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Response of Different Levels of Zinc and Potassium with Biofertilizers for Yield and Quality of Potato Tubers (cv. Kufri Jyoti)

Rajkumar Chaurasiya, Shailesh Kumar Singh, Dinesh Baboo Tyagi, Nikita Nehal, Dashrath Bhati, Shudheer Kumar Pathak

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ABSTRACT

Potato is a heavy feeder of plant nutrients having very high requirement of nitrogen, phosphorus, potassium and other nutrients. Being a tuber crop, it has high utilization efficiency of potassium and zinc and responds well to biofertilizer application. The present investigation was carried out with the objectives to find out the effect of different levels of potassium and zinc in combination with the biofertilizers (PSB and KSB) on yield and quality of potato tubers. Significantly minimum days to maturity, maximum number of tubers, better quality of tuber and improved biochemical properties of tuber like starch, sugar and protein content was reported with $K_3Z_3B_1$ (80 kg/ha, 6 kg/ha and *Azotobacter* + PSB). Significantly maximum number of tubers per plant were recorded in higher level of potassium as in K_3 (8.00, 8.07 and 8.04) and the treatment having high dose of zinc in Z_3 (7.46, 7.53 and 7.49). The maximum protein content (5.18, 5.20 and 5.19 %), the maximum total sugar percent (0.167, 0.178 and 0.173 %) and maximum starch content (16.01, 16.01 and 16.01 %) was recorded after application of high level of potassium as in K_3 (80 kg/ha) in first year, second year and in pooled respectively. Similarly, the maximum protein content (5.16, 5.17 and 5.16 %), maximum total sugar percent (0.153, 0.163 and 0.158%) and maximum starch content (14.53, 14.56 and 14.55 %) was recorded after application of high level of zinc as in Z_3 (6 kg/ha).

Keywords *Azotobacter*, Potassium solubilizing bacteria (KSB), Phosphate solubilizing bacteria (PSB), Protein, Starch.

Rajkumar Chaurasiya [1], Shailesh Kumar Singh [2]*, Dashrath Bhati [5]
[1] Research Scholar, [2] Professor, [5] Assistant Professor
Department of Horticulture, School of Agriculture, ITM University, Gwalior, MP 474001, India

Dinesh Baboo Tyagi [3]
[3] Associate Professor, Department of Agriculture Economics and Extension, School of Agriculture, ITM University, Gwalior, MP 474001, India

Nikita Nehal [4]
[4] Assistant Professor, School of Agriculture, Galgotias University, Greater Noida, UP, India

Sudheer Kumar Pathak [6]
[6] Assistant Professor, Department of Genetics and Plant Breeding, School of Agriculture, ITM University, Gwalior, MP 474001, India

Email: drshaileshhrt@gmail.com
*Corresponding author

INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the most common vegetable crops widely grown throughout the world. 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). It is a heavy feeder of plant nutrients having very high requirement of nitrogen, phosphorus, potassium and other nutrients. Potassium (K) plays significant role in tuber yield and quality in potato by influencing synthesis, location, transformation and storage of carbohydrates, tuber quality and processing characteristics as well as plant resistance to stress and diseases (Ebert 2009) and also by enhancing storage life and improvement of shipping quality and shelf life of potato.

Indian soils are generally high in total K but only a small fraction of it is present in available form because of dynamic equilibriums between exchangeable, non-exchangeable and fixed K. With high crop intensity and high K removal, the soils are becoming deficient in K. Further, potassium application has been neglected by majority of farmers in our country resulting in continual depletion and deficiency of soil K (Lal *et al*. 2007). Zinc (Zn) contributes towards synthesis of growth promoters like auxins (IAA-Indole Acetic Acid) and gibberellins while reduces the level of inhibitors like abscisic acid (ABA) to improve the IAA/ ABA and cytokinin / ABA ratio, which induces the formation and growth of stolon resulting the increase in number of tubers, mean tubers weight and finally high performance of potato crop is due to utilization of zinc Zn fertilizers in potato (Gangele *et al*. 2020). Zn plays an important role in oxidation-reduction reactions in the plants therefore, application of zinc for sustaining crop yield appears essential.

