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Economic Indicators of Potato Cultivation after Application of Potassium and Zinc in Combination with Biofertilizers

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ABSTRACT

Potassium (K) is known for enlargement of tuber size or inducing tuberization, resulting in accumulation of carbohydrate and improvement in yield. Zinc is known to improve the formation and growth of stolon which is positively correlated with tuberization to improve tuber yield and finally high gross income. Application of biofertilizers ensures the conversion of unavailable nutrients in the available form. The present investigation was carried out to standardize the doses of potassium and zinc and suitability of biofertilizers for ensuring better income, benefit : cost ratio and effective income index during potato cultivation. The application of potassium at the rate of 80 kg/ha and zinc at the rate of 4 to 6 kg/ha in combination with *Azotobacter*+PSB (phosphate solubilizing bacteria) each at the rate of 2.5 kg/ha as biofertilizers or bio-inoculants ensured high gross income (Rs. 471727/ha), net income (Rs. 344802/ha), B : C ratio (3.62) and effective income index or EII (6.85) in cultivation of potato. A strong correlation of these attributes was reported with the potato yield. Also, correlation of EII and B : C ratio with net income and gross income was very high (more than 0.9); however, the correlation with cost of cultivation was non-significant.

Key words: Benefit : cost ratio, biofertilizers, effective income index (EII), net income, potassium, potato, zinc

INTRODUCTION

Potato *(Solanum tuberosum* L.) is one of the most important vegetable crops which is 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 (Lallawmkima *et al.*, 2018a). It is a heavy feeder of plant nutrients and is having very high requirement of nitrogen, phosphorus, potassium and other nutrients.

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. Further its application is being neglected by farmers due to high cost and less availability. With high crop intensity and high K removal, the soils are becoming potassium deficient in major potato growing belt resulting in reduced economic yield. Potassium application plays significant role in increasing yield of potato tubers which is either by improving tuberization or by increasing bulkiness of tubers or both resulting in accumulation of carbohydrate. However, low replenish and high loss of potassium by leaching in soil causing its widespread deficiency in intensively potato growing areas. Therefore, careful attention should be given in potassium fertilization to maximize the quality and yield of potato tuber (Lallawmkima *et al.*, 2018b).

Biofertilizers are natural fertilizers containing micro-organisms which help in enhancing the

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productivity by biological nitrogen fixation or solubilization of insoluble phosphate or producing hormones, vitamins and other growth regulators required for plant growth (Gangele *et al.*, 2020). Further, it has also ability to make the unavailable nutrients in the available form. Potato responds well to zinc as it improves the IAA-ABA and cytokinin-ABA ratio, which induces the formation and growth of stolon resulting in improvement of tuberization, yield and finally high gross income (Gangele *et al.*, 2020).

Application of potassium, zinc and biofertilizers as per recommendation becomes essential for getting high yield and income to the farmers. The present investigation was carried out to standardize the doses of potassium and zinc and suitability of biofertilizers for ensuring highest income and benefit : cost ratio during potato cultivation.

MATERIALS AND METHODS

The investigation was conducted during **rabi** season of 2019-20 and 2020-21 at research farm of ITM University Gwalior (M. P.). The meteorological data during the year 2019-20 indicated that the total rainfall received during crop growth period was 30.0 mm. The minimum and maximum temperature during crop growth period varied from 3.90 to 18.90°C and from 17.80 to 36.00°C, with season's average values of 10.38 and 27.94°C, respectively. The morning and evening relative humidity ranged between 67.00 to 95.00% and 17.40 to 69.40% with season's average of 87.04 and 36.36%, respectively. The evaporation varied from 0.80 to 6.90 mm with an overall average of 2.70 mm. Meteorological data during year 2020-21 indicated that there were no rains received during crop growth period. The minimum and maximum temperature during crop growth period varied from 5.90 to 21.20°C and from 19.70 to 40.40°C, with season's average values of 10.67 and 27.72°C, respectively. The morning and evening relative humidity ranged between 56.50 to 98.30% and 24.40 to 57.70% with season's average of 84.05 and 39.86%, respectively. The evaporation varied from 1.0 to 9.20 mm with an overall average of 3.39 mm. The soil of the experimental field was sandy loam with good drainage and uniform texture with very low, medium and medium NPK status, respectively. The previous history of the experimental field was as below:

