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Effect of NPK Levels on Potato (*Solanum tuberosum* L.) Tuber Yield Attributes in the North Zone of Bihar, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This field research was carried out on a potato crop of the cultivar *Kufri Lalit* in the Rabi season of 2021–2022. at research farm of TCA, Dholi (Muzaffarpur), Bihar13 treatments and 3 replications were used in this experiment's randomised block design. The experimental location had a sandy loam texture, a reaction pH of 8.47 that is alkaline a low organic carbon content of 0.43%, and accessible N (223 kg ha^{-1}). However, P (16.95 kg ha^{-1}) and K (131.46 kg ha^{-1}) availability is

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moderate. The varying levels of key nutrients had a substantial impact on all growth and yield parameters, including percent emergence, plant height, shoot and leaf number plant^{-1}, dry matter accumulation, tuber bulking rate and yield. Among all treatments, treatment T_{10} (240N, $120P_2O_5$ and $150K_2O$ kg ha^{-1}) recorded highest per cent emergence (94.00 %), plant's height (44.27), shoot's number plant^{-1} (5.60), leave's number plant^{-1} (56.30), tuber yield (26.53 t ha^{-1}) and treatment T_{10} also recorded statistically at par with treatment T_6.

Keywords: Potato; treatments; varying levels; alkaline.

1. INTRODUCTION

Potato (*Solanum tuberosum* L.) is classified under family Solanaceae and in terms of human consumption world's IIIrd most significant food crop after wheat and rice. Potato appears to have developed via isolation in both geography and ecology. In general, potatoes needed an acidic soil with a pH of 5.5 for optimum growth and development. A number of many types of soils Mollisols, Inceptisols, Alfisols, Entisols, and Vertisols, are also used to grow potatoes. In terms of texture, sandy loam soils with a pH 5.50 to 8.0 are said to be the best for growing potatoes. Because of its sensitivity to alkalinity, potato cultivation should be avoided on soils with a pH of more than 8.2. [1]. The most significant dietary component of the potato, which has excellent nutritional value and contains crucial essential dietary elements, is carbohydrates, Proteins, minerals including calcium (Ca), phosphorus (P), and iron (Fe), as well as vitamins B_1, B_2, B_6, and C are other essential components. It is made up of 70-82 percent water, 11-23 percent carbs, 0.8-3% protein, 0.1-% fat, 1.1-% mineral, and 17-29 percent dry matter. Ash content is 0.90 percent [1].

Nitrogen is mostly contained in plants in the form of the plant cell wall, chlorophyll, protein content, DNA, and RNA. In general, a plant employs nutrients to carry out tissue growth, cell expansion, and the development of organs and systems. Nitrogen makes up between 2 and 7 percent of the Plant. The amount of nitrogen that plants need varies depending on the species. Plants that need a lot of water have large vegetative development, food reserves, or reproductive structures. Nitrate and ammonium in soils are the two main nitrogen sources for plants. Owen and Jones, [2]. A lack of nutrients can cause stunted growth, tissue death, or yellowing of the leaves because less chlorophyll, a pigment vital to photosynthesis, is produced.

After nitrogen, phosphorus (P) is the mineral nutrient that has the greatest impact on crop output in the potato plant. P is the most significant primary nutrient limiting factor for potato development after nitrogen and potassium, according to Jasim *et al.* (2020). Reduced carbon absorption results from a lack of a deficiency in P that directly impacts photosynthesis by lowering the quantity of inorganic P available in the chloroplast. a deficiency in P in leaf mesophyll cells. According to enhanced photo assimilation to the roots is promoted by phosphorus deficit. At a yield of 29 t ha^{-1},

potatoes lose around $91K_2O$ kg ha^{-1}, with potassium enhancing both marketable and total tuber weight by increasing average tuber diameters. Moinuddin *et al.,* [3]. More so than on yield, potassium fertilisation has a beneficial impact on the quality of the tubers. The most popular techniques for recommending potassium for crops are based on soil testing., and while they occasionally work well for directing fertiliser applications, it is important to establish the crucial level of soil test potassium. The alternative strategy is to base fertiliser recommendations on agronomic effectiveness and yield response. Similar to how nitrogen absorption by potato crops is influenced by meteorological conditions, soil type, fertility, farmed variety, and crop management techniques. According to Bhattarai and Swarnima [4] Maintaining osmotic potential enhances root permeability and water absorption, regulates ionic equilibrium controls stomata in plants and stimulates enzymatic reactions. Potassium aids in all of these processes.

