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Effect of Potassium and Boron levels on yield and quality of Potato

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ABSTRACT

A field experiment was conducted during the Rabi season at Nalanda College of Horticulture Noorsarai, Nalanda, Bihar, India to evaluate the effect of potassium (75%,100%,125%,150%) of RDF(120:90;100 N:P205:K20) and boron (0,1,2,3 kg/ha) levels on potato yield and quality during rabi season with factorial RBD design with three replication. The result of three consecutive years (2020-2021, 2021-22 and 2022-23) data revealed that T-15 150 % of RDF (equivalent to 150 kg/ha potash) along with 2 kg Boron/ha given significantly higher no of tuber /hill (9.05), tuber wt (89.87g), total tuber yield (401.02 q/ha), dry matter (20.8%), Minimum total weight loss (22.79 %), Vit-c (20.67 mg/100 g) and reducing sugar (1.74 %), Net return of Rs 2.44 lakh/ha and B/C ratio 3.17 in the environmental condition of Nalanda college of horticulture, Noorsarai ,Nalanda Bihar. There are several challenges for effect of Potassium and Boron levels on yield and quality of potatoes like nutrient imbalance, soil variability, crop sensitivity, monitoring and testing etc. Potatoes are sensitive to nutrient deficiencies or excesses, different soil types and environmental conditions. Proper Potassium and Boron levels, alongwith sustainable agriculture improve efficiency of tuber production and quality by minimizing environmental impact, reducing waste and optimize fertilization practices.

Keywords: *Potato, Potassium, Boron, Quality, Yield, Total weight loss, Dry matter, Reducing sugar, Vitamin C.*

INTRODUCTION

Potato (*Solanum tuberosum*.L) family- Solanaceae, the king of vegetables, has emerged as one of the most important food crops of India.. Bihar, the land of Rivers and Riches, is also a natural abode of some of the best varieties of potatoes. They are acclaimed around the globe as the power of energy. Among the food crops potato ranks fourth after rice, wheat and maize. The vegetable, basket is incomplete without this king of vegetables, a sustaining force and a culinary delight. The power of potatoes is known for sustaining millions of lives by providing nutritious food in times of war and hunger. The high production potential per unit area, high nutritional value, and great taste make potatoes one of the most important food crops in the world. The tantalizing taste of nutrient-rich potato makes it an essential part of every breakfast, lunch, and dinner, the world over, an array of delicious dishes made from potato speaks about the varieties it offers to the plate. Full of energy, and providing carbohydrates, potatoes are low in fat, content. Potato is a low-calorie food; it is a rich source of protein, minerals, vitamins, and superior dietary fibers. To cater to needs of people of different ages, sections and strata of society, potato is eaten in various forms of delicacies-fried and non fried ones. The population in south Asian countries including India, especially eastern UP, Bihar, and Orrisa suffer from mal-nutrition. For the supply of minerals like phosphorus, calcium, and iron potatoes play a leading role, in carbohydrates, fiber, fat, and vitamin production. Potatoes also surpass the major crops of Bihar and the country as a whole.

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Moreover it is used in many industries for starch and Alcohol production [1]. Potato crops prefer well-drained, light deep, loose soil that has high organic matter.

Potassium is a limiting factor in such types of soil as soil solution K has a high chance of leaching and thus loss from the soil systems. Because of higher loss and low replenishments of potassium, wide spread deficiency of potassium has been reported in many intensively cultivated soils and the application of K fertilizers has responded satisfactorily. [20], [13] pointed out that K plays an essential role in enzyme activation, protein synthesis, photosynthesis, osmoregulation, stomata movement, energy transfer, phloem transport, cation- anion balance and stress resistance.

Potassium is one of the most essential nutrients required for plant development. It plays a vital role in several physiological processes such as Photosynthesis, translocation of photosynthetes, control of ionic balance, regulation of plant stomata and transpiration, activation of plant enzymes, and many other processes.[14], [5]. Potassium also enhances protein synthesis resulting in better foliage growth. In plant cells potassium maintains osmotic potential which enhances water uptake and root permeability and acts as a guard cell besides this it also increases water use efficiency [22].

