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Response of potato cv. Kufri sadabahar to zinc fertilization

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Abstract
In order to investigate the response of potato cv. 'Kufri Sadabahar' with respect to various doses of zinc sulphate (15, 20 and 25 kg/ha) as basal and split application, field experiments were conducted during winter season of 2014-15 and 2015-16 at Vegetable Research Centre, G.B. Pant University of Agriculture & Technology, Pantnagar, Udham Singh Nagar, Uttarakhand. The pooled data indicated that dry leaf weight (0.89g) at 75 days after planting (DAP), number of tubers (11.50 per plant) at de-haulming, weight of tubers (558.33g per plant) at de-haulming and tuber yield (47.24 kg per plot) were maximum under treatment T_7 (zinc sulphate @ 25 kg ha^{-1} as basal). The maximum total chlorophyll content (1.23 mg/g) was recorded under treatment T_7 (zinc sulphate @ 25 kg ha^{-1} as basal) at initial stage of growth *i.e.*, 45 DAP, whereas, it was maximum (1.10 and 0.86 mg/g) under treatment T_9 (zinc sulphate @ 12.5 kg ha^{-1} as basal and 12.5 kg ha^{-1} at the time of earthing up) during 60 and 75 DAP, respectively. Results also indicated that the emergence per cent was statistically non-significant at 30 DAP. Based on present study, it can be concluded that zinc sulphate application as basal and/ or split at 25 kg/ha increases plant growth and yield of potato cv. 'Kufri Sadabahar' under *tarai* region of Uttarakhand.

Keywords: Chlorophyll, growth, potato, yield, zinc sulphate

Introduction
Potato (*Solanum tuberosum* L.) is a staple food crop as well as an integral part of human diet. It produces more carbohydrates (18-22 per cent) and protein (524 kg/ha) as compared to wheat (Sazid and Aftab, 2009) [23], but the productivity of potato is very low in Uttarakhand as well as in India because of imbalanced use and/or deficiency of nutrients. Potato is a short duration but heavy feeder crop that's why the applications of organic and inorganic fertilizers are considered essential to enhance potato tuber yield (Bose and Som, 1993) and balanced dose of NPK along with optimum amount of micronutrients like zinc, boron and manganese should also be applied. Micronutrients are needed only in small quantities and are very essential for plant health (Kanwar and Youngdhal, 1985) [15].

Soil in most part of the world is soils are zinc deficient. Plant and soil analysis have shown that 49 per cent of Indian soils are potentially deficient in zinc (Alloway, 2008a) [3]. Consequently, many crops experience reduced growth, yield and tissue Zn concentrations (Cavagnaro, 2008) [9]. Deficiency of zinc is common under sandy or light soil conditions (Alloway, 2008b) [4] and potato is generally cultivated under sandy loam soil for proper growth and development of tubers (economic part) that's why productivity of potato is very much affected under sandy to sandy loam soil.

Zinc has an important role either as a metal component of enzymes or as a structural, functional or regulatory co-factor of various enzymes (Grotz and Guerinot, 2006) [11]. A positive interaction between increasing levels of zinc and nitrogen fertilizers improves chlorophyll content of potato leaves. Zinc also act as a co-factor for pigment biosynthesis (Balashouri, 1995) [5] as well as it plays important role in photosynthesis and biosynthesis of plant growth promoters (Singh *et al.*, 2013) [24]. Chlorophyll content increase in the leaves of plants grown from the zinc sulphate treated tubers mainly due to a considerable increase in cytokinin/ABA ratio. Zinc increased the tuber number and weight due to increase in the number of phellem cell layers of potato tubers (Puzina, 2004) [20] and change in hormonal balance towards a substantial increase in the cytokinin content and the cytokinin: abscisic acid ratio. Therefore, the aim of the present study was to assess the response of potato cv. Kufri Sadabahar to zinc fertilization.

