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Effect of biofertilizers and levels of zinc and potassium on growth of potato (*Solanum tuberosum* L.)

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Abstract
The present investigation entitled **"Effect of biofertilizers and levels of zinc and potassium on growth of potato (*Solanum tuberosum* L.)"** The present experiment was laid out in the experimental field of department of Horticulture, College of Agriculture, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (M.P.) during first year (2018 – 19), second year (2019 – 20) and pooled with 18 treatments of three levels of potassium i.e. 20, 40 and 60 kg/ha, three levels of zinc i.e. 1.5, 3.0 and 4.5 kg/ha and two bio fertilizers, *Azotobacter* and PSB have been presented in the preceding chapter. The experiment was laid out in Randomized Block Design with eighteen treatments including control and replicated three times each. The observations were recorded on different aspects of days to sprouting, number of branches per plant, plant height (cm), number of leaves per plant, length of leaves (cm), width of leaves (cm) and diameter of stem (cm). The result of experiment revealed that the potassium (60kg/hac) significantly improved growth parameters among all the potassium levels and zinc (4.5kg/hac) was significantly always affected the all growth parameters, whereas biofertilizers PSB enhanced all the growth parameters at different growth stages.

Keywords: biofertilizer, potash, zinc, growth and potato

Introduction
Potato (*Solanum tuberosum* L.) is one of the most important vegetable crops widely grown throughout the world. It belongs to the family solanaceae and considered to be originated in South America. Potato is world's fourth important food crop after wheat, rice and maize (Rana, 2008) [13]. The widely grown potato is an autotetraploid with 2n=48. The potato is unique and different from other crops in the sense that food material is stored in underground stem parts called tubers. Potato provides a source of low cost energy to the human diet and is a rich source of starch, vitamin C, vitamin B and minerals (Kumar *et al*., 2013) [14]. Potassium plays a role in sugar translocation and starch synthesis in plants. Due to the high starch of the potato tuber, K is an important nutrient in tuber development (Rhue *et al.* 1986) [15]. Potassium has a vital role in photosynthesis process that favours high energy status, regulates opening and closing of leaf stomata, nutrients translocation, water uptake, vitamin contents and organic acid concentration in plants (Bergmann, 1992) [16]. Bio fertilizers are natural fertilizers containing micro-organisms which help in enhancing the productivity by biological nitrogen fixation or solubilization of insoluble phosphate or producing hormones, vitamins and other growth regulators required for plant growth. Zinc improves the IAA/ABA and cytokinin / ABA ratio, which induces the formation and growth of stolon mainly due to decrease ABA content with increase in gibberellins content of plant. Increase in number of tubers, mean tubers weight and finally high performance of potato crop is due to utilization of zinc fertilizers in potato. Many adverse effects of Zn deficiency on growth and yield of potato plant have been reported (Grewal and Trehan, 1979) [17] as Zn plays an important role in oxidation-reduction reactions in the plants. Therefore application of zinc for sustaining crop yield appears essential. So far, the information on Zinc nutrition of potato crop is lacking. In view of the paucity of information with regard to the effects of Zn on potato, the present study may prove useful and creative.

Material and methods
The present experiment was laid out in the experimental field of department of Horticulture, College of Agriculture, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (M.P.). The experiment was laid out in the Randomized Completely Block Design with three replications. Each replication was comprised of 18 treatment combinations.

The following treatment combinations involving three levels of potassium *viz*. 20, 40 and 60 kg $ha^{-1}$and three levels of zinc i.e. 1.5, 3.0 and 4.5 kg ha^{-1} and two types of bio fertilizers PSB and *Azotobacter* were applied before planting in potato variety Kufri Chipsona-1.

Result and discussion

On the basis of two year mean the pooled average was observed that the minimum days to sprouting (10.4 10.52 and 10.49) were observed in K_3 (60 kg/ha) potassium level in first year, second year and in pooled. Maximum days to sprouting (11.65, 11.75 and 11.70) were recorded in K_1 (20 kg/ha) in first year and similar trend was followed in second and in pooled mean year. The findings are in close harmony with the result of Hosseini *et al*. (2017) [6].