Boron is involved in numerous important processes, including protein synthesis, transport of sugar , respiration , RNA, plant hormones and carbohydrate metabolism, flowering and fruiting [19], [07]. Moreover, the function of boron is related to cell wall synthesis, lignifications, and cell wall structure by cross-linking of cell wall polysaccharides as well as the structural integrity of bio-membranes [18]. Boron is critical for the process of cell differentiation at all growing tips of plants (meristems), where cell division is active [02]. Boron plays an essential role in the development and growth of new cells in the meristem, proper pollination and fruit or seed set, translocation of sugar, starch, nitrogen, and phosphorus, synthesis of amino acid and protein, regulation of carbohydrates-metabolism and stabilizer stabilizes the oxidative systems in plants.

MATERIAL AND METHODS

A field experiment was conducted at the farm of the Nalanda College of Horticulture, Noorsarai, Nalanda, in three consecutive Rabi seasons of 2020-21, 2021-22, and 2022-23. The soil is slightly saline in reaction (PH 8.10) with low content in organic matter (0.76%) total-available nitrogen (175 kg/ha), phosphorus (56.77 kg/ha) potash (170.40 kg/ha) and Boron (10.10 PPM). Four levels of potassium (75,100,125,150 % of RDF from MOP and four levels of Boron (0, 1, 2, 3 kg/ha) from borax were the treatment variables. The trial was set up in a randomized complete block design under a factorial arrangement with three replications-and eight treatments. Cowdung at the rate of 5t/ha was used in all the plots. Unit plot size was 3.0m x 4m.full doses of DAP, cowdung and 1/2 dose of urea were applied at the time of final land preparation The remaining urea was top dressed in two equal installments after the 4th and 8th week of transplanting. The variety K. Lalit was used as a test crop-Tuber was transplanted on 5th November in 2020,10th November 2021 and 7th November 2022 at a spacing of 60 cm x 15 cm. Mulching ,weeding, and irrigation were done and plant protection measures were taken whenever required at maturity. These samples were dried at 70 degrees C in the oven until a constant weight was attained these dry bulbs were used for the estimation of NPK and S contents nitrogen content in the bulb was determined by Kjeldahl digestion method, Phosphorus content by calorimetrically using the chlorostannus reduce molybdenum phosphoric blue color method in the phosphoric system.

Potassium was determined by using a flame photometer and boron content was determined by the ASI method. Nitrogen, phosphorus, potassium and boron uptake were estimated as the dry matter multiplied by NPK and B contents (%). Ten randomly selected plants were harvested from each plot to record the data related to growth parameters. The crop was harvested on the 5th of March in 2021, the 12th in 2022 and 4th March 2023. Bulb yield was recorded-from an area of 12-meter squares from each plot avoiding the border effect. The data were then statistically analyzed and means were compared by using the least significant difference (LSD) test. After harvesting the tubers are stored in open plastic crates for four months. Thereafter, Dry matter %, Reducing sugar %, Vitamin-C mg/100g, and Total weight loss could be calculated.

RESULTS AND DISCUSSION

1. Effect of potassium levels

The result demonstrated that potassium on growth and yield of potato cultivar Kufri Lalit. The maximum plant height (51.02cm), No of leaves(53.95), No of tuber/hill (8.81), Tuber weight (82.42 g), and Total tuber yield (364.34 q/ha) were recorded in K4 (150% of RDF) while minimum with K1 (75% of RDF) similar findings have been reported by [11], [04]. Increase in growth, yield and quality attributes of the plant might be due to increased uptake of potassium and its supply resulting in higher production of carbohydrates and phyto- hormones which were manifested in the form of enhanced growth as explained Increase in total yield and the yield of large tubers due to K large molecular weight substances with in storage fertilization may be due to the stimulating effect of potassium on photosynthesis, phloem loading and translocation as well as the synthesis of organs contributing to the rapid bulking of the tubers [16]. Also, Dry matter % (20.13), Reducing sugar % (1.66), Vit-c (19.91mg/ 100g and Minimum % Total wt loss (26.35) were obtained with K4 (150% of RDF) at par .with K3 (125% of RDF), Reducing sugar (1.51%) and minimum Total wt loss (27.42 %). These results are in agreement with those obtained by [11], [04].

