn ha^{-1}, Zn_4= 6 kg Zn ha^{-1}
The figures having same letter (s) do not differ significantly at 5% level of probability analyzed by Tukey.

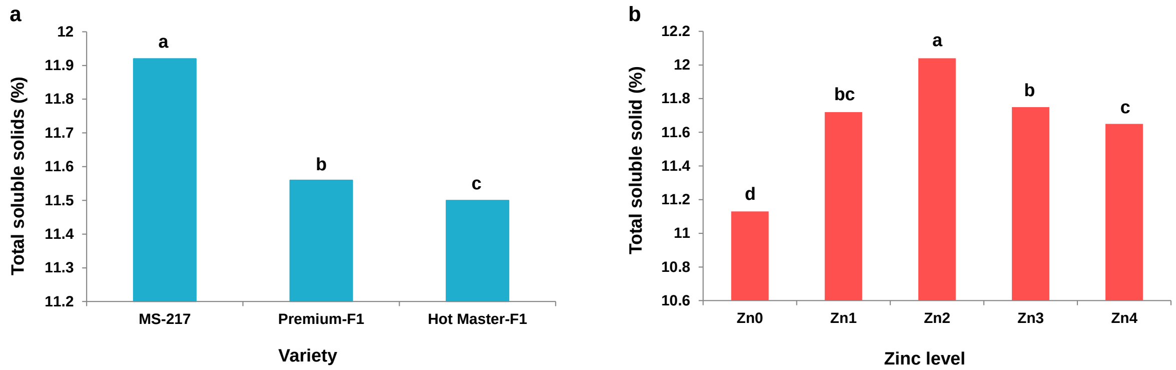

Fig. 2: Effect of varieties (a) and zinc levels (b) on total soluble solids of chilli fruit
Zn_0= 0 kg Zn ha^{-1}, Zn_1= 1.5 kg Zn ha^{-1}, Zn_2= 3 kg Zn ha^{-1}, Zn_3= 4.5 kg Zn ha^{-1}, Zn_4= 6 kg Zn ha^{-1}
The figures having same letter (s) do not differ significantly at 5% level of probability analyzed by Tukey.

Titrable acidity

Titrable acidity **(**TA) showed significant variation (p<0.05) in respect to chilli varieties and different zinc levels (Fig. 3a and 3b). In varieties, the highest (1.14%) and lowest (1.06%) TA were observed from V_2 (Premium-F_1) and V_3 (Hot Master-F_1), respectively (Fig. 3a). It might be due to genetic influence which is directly related to variations of TA content in chilli fruit. In zinc levels, maximum (1.55%) and minimum (0.60%) TA were achieved from Zn_4 (6 kg Zn ha^{-1}) and Zn_0 control (0 kg Zn ha^{-1}), respectively (Fig. 3b). The increasing trend of TA in chilli fruit was found in the present study with the increased level of zinc application which is supported by the findings of García-López *et al.* (2019).

