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Effect of Foliar Application of Zinc on Potato (*Solanum tuberosum* L.) in Bhaktapur, Nepal

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Abstract

The research entitled "Effect of foliar application of zinc on potato (*Solanum tuberosum* L.) in Bhaktapur, Nepal" was conducted with the objective to increase the yield of potato through foliar application of zinc during mid-January to April 2018. The experiment was laid out in Randomized Complete Block Design (RCBD) with 3 replications and 7 treatments. The treatments employed were control (water spray), single spray with 60ppm Zn-EDTA, single spray with 120ppm Zn-EDTA, single spray with 180ppm Zn-EDTA, double spray with 60ppm Zn-EDTA, double spray with 120ppm Zn-EDTA and double spray with 180ppm Zn-EDTA at 45DAP and 65DAP. The growth parameters including plant height, stem diameter and plant canopy were recorded at 45 DAE and 60DAE whereas yield parameters including number of tubers per plant, individual tuber weight and tuber yield were measured at harvest. Results revealed that the growth and yield contributing characters of potato were significantly affected by foliar application of zinc. It was observed that all the concentrations of zinc increased the plant height compared to control. Minimum plant height of 27.53cm was recorded with control and maximum height of 43.20cm was recorded with two foliar spray with 180ppm Zn-EDTA solution. The results obtained with 180ppm was found significantly superior to its lower doses and control for increasing stem diameter and plant canopy too. The highest stem diameter (9.66mm) and the maximum plant canopy (48.67cm) was recorded with double pray of 180ppm Zn-EDTA whereas the lowest stem diameter (7mm) and the lowest canopy (31.90cm) was recorded with control. Tuber yield was also found as the highest (23.29 mt/ha) with two foliar spray of 180ppm Zn-EDTA solution. The tuber yield of potato was found quite strongly correlated with individual tuber weight (R2 = 0.6876). The results suggested that foliar applications of Zn-EDTA@180ppm at 45DAP and 65DAP is suitable in potato production with respect to better growth and yield in Sudal, Bhaktapur.

Keywords: Potato; Zinc; Production; Yield; Ethylenediaminetetraacetic acid; Days After Planting; Days After Emergence; Randomized Complete Block Design; Farmyard Manure; Nitrogen Phosphorus Potassium

Abbrevations: EDTA: Ethylenediaminetetraacetic acid; PPM: parts per million; DAP: Days After Planting; DAE: Days After Emergence; RCBD: Randomized Complete Block Design; FYM: Farmyard Manure; NPK: Nitrogen Phosphorus Potassium

Introduction

Potato (*Solanum tuberosum* L.) is a starchy, tuberous crop of the Solanaceae family (also known as the nightshades). Balance of fertilizers is a key factor for productivity of potato and if the field is not adequately fertilized, considerable yield losses are apparent. According to the Food and Agriculture Organization (FAO), about 30% of the cultivable soils of the world contain low levels of plant available Zn [1]. The deficiency of micronutrients is more prevalent in Nepalese soils [2]. Some 80to90% of soil samples were deficient in boron (B), 20to50% in zinc (Zn), and 10to20% in molybdenum (Mo) [3]. Zinc is an important micro-nutrient needed for good growth and performance of potato. The symptoms of boron deficiency in potato appear as a chlorosis in the interveinal areas of new leaves producing a banding or striping appearance. Leaf and plant growth become stunted with increasing severity of the deficiency; leaves eventually die and fall of the plant. Brown necrotic tissues are also seen, within which the whitish spots develop. Symptoms may also start on older leaves [4]. In hilly district such as Bhaktapur, deficiency of micronutrient is limiting the production of potato and thus the production potentiality is not fully attained. Although several studies have been conducted on micronutrient requirements of potato in the various parts of the world, there is limited information under Nepalese soil conditions on this aspect. Moreover, no research work has been reported on the effects of zinc in potato production in the Bhaktapur district. The present research, therefore, was conducted to determine the effects of different concentrations of zinc on the growth and yield attributes of potato.