Biofertilizers are natural fertilizers containing micro-organisms which help in enhancing the productivity by biological nitrogen fixation or solubilization of insoluble phosphate (Yosefi *et al*. 2011) or producing hormones, vitamins and other growth regulators required for plant growth (Gangele *et al*. 2020). Biofertilizers containing beneficial bacteria and fungi improve soil chemical and biological characteristics, phosphate solubility and agricultural production (El-Habbasha *et al*. 2007, Yosefi *et al*. 2011). Biofertilizers comprised of nitrogen fixers (*Azotobacter chroococcum*), phosphate solublizer (*B. megaterium*) and potash dissolvers (*B. mucilaginosus*), plant growth promoting rhizobacteria (PGPRS), (Ezz *et al*. 2011) which are helpful to increase the plant growth, nutrient uptake significantly in maize crop and also improved soil properties such as organic matter content and total nitrogen in soil (Wu *et al*. 2005). Keeping above facts in consideration, the present investigation was carried out with the objectives to find out the effect of different levels of potassium and zinc in combination with the biofertilizers (PSB and KSB) on yield and quality of potato tubers.

MATERIALS AND METHODS

The experiment was carried out in two consecutive cropping seasons of potato during years viz., 2019-20 and 2020-21. The location is characterized as subtropical environment having hot summer with the highest temperature exceeding 45°C during May – June, cold winters with expected frost and the lowest temperature reaching to 2°C during December – January. The soil of the experimental field was sandy loam with 17.07% clay, 22.25% silt and 60.68% sand having pH ranging from 7.8 (normal) with good drainage and uniform texture, very low nitrogen (10.5 to 218.0 kg/hectare), medium phosphorus (15.12-15.56 kg/ hectare) and medium potassium (185-192 kg/hectare).

The experiment was carried out in the Randomized Block Design with comprising three levels of potassium viz. K_1 (K_2O @ 40 kg ha^{-1}), K_2 (K_2O @ 60 kg ha^{-1}) and K_3 (K_2O @ 80 kg ha^{-1}), three levels of zinc i.e., Z_1 (Zn @ 2 kg ha^{-1}), Z_2 (Zn @ 4 kg ha^{-1}) and Z_3 (Zn @ 6 kg ha^{-1}) and two types of biofertilizers combinations at the rate of 5 kg ha^{-1} as B_1 (*Azotobacter* + PSB) and B_2 (*Azotobacter* + KSB). The treatment combinations (18) include: T_1 - $K_1Z_1B_1$; T_2 - $K_1Z_1B_2$; T_3 - $K_1Z_2B_1$; T_4 - $K_1Z_2B_2$; T_5 - $K_1Z_3B_1$; T_6 - $K_1Z_3B_2$; T_7 - $K_2Z_1B_1$; T_8 - $K_2Z_1B_2$; T_9 - $K_2Z_2B_1$; T_{10} - $K_2Z_2B_2$; T_{11} - $K_2Z_3B_1$; T_{12} - $K_2Z_3B_2$; T_{13} - $K_3Z_1B_1$; T_{14} - $K_3Z_1B_2$; T_{15} - $K_3Z_2B_1$; T_{16} - $K_3Z_2B_2$; T_{17} - $K_3Z_3B_1$; T_{18} - $K_3Z_3B_2$ and 3 replications. Before planting tuber seeds were dipped in 0.2% solution of Mancozeb for 10 minutes and spread at a cool and moist place to check fungal infection. The healthy, uniform medium sized tubers (35 – 45 mm or 45 – 50 g) were used (30 - 35q ha^{-1}) and dibbled at a spacing of 60 cm row to row and 20 cm plant to plant. The first irrigation was given immediately after planting to ensure proper establishment of sprout followed by the subsequent irrigations at interval of 15 days till January and at an interval of

10 days during February months.