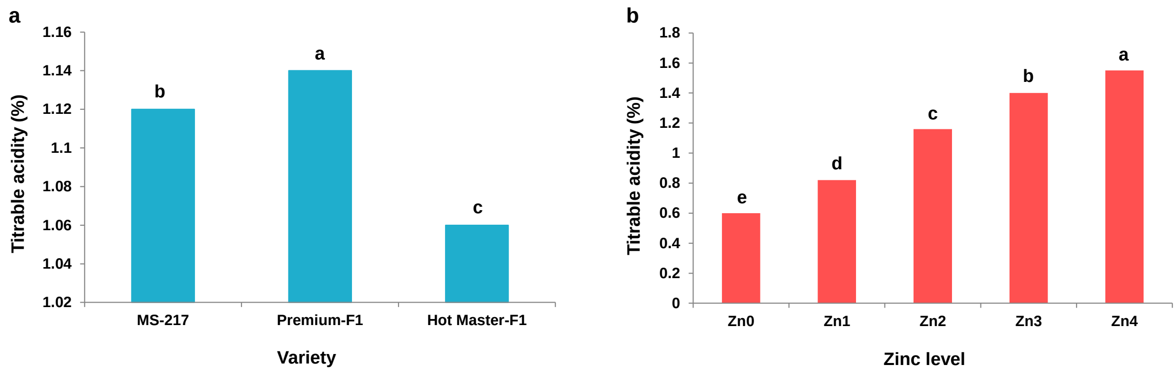

Fig. 3: Effect of varieties (a) and zinc levels (b) on titrable acidity of chilli fruit
Zn_0= 0 kg Zn ha^{-1}, Zn_1= 1.5 kg Zn ha^{-1}, Zn_2= 3 kg Zn ha^{-1}, Zn_3= 4.5 kg Zn ha^{-1}, Zn_4= 6 kg Zn ha^{-1}
The figures having same letter (s) do not differ significantly at 5% level of probability analyzed by Tukey.

Vitamin C (Ascorbic acid)

Vitamin C content varies based on different factors such as cultivar, plant nutrition, production practice and maturity (Pérez-López *et al.* 2007). Significant variation (p<0.05) was found in relation to vitamin C content of chilli varieties and different zinc levels (Fig. 4a and 4b). In varieties, the highest (83.05 mg/100 g) and lowest (76.87 mg/100 g) vitamin C content were obtained from V_2 (Premium-F_1) and V_1 (MS-217), respectively (Fig. 4a). Varietal characters might influence the variations of vitamin C content in chilli fruit (Pérez-López *et al.* 2007; Chowdhury *et al.* 2017). In zinc levels, maximum (86.97 mg/100 g) and minimum (72.51 mg/100 g) vitamin C content were recorded from Zn_3 (4.5 kg Zn ha^{-1}) and Zn_0 control (0 kg Zn ha^{-1}), respectively (Fig. 4b). This finding proposes that beyond optimum dose vitamin C of chilli was declined. This result was similarly agreed by Shadia (2014) and Chowdhury *et al.* (2018) who observed that Zn application at increased concentrations improved vitamin C content of fruit.

Fruit pH

Varieties of chilli and different zinc levels showed significant variation (p<0.05) in case of fruit pH (Fig. 5a and 5b). In varieties, the highest (4.31) and lowest (3.80) fruit pH were noticed from V_3 (Hot Master-F_1) and V_2 (Premium-F_1), respectively (Fig. 5a). Genetic influences might be related to variations of pH content in chilli fruit. In zinc levels, maximum (4.21) and minimum (3.95) pH content were found from Zn_0 control (0 kg Zn ha^{-1}) and Zn_4 (6 kg Zn ha^{-1}), respectively (Fig. 5b). This result showed correlation among pH with titrable acidity and ascorbic acid content of chilli fruit which is agreed with the findings of Wang and Lin (2002). Fruits containing less amount of pH (grown in control treatment) indicate presence of more citric acid, which is beneficial for human consumption (Wang and Lin 2002). Additionally, fruit with low pH is more suitable for ripening while it also improves shelf life (Hernández-Pérez *et al.* 2005).