2. Effect of Boron levels

Boron showed influence on the growth and yield parameters of potato cv. Kufri Lalit, .The maximum plant height (43.00 cm), No of leaves (44.18), No of tuber/hill(8.27), Tuber wt (71.95g), Total tuber yield(306.42) q/ha were recorded significantly in B3(2kg B/ha) which was at par with B4 (3 kg B/ha) .But in case of. the plant height (42.22 cm), No of leaves(43.75) ,No of tuber /hill(8.14) ,Tuber weight(71.65 g) and Total tuber yield (282.71q/ha). Increasing boron reaching the maximum at 2 kg B/ha there after reduced. [21] confirmed that the application of boron reduces chlorophyll degradation in radish leaves by lowering nickel toxicity. The overall increase in the quality of the plant might be due to the increased uptake of Boron upto B3 (table-2). The maximum dry matter content of the tuber (20.13%), Reducing sugar(1.60%),Vit-c (20.22mg/100g) and Minimum total weight loss (25.68%) were recorded with is at par with B4 @3 kg/ha in dry matter (17.59 %), Reducing sugar (1.49 %) ,Vit-c (19.94 mg/100g) and Minimum tuber weight loss(25.68 %).Boron exerts a positive effect on improving frying quality of potatoes by reduction of reducing sugar and total phenol content [09].

3. Combined effects of potassium and Boron

Almost all the parameters were significantly influenced by the combined effect of different levels of potassium and boron except, plant height and, no. of leaves of potato cv. Kufri Lalit, the maximum no. of Tuber/hill was 9.05, Tuber weight (89.87 g), and Total tuber yield (401.02 q/ha) were recorded. Greater tuber yield may further be attributed to increased availability of these nutrients for the actively growing plants [17], increasing RNA and DNA contents in reproductive tissues [15], and thereby increased translocation of photosynthesis from source to sink or tubers during entire tuber growth stage. But in the case of plant height and no of leaves-data was non-significant. Also the maximum dry matter accumulation (20.80%), reducing sugar (1.74 %), Vit-C. (20.67 mg/100g) and Minimum % loss of tuber wt (22.74). The positive effect of potassium sources and boron combination treatment on starch could be interpreted by multiple physiological functions of both elements. Also, the foliar application of potassium and boron enhanced the dry matter content of tubers, which is highly essential for processing into chips and fries as stated by [03]. In this connection, [06] showed that using potassium plus boron as foliar spray produced the highest values of starch and total sugars percentage in potato tubers ability of potassium to improve dry matter and specific gravity. The positive effect of potassium sources and boron combination treatment on starch could be interpreted by multiple physiological functions of both elements. The ability of potassium to improve dry matter and specific gravity was reported by [08].

The combined effect of potassium and Boron on potato uptake was found to be synergistic .Further increase of potassium levels (150 % of RDF) equivalent to 150 kg potash and Boron 2 kg /ha tends to decrease the potassium uptake by potato tuber following the pattern similar to be obtained boron uptake.

Potassium and Boron might have promoted the availability of native soil potassium and Boron reflected by their uptake. These increases may be ascribed to the role of foliar spray with potassium on increasing photosynthetic activity which accounts much for the high translocation of photo-assimilates from leaves to the tuber [10]. Boron increases the rate of photosynthesis by affecting the photo phosphorylation process into chloroplasts and shifting the hormonal balance in leaves and tubers especially IAA which is important for tuber growth after the onset of tuberization [12], Also, it has roles in cell elongation and nucleic acid synthesis. Also, it has roles in cell elongation and nucleic acid synthesis.