Among the zinc levels, early sprouting was found in Z_3 (4.5 kg/ha) and maximum days to sprouting (11.23, 11.31 and 11.27) were noted in Z_1 (1.5 kg/ha) with non significant differences, whereas PSB biofertilizer showed minimum days to sprouting (10.93, 11.00 and 10.97) and Azotobactor was show maximum (11.06, 11.14 and 11.10) days with no significant difference zinc and biofertilizer failed to record any significant changes in the days to sprouting of potato. These finding reflects that zinc and bio fertilizer has no-impact on days to sprouting. The findings are in close harmony with the result of Joshi *et al*. (2014) [7].

It is obvious from the data that the potassium treatment K_3 (60 kg/ha) was recorded significantly maximum (7.48, 7.50 and 7.49) branches $plant^{-1}$ at 60 DAP. However, minimum (4.97, 5.00 and 4.99) branches $plant^{-1}$ was recorded in treatment K_1 (20 kg/ha) at 60 DAP. The findings are in close harmony with the result of Zelelew *et al.* (2016) [12] and Masimba *et al*. (2016) [10].

Zinc treatment Z_3 (4.5 kg/ha) was recorded significantly maximum (6.72, 6.78 and 6.75) branches per plant, while, it was recorded minimum (5.61, 5.63 and 5.62) branches per plant in Z_1 (1.5 kg/ha) at 60 DAP. The results are closely with Vinod *et al.* (2008) [11].

Among biofertilizers PSB (B_1) was showed maximum (6.28, 6.34 and 6.31) numbers of branches per plant and minimum (5.99, 6.00 and 5.99) was seen in Azotobactor (B_2) the results are closely harmony with Kumar *et al*. (2001) [9].

The data revealed that significantly maximum plant height (19.06, 19.10 and 19.08 cm at 30 DAP, 30.11, 30.26 and 30.18 cm at 60 DAP and 40.60, 40.69 and 40.64 cm at 90 DAP) were recorded in the treatment K_3 (60 kg/ha) and it was followed by K_2 (40 kg/ha). While, lowest plant height (14.11, 14.01 and 14.06 cm at 30 DAP, 25.82, 25.82 and 25.82 cm at 60 DAP and 35.23, 35.23 and 35.23 cm at 90 DAP) was observed at different DAP in treatment K_1 (20 kg/ha). In first year, second year and in pooled. Similar results have been reported by Koodi *et al*. (2017) [8] and Bhat *et al*. (2017) [2].

In case of zinc, the treatment Z_3 (4.5 kg/ha) was showed significantly maximum (17.54, 17.50 and 17.52 cm at 30 DAP, 28.67, 28.73 and 28.70 cm at 60 DAP and 38.76, 38.79 and 38.77 cm at 90 DAP) plant height. However, the minimum (15.62, 15.72 and 15.67 cm at 30 DAP, 26.96, 26.83 and 26.89 cm at 60 DAP and 36.44, 36.37 and 36.41 cm at 90 DAP) plant height was recorded in Z_1 (1.5 kg/ha) treatment. The findings are in close harmony with the result of Vinod *et al.* (2008) [11].

Bio fertilizers were also play significant role in plant height at different DAP, maximum (16.97, 16.96 and 16.96 cm at 30 DAP, 28.12, 28.14 and 28.13 cm at 60 DAP and 37.99, 38.01 and 38.00 cm at 90 DAP) plant height was recorded in B_1 (PSB 5kg/ha) while minimum plant height (16.10, 16.21 and 16.16 cm at 30 DAP, 27.47, 27.47 and 27.47 cm at 60 DAP and 37.38, 37.39 and 37.38 cm at 90 DAP) was recorded in B_2 (Azotobacter 5kg/ha) in first year, second year and in pooled.

Significantly maximum (15.31, 15.58 and 15.45) leaves per plant were recorded in the treatment K_3 (60 kg/ha) followed by K_2 (40 kg/ha) however, lowest (12.14, 12.02 and 12.08) leaves plant in K_1 (20 kg/ha). Similar results have been reported by Zelelew *et al*. (2016) [12].

In case of zinc, the Z_3 (4.5 kg/ha) was recorded significantly maximum (14.51, 14.70 and 14.61) leaves per plant, whereas minimum (13.12, 13.20 and 13.16) leaves $plant^{-1}$ was recorded in treatment Z_1 (1.5 kg/ ha) in first year, second year and in pooled respectively.