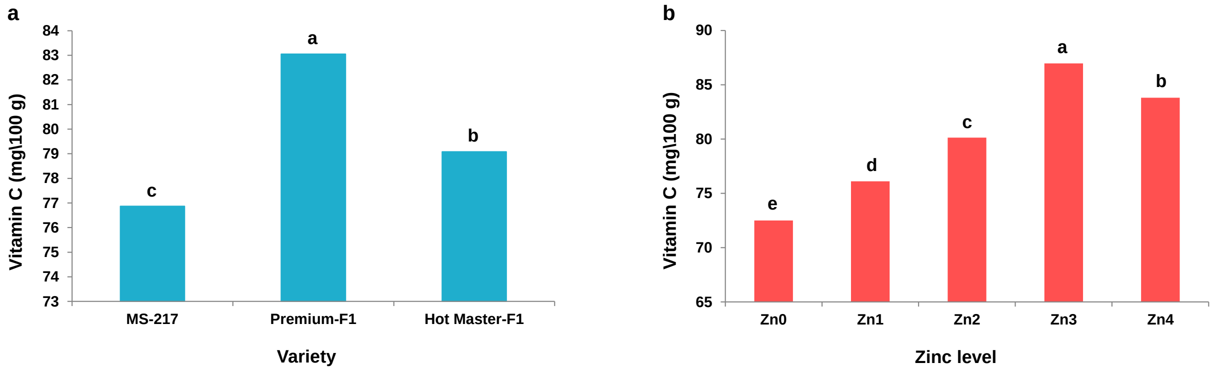

Fig. 4: Effect of varieties (a) and zinc levels (b) on vitamin C of chilli fruit

Zn_0= 0 kg Zn ha^{-1}, Zn_1= 1.5 kg Zn ha^{-1}, Zn_2= 3 kg Zn ha^{-1}, Zn_3= 4.5 kg Zn ha^{-1}, Zn_4= 6 kg Zn ha^{-1}

The figures having same letter (s) do not differ significantly at 5% level of probability analyzed by Tukey.

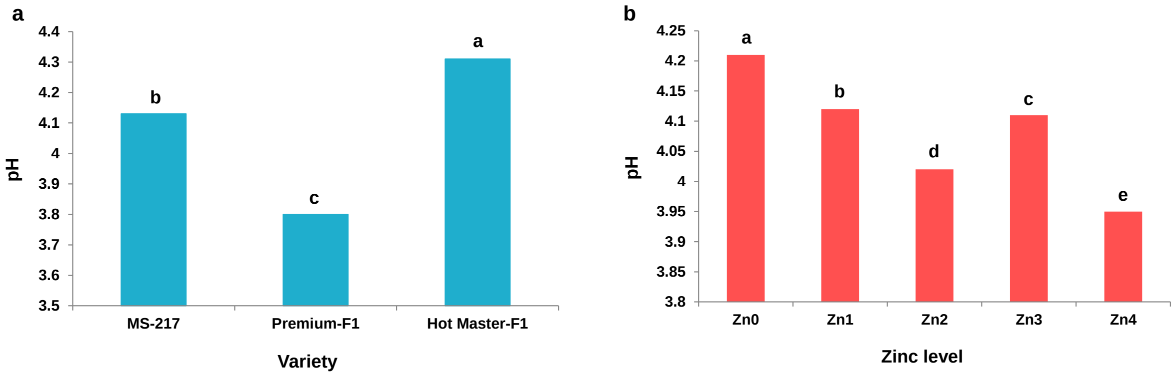

Fig. 5: Effect of varieties (a) and zinc levels (b) on pH of chilli fruit

Zn_0= 0 kg Zn ha^{-1}, Zn_1= 1.5 kg Zn ha^{-1}, Zn_2= 3 kg Zn ha^{-1}, Zn_3= 4.5 kg Zn ha^{-1}, Zn_4= 6 kg Zn ha^{-1}

The figures having same letter (s) do not differ significantly at 5% level of probability analyzed by Tukey.

Mineral properties

Calcium

Significant variation (p<0.05) was observed in respect to calcium (Ca) content of chilli varieties and different zinc levels (Table 1 and 2). In varieties, the highest (2.493%) and lowest (1.340%) Ca content were observed from V_3 (Hot Master-F_1) and V_1 (MS-217), respectively (Table 1). The differences of Ca content among the varieties might be due to genetical effects of chilli fruit (Raimi *et al.* 2014). In zinc levels, maximum (2.611%) and minimum (1.344%) Ca content were achieved from Zn_2 (3.0 kg Zn ha^{-1}) and Zn_0 control (0 kg Zn ha^{-1}), respectively (Table 2). This results indicate that maximum uptake of Ca occurs at 3.0 kg Zn ha^{-1} and after that it was declined. Similar trend of findings i.e. Ca increases with the increased application of zinc or iron or their combination upto a certain level in sweet chilli (Shadia 2014). Singh and Singh (2004) reported that zinc application increased chlorophyll content and raised the concentration of Ca in tissues.