Year	Crop rotation
2013-14	Cowpea - Tomato - Fallow
2014-15	Brinjal - Cabbage - Fallow
2015-16	Okra - Tomato - Fallow
2016-17	Cowpea - Potato
2017-18	Okra - Potato

The experiment was laid out in the randomized block design with 18 treatment combinations and each one was replicated thrice. The various treatment combinations were formulated by using three levels of potassium [K_1 (K_2O @ 40 kg/ha), K_2 (K_2O @ 60 kg/ha) and K_3 (K_2O @ 80 kg/ha)]; three levels of zinc [Z_1 (Zn @ 2 kg/ha), Z_2 (Zn @ 4 kg/ha) and Z_3 (Zn @ 6 kg/ha)] and two types of biofertilizers combination [B_1 (*Azotobacter*+PSB, each at 2.5 kg/ha) and [B_2 (*Azotobacter*+KSB, each at 2.5 kg/ha)]. The standard cultivation practices were followed during the investigation.

RESULTS AND DISCUSSION

The cost of cultivation for potato estimated after application of different levels of potassium and zinc with biofertilizers (Table 1) revealed that the maximum cost of cultivation (Rs. 132175, 129175 and 127175/ha) was found in $K_3Z_3B_2$ and the minimum cost of cultivation (Rs. 129968, 126968 and 124968/ha) was recorded in $K_1Z_1B_1$ in first year, second year and in pooled, respectively. The variation in gross income from potato cultivation after application of different combinations of potassium and zinc levels with biofertilizers was estimated on the basis of prevailing market price of potato at the time of harvesting (Table 1) and the highest gross income (Rs. 468520, 474933 and 471727/ha) was found in $K_3Z_3B_1$, while the minimum gross income (Rs. 211200, 213333 and 212267/ha) was found under treatment combination $K_1Z_1B_2$ in first year, second year and in pooled estimation, respectively. This might be associated with the variation in marketable yield of potato as a strong correlation was reported between yield and various parameters of income (Table 2). The variation in net income from potato cultivation

Table 1. Economic parameters of potato cultivation after application of different combinations of potassium and zinc levels with biofertilizers

Treatment	Cost of cultivation (Rs./ha)			Gross income (Rs./ha)			Net income (Rs./ha)		
	Year-1	Year-2	Pooled data	Year-1	Year-2	Pooled data	Year-1	Year-2	Pooled data
$K_1Z_1B_1$	129968	126968	124968	240133	242267	241200	110165	115299	116232
$K_1Z_1B_2$	130218	127218	125218	211200	213333	212267	80982	86115	87049
$K_1Z_2B_1$	130418	127418	125418	252833	252697	252765	122415	125279	127347
$K_1Z_2B_2$	130668	127668	125668	247913	252560	250237	117245	124892	124569
$K_1Z_3B_1$	130868	127868	125868	269500	271600	270550	138632	143732	144682
$K_1Z_3B_2$	131118	128118	126118	261800	263480	262640	130682	135362	136522
$K_2Z_1B_1$	130486	127486	125486	302720	300960	301840	172234	173474	176354
$K_2Z_1B_2$	130736	127736	125736	288243	291110	289677	157507	163374	163941
$K_2Z_2B_1$	130936	127936	125936	318450	313500	315975	187514	185564	190039
$K_2Z_2B_2$	131186	128186	126186	304773	305947	305360	173587	177761	179174
$K_2Z_3B_1$	131386	128386	126386	341473	341780	341627	210087	213394	215241
$K_2Z_3B_2$	131636	128636	126636	330750	332400	331575	199114	203764	204939
$K_3Z_1B_1$	131025	128025	126025	366400	362240	364320	235375	234215	238295
$K_3Z_1B_2$	131275	128275	126275	352187	351560	351873	220912	223285	225598
$K_3Z_2B_1$	131475	128475	126475	393500	400167	396833	262025	271692	270358
$K_3Z_2B_2$	131725	128725	126725	376647	381873	379260	244922	253148	252535
$K_3Z_3B_1$	131925	128925	126925	468520	474933	471727	336595	346008	344802
$K_3Z_3B_2$	132175	129175	127175	424830	431800	428315	292655	302625	301140