Nitrogen, phosphorus and potassium were applied, through urea, single super phosphate and murate of potash, respectively. A uniform dose of 180 kg N ha^{-1} and 100 kg P_2O_5 ha^{-1} was applied to all the plots while K_2O was applied as per the treatments. Vermicompost and potassium as per treatment were applied in respective plot before planting. Full quantity of phosphorus, potassium fertilizer and vermicompost along with half dose of nitrogen was applied before planting while, the rest half nitrogen was applied in two split doses during was earthing up. The observations on different aspects such as yield attributing parameters, quality parameters and biochemical analysis were recorded and statistically analyzed to evaluate the significance of various treatments.

RESULTS AND DISCUSSION

Crop maturity and crop yield

The investigations revealed a significant variation among the different levels of zinc and potassium with

Table 1. Effect of different levels of zinc and potassium with biofertilizers and their interaction on yield attributing parameters of potato.

Treatments	Days to maturity			Number of tubers (plant^{-1})			Average yield (g plant^{-1})		
	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled
Levels of potassium (40, 60 and 80 kg ha^{-1})									
K_1	110.06	110.11	110.08	6.02	6.08	6.05	247.23	249.32	248.28
K_2	105.33	105.61	105.47	7.06	7.06	7.06	314.40	314.28	314.34
K_3	103.28	103.83	103.56	8.00	8.07	8.04	397.01	400.43	398.72
SEm (±)	0.268	0.259	0.186	0.029	0.028	0.020	1.352	1.263	0.925
CD at 5%	0.771	0.747	0.527	0.083	0.080	0.057	3.891	3.634	2.616
Levels of zinc (2, 4 and 6 kg ha^{-1})									
Z_1	107.33	107.72	107.53	6.67	6.67	6.67	293.48	293.58	293.53
Z_2	106.28	106.56	106.42	6.96	7.01	6.98	315.69	317.79	316.74
Z_3	105.06	105.28	105.17	7.46	7.53	7.49	349.48	352.67	351.07
SEm (±)	0.268	0.259	0.186	0.029	0.028	0.020	1.352	1.263	0.925
CD at 5%	0.771	0.747	0.527	0.083	0.080	0.057	3.891	3.634	2.616
Biofertilizers application as *Azotobacter* with PSB and KSB (2.5 kg ha^{-1} each)									
B_1	105.85	106.22	106.04	7.16	7.18	7.17	328.17	328.90	328.54
B_2	106.59	106.81	106.70	6.89	6.96	6.93	310.93	313.78	312.36
SEm (±)	0.219	0.212	0.152	0.023	0.023	0.016	1.104	1.031	0.755
CD at 5%	0.629	0.610	0.431	0.068	0.066	0.046	3.177	2.967	2.136
Interaction effect (potassium, zinc and biofertilizers)									
T_1- $K_1Z_1B_1$	111.00	111.67	111.33	6.00	6.06	6.03	240.13	242.27	241.20
T_2- $K_1Z_1B_2$	112.00	113.00	112.50	5.28	5.33	5.31	211.20	213.33	212.27
T_3- $K_1Z_2B_1$	110.00	109.67	109.83	6.17	6.16	6.17	252.83	252.70	252.77
T_4- $K_1Z_2B_2$	110.67	111.00	110.83	6.05	6.16	6.10	247.91	252.56	250.24
T_5- $K_1Z_3B_1$	107.67	107.00	107.33	6.42	6.47	6.44	269.50	271.60	270.55
T_6- $K_1Z_3B_2$	109.00	108.33	108.67	6.23	6.27	6.25	261.80	263.48	262.64
T_7- $K_2Z_1B_1$	106.33	106.00	106.17	6.88	6.84	6.86	302.72	300.96	301.84
T_8- $K_2Z_1B_2$	107.00	106.33	106.67	6.70	6.77	6.74	288.24	291.11	289.68
T_9- $K_2Z_2B_1$	104.67	105.33	105.00	7.08	6.97	7.02	318.45	313.50	315.98
T_{10}- $K_2Z_2B_2$	105.33	105.67	105.50	6.93	6.95	6.94	304.77	305.95	305.36
T_{11}- $K_2Z_3B_1$	104.00	105.00	104.50	7.42	7.43	7.43	341.47	341.78	341.63
T_{12}- $K_2Z_3B_2$	104.67	105.33	105.00	7.35	7.39	7.37	330.75	332.40	331.58
T_{13}- $K_3Z_1B_1$	103.67	104.67	104.17	7.63	7.55	7.59	366.40	362.24	364.32
T_{14}- $K_3Z_1B_2$	104.00	104.67	104.33	7.49	7.48	7.49	352.19	351.56	351.87
T_{15}- $K_3Z_2B_1$	103.33	103.67	103.50	7.87	8.00	7.94	393.50	400.17	396.83
T_{16}- $K_3Z_2B_2$	103.67	104.00	103.83	7.69	7.79	7.74	376.65	381.87	379.26
T_{17}- $K_3Z_3B_1$	102.00	103.00	102.50	9.01	9.13	9.07	468.52	474.93	471.73
T_{18}- $K_3Z_3B_2$	103.00	103.00	103.00	8.33	8.47	8.40	424.83	431.80	428.32
SEm (±)	0.656	0.635	0.457	0.070	0.068	0.049	3.312	3.093	2.266
CD at 5%	NS	NS	NS	0.203	0.197	0.139	9.531	8.900	6.408