Material and methods
The present investigation was carried out during the winter season 2014-15 and 2015-16 at Vegetable Research Centre, G.B. Pant University of Agriculture and Technology, Pantnagar,

Udham Singh Nagar, Uttarakhand. The soil of experimental field was sandy loam with neutral pH (7.2) and available zinc (0.94 ppm).

The experiment was laid out in Randomized Completely Block Design with three replications and ten treatments (Table-1). The recommended dose of fertilizers (160 kg N, 100 kg P_2O_5 and 120 kg K_2O/ha) were also applied. At the time of planting, full dose of phosphorus and potassium applied whereas, nitrogen applied with half amount and remaining amount of nitrogen applied at the time of earthing-up. Zinc sulphate was applied according to the various treatments of experiment. Well-sprouted seed tubers (50-60 g), were planted at 60 × 20 cm spacing during last week of October. The potato crop was de-haulmed at 80 DAP. The data was subjected to analysis of variance (ANOVA) using method given by Panse and Sukhatme (1987) [19].

Middle portion of fourth leaf was taken from five plants of each plot from which total chlorophyll was estimated by the method of Bruinsma (1963) [8]. 0.5 g leaves were weighed with the help of electronic balance then crushed with mortar and pestel in 80% acetone and immediately filtered with the help of Whatman No. 1 filter paper and volume was made upto 50 ml with 80% acetone. Spectrophotometer was used and total chlorophyll was estimated with the help of following formula:

$$Total\ chlorophyll\ = \{20.2\ (A645) + 8.02\ (A663)\}\frac{V}{1000\ x\ W}$$

Where,

A_{645} = Absorbance at 645 nm

A_{663} = Absorbance at 663 nm

V = Volume made up (ml)

W = Weight of tissue taken (g)

The final value expressed in mg/g fresh weight of leaves.

The number of plants emerged out in each plot were counted at 30 DAP and emergence per cent was calculated by following formula:

$$Emergence\ per\ cent\ = \frac{Number\ of\ plants\ emerged}{Number\ of\ tubers\ planted} \times\ 100$$

Different sized leaves from each tagged plants were taken randomly and collected at 75 days after planting. The leaf samples taken from each plot were sun dried for 7-8 hrs/day for 2-3 days and then dried in oven at about 55-60 °C till the samples attained a constant weight. After drying, the samples were weighed with the help of electronic balance and expressed in grams per plant.

Tubers of randomly selected five plants from each plot were taken at de-haulming stage then counted and weighed after proper washing, cleaning and drying. Average weight was expressed in grams then total tuber yield of harvested tubers per plot was calculated on the basis of average tuber yield per plant and converted into kg.

Result and Discussion

Pooled data (Table 2) indicated that, the maximum total chlorophyll content at 45 DAP (1.23 mg/g) was recorded under T_7 (zinc sulphate @ 25 kg/ha at the time of planting + RDF), whereas, at 60 and 75 DAP, the maximum total chlorophyll content (1.10 mg/g and 0.86 mg/g, respectively) was recorded under treatment T_9 (zinc sulphate @ 12.5 kg/ha at the time of planting and 12.5 kg/ha at the time of earthing up + RDF). Results also indicated that the minimum total chlorophyll content (1.00, 0.85 and 0.65 mg/g) was recorded under treatment T_{10} (RDF without zinc sulphate) during all the growth stages *i.e.*, 45, 60 and 75 DAP, respectively. It is evident from the data (table 1) that chlorophyll content of potato leaf increased with the application of zinc sulphate because zinc act as a co-factor for pigment biosynthesis (Balashouri, 1995) [5]. Nitrogen increases chlorophyll content and a positive interaction between increasing levels of zinc and nitrogen fertilizers improves chlorophyll content of potato leaves. These findings were confirmed by Puzina (2004) [20] and Joshi (2004) [13]. El-Haddad and Awad (2007) [10] also reported that chlorophyll content increased with the application of micronutrients (Zn, Fe and Mn).