Magnesium

There was significant variation (p<0.05) in case of magnesium (Mg) content of chilli varieties and different zinc levels (Table 1 and 2). In varieties, the highest (0.414%) and lowest (0.398%) Mg content were obtained from V_3 (Hot Master-F_1) and V_1 (MS-217), respectively (Table 1). Varietal characters might influence the variations of Mg content in chilli fruit (Raimi *et al.* 2014). In zinc levels, maximum (0.431%) and minimum (0.377%) Mg content were recorded from Zn_3 (4.5 kg Zn ha^{-1}) and Zn_0 control (0 kg Zn ha^{-1}), respectively (Table 2). Results indicate that maximum uptake of Mg occurs at 4.5 kg Zn ha^{-1} and after that it was declined. Singh and Singh (2004) also reported that zinc application increased chlorophyll content and increased the concentration of Mg in tissues.

Potassium

Varieties of chilli and different levels of zinc showed significant variation (p<0.05) in relation to potassium (K) content (Table 1 and 2). In varieties, the highest (2.827%) and lowest (2.447%) K content were obtained from V_1 (MS-217) and V_3 (Hot Master-F_1), respectively (Table 1). Genetic influences might be related to variations of K content in chilli fruit (Raimi *et al.* 2014). In zinc levels, maximum (2.867%) and minimum (2.333%) K content were recorded from Zn_3 (4.5 kg Zn ha^{-1}) and Zn_0 control (0 kg Zn ha^{-1}), respectively (Table 2). This results indicate that maximum uptake of K occurs at 4.5 kg Zn ha^{-1} and after that it was declined. This result is the similar trend with the findings of Shadia (2014) that K increases with the increased application of zinc or iron or their combination upto a certain level in sweet chilli. Singh and Singh (2004) also reported that zinc application increased chlorophyll content and raised the concentration of K in tissues.

Phosphorous

Significant variation (p<0.05) was observed in respect to phosphorus (P) content of chilli varieties and different levels of zinc (Table 1 and 2). In varieties, the highest (0.139%) and lowest (0.121%) P content were noted from V_3 (Hot Master-F_1) and V_2 (Premium-F_1), respectively (Table 1). The differences of P content might be due to varietal characters of chilli fruit. In zinc levels, maximum (0.134%) and minimum (0.122%) P content were found from Zn_3 (4.5kg Zn ha^{-1}) and Zn_0 control (0 kg Zn ha^{-1}), respectively (Table 2). Results indicate that maximum uptake of P occurs at 4.5 kg Zn ha^{-1} and after that it was declined. This result is the same trend with the findings of Shadia (2014) that phosphorus increases with the increased application of zinc or iron or their combination up to a certain level in sweet chilli. Singh and Singh (2004) also reported that zinc application increased chlorophyll content and raised the concentration of P in tissues.

Sodium

Significant variation (p<0.05) was observed in case of sodium (Na) content of chilli varieties and different levels of zinc (Table 1 and 2). In varieties, the highest (3.587%) and lowest (2.947%) Na content were observed from V_1 (MS-217) and V_2 (Premium-F_1), respectively (Table 1). Varietal characters might influence the differences of Ca content of chilli fruit (Raimi *et al.* 2014). In zinc levels, maximum (4.289%) and minimum (2.478%) Na content were achieved from Zn_1 (1.5 kg Zn ha^{-1}) and Zn_3 (4.5 Kg ha^{-1}), respectively (Table 2). In this study, increasing Zn application might reduce the uptake of Na nutrients and reduce the concentration of Na in tissues of chilli fruit. Shadia (2014) found the similar trend of observation in sweet pepper where Na content decreased significantly with increasing Zn application.