2. MATERIALS AND METHODS

The current research trial investigated in plot number 11 at TCA Farm, Dh0li, Muzaffarpur, Dr. RPCAU, Pusa (Samastipur), Bihar, during the Rabì seas0n of 2021-2022. The experimental site situated at 25^{0}98' North (N) latitude and 85^{0}60' East I longitude on the Burhi Gandak river's southern bank, which is 52.2 metres above mean sea level. Experimental soil was calcareous-alluvium and somewhat alkaline in nature heaving pH 8.47 and soil was moderately fertile-being low organic carbon (0.43%), nitrogen (223 kg ha^{-1}), potassium (131.46 kg ha^{-1}) and medium phosphorus content (16.95%). The crop was sown in November eighteen at 60x20 row to row and plant to plant spacing. Experiment was laid out in RCBD statistical design with 3 replications involving following treatments T_1-(Control), T_2 (150N, $90P_2O_5$ and $100K_2O$ kg ha^{-1}), T_3 (0N, $80P_2O_5$ and $150K_2O$ kg ha^{-1}), T_4 (120N, $8OP_2O_5$ and $150K_2O$ kg ha^{-1}), T_5 (180N, $80P_2O_5$ and $150K_2O$ kg ha^{-1}), T_6 (240N, $80P_2O_5$ and $150K_2O$ kg ha^{-1}), T_7 (300N, $80P_2O_5$ and $150K_2O$ kg ha^{-1}), T_8 (240N, $0P_2O_5$ and $150K_2O$ kg ha^{-1}), T_9 (240N, $40P_2O_5$, and $150K_2O$ kg ha^{-1}), T_{10} (240N, $120P_2O_5$ and $150K_2O$ kg ha^{-1}), T_{11} (240N, $80P_2O_5$ and $0K_2O$ kg ha^{-1}), T_{12} (240N, $80P_2O_5$ and $50K_2O$ kg ha^{-1}), T_{13} (240N, $80P_2O_5$ and $100K_2O$ kg ha^{-1}).

The variety *Kufri Lalit* was developed by clonal selection from the hybrid 85-P-670 x CP-3192 with selection number 2001-P-55 at CPRI, Shimla (HP.) in 2014. It is released for cultivation mainly in North-eastern plains of India.

% Plant emergence = total number emerged plants / total planted tubers x 100

2.1 Plant's Height

Randomly chosen 5 plants from every plot were measured in height extending from the soil to the plant neck. The height was averaged using centimeter measurements.

2.2 Total Shoot's Number Plant^{-1}

The potato's shoots number $plant^{-1}$ counted at an interval of two weeks in each plot from randomly selected plant.

2.3 Total Leave’s Number Plant^{-1}

The number of plant's leaves $plant^{-1}$ was counted from randomly selected five plant of net plot area of each plot at 45DAP, 60DAP, 75DAP, and at harvest.

2.4 Accumulation of Dry Matter (g plant^{-1})

Measurements of dry matter accumulated (g $plant^{-1}$) where two plants plucked from every plot of each treatment's gross plot area. The weight of the entire plant (tuber and shoots) was measured and averaged. The plants were then cut into bits, and 100 g of the total ‘homogenous samples’ were stored in paper bags, dried by oven, and then baked at 70^0 degrees Celsius in hot air oven till a consistent mass was achieved. As a result, the dry weight $plant^{-1}$ $treatment^{-1}$ ratio was calculated.

2.5 Tuber's Bulking Rate (g day^{-1}plant^{-1})

Tuber's bulking rate observation was taken at 45DAP, 60DAP, 75DAP and at harvest. On fresh weight basis of tubers, an increase tuber weight at 15-day intervals was calculated splitting the weight of tubers between 15 days intervals in g $day^{-1}plant^{-1}$.

2.6 Tuber's Yield (t ha^{-1})

All the collected tubers from the net plot area of each where shadow dried tuber weights was calculated by using electronic balance into t ha^{-1}.

2.7 Haulm Yield (t ha^{-1})

Fifteen plants selected from each plot of net plot area were removed and properly Dried, and the mass of the vines was documented in kilograms $plot^{-1}$.