Table 2. Correlation study of various economic traits with yield

Attributes	Yield (q/ha)	Cost of cultivation (Rs/ha)	Gross income (Rs./ha)	Net income (Rs/ha)	B : C ratio	EII
Yield (q/ha)	1.000					
Cost of cultivation (Rs./ha)	0.230^{NS}	1.000				
Gross income (Rs./ha)	1.000**	0.230^{NS}	1.000			
Net income (Rs./ha)	1.000**	0.200^{NS}	1.000**	1.000		
B : C ratio	0.997**	0.153^{NS}	0.997**	0.999**	1.000	
EII	0.986**	0.372**	0.986**	0.980**	0.970**	1.000

*,**Significant at P=0.05 and P=0.01 levels, respectively.

after application of different combinations of potassium and zinc levels with biofertilizers was estimated (Table 1) and the highest net income (Rs. 336595, 346008 and 344802/ha) was estimated in $K_3Z_3B_1$, while the minimum net income (Rs. 80982, 86115 and 87049/ha) was estimated in $K_1Z_1B_2$ in first year, second year and in pooled estimation, respectively. The highest net returns related to application of high level of K or Zn and PSB in different treatments in comparison to low levels of K or Zn and KSB might be correlated with higher economic yield in these treatments (Table 2). For any cultivation practice to be acceptable to the farming society, it is necessary to have profitability which is only possible if the product has higher money value, and the inputs are less costly. Several economic indices are available to evaluate the profitability of cropping systems; however, no single index can give ideal comparison of different treatments, so a number of indices are used together to assess the economic viability of the system (Singh *et al.*, 2018a). The variation in benefit : cost (B : C) ratio of potato cultivation after application of different combinations of potassium and zinc levels with biofertilizers revealed the highest B : C ratio (3.55, 3.68 and 3.62) in $K_3Z_3B_1$, while the minimum B : C ratio (1.62, 1.68 and 1.65) in $K_1Z_1B_2$ in first year, second year and in pooled estimation, respectively (Fig. 1). The higher B : C in such treatments was correlated to the net income where higher net income and relatively lower cost of cultivation could be accountable for higher B : C ratio (Table 2).

Since the price of farm products changes from year to year, season to season and place to place, the profitability of the system also changes accordingly. In the present study, cost of cultivation, gross returns, net returns, benefit : cost ratio (B : C ratio) and effective

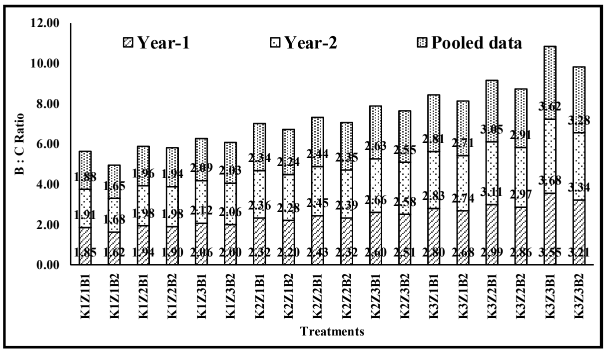

Fig. 1. Benefit : Cost (B : C) ratio of potato cultivation in year-1 (2018-19) and year-2 (2019-20) after application of different levels of potassium and zinc with biofertilizers.

income index (EII) were estimated. The EII is the relative value which is measured by comparing the net income of a cropping system with the net income of control or common cropping system of the region. This analysis can be an ideal indicator of a good cropping system as it includes all the factors viz., cost of cultivation, monetary return, relation with the existing practice and profitability of a cropping system. Further, it also ensures that the cropping system to be adopted should be better than the existing cropping system in the form of profitability.