Sulphur

Varieties of chilli and different levels of zinc showed significant variation (p<0.05) in relation to sulphur (S) content (Table 1 and 2). In varieties, the highest (0.05%) and lowest (0.042%) S content were obtained from V_1 (MS-217) and V_3 (Hot Master-F_1), respectively (Table 1). Genetic influences might be related to variations of S content in chilli fruit. In zinc levels, maximum (0.051%) and minimum (0.04%) S content were recorded from Zn_2 (3 kg Zn ha^{-1}) and Zn_0 control (0 kg Zn ha^{-1}), respectively (Table 2). The maximum S at 3 kg Zn ha^{-1} indicates its optimum level and after that it was declined. This optimum level of Zn application might improve the uptake of S nutrients and raise the concentration of S in tissues of chilli fruit. This result is partially agreed with the finding of Begum *et al.* (2015) who observed that higher rate of Zn application increased the S uptake in onion bulb.

Table 1: Effect of varieties on mineral contents of chilli fruit

Variety	Mineral contents (%)					
	Ca	Mg	K	P	Na	S
V_1: MS-217	1.340 c	0.398 c	2.827 a	0.125 b	3.587 a	0.050 a
V_2: Premium-F_1	1.930 b	0.409 b	2.487 b	0.121 c	2.947 b	0.047 b
V_3: Hot Master-F_1	2.493 a	0.414 a	2.447 b	0.139 a	2.953 b	0.042 c
Level of significance	**	**	**	**	*	*
CV (%)	9.56	8.20	9.06	7.73	13.12	6.96

* and ** indicate significant at 5% and 1% level of probability, respectively; CV = Co-efficient of variation.
In a column, figures having same letter (s) do not differ significantly at 5% level of probability analyzed by Tukey.

Table 2: Effect of zinc levels on mineral contents of chilli fruit

Zinc Level	Mineral contents (%)					
	Ca	Mg	K	P	Na	S
Zn_0: 0.0 kg ha^{-1}	1.344 d	0.377 e	2.333 d	0.122 e	3.556 b	0.040 e
Zn_1: 1.5 kg ha^{-1}	1.789 c	0.424 b	2.489 cd	0.132 b	4.289 a	0.045 d
Zn_2: 3.0 kg ha^{-1}	2.611 a	0.420 c	2.667 b	0.128 c	2.733 c	0.051 a
Zn_3: 4.5 kg ha^{-1}	2.139 b	0.431 a	2.867 a	0.134 a	2.478 d	0.048 b
Zn_4: 6.0 kg ha^{-1}	1.722 c	0.381 d	2.578 bc	0.124 d	2.756 c	0.046 c
Level of significance	**	*	*	**	*	**
CV (%)	9.56	8.20	9.06	7.73	13.12	6.96

* and ** indicate significant at 5% and 1% level of probability, respectively; CV = Co-efficient of variation.
In a column, figures having same letter (s) do not differ significantly at 5% level of probability analyzed by Tukey.

Conclusion

Significant effects ($p<0.05$) were noticed in relation to physico-chemical quality attributes of varieties and zinc levels in chilli fruit. Among the varieties, Hot Master-F_1 revealed the best performances on fruit firmness, pH, calcium, magnesium, and phosphorus; MS-217 revealed the best performances on potassium, sodium, sulphur, and TSS; and Premium-F_1 revealed the best performances on TA and vitamin C. Among the zinc levels, application of 4.5 kg Zn ha^{-1} gave the best effects on fruit firmness, vitamin C, potassium, magnesium, and phosphorus; 3 kg Zn ha^{-1} gave the best effects on TSS, calcium, and sulphur; and 1.5 kg Zn ha^{-1} and 6 kg Zn ha^{-1} gave the best effects on sodium and TA, respectively. Across average variety, application of 4.5 kg Zn ha^{-1} followed by 3 kg Zn ha^{-1} seems to be most effective in enhancing physico-chemical quality attributes of chilli. From this study, it may recommend that application of zinc can improve the quality of chilli fruit although the level of responses depends on varieties.

References

Aktaş H, ABAK K, Öztürk L, Çakmak İ (2007) The effect of zinc on growth and shoot concentrations of sodium and potassium in pepper plants under salinity stress. *Turkish Journal of Agriculture and Forestry*, **30(6)**: 407–412.