biofertilizers for various yield related parameters like crop maturity, number of tubers per plant and tuber yield per plant (Table 1). The results of first year, second year and in pooled basis indicated that the minimum days to maturity (103.28, 103.83 and 103.56 days) was recorded in K_3 (60 kg ha^{-1}) among potassium levels and maximum days to maturity (110.06, 110.11 and 110.08 days) recorded in K_1 (40 kg/ha). Among various levels of zinc, Z_3 (6 kg/ha) gave minimum days to maturity (105.06, 105.28 and 105.17 days) while maximum days to maturity (107.33, 107.72 and 107.53 days) was recorded in Z_1 (2 kg/ha) in first year, second year and in pooled, respectively. The biofertilizers significantly affected days to maturity B_1 (*Azotobacter* + PSB) and showed minimum days to maturity (105.85, 106.22 and 106.04 days) and B_2 (*Azotobacter* + KSB) was taken maximum days to maturity (106.59, 106.81 and 106.70 days) in both years and in pooled.

Significantly maximum number of tubers (8.00, 8.07 and 8.04) per plant were recorded in higher level of potassium as in K_3 (80 kg/ha), while the minimum number of tubers (6.02, 6.08 and 6.05) were recorded in treatment with lower level of potassium as in K_1 (40 kg/ha) in both years and in pooled, respectively. In case of zinc, the significantly maximum (7.46, 7.53 and 7.49) was obtained in treatment having high dose of zinc in Z_3 (6 kg/ha), while the minimum (6.67, 6.67 and 6.67) was noted in Z_1 (2 kg/ha) in first year, second year and in pooled, respectively. Although both the biofertilizers have resulted in significant yield improvement but application of B_1 (*Azotobacter* + PSB) showed significantly maximum number of tubers per plant (7.16, 7.18 and 7.17) in comparison to B_2 (*Azotobacter* + KSB). Significantly maximum number of tubers (9.01, 9.13 and 9.07) per plant were recorded in treatment combination $K_3Z_3B_1$ and is followed by $K_3Z_3B_2$, while the minimum number of tubers per plant (5.28, 5.33 and 5.31) was recorded in treatment $K_1Z_1B_2$. A similar trend was reported for tuber yield per plant due to application of high dose of potassium in K_3 (80 kg/ha) and high dose of zinc in Z_3 (6 kg/ha) in presence of biofertilizers as PSB or KSB.