Among biofertilizer B_1 (PSB 5 Kg/ha) was showed significant result, maximum (14.14, 14.26 and 14.20) numbers of leaves was recorded in B_1 and minimum (13.58, 13.74 and 13.66) was recorded in B_2 (Azotobacter 5 Kg/ha) Choudhary *et al.* (2010) [3].

The results revealed that significantly maximum length (4.90, 4.91 and 4.91 cm) and width of leaves (3.59, 3.64 and 3.62 cm) and diameter of stem (3.31, 3.26 and 3.9 cm) were noted in the treatment K_3 (60 kg/ha) followed by K_2 (40 kg/ha) however, lowest length of leaves (3.62, 3.61 and 3.61 cm), width of leaves (2.77, 2.80 and 2.78 cm) and diameter of stem (2.42, 2.47 and 2.44 cm) in K_1 (20 kg/ha). This could be due to the application of doses of potassium fertilizer increase the uptake/ availability of nitrogen, which might be promoting growth to enhance synthesis of or accumulation of proteins, amino acids and enzymes which are responsible for cell division and cell elongation thus resulted in improvement in length and width of leaves and diameter of stem. The findings are in close harmony with the result of Ali *et al*. (2013) [1].

In case of zinc, the Z_3 (4.5 kg/ha) was recorded significantly maximum length (4.51, 4.47 and 4.49 cm) and width of leaves (3.35, 3.40 and 3.38 cm) and diameter of stem (3.07, 3.02 and 3.05 cm), whereas minimum length (3.93, 3.95 and 3.94 cm) and width of leaves (3.01, 3.03 and 3.02 cm) and diameter of stem (2.67, 2.68 and 2.67 cm) was recorded in treatment Z_1 (1.5 kg/ ha) in first year, second year and in pooled respectively. The optimum supply of zinc is of paramount importance for proper growth and development of plant. The growth is limited, by deficiency of zinc. An increase in zinc supply in soil has caused an increase uptake of zinc by crop, though it also depends on the absorption and utilization capacities of a plant. In the present experiment, the potato plants responded to three different levels of zinc sulphate application. There had been a consistent increase in height of plant, leaf length, width of leaf and diameter of stem with an increase in zinc level during two consecutive Rabi seasons. As a result, there is less deposition of carbohydrates in the vegetative portion and protoplasm is formed which gives rise the formation of growth structure in the plant. Zinc being an integral constituent of auxin is likely to increase level of auxin in the plant, which is indirectly exhibited by enhanced growth of plant and their parts. Which are in agreement with the work of Forestor (1983) [4] and Hooda and Pandita (1982) [5].

Among biofertilizer B_1 (PSB 5 Kg/ha) was showed significant result, maximum length (4.29, 4.30 and 4.30 cm) and width of leaves (3.24, 3.27 and 3.26 cm) and diameter of stem (2.91, 2.89 and 2.90 cm) were recorded in B_1 and minimum length (4.14, 4.10 and 4.12 cm) and width of leaves (3.12, 3.16 and 3.14 cm) and diameter of stem (2.78, 2.78 and 2.78 cm) were recorded in B_2 (Azotobacter 5 Kg/ha) because of bio fertilizer provide and increase supply of unavailable nutrients in soil,

biofertilizer also are helpful to increase use efficiency of chemical fertilizer so plant obtain proper nutrient to soil and gain batter growth. The similar results was showed by Choudhary *et al.* (2010) [3]

Table 1: Effect of biofertilizers and levels of zinc and potassium on growth of potato (*Solanum tuberosum* L.)