The variation in effective income index (EII) from potato cultivation after application of different combinations of potassium and zinc levels with biofertilizers was estimated in relation to the net income obtained when potassium, zinc and biofertilizers were applied at lowest level during cultivation of potato as common practices adopted by the farmers (Fig. 2). A high degree of effectiveness was reported under different combinations of treatments with the highest EEI value in $K_3Z_3B_1$followed by $K_3Z_3B_2$, while the minimum EII value (1.73, 1.63 and 1.68) under treatment combination $K_1Z_1B_2$ in first year, second year and in pooled estimation, respectively. This could be associated with the greater net income in terms of effectiveness of unit rupee of investment as payment to factors of production. Thus, increase in income due to application of high levels of K or Zn with biofertilizers is good practice to maximize the input efficiency in terms of net income.

The variation in cost of cultivation is primarily due to variation in potassium levels, zinc levels and biofertilizers applied in different treatments accounting for variation in input cost so the per hectare cost of cultivation of potato (Ramandeep *et al.*, 2018; Amgain, 2020). The result on the gross income, net income, B : C ratio and EII value revealed the maximum estimates under treatment combination $K_3Z_3B_1$ and $K_3Z_3B_2$ confirming the improvement in monetary return with increased level of potassium and zinc in combination with biofertilizers as Azotobacter and PSB or KSB for potato cultivation. These findings are in conformity with the findings of Zelelew *et al.* (2016), Alam *et al.* (2017) and Lallawmkima *et al.* (2018b). Influence of high level of K in the treatments having K_3 might be associated with greater translocation of photosynthates, improved tuberization and accumulation of starch in tuber resulting greater economic yield and so income (de Mello Prado, 2021). Further, higher level of zinc (Z_3) might be associated with greater synthesis of growth promoters resulting improvement in stolen formation and tuberization in potato mediated by increased synthesis of amino acids (Singh *et al.*, 2018b; Zhang *et al.*, 2018). In the treatments having same level of K and Zn, PSB had responded better than KSB as it was responsible for mobilization of phosphorus in the available form to the plants and nullifying the antagonistic impact of soil calcification on bioavailability of phosphorus which is a major nutrient to the plants resulting higher economic yield and income (Adnan *et al.*, 2017; Singh and Lallawmkima, 2018).

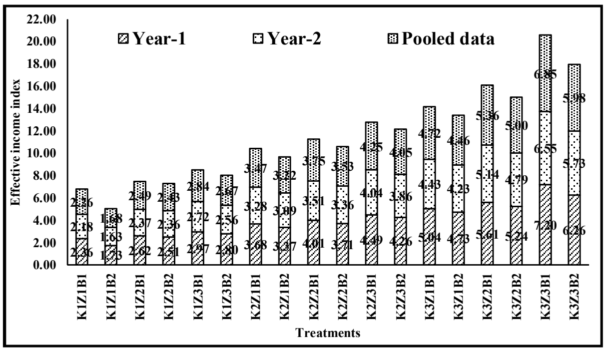

Fig. 2. Effective income index (EII) of potato cultivation in Year-1 (2018-19) and Year-2 (2019-20) after application of different levels of potassium and zinc with biofertilizers.

CONCLUSION

The present investigation confirmed the application of potassium at the rate of 80 kg/

ha and zinc at the rate of 4 to 6 kg/ha in combination with *Azotobacter* + KSB or PSB (2.5 kg/ha each) as biofertilizers or bio-inoculants for securing high gross income, net income, B : C ratio and effective income index (EII) in cultivation of potato. This may result in a stable B : C ratio of 2 or more and a sustainable effective income index of 5 or more to the potato growers.

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