Among in potassium levels on the basis of two year mean data and the pooled average value, the treatment K_3 (80 kg/ha) was found significantly superior to other treatments in both the years and in pooled. It gave significantly the maximum number of tubers and tuber yield per plant with early maturity while minimum was found in treatment K_1 (40 kg/ha) with the delayed maturity. This might be associated with influence of potassium on photosynthesis, favoring high energy status which helped the crop for timely and appropriate nutrients translocation and water absorption by roots to ensure accumulation of more photosynthates for more tuberization (Pervez *et al*. 2013, Zelelew *et al*. 2016, Fekadu 2016, Ghosh *et al*. 2017, Hosseini *et al*. 2017, Silva *et al*. 2018, Bista and Bhandari 2019). The high level of zinc application in Z_3 (6 kg/ha) resulted in significantly maximum number of tubers and tuber yield per plant with minimum days to maturity which could be result of accelerated synthesis of auxin and amino acid particularly tryptophan in plant contributing towards more photosynthesis and accumulation of food in the form of potato tuber as described by Ali *et al*. (2019), Parmar *et al*. (2016), Jawad (2016), Sharma and Singh (2017), Sarker *et al*. (2018), Khan *et al*. (2019), Dhakal and Shrestha (2019) and Ierna *et al*. (2020) through various investigation.

Among in biofertilizers, B_1 (*Azotobacter* + PSB) showed better yield attributing parameters and early maturity which may be due to proper nutrient mobilization and supply from insoluble sources and the growth promoting effects over stolon formation and tuberization and can be supported by findings of Nedunchezhiyan *et al*. (2010), Choudhary *et al*. (2010), Sharma *et al*. (2015), Ramandeep *et al*. (2018), Gangele *et al*. (2020) and Saxena and Singh (2020). Interaction effects of zinc and potassium with biofertilizers revealed that significantly maximum number of tubers and tuber yield per plant in treatment combination with higher level of potassium and zinc. It might due to proper and better nutrient supply to plant from soil in presence of PGPRs (PSB or KSB) and increased availability of K and Zn which could be responsible for improved photosynthesis in plant due to greater leaf area and number of leaves, producing greater starch for plant and tuberization (Prativa and Bhattarai 2011, Islam *et al*. 2017, Gangele *et al*. 2020).

***Quality parameters*:** The present investigations re-

vealed a significant variation among different levels of zinc and potassium with biofertilizers for dry matter content, specific gravity and TSS of potato tuber (Table 2). The maximum dry matter content (24.85, 24.87 and 24.86 %), maximum specific gravity (1.091, 1.093 and 1.092) and maximum TSS (5.90, 5.92 and 5.91 %) was recorded in high potassium application as in K_3 (80 kg/ha) while lowest was recorded in K_1 (40 kg/ha). Among in zinc levels Z_3 (6 kg/ha) contributed towards maximum dry matter content (24.20, 24.20 and 24.20 %), maximum specific gravity (1.89, 1.89 and 1.089) and maximum TSS (5.90, 5.92 and 5.91 %) in potato tubers, while minimum was recorded in Z_1 (2 kg/ha) in both years and in pooled.

Biofertilizers also significantly affected dry matter content where B_1 (*Azotobacter* + PSB) showed minimum dry matter content (23.97, 23.98 and 23.98 %), minimum specific gravity (1.086, 1.087 and 1.086) and maximum TSS (5.72, 5.72 and 5.72 %) content in tubers in comparison to B_2 (*Azotobacter* + KSB). Interaction effect between different levels of zinc and potassium with biofertilizers showed not significantly difference between treatment combina-

Table 2. Effect of different levels of zinc and potassium with biofertilizers and their interaction on quality parameters of potato tubers.