Economics

An economic evaluation of treatments revealed that the application of potassium as well as Boron enhanced the gross income, Net income as well as cost-benefit ratio highest gross income (Rs 320816.00 /ha), Net income (Rs243958.00 /ha) as well as cost-benefit ratio (3.17), were recorded with application of potassium (150 kg/ha potash) along with 2 kg Boron. These results may be due to an increase in economic yield with increasing dose of potassium and boron. More increase in economic yield as compared to increase in expenditure resulted in higher total return, net income as well as per rupee investment under potassium (150 kg potash) along with 2 kg boron. (Table-5)

Conclusion

The study revealed that potassium enhanced potato tuber yield and improved the quality of the produce. Plant nutritional status and tuber quality were positively affected by Potassium and Boron application. There was a significant difference in the response of potatoes regarding the yield among both the applied K and B levels. This meant that both levels were equally effective as far as yield is concerned.

Future Scope of the Experiment

By adjusting nutrient management to particular environmental and agronomic conditions, Soil and Crop Specificity, Precision Agriculture, Synergistic Effects, Nutrient Uptake Mechanisms, Climate Change Resilience, Sustainable Fertilization Practices, and Quality Enhancement make potato farming more accurate, sustainable, and profitable.

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Table -1 Individual effect of Potassium and Boron levels on growth and yield of Potato (Three year pooled data)

Treatments	Plant height in (cm)	No of leaves	No of tuber /hill	Tuber weight in gram	Total weight in (q/ha)
K1@75%of RDF	27.66	28.33	6.19	52.81	190.75
K2@100%f RDF	33.69	35.95	7.84	68.32	250.21
K3@125%f RDF	42.74	45.44	8.41	76.94	302.09
K4@150%of DF	51.02	53.95	8.81	82.42	364.34
CD@ 5%	3.23	3.58	0.24	4.99	17.81
SE(m)	1.12	1.23	0.081	1.72	6.14
B1@0 kg /ha	36.40	37.92	7.26	65.27	245.50
B2@ 1 kg/ha	39.27	40.82	7.62	70.53	272.75
B3@ 2 kg/ha	43.00	44.18	8.27	71.95	306.42
B4 @3 kg/ha	42.22	43.75	8.14	71.65	282.71
CD@ 5%	3.23	3.58	0.24	N/S	17.81
SE(m)	1.12	1.23	0.081	1.72	6.14
Interaction	N/S	N/S	0.47	9.98	35.63

Table 1a. Interaction effect of Potassium and Boron levels on tuber/hills

K Levels	B1	B2	B3	B4	Mean(B)	CD(P=0.05)	SE(m)
K1	4.98	6.25	6.55	6.98	6.19	K=0.23	0.08
K2	6.95	7.50	8.85	8.08	7.85	B=0.23	0.08
K3	8.50	8.02	8.62	8.51	8.41	KXB=0.47	0.16
K4	8.61	8.72	9.05	9.01	8.81		
Mean(K)	7.26	7.62	8.23	8.14			

Table 1b. Interaction effect of Potassium and Boron levels on tuber yield (q/ha)

K Levels	B1	B2	B3	B4	Mean(B)	CD(P=0.05)	SE(m)
K1	190.00	202.33	200.00	170.67	190.75	K=17.80	6.14
K2	187.00	243.33	295.67	275.83	250.21	B=17.80	6.14
K3	272.67	298.00	329.00	308.67	302.09	KXB=35.63	12.33
K4	332.33	348.33	401.02	375.67	364.34		
Mean(K)	245.50	272.75	306.42	282.71			

Table -2 Individual effect of Potassium and Boron levels on quality of potato (three year pooled data)

Treatments	Dry matter %	Reducing sugar %	Vit-C mg/100g	% Total wt loss
K1@75%of RDF	14.99	1.28	18.08	33.64
K2@100%f RDF	16.38	1.39	18.77	30.04
K3@125%f RDF	18.37	1.51	19.55	27.42
K4@150%of DF	20.13	1.66	19.91	26.35
CD@ 5%	0.36	0.018	0.35	1.74
SE(m)	0.13	0.006	0.12	0.60
B1@0 kg /ha	17.05	1.39	17.95	33.57
B2@ 1 kg/ha	17.48	1.36	18.21	31.63
B3@ 2 kg/ha	17.76	1.60	20.22	25.68
B4 @3 kg/ha	17.59	1.49	19.94	26.26
CD@ 5%	0.36	0.018	0.35	1.74
SE(m)	0.13	0.006	0.12	0.60
Interaction	0.56	0.018	0.87	0.59