Treat. Symb.	Treatment	Days to sprouting			Number of branches per plant at 60 DAP			Plant height at 30 DAP			Plant height at 60 DAP			Plant height at 90 DAP		
		1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled
K_1	20 kg/ha	11.65	11.75	11.70	4.97	5.00	4.99	14.11	14.01	14.06	25.82	25.82	25.82	35.23	35.23	35.23
K_2	40 kg/ha	10.87	10.95	10.91	5.96	5.99	5.98	16.45	16.65	16.55	27.46	27.34	27.40	37.21	37.18	37.20
K_3	60 kg/ha	10.46	10.52	10.49	7.48	7.50	7.49	19.06	19.10	19.08	30.11	30.26	30.18	40.60	40.69	40.64
SEm ±		0.135	0.135	0.096	0.037	0.044	0.029	0.061	0.062	0.043	0.079	0.054	0.048	0.045	0.048	0.033
CD 5%		0.389	0.390	0.271	0.105	0.128	0.081	0.176	0.177	0.123	0.228	0.157	0.136	0.130	0.138	0.093
Z_1	1.5 kg/ha	11.23	11.31	11.27	5.61	5.63	5.62	15.62	15.72	15.67	26.96	26.83	26.89	36.44	36.37	36.41
Z_2	3.0 kg/ha	10.99	11.08	11.03	6.09	6.10	6.09	16.45	16.54	16.49	27.76	27.85	27.80	37.85	37.94	37.89
Z_3	4.5 kg/ha	10.76	10.84	10.80	6.72	6.78	6.75	17.54	17.50	17.52	28.67	28.73	28.70	38.76	38.79	38.77
SEm ±		0.135	0.135	0.096	0.037	0.044	0.029	0.061	0.062	0.043	0.079	0.054	0.048	0.045	0.048	0.033
CD 5%		NS	NS	NS	0.105	0.128	0.081	0.176	0.177	0.123	0.228	0.157	0.136	0.130	0.138	0.093
B_1	PSB (5 Kg/ha)	10.93	11.00	10.97	6.28	6.34	6.31	16.97	16.96	16.96	28.12	28.14	28.13	37.99	38.01	38.00
B_2	Azotobacter (5 Kg/ha)	11.06	11.14	11.10	5.99	6.00	5.99	16.10	16.21	16.16	27.47	27.47	27.47	37.38	37.39	37.38
SEm ±		0.110	0.111	0.078	0.030	0.036	0.023	0.050	0.050	0.035	0.065	0.044	0.039	0.037	0.039	0.027
CD 5%		NS	NS	NS	0.086	0.104	0.066	0.144	0.145	0.100	0.187	0.128	0.111	0.106	0.113	0.076

Table 2: Effect of biofertilizers and levels of zinc and potassium on growth of potato (*Solanum tuberosum* L.)

Treat. Symb.	Treatment	Number of leaves per plant at 60 DAP			Length of leaves at 60 DAP			Width of leaves at 60 DAP			Diameter of stem at 60 DAP		
		1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled
K_1	20 kg/ha	12.14	12.02	12.08	3.62	3.60	3.61	2.77	2.80	2.78	2.42	2.47	2.44
K_2	40 kg/ha	14.12	14.40	14.26	4.13	4.10	4.12	3.18	3.21	3.20	2.80	2.78	2.79
K_3	60 kg/ha	15.31	15.58	15.45	4.90	4.91	4.91	3.59	3.64	3.62	3.31	3.26	3.29
SEm ±		0.091	0.095	0.066	0.023	0.023	0.016	0.018	0.018	0.013	0.025	0.031	0.020
CD 5%		0.262	0.275	0.186	0.068	0.066	0.047	0.051	0.051	0.036	0.071	0.090	0.056
Z_1	1.5 kg/ha	13.12	13.20	13.16	3.93	3.95	3.94	3.01	3.03	3.02	2.67	2.68	2.67
Z_2	3.0 kg/ha	13.95	14.10	14.02	4.22	4.19	4.20	3.19	3.21	3.20	2.79	2.81	2.80
Z_3	4.5 kg/ha	14.51	14.70	14.61	4.51	4.47	4.49	3.35	3.40	3.38	3.07	3.02	3.05
SEm ±		0.091	0.095	0.066	0.023	0.023	0.016	0.018	0.018	0.013	0.025	0.031	0.020
CD 5%		0.262	0.275	0.186	0.068	0.066	0.047	0.051	0.051	0.036	0.071	0.090	0.056
B_1	PSB (5 Kg/ha)	14.14	14.26	14.20	4.29	4.30	4.30	3.24	3.27	3.26	2.91	2.89	2.90
B_2	Azotobacter (5 Kg/ha)	13.58	13.74	13.66	4.14	4.10	4.12	3.12	3.16	3.14	2.78	2.78	2.78
SEm ±		0.074	0.078	0.054	0.019	0.019	0.013	0.015	0.015	0.010	0.020	0.025	0.016
CD 5%		0.214	0.224	0.152	0.055	0.054	0.038	0.042	0.042	0.029	0.058	0.073	0.046

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