Pooled data depicted in table 3 indicated that emergence per cent of tubers at 30 days after planting did not vary significantly with the treatments during both the years. It might be probably due to the fact that food material already stored in the seed tubers which gave initial boost to the emerging plants. These results were confirmed by the findings of Bari *et al.* (2001) [6] and Kourosh *et al.* (2004) [16] who reported that plant emergence was not influenced by zinc levels.

Pooled data presented in table 3 shows that the maximum dry weight of leaf (0.90, 0.88 and 0.89 g) was recorded under treatment T_9 (zinc sulphate @ 12.5 kg/ha at the time of planting and 12.5 kg/ha at the time of earthing up + RDF), whereas the minimum dry weight of leaf (0.54 g) was recorded under treatment T_{10} (RDF without zinc sulphate) at 75 DAP. It might be probably due to the fact that zinc increases the size of leaf (area) and dry matter content of leaves because zinc play important role in photosynthesis as well as biosynthesis of auxin, a growth promoting hormone. These results were confirmed by the findings of Puzina (2004) [20], Abd El- Baky *et al.* (2010) [1] and Panitnok *et al.* (2013) [18] who reported significant increase in dry weight of leaf with the application of zinc as compared to control (without zinc).

A critical observation of the data (Table 4) revealed that the maximum number of tubers, tuber weight per plant and tuber yield per plot (11.50, 558.33 g and 47.24 kg, respectively) were recorded under treatment T_7 (zinc sulphate @ 25 kg/ha at the time of planting + RDF), whereas, the minimum number of tubers, tuber weight per plant and tuber yield per plot (7.92, 412.50 g and 34.96 kg, respectively) were recorded under treatment T_{10} (RDF without zinc sulphate). Weight of tubers per plant increased with the application of zinc sulphate because it is positively correlated with total number of tubers per plant and size of tubers. Total number of tubers per plant increased with the application of zinc sulphate because zinc affects the hormonal status of potato plant. On other hands, zinc improves the IAA/ABA and cytokinin/ABA ratio, which induces the formation and growth of stolons (Puzina, 2004) [20]. These results were confirmed by the findings of Sati *et al.* (2017) [22], Taya *et al.* (1994) [25], Bari *et al.* (2001) [6], Raghav and Singh (2003) [21], Al-Jobori and Al-Hadithy (2014) [2], Taheri *et al.* (2012) and Mousavi *et al.* (2007).

Table 1: Details of treatments

Symbols	Treatment combinations
T_1	Zinc sulphate* @ 15 kg/ha at the time of planting + RDF**
T_2	Zinc sulphate @ 15 kg/ha at the time of earthing up + RDF
T_3	Zinc sulphate @ 7.5 kg/ha at the time of planting and 7.5 kg/ha at the time of earthing up + RDF
T_4	Zinc sulphate @ 20 kg/ha at the time of planting + RDF
T_5	Zinc sulphate @ 20 kg/ha at the time of earthing up + RDF
T_6	Zinc sulphate @ 10 kg/ha at the time of planting and 10 kg/ha at the time of earthing up + RDF
T_7	Zinc sulphate @ 25 kg/ha at the time of planting + RDF
T_8	Zinc sulphate @ 25 kg/ha at the time of earthing up + RDF
T_9	Zinc sulphate @ 12.5 kg/ha at the time of planting and 12.5 kg/ha at the time of earthing up + RDF
T_{10}	Control (RDF without zinc sulphate)

*Zinc sulphate: Zinc sulphate monohydrate (33% Zn)
**RDF: Recommended dose of fertilizer *i.e.*, 160:100:120 Kg N:P_2O_5:K_2O/ha.

Table 2: Effect of zinc sulphate application on total chlorophyll content of potato leaves.