Table 2a. Interaction effect of Potassium and Boron levels on dry matter (%)

K Levels	B1	B2	B3	B4	Mean(B)	CD(P=0.05)	SE(m)
K1	14.20	14.97	15.20	16.60	15.24	K=0.28	0.97
K2	16.32	16.98	15.89	16.35	16.38	B=0.28	0.97
K3	18.32	17.98	18.97	18.22	18.37	KXB=0.56	1.94
K4	19.36	19.98	20.80	20.21	20.09		
Mean(K)	17.05	17.45	17.71	17.84			

Table 2b. Interaction effect of Potassium and Boron levels on reducing sugar (%)

K Levels	B1	B2	B3	B4	Mean(B)	CD(P=0.05)	SE(m)
K1	1.19	1.18	1.69	1.12	1.30	K=0.009	0.003
K2	1.34	1.26	1.28	1.70	1.39	B=0.009	0.003
K3	1.48	1.37	1.72	1.46	1.51	KXB=0.018	0.006
K4	1.55	1.65	1.74	1.68	1.66		
Mean(K)	1.39	1.36	1.61	1.49			

Table 2c. Interaction effect of Potassium and Boron levels on Vit-c mg/100g

K Levels	B1	B2	B3	B4	Mean(B)	CD(P=0.05)	SE(m)
K1	16.20	16.60	19.65	19.86	18.08	K=0.44	0.15
K2	17.62	17.80	20.02	19.65	18.80	B=0.44	0.15
K3	18.96	19.03	20.50	19.73	19.55	KXB=0.87	0.30
K4	19.03	19.40	20.67	20.53	19.91		
Mean(K)	17.95	18.21	20.21	19.94			

Table 2d. Interaction effect of Potassium and Boron levels on % Total wt loss

K Levels	B1	B2	B3	B4	Mean(B)	CD(P=0.05)	SE(m)
K1	39.90	38.60	28.35	27.70	33.64	K=0.29	0.10
K2	33.60	32.20	26.50	27.86	30.04	B=0.29	0.10
K3	30.90	27.00	24.93	25.60	27.11	KXB=0.59	0.20
K4	29.90	28.74	22.74	23.96	26.34		
Mean(K)	33.57	31.63	25.63	26.28			

Table 3. Economics as influenced by Potassium and Boron levels on Potato (Three year pooled data)

Treatments	Yield (q/ha)	Gross Return(Rs/ha)	Net return(Rs/ha)	Cost/ha	B:C Ratio
T1 (KIBI)	190.00	152000	77538.20	74461.8	1.04
T2 (KIB2)	202.33	161600	86360.10	75239.9	1.15
T3 (KIB3)	200.00	160000	83982.40	76017.6	1.10
T4 (KIBI)	170.67	136356	59740.40	76795.6	0.78
T5 (KIBI)	187.00	149600	74858.20	74741.8	1.00
T6 (KIBI)	242.33	193864	118344.10	75519.9	1.57
T7 (KIBI)	295.67	236536	160238.40	76297.6	2.10
T8 (KIBI)	277.50	222000	144925.00	77075.6	1.88
T9 (KIBI)	272.67	281136	206114.20	75021.8	2.75
T10 (KIBI)	298.00	238400	162600.10	75799.9	2.14
T11 (KIBI)	329.00	263200	186622.40	76577.6	2.44
T12 (KIBI)	308.67	246936	169580.40	77355.6	2.19
T13 (KIBI)	332.33	265864	190562.20	75301.8	2.53
T14 (KIBI)	348.33	278664	202584.10	76079.9	2.66
T15 (KIBI)	401.02	320816	243958.40	76857.6	3.17
T16 (KIBI)	375.67	300536	222900.40	77635.6	2.87

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