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

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Abstract
The present investigation entitled *"Impact of biofertilizers and levels of zinc and potassium on growth analytical parameters 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 dry weight per plant (g), leaf area per plant (cm^2), leaf area index, net assimilation rate (mg cm^{2-1} day^{-1}), days to sprouting and crop growth rate (g m^{2-1} day^{-1}). 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 analytical 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). 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). 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). 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). 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) 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) [8].

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) [10].

Dry weight per plant was significantly influenced by various treatments of levels of potassium. Significantly maximum (22.60, 22.71 and 22.65 g) dry weight per plant were recorded in treatment K_3 (60 kg/ha). While the minimum (19.46, 19.52 and 19.49 g) dry weight of plant was recorded in treatment 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 an accumulation of proteins, amino acids and enzymes which are responsible for cell division and cell elongation thus resulted in improvement in dry weight $plant^{-1}$. The findings are in close harmony with the result of Asmaa and Magda (2010) [2] and Pervez *et al.* (2013) [12].

In case of zinc, the significantly maximum (21.47, 21.58 and 21.52 g) dry weight was obtained in treatment Z_3 (4.5 kg/ha), however, minimum (20.61, 20.69 and 20.65 g) dry weight was noted in Z_1 (1.5 kg/ha) in first year, second year and in pooled respectively. Probable reason may be due to adequate zinc supply under favourable condition of plant growth leads to protein formation from the manufactured carbohydrates. 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 These findings are in agreement with the findings of Hooda and Pandita (1982) [7] and Ossomet *et al.* (2003) [11].

Bio fertilizer are also showed significantly maximum (21.17, 21.27 and 21.22 g) dry weight of plant in treatment B_1 (PSB 5 Kg/ha) and minimum (20.94, 21.02 and 20.98 g) dry weight of plant was found in B_2 (Azotobacter 5 Kg/ha) due to proper nutrient supply results was closely to Raghav and Kamal (2009) [13].

Significantly maximum leaf area $plant^{-1}$ (285.13, 287.01 and 286.07 cm^2) and leaf area index (0.253, 0.254 and 0.251) was noted in treatment K_3 (60 kg/ha). While the minimum leaf area $plant^{-1}$ (157.13, 156.70 and 156.91 cm^2) and leaf area index (0.151, 0.150 and 0.151) of plant was recorded in treatment 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 leaf area $plant^{-1}$ and leaf area index. These findings are in agreement with the findings of Azarpour *et al.* (2014) [3] and Fekadu Asfaw (2016) [5].

In case of zinc, the significantly maximum leaf area $plant^{-1}$ (238.04, 237.43 and 237.73 cm^2) and leaf area index (0.220, 0.222 and 0.221) was obtained in treatment Z_3 (4.5 kg/ha), however, minimum leaf area $plant^{-1}$ (200.96, 201.96 and 201.43 cm^2) and leaf area index (0.185, 0.184 and 0.184) was noted in Z_1 (1.5 kg/ha) in first year, second year and in pooled respectively. Probable reason may be due to Zinc occupies a prime position among the nutrient elements needed for plant growth. 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 leaf area index leaf area similar results was found by Ali *et al.* (2013) [1], Vinod *et al.* (2008) [14] and Ossomet *et al.* (2003) [11].

Bio fertilizer also showed significantly maximum (226.91, 226.88 and 226.90 cm^2) leaf area $plant^{-1}$ and leaf area index (0.207, 0.208 and 0.208) of plant in treatment B_1 (PSB 5 Kg/ha) and minimum leaf area $plant^{-1}$ (216.40, 217.32 and 316.86 cm^2) and leaf area index (0.197, 0.199 and 0.198) of plant was found in B_2 (Azotobacter 5 Kg/ha) it might be due to its role in physiological process as such as cell division and cell elongation, which consequently increased the leaf area $plant^{-1}$ and leaf area index of potato plants. Hussein *et al.* (2002) [9], Raghav and Kamal (2009) [13].

The data clearly showed that the net assimilation rate and CGR was significantly influenced by the different treatments. The NAR (0.0015, 0.0020 and 0.0018) and CGR (0.055, 0.060 and 0.058) significantly lowest was recorded in treatment K_3 (60 kg/ha) and maximum NAR (0.0032, 0.0037 and 0.0034) and CGR (0.113, 0.117 and 0.115) in treatment K_1 (20 kg/ha). These findings are in agreement with the findings of Azarpour *et al*. (2014) [3] for both traits and Ghosh *et al*. (2017) [6]