Treatments	Dry matter content (%)			Specific gravity			TSS (%)		
	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled
Levels of potassium (40, 60 and 80 kg ha^{-1})									
K_1	22.82	22.82	22.82	1.081	1.082	1.082	5.46	5.46	5.46
K_2	23.87	23.91	23.89	1.087	1.088	1.087	5.70	5.70	5.70
K_3	24.85	24.87	24.86	1.091	1.093	1.092	5.90	5.92	5.91
SEm (±)	0.040	0.038	0.028	0.0004	0.0004	0.0003	0.008	0.007	0.005
CD at 5%	0.116	0.108	0.078	0.0012	0.0011	0.0008	0.022	0.019	0.014
Levels of zinc (2, 4 and 6 kg ha^{-1})									
Z_1	23.50	23.50	23.50	1.084	1.086	1.085	5.60	5.61	5.60
Z_2	23.84	23.90	23.87	1.086	1.087	1.087	5.68	5.69	5.69
Z_3	24.20	24.20	24.20	1.089	1.089	1.089	5.78	5.78	5.78
SEm (±)	0.040	0.038	0.028	0.0004	0.0004	0.0003	0.008	0.007	0.005
CD at 5%	0.116	0.108	0.078	0.0012	0.0011	0.0008	0.022	0.019	0.014
Biofertilizers application as *Azotobacter* with PSB and KSB (2.5 kg ha^{-1} each)									
B_1	23.97	23.98	23.98	1.087	1.088	1.088	5.72	5.72	5.72
B_2	23.72	23.75	23.74	1.086	1.087	1.086	5.65	5.67	5.66
SEm (±)	0.033	0.031	0.023	0.0003	0.0003	0.0002	0.006	0.005	0.004
CD at 5%	0.095	0.088	0.064	0.0010	0.0009	0.0007	0.018	0.015	0.012
Interaction effect (potassium, zinc and biofertilizers)									
T_1- $K_1Z_1B_1$	22.65	22.74	22.69	1.080	1.080	1.080	5.40	5.42	5.41
T_2- $K_1Z_1B_2$	22.21	22.25	22.23	1.078	1.080	1.079	5.29	5.32	5.31
T_3- $K_1Z_2B_1$	23.00	22.99	23.00	1.082	1.083	1.082	5.54	5.51	5.53
T_4- $K_1Z_2B_2$	22.79	22.81	22.80	1.082	1.082	1.082	5.42	5.44	5.43
T_5- $K_1Z_3B_1$	23.22	23.14	23.18	1.083	1.085	1.084	5.58	5.56	5.57
T_6- $K_1Z_3B_2$	23.07	23.02	23.04	1.083	1.084	1.083	5.55	5.54	5.55
T_7- $K_2Z_1B_1$	23.71	23.64	23.67	1.084	1.086	1.085	5.68	5.68	5.68
T_8- $K_2Z_1B_2$	23.50	23.45	23.48	1.083	1.086	1.085	5.62	5.64	5.63
T_9- $K_2Z_2B_1$	23.98	24.08	24.03	1.088	1.088	1.088	5.72	5.71	5.71
T_{10}- $K_2Z_2B_2$	23.77	23.93	23.85	1.086	1.088	1.087	5.69	5.69	5.69
T_{11}- $K_2Z_3B_1$	24.17	24.22	24.20	1.089	1.090	1.090	5.78	5.75	5.77
T_{12}- $K_2Z_3B_2$	24.10	24.12	24.11	1.089	1.088	1.088	5.72	5.73	5.72
T_{13}- $K_3Z_1B_1$	24.53	24.55	24.54	1.090	1.092	1.091	5.81	5.81	5.81
T_{14}- $K_3Z_1B_2$	24.40	24.37	24.38	1.090	1.091	1.090	5.78	5.79	5.79
T_{15}- $K_3Z_2B_1$	24.92	24.86	24.89	1.091	1.093	1.092	5.90	5.92	5.91
T_{16}- $K_3Z_2B_2$	24.59	24.71	24.65	1.090	1.092	1.091	5.84	5.86	5.85
T_{17}- $K_3Z_3B_1$	25.58	25.62	25.60	1.095	1.097	1.096	6.10	6.12	6.11
T_{18}- $K_3Z_3B_2$	25.08	25.11	25.09	1.093	1.094	1.093	5.94	6.00	5.97
SEm (±)	0.099	0.092	0.092	0.0010	0.0009	0.0007	0.018	0.016	0.012
CD at 5%	NS	NS	NS	NS	NS	NS	0.053	0.046	0.035