Ali S, Javed HU, Rehman RNU, Sabir IA, Naeem MS, Siddiqui MZ, Saeed DA, Nawaz MA (2013) Foliar application of some macro and micro nutrients improves tomato growth, flowering and yield. *International Journal of Biosciences*, **3(10)**: 280–287.

APHA (American Public Health Association) (2005) Standard methods for the examination of water and wastewater, 23rd Edn. American Public Health Association (APHA): Washington, DC.

AOAC (2000) Official methods of Analysis, 17th Edn. Association of Official Analytical Chemist, Washington DC. 2200 pp.

Batra VK, Kamboj M, Arora SK, Mange RS (2006) Effect of foliar application of micronutrients on the quality and shelf-life of tomato. *Haryana Journal of Horticultural Sciences*, **35(1&2)**: 140–142.

Begum R, Jahiruddin M, Kader MA, Haque MA, Hoque ABMA (2015) Effects of zinc and boron application on onion and their residual effects on mungbean. *Progressive Agriculture*, **26(2)**: 90–96.

Bose US, Tripathi SK (1996) Effect of micronutrients on growth, yield and quality of tomato cv. Pusa Ruby in MP. *Crop Research-Hisar*, **12**: 61–64.

Chowdhury MSN, Ahamed KU, Sultana T, IslamR (2018). Effect of foliar application of liquid nutrient solution on morpho-physiology, quality and yield performance of chilli (*Capsicum frutescens*) germplasm, *Journal of Experimental Agriculture International*, **24(5)**: 1–10.

Chowdhury MSN, Sarkar S, Uddin AJ, Sultana T, Roni MZK, Islam R (2017) Morpho-physiology, yield and quality assessment on five local landrace chilli germplasms. *Asian Journal of Agriculture and Rural Development*, **7(11)**: 233–243.

Ganguly S, Praveen KP, Para PA (2017) Medicinal properties of chilli pepper in human diet. *ARC Journal of Public Health and Community Medicine*, **2(1)**: 6–7.

García-López JI, Niño-Medina G, Olivares-Sáenz E, Lira-Saldivar RH, Barriga-Castro ED, Vázquez-Alvarado R, Rodríguez-Salinas PA, Zavala-García F (2019) Foliar application of zinc oxide nanoparticles and zinc sulfate boosts the content of bioactive compounds in habanero peppers. *Plants*, **8(8)**: 254.

Gurmani AR, Khan SU, Andaleep R, Waseem K, Khan A (2012) Soil application of zinc improves growth and yield of tomato. *International Journal of Agriculture and Biology*, **14(1)**: 91–96.

Hassan MA, El-Tohamy MA, Mohamed AA (2011) Response of garlic cultivation in alkaline soil to foliar application of some plant nutritive compounds. *Egyptian Journal of Applied Sciences*, **26(5)**: 102–117.

Hatwar GP, Gondane SM, Urkade SM (2003) Effect of micronutrients on growth and yield of chilli. *Journal of Soils and Crops*, **13(1)**: 123–125.

Hernández-Pérez T, Carrillo-López A, Guevara-Lara F, Cruz-Hernández A, Paredes-López O (2005) Biochemical and nutritional characterization of three prickly pear species with different ripening behavior. *Plant Foods for Human Nutrition*, **60(4)**: 195–200.

Hossain MA, Jahiruddin M, Islam MR, Mian MH (2008) The requirement of zinc for improvement of crop yield and mineral nutrition in the maize-mungbean-rice system. *Plant and Soil*, **306**: 13–22.

Howard LR, Talcott ST, Brenes CH, et al. (2000) Changes in phytochemical and antioxidant activity of selected pepper cultivars (*Capsicum* species) as influenced by maturity. *Journal of Agricultural and Food Chemistry,* **48(5)**:1713–1720.

Jahiruddin M (2011) Screening, selection and molecular characterization of boron efficient wheat genotypes. Project Completion Report, Dept. of Soil Science, BAU, Mymensingh.

Jahiruddin M, Islam MR (2014) Project Report (2011-2014). Requirement of micronutrients for crops and cropping patterns. PIU-BARC (NATP Phase-I) project. Project ID No. 339.