In case of zinc, the significantly minimum NAR (0.0020, 0.0024 and 0.0022) and CGR (0.072, 0.078 and 0.075) was obtained in treatment Z_3 (4.5 kg/ha), however, maximum NAR (0.0027, 0.0033 and 0.0030) and CGR (0.091, 0.096 and 0.093) was noted in Z_1 (1.5 kg/ha) in first year, second year and in pooled respectively

Bio fertilizer are also showed significantly minimum NAR (0.0022, 0.0027 and 0.0025) and CGR (0.080, 0.085 and 0.083) of plant in treatment B_1 (PSB 5 Kg/ha) and maximum NAR (0.0024, 0.0030 and 0.0027) and CGR (0.084, 0.089 and 0.086) of plant was found in B_2 (Azotobacter 5 Kg/ha)

This revealed that as the LAI increased at higher doses of potassium, zinc and bio fertilizer reflected the shading effect of the leaves may have caused reduction in photosynthesis and NAR and also CGR. It may also be due to the reduced photosynthesis of the older leaves. These findings are in agreement with the findings of Banerjee *et al*. (2012) [4].

Table 1.

Treat. Symb.	Treatment	Days to sprouting			Dry weight of plant at 60 DAP			Leaf area cm² at 60 DAP		
		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	19.46	19.52	19.49	157.13	156.70	156.91
K_2	40 kg/ha	10.87	10.95	10.91	21.10	21.20	21.15	222.70	222.60	222.65
K_3	60 kg/ha	10.46	10.52	10.49	22.60	22.71	22.65	285.13	287.01	286.07
SEm ±		0.135	0.135	0.096	0.047	0.037	0.030	1.646	4.070	2.195
CD 5%		0.389	0.390	0.271	0.136	0.105	0.085	4.737	11.712	6.208
Z_1	1.5 kg/ha	11.23	11.31	11.27	20.61	20.69	20.65	200.96	201.91	201.43
Z_2	3.0 kg/ha	10.99	11.08	11.03	21.09	21.17	21.13	225.96	226.97	226.47
Z_3	4.5 kg/ha	10.76	10.84	10.80	21.47	21.58	21.52	238.04	237.43	237.73
SEm ±		0.135	0.135	0.096	0.047	0.037	0.030	1.646	4.070	2.195
CD 5%		NS	NS	NS	0.136	0.105	0.085	4.737	11.712	6.208
B_1	PSB (5 Kg/ha)	10.93	11.00	10.97	21.17	21.27	21.22	226.91	226.88	226.90
B_2	Azotobacter (5 Kg/ha)	11.06	11.14	11.10	20.94	21.02	20.98	216.40	217.32	216.86
SEm ±		0.110	0.111	0.078	0.039	0.030	0.024	1.344	3.323	1.792
CD 5%		NS	NS	NS	0.111	0.086	0.069	3.868	9.563	5.069

Table 2.

Treat. Symb.	Treatment	Leaf area index at 60 DAP			Net assimilation rate (30-60 DAP)			Crop growth rate (30-60 DAP)		
		1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled
K_1	20 kg/ha	0.151	0.150	0.151	0.0032	0.0037	0.0034	0.113	0.117	0.115
K_2	40 kg/ha	0.203	0.205	0.204	0.0022	0.0028	0.0025	0.077	0.083	0.080
K_3	60 kg/ha	0.253	0.254	0.254	0.0015	0.0020	0.0018	0.055	0.060	0.058
SEm ±		0.001	0.001	0.001	0.00007	0.00019	0.00010	0.001	0.002	0.001
CD 5%		0.003	0.003	0.002	0.00019	0.00054	0.00028	0.003	0.006	0.003
Z_1	1.5 kg/ha	0.185	0.184	0.184	0.0027	0.0033	0.0030	0.091	0.096	0.093
Z_2	3.0 kg/ha	0.202	0.204	0.203	0.0023	0.0029	0.0026	0.082	0.087	0.085
Z_3	4.5 kg/ha	0.220	0.222	0.221	0.0020	0.0024	0.0022	0.072	0.078	0.075
SEm ±		0.001	0.001	0.001	0.00007	0.00019	0.00010	0.001	0.002	0.001
CD 5%		0.003	0.003	0.002	0.00019	0.00054	0.00028	0.003	0.006	0.003
B_1	PSB (5 Kg/ha)	0.207	0.208	0.208	0.0022	0.0027	0.0025	0.080	0.085	0.083
B_2	Azotobacter (5 Kg/ha)	0.197	0.199	0.198	0.0024	0.0030	0.0027	0.084	0.089	0.086
SEm ±		0.001	0.001	0.001	0.00005	0.00015	0.00008	0.001	0.002	0.001
CD 5%		0.002	0.002	0.002	0.00015	NS	0.00023	0.002	NS	0.003

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