Materials and Methods

Treatment details

The experiment was conducted at one of the farmer's field of Sudal, Bhaktapur, Nepal. Field experiment was conducted during mid-January 2018 to April 2018 in a Randomized Complete Block Design consisting of seven treatments with three replications. The test crop was potato of variety Khumal Seto - 1. Zinc was applied through Zn- EDTA (12 % Zn). The plot size was 3 x 2.4 rn2 having two rows with 12 plants in each row and each row were separated by 0.5m spacing. Nitrogen, Phosphorus and Potassium were applied in each treatment through urea, DAP and MOP respectively. The treatments were as follows:

T1: Control

T2: Single foliar spray of Zn-EDTA@60ppm

T3: Single foliar spray of Zn-EDTA@120ppm

T4: Single foliar spray of Zn-EDTA@180ppm

T5: Two foliar spray of Zn-EDTA@60ppm

T6: Two foliar spray of Zn-EDTA@120 ppm

T7: Two foliar spray of Zn-EDTA@180 ppm

The first spraying was done at 45 days after sowing and the second spraying was done 20 days after the first spraying. Farmyard manure@20mt/ha and NPK@100:100:60Kg/ha were applied. Full doses of FYM, phosphorus, potash and half dose of nitrogen were applied as a basal dose and remaining half dose of nitrogen was top dressed at the time of first earthing up. Insect pests and diseases were controlled with the spraying of Thiodane and Dithane M–45. The commercial form of Zn-EDTA, Chelamin Technical (Zn-EDTA 12%) manufactured by Aries agro limited, India was used. In 10 litres of water, 0.6 g of it was dissolved to make 60 ppm solution. Similarly, in 10litres of water, 1.2g of it was dissolved to make 120ppm solution and 1.8g of it was dissolved in 10litres of water to make 180 ppm solution. Application of zinc solutions was done at evening time to reduce evaporation loss. Spraying was done using knapsack sprayer. Potato tubers were planted on 18 January 2018 and were harvested on 26 April 2018.

Data observation and statistical analysis

The major growth parameters observed were plant height, stem diameter and canopy cover. They were measured 45 and 60DAE. Central five plants were chosen as sample plants for measurement of parameters. The major yield parameters observed were number of tubers per plant, individual tuber weight and tuber yield. They were measured after harvest of the crop. The analysis of variance followed by DMRT (Duncan's Multiple Range Test) was used to analyze the data and to separate the means. Liner relationship between yield and yield attributing characters was used to better interpret the result. Data entry was done in Ms-excel and data analysis was done using statistical software Genstat.

Results and Discussion

Effect of zinc on growth characteristics of potato

Table 1: Effect of foliar spray of Zn-EDTA on plant height of potato in Bhaktapur, Nepal, 2018.

Treatments	45 DAE	60 DAE
Control	22.57d	27.53d
Single spray of Zn-EDTA@60ppm	23.37d	28.37d
Single spray of Zn-EDTA@120ppm	25.80cd	30.80cd
Single spray of Zn-EDTA@180ppm	27.83bc	32.83c
Two spray of Zn-EDTA@60ppm	28.17bc	33.17c
Two spray of Zn-EDTA@120ppm	31.30b	37.30b
Two spray of Zn-EDTA@180ppm	37.47a	43.20a
P- value	***	***
LSD0.05	3.92	3.66
SEm (±)	1.27	1.19
CV (%)	7.9	6.2
Grand Mean	28.07	33.31

Note: Means are separated by DMRT and columns represented with same letter (s) are non-significant at 5 % level of significance.