Lindsay WL (1972) Zinc in soils and plant nutrition. In Advances in agronomy. Vol. 24. Academic Press. pp. 147–186.

Malawadi MN, Shashidhara GB, Palled YB (2010) Effect of secondary and micronutrients on yield, nutrient uptake and quality of chilli. *Karnataka Journal of Agricultural Sciences*, **17(3)**: 553–556.

Negm MA, Zaki RN, El-Meneasy AIA (2004) Effect of iron and zinc as foliar application on sorghum grown in a calcareous soil. *Egyptian Journal of Soil Science*, **44(4)**: 465–475.

Obata H, Kawamura S, Senoo K, Tanaka A (1999) Changes in the level of protein and activity of Cu/Zn-superoxide dismutase in zinc deficient rice plant, *Oryza sativa* L. *Soil Science and Plant Nutrition*, **45(4)**: 891–896.

Page AL, Miller RH, Keeney DR (1982) Methods of soil analysis. 2nd Edn. Amercen Society of Agronomy, Madison, WI, USA.

Pawar SS, Bharude NV, Sonone SS, et al. (2011) Chilies as food, spice and medicine: A perspective. *International Journal of Pharmacy and Biological Sciences*, **1(3)**: 311–318.

Pérez-López AJ, del Amor FM, Serrano- Martínez A, Fortea MI, Núñez- Delicado E (2007) Influence of agricultural practices on the quality of sweet pepper fruits as affected by the maturity stage. *Journal of the Science of Food and Agriculture*, **87(11)**: 2075–2080.

Raimi MM, Shittu SA, Oyetade OA (2014) Physicochemical properties and mineral composition of *Capsicum annum* and *Capsicum frutescens* oils. *IOSR Journal of Applied Chemistry*, **7**: 112–116.

Ranganna S (1977) Manual of analysis of fruit and vegetable products. Tara-McGraw Hill, New Delhi. pp. 634.

Ranganna S (1979) Manual of analysis of fruits and vegetables products. Tata McGrew-Hill Publishing Company, New Delhi, India. pp. 102–140.

Savitha HR (2008) Effect of Iron-EDTa on yield and quality of red chilli (*Capsicum annuum* L.) in acalcareous vertisol of zone-8 of Karnataka (Doctoral dissertation, UAS, Dharwad).

Shadia BD (2014) Response of pepper (*Capsicum annum* L.) to different sources of microelements on growth, yield and chemical composition under Ras Sudr conditions. *Annals of Agricultural Sciences*, **52(2)**: 273–285

Shaheen AM, Fatma M, Rizk A, Singer SM (2007) Growing onion plants without chemical fertilization. *Research Journal of Agriculture and Biological Sciences*, **3(2)**: 95–104.

Shil KNC, Naser HM, Brahma S, Yousuf MN, Rashid MH (2013) Response of chilli (*Capsium annuum* L.) to zinc and boron application. *Bangladesh Journal of Agricultural Research*, **38(1)**: 49–59.

Singh HP, Singh TN (2004) Effect of sources and levels of zinc on growth, yield and mineral composition of rice in alkali soil. *Indian Journal of Plant Physiology*, **9(4)**: 378–382.

Tamilselvi P, Vijayakumar RM, Nainar P (2005) Studies on the effect of foliar application of micronutrients on growth and yield of tomato (*Lycopersicon esculentum* Mill.) cv PKM-1. *South Indian Journal of Horticulture*, **53(1/6)**: 46–51.

Tandon HLS (1995) Methods of analysis of soils, plants, water and fertilizer. New Delhi: Fertilizer. Development of Consultation Organization.

Tisdale IS, Nelson IW, Beaton DJ, Havlin IJ (1997) Soil fertility and fertilizers. 5th Edn. Prentice Hall of India.

Wang SY, Lin SS (2002) Composts as soil supplement enhanced plant growth and fruit quality of strawberry. *Journal of Plant Nutrition*, **25(10)**: 2243–2259.