tions for dry matter content and specific gravity of potato tubers; however, the significant interaction was noticed for TSS (%) of potato tubers and maximum TSS (6.10, 6.12 and 6.11 %) was estimated in treatment combination $K_3Z_3B_1$ in both years and in pooled respectively. Potato needs higher level of potassium for optimum tuber production as compared to other commercial crops ensures more dry matter content, specific gravity and TSS (%) in short growth duration (Bhattarai and Swarnima 2016, Fekadu 2016, Ghosh *et al*. 2017, Silva *et al*. 2018, Bista and Bhandari 2019). The positive influence of zinc application on plant growth and redox processes in plant cell might be accountable for greater dry matter content, specific gravity and TSS (%) in potato tubers (Parmar *et al*. 2016, Khan *et al*. 2019, Ierna *et al*. 2020). Further, application of biofertilizers as PSB or KSB has significant influence over mobilization of minerals resulting better dry matter content, specific gravity and TSS % in first year, second year and in pooled, respectively (Saikia and Deka 2006, Lal and Khurana 2007).

***Biochemical analysis*:** The biochemical studies for protein content, total sugar and starch content were

Table 3. Effect of different levels of zinc and potassium with biofertilizers and their interaction on biochemical parameters of potato tubers.

Treatments	Protein content (%)			Total sugar (%)			Starch content (%)		
	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled
Levels of potassium (40, 60 and 80 kg ha^{-1})									
K_1	5.11	5.12	5.12	0.123	0.124	0.124	12.13	12.15	12.14
K_2	5.13	5.15	5.14	0.150	0.159	0.154	13.14	13.14	13.14
K_3	5.18	5.20	5.19	0.167	0.178	0.173	16.01	16.01	16.01
SEm (±)	0.004	0.006	0.004	0.0022	0.0043	0.0024	0.011	0.009	0.007
CD at 5%	0.013	0.017	0.011	0.0064	0.0125	0.0069	0.031	0.027	0.020
Levels of zinc (2, 4 and 6 kg ha^{-1})									
Z_1	5.12	5.14	5.13	0.138	0.137	0.138	13.08	13.08	13.08
Z_2	5.14	5.16	5.15	0.149	0.161	0.155	13.67	13.66	13.67
Z_3	5.16	5.17	5.16	0.153	0.163	0.158	14.53	14.56	14.55
SEm (±)	0.004	0.006	0.004	0.0022	0.0043	0.0024	0.011	0.009	0.007
CD at 5%	0.013	0.017	0.011	0.0064	0.0125	0.0069	0.031	0.027	0.020
Biofertilizers application as *Azotobacter* with PSB and KSB (2.5 kg ha^{-1} each)									
B_1	5.14	5.16	5.15	0.149	0.155	0.152	13.99	14.00	14.00
B_2	5.14	5.15	5.14	0.144	0.152	0.148	13.52	13.54	13.53
SEm (±)	0.004	0.005	0.003	0.0018	0.0035	0.0020	0.009	0.008	0.006
CD at 5%	NS	NS	NS	NS	NS	NS	0.025	0.022	0.016
Interaction effect (potassium, zinc and biofertilizers)									
T_1- $K_1Z_1B_1$	5.11	5.11	5.11	0.120	0.084	0.102	11.97	12.01	11.99
T_2- $K_1Z_1B_2$	5.10	5.10	5.10	0.100	0.093	0.097	11.61	11.63	11.62
T_3- $K_1Z_2B_1$	5.12	5.12	5.12	0.130	0.143	0.137	12.15	12.13	12.14
T_4- $K_1Z_2B_2$	5.11	5.11	5.11	0.130	0.137	0.133	12.08	12.06	12.07
T_5- $K_1Z_3B_1$	5.12	5.13	5.13	0.130	0.137	0.133	12.80	12.83	12.82
T_6- $K_1Z_3B_2$	5.12	5.12	5.12	0.130	0.150	0.140	12.18	12.24	12.21
T_7- $K_2Z_1B_1$	5.13	5.15	5.14	0.147	0.157	0.152	12.90	12.89	12.90
T_8- $K_2Z_1B_2$	5.12	5.13	5.13	0.147	0.140	0.143	12.86	12.88	12.87
T_9- $K_2Z_2B_1$	5.13	5.15	5.14	0.150	0.170	0.160	13.00	12.97	12.99
T_{10}- $K_2Z_2B_2$	5.13	5.15	5.14	0.150	0.160	0.155	12.92	12.92	12.92
T_{11}- $K_2Z_3B_1$	5.14	5.16	5.15	0.157	0.160	0.158	13.97	14.00	13.99
T_{12}- $K_2Z_3B_2$	5.13	5.16	5.15	0.150	0.167	0.158	13.16	13.18	13.17
T_{13}- $K_3Z_1B_1$	5.15	5.17	5.16	0.160	0.180	0.170	15.03	15.00	15.02
T_{14}- $K_3Z_1B_2$	5.14	5.16	5.15	0.157	0.170	0.163	14.08	14.06	14.07
T_{15}- $K_3Z_2B_1$	5.18	5.21	5.20	0.170	0.177	0.173	15.94	15.96	15.95
T_{16}- $K_3Z_2B_2$	5.17	5.19	5.18	0.167	0.177	0.172	15.91	15.93	15.92
T_{17}- $K_3Z_3B_1$	5.22	5.24	5.23	0.180	0.187	0.183	18.17	18.19	18.18
T_{18}- $K_3Z_3B_2$	5.20	5.23	5.21	0.170	0.177	0.173	16.91	16.95	16.93
SEm (±)	0.011	0.015	0.009	0.0055	0.0106	0.0060	0.026	0.023	0.017
CD at 5%	NS	NS	NS	NS	NS	NS	0.076	0.065	0.049