Plant height: All the concentrations of Zn-EDTA had increased the plant height at 45 and 60 DAE significantly (Table 1). The highest plant height was recorded with two times spray with 180ppm Zn-EDTA (37.47cm) followed by double spray with 120ppm (31.30cm), double spray with 60ppm Zn-EDTA (28.17cm), single spray with 180ppm (27.83cm), single spray with 120ppm (25.80cm), single spray with 60ppm Zn-EDTA (23.37cm) and the least plant height was observed with control (22.57cm) at 45 DAE. Height of plant sprayed with 60ppm Zn-EDTA at once was found statistically similar with those kept under control. Similarly, single spray with 180ppm Zn-EDTA and double spray with 60ppm Zn-EDTA gave statistically similar results to that given by double spray with 150ppm Zn-EDTA. Similar increasing trend of plant height was recorded at 60 DAE also. The highest plant height was recorded in plants with double spray of 180ppm Zn-EDTA (43.20cm) followed by double spray with120 ppm Zn-EDTA, 60ppm Zn-EDTA double spray, 180ppm Zn-EDTA single spray, 120ppm Zn-EDTA single spray, 60ppm Zn-EDTA single spray and the least was recorded in control (27.53cm). Plant height recorded at single spray with 60ppm Zn-EDTA and control was found statistically similar. The results are in agreement with previous experiments conducted across different parts of the globe. A similar effect was reported by Alam and Shereen [5] who observed the effect of different levels of zinc and phosphorous on wheat during water culture experiment and found that wheat shoot length was increased in almost all treatments as compared to the control. Similarly, significant increase in plant height was observed by Tahir et al. [6] who observed the effect of different chelated zinc sources on the growth and yield of maize. Kaya et al. [7] reported that added Zn significantly increased plant height via increasing internodal distance.

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Stem diameter: The data on mean stem diameter as affected by different concentrations of Zn-EDTA are shown in Table 2. At 45 DAE, the highest stem diameter (7.537mm) was recorded with double spray with 180ppm Zn-EDTA. The lowest stem diameter was recorded in control (3.715 mm). Stem diameter recorded at double spray with 120ppm, 60ppm and single spray with 180ppm are statistically similar. Similar results were obtained at 60 DAE also. Stem diameter at 60 DAE was also affected by different concentrations of chelated zinc ranging from 7.006mm to 9.660mm, highest being recorded at 180ppm Zn-EDTA double spray and lowest at control. In a similar type of study, Tahir et al. [6] obtained similar increasing in this trait with zinc application.

Table 2: Effect of foliar spray of Zn-EDTA on stem diameter of potato in Bhaktapur, Nepal, 2018.

Treatments	45 DAE	60 DAE
Control	3.71c	7.00c
Single spray of Zn-EDTA@60ppm	4.88bc	7.43bc
Single spray of Zn-EDTA@120ppm	4.77bc	7.74bc
Single spray of Zn-EDTA@180ppm	5.72b	8.06b
Two spray of Zn-EDTA@60ppm	5.30b	8.38b
Two spray of Zn-EDTA@120ppm	5.52b	8.38b
Two spray of Zn-EDTA@180ppm	7.53a	9.66a
P- value	**	**
LSD0.05	1.35	0.9
SEm (±)	0.44	0.29
CV (%)	14.2	6.3
Grand Mean	5.35	8.1

Note: Means are separated by DMRT and columns represented with same letter (s) are non-significant at 5 % level of significance.

Table 3: Effect of foliar spray of Zn-EDTA on plant canopy of potato in Bhaktapur, Nepal, 2018.

Plant Canopy (cm)	
Treatments	60 DAE
Control	31.90e
Single spray of Zn-EDTA@60ppm	32.83e
Single spray of Zn-EDTA@120ppm	38.17d
Single spray of Zn-EDTA@180ppm	40.27cd
Two spray of Zn-EDTA@60ppm	42.13bc
Two spray of Zn-EDTA@120ppm	44.80b
Two spray of Zn-EDTA@180ppm	48.97a
P- value	***
LSD0.05	3.24
SEm (±)	1.05
CV (%)	4.6
Grand Mean	39.87

Note: Means are separated by DMRT and columns represented with same letter (s) are non-significant at 5 % level of significance.

Plant canopy: The data on mean plant canopy as affected by different concentrations of Zn-EDTA are depicted in Table 3. Significant increase in plant canopy was observed with the application of Zn-EDTA. Two spray with 180ppm Zn- EDTA resulted in the maximum canopy cover (48.97cm) which was significantly higher than other treatments. The lowest canopy was found in plots where no zinc spray was done (31.90cm). This result was statistically similar to the result obtained from the plots where single spray with 60 ppm Zn-EDTA was done. Result obtained from two spray with 120 ppm Zn-EDTA at par with two spray with 60ppm Zn-EDTA. Similar results were obtained by Lal Bahadur et al. [8] who observed marked increase in tree canopy of mango with foliar application of zinc.

Effect of zinc on yield characteristics of potato

Table 4: Effect of foliar spray of Zn-EDTA on yield and yield attributing characters of potato in Bhaktapur, Nepal, 2018.