Treatments	Total chlorophyll content (mg/g)								
	45 DAP			60 DAP			75 DAP		
	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled
T_1	1.08	1.25	1.17	0.83	1.00	0.92	0.64	0.75	0.70
T_2	0.97	1.13	1.05	0.93	1.03	0.98	0.68	0.81	0.74
T_3	1.04	1.17	1.10	0.92	1.05	0.98	0.70	0.85	0.77
T_4	1.08	1.28	1.18	0.91	1.06	0.98	0.69	0.84	0.77
T_5	0.97	1.18	1.08	0.90	1.07	0.99	0.72	0.88	0.80
T_6	1.08	1.25	1.16	0.93	1.09	1.01	0.76	0.90	0.83
T_7	1.13	1.32	1.23	0.95	1.12	1.03	0.73	0.91	0.82
T_8	1.03	1.20	1.12	0.98	1.13	1.06	0.75	0.93	0.84
T_9	1.09	1.25	1.17	1.05	1.15	1.10	0.76	0.97	0.86
T_{10}	0.91	1.08	1.00	0.79	0.91	0.85	0.61	0.68	0.65
S Em±	0.04	0.04	0.04	0.03	0.04	0.03	0.03	0.03	0.02
CD at 5%	0.13	0.11	0.11	0.10	0.13	0.10	0.08	0.09	0.06

Table 3: Effect of zinc sulphate application on emergence per cent and dry leaf weight of potato.

Treatments	Emergence per cent at 30 DAP			Dry leaf weight at 75 DAP (g)		
	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled
T_1	94.29	93.33	93.81	0.61	0.66	0.64
T_2	92.86	94.76	93.81	0.67	0.69	0.68
T_3	94.29	95.71	95.00	0.75	0.74	0.74
T_4	94.29	97.14	95.71	0.74	0.80	0.77
T_5	93.33	96.19	94.76	0.76	0.79	0.77
T_6	95.24	96.19	95.71	0.80	0.83	0.81
T_7	96.19	94.76	95.48	0.79	0.84	0.81
T_8	94.76	96.67	95.71	0.83	0.85	0.84
T_9	94.76	95.71	95.24	0.90	0.88	0.89
T_{10}	95.24	96.40	95.82	0.52	0.56	0.54
S Em±	1.62	1.39	1.07	0.04	0.03	0.03
CD at 5%	NS	NS	NS	0.11	0.10	0.09

Table 4: Effect of zinc sulphate application on number of tubers, weight of tubers per plant and potato tuber yield.

Treatments	Number of tubers per plant at de-haulming stage			Weight of tubers per plant at de-haulming stage (g)			Tuber yield (kg/plot)		
	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled
T_1	9.00	9.67	9.33	466.67	503.33	485.00	38.51	40.13	39.32
T_2	8.17	8.33	8.25	416.67	475.00	445.83	36.31	38.68	37.50
T_3	8.67	9.00	8.83	441.67	483.33	462.50	37.01	39.15	38.08
T_4	9.00	9.67	9.33	483.33	525.00	504.17	40.51	43.00	41.75
T_5	8.50	8.67	8.58	433.33	483.33	458.33	38.53	40.40	39.47
T_6	9.00	9.50	9.25	508.33	541.67	525.00	39.03	41.35	40.19
T_7	11.00	12.00	11.50	541.67	575.00	558.33	46.08	48.40	47.24
T_8	9.33	9.67	9.50	491.67	525.00	508.33	40.70	43.98	42.34
T_9	10.17	10.44	10.31	516.67	558.33	537.50	44.39	46.83	45.61
T_{10}	7.50	8.33	7.92	391.67	433.33	412.50	34.54	35.38	34.96
S Em±	0.42	0.40	0.44	24.20	23.58	22.94	2.15	2.43	2.09
CD at 5%	1.26	1.18	1.32	71.90	70.05	68.16	38.51	40.13	39.32

Conclusion

On the basis of the findings of present experiments, the soil application of 25 kg/ha zinc sulphate at the time of planting along with 160 N : 100 P_2O_5 : 120 K_2O kg/ha can be recommended to improve the number and weight of tubers per plant, whereas zinc sulphate @ 12.5 kg/ha at the time of

planting and 12.5 kg/ha at the time of earthing-up along with 160 N : 100 P_2O_5 : 120 K_2O kg/ha can be recommended to improve the dry leaf weight and total chlorophyll content of potato leaf.

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