observed to be significantly influenced by different levels of potassium and zinc application in potato crop; however, there was no significant effect of biofertilizers application and interaction of various factors on biochemical parameters under study, except starch content (Table 3). The maximum protein content (5.18, 5.20 and 5.19 %), the maximum total sugar percent (0.167, 0.178 and 0.173 %) and maximum starch content (16.01, 16.01 and 16.01 %) was recorded after application of high level of potassium as in K_3 (80 kg/ha) in first year, second year and in pooled respectively. This result might be due to increased nutrient inputs which positively responded to crude protein and higher inputs of N nutrients increased protein content of potato tubers (Haddad *et al*. 2016, Khan *et al*. 2019).

Similarly, the maximum protein content (5.16, 5.17 and 5.16 %), maximum total sugar percent (0.153, 0.163 and 0.158%) and maximum starch content (14.53, 14.56 and 14.55 %) was recorded after application of high level of zinc as in Z_3 (6 kg/ha). This might be associated with increased uptake of micronutrients in presence of high level of zinc application (Sasan *et al*. 2005). Further, micronutrients fertilization is also accountable for enhanced mineral composition in potatoes which can improve biochemical parameters of potato tubers (Ierna *et al*. 2020). Although biofertilizer showed non-significant result on protein content and total sugar, the positive influence over starch content might be associated with its influence on photosynthesis mechanism. While the interaction effect of zinc and potassium with biofertilizers showed non-significant effect on protein content and total sugar percent in potato, its has significantly influenced the starch content of potato tuber. Potassium, zinc and biofertilizer provided proper nutrient to plant and nutrients were helpful to produce more starch and sugar in potato tubers (Nedunchezhiyan *et al*. 2010, Bansal and Trehan 2011, Bhattarai and Swarnima 2016, Hosseini *et al*. 2017, Gangele *et al*. 2020).

CONCLUSION

The higher level of potassium as in K_3 (80 kg/ha) and zinc as in Z_3 (6 kg/ha) with biofertilizer B_1 (*Azotobacter* + PSB) had significantly influenced the yield attributing parameters (days to maturity, number of tubers per plant and tuber yield per plant), quality parameters (dry matter content, specific gravity and TSS) and biochemical analysis (protein content, total sugar and starch content). The combined application of high level of potassium and zinc with PSB ($K_3Z_3B_1$) has resulted in maximum yield attributing parameters (days to maturity, number of tubers per plant and tuber yield per plant), quality parameters (dry matter content, specific gravity and TSS) and biochemical analysis (protein content, total sugar and starch content).

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