Treatments	Number of tuber/plants	Individual Tuber Weight (g)	Tuber Yield (mt/ha)
Control	3.53	46.40c	9.93f
Single spray of Zn-EDTA@60ppm	4	50.13c	11.56ef
Single spray of Zn-EDTA@120ppm	4.13	51.00c	13.18de
Single spray of Zn-EDTA@180ppm	3.93	56.46bc	14.19cd
Two spray of Zn-EDTA@60ppm	3.2	64.96ab	15.74c
Two spray of Zn-EDTA@120ppm	4.26	66.24ab	20.61b
Two spray of Zn-EDTA@180ppm	3.93	71.45a	23.29a
P- value	NS	**	**
LSD0.05	0.91	9.43	1.94
SEm (±)	0.29	3.06	0.63
CV (%)	13.3	9.1	7
Grand mean	3.86	58.1	15.5

Note: Means are separated by DMRT and columns represented with same letter (s) are non-significant at 5 % level of significance.

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Number of tubers per plant, Individual tuber weight and tuber yield: The mean number of tubers per plant, individual tuber weight and tuber yield as influenced by different conc entrations of Zn-EDTA are presented in Table 4. The effect of Zn-EDTA was not found significant for total num ber of tuber yield per plant. However, the highest number of tubers/plants was found in two spray with 120ppm Zn-EDTA (4.26). The minimum average tuber yield per plant was recorded from plots where two spray wi th 60ppm Zn-EDTA was done (3.20). In case of individual tuber weight, the effect of Zn-EDTA treatment was found significant. Lowest tuber weight was obtained in control (46.40g) and maximum (71.45g) was recorded from plots where two spray with 180 ppm Zn-EDTA was done. In terms of tuber yield (t/ha), there is significant variation between different treatments. Highest tuber yield was obtained in 180 ppm Zn-EDTA double spray (23.29mt/ha) and lowest in 0 ppm (9.93mt/ha). Tuber yield from control plot and from plots where single spray of 120ppm Zn- EDTA solution was sprayed are also statistically similar. Manna, Maity, & Ghoshal [9] confirmed the beneficial effect of foliar application of zinc and boron on bulb yield and quality of onion.

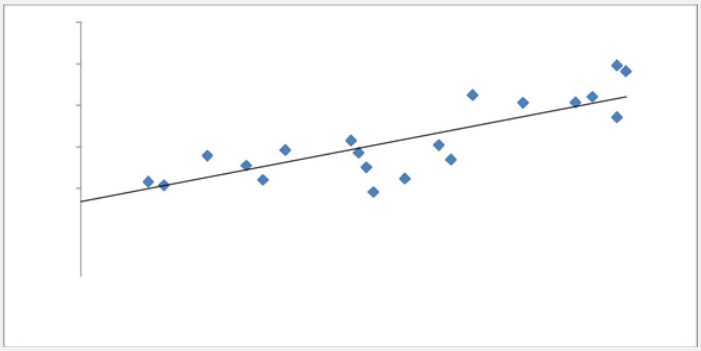

Figure 1: An outline of a version of large-scale anti-hail protection network

Linear relation between yield parameters: To better interpret the results and understand relationship between yield and yield attributing characters, association between these characteristics were evaluated (Figure 1). Positive linear relationship of tuber yield with the individual tuber weight was observed suggesting that increase in individual tuber weight will positively influence the tuber yield [10].

Conclusion

The research concludes that Zinc has significant effects on potato production. Plant height and stem diameter were significantly increased with increasing concentrations of zinc at 45 and 60 DAE which is maximum at two sprays with 180 ppm Zn-EDTA solution. Canopy cover was also found to increase significantly with increasing concentrations of zinc at 60 DAE which is highest at two sprays with 180ppm Zn-EDTA solution. Individual tuber weight and tuber yield is also maximum at two foliar applications with 180ppm Zn-EDTA solution. However, the result for number of tubers was found to be non- significant. Foliar application of Zn-EDTA@180ppm at 45 and 65 days after planting was better treatment for potato cv. Khumal Seto-1 in Bhaktapur, Nepal, 2018 to get optimum tuber yield and greater net incomes.

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