Harvest index (%)= Tuber's yield (t ha-1) / (Tuber's yield + Vine's yield) (t ha-1) x100

3. RESULTS AND DISCUSSION

3.1 Growth Parameter

Data presented in Table No.- 1 revealed that Response of different nutrients level on Plant emergence (%) at 30 DAP, Plant height(cm), Number of Shoots $plant^{-1}$and Number leaves $plant^{-1}$ reading were significantly increased by the application of different levels of NPK compare with control. Generally, the maximum value of growth parameter was observed with the was noted in treatment T_{10} (240N, $120P_2O_5$ $150K_2O$ kg ha^{-1}) as compared to other treatments and these are statistically at par with the T_7 (300N, $80P_2O_5$ $150K_2O$ kg ha^{-1}) and T_6 (240N, $80P_2O_5$ $150K_2O$ kg ha^{-1}). In plant emergence different treatments had a non-significant effect on germination in percent at 30 DAP. Fertilizer levels generally had almost no impact on germination as compared to alternative treatments, NPK kg ha^{-l} had uneven germination at 30^{th} day after

Table 1. Response of different nutrients level on Plant emergence (%) at 30 DAP, Plant height(cm), Number of Shoots plant-1and Number leaves plant-1

Treatments					Plant height(cm)				Number of Shoots plant^{-1}				Number leaves plant^{-1}			
	N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})	Plant emergence (%) at 30 DAP	45 DAP	60 DAP	75 DAP	At harvest	45 DAP	60 DAP	75 DAP	At harvest	45 DAP	60 DAP	75 DAP	At harvest
T_1	Control			87.79	18.9	22.5	24.63	27.96	2.53	2.97	3.27	3.27	27.33	32.33	36.23	21.8
T_2	150	90	100	92.45	27.4	34	36	38.6	3.65	4.44	4.9	4.9	39.83	45.64	47.56	33.04
T_3	0	80	150	90.48	23.2	24.04	28.6	33.33	2.6	3.33	3.78	3.78	32.54	35.78	37.8	24.56
T_4	120	80	150	92.33	26.6	34.57	34.54	37.8	3.53	4.2	4.83	4.83	39.3	43.9	46	32
T_5	180	80	150	93.2	28.17	35.07	38.9	41	4	4.9	5.04	5.04	40.6	47.6	51.6	34.27
T_6	240	80	150	93.78	29	35.9	39.63	41.8	4.27	5.33	5.42	5.42	42.7	50.77	54.6	35.33
T_7	300	80	150	92.01	30.9	37	41.5	43.1	4.07	5.23	5.19	5.19	41.67	49.93	53.7	34.37
T_8	240	0	150	88.23	24.74	31.46	32.44	36	2.97	3.74	4.17	4.17	36.67	40.8	43.8	29.43
T_9	240	40	150	92	25.7	33.9	34	37	3.23	3.97	4.78	4.78	38	43.33	45.8	31.8
T_{10}	240	120	150	94	32.3	37.8	42	44.27	4.5	5.47	5.6	5.6	43.2	52.43	56.3	37.5
T_{11}	240	80	0	89.52	24.6	28.38	31	34.8	2.8	3.6	3.9	3.9	34	37.27	39.9	27.8
T_{12}	240	80	50	91.86	25	32.5	33.3	36.4	3.08	3.8	4.47	4.47	37.6	42	45.12	30.8
T_{13}	240	80	100	92.9	27.9	34.87	37.6	39	3.8	4.78	5	5	40.36	46.33	49.9	33.9
SEm (±)				3.14	1.11	0.93	0.91	1	0.15	0.18	0.13	0.13	0.92	1.37	1.56	0.88
LSD (p=0.05)				NS	3.23	2.71	2.65	2.92	0.43	0.53	0.39	0.39	2.69	3.99	4.56	2.57

Table 2. Response of different nutrients level on Dry matter accumulation (g plant^{-1}), Bulking rate (g day^{-1} plant^{-1}), Harvest index (%), haulm yield (t ha^{-1}) and Tuber yield (t ha^{-1})

Treatments				Dry matter accumulation (g plant^{-1})				Bulking rate (g day^{-1} plant^{-1})			Harvest Index (%)	Haulm yield (t ha^{-1})	Tuber yield (t ha^{-1})
	N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})	45 DAP	60 DAP	75 DAP	At harvest	45 DAP	60 DAP	75 DAP			
T_1	Control			19.64	22.64	29	11.28	2.52	3.43	0.97	63.62	6.45	11.28
T_2	150	90	100	26.23	22.24	45.43	77.19	3.25	68.31	2.94	68.31	10.32	22.24
T_3	0	80	150	21.33	15.94	33.76	56.91	2.63	68.15	1.42	68.15	7.45	15.94
T_4	120	80	150	25.46	21.54	43.96	75.05	3.14	68.61	2.61	68.61	9.86	21.54
T_5	180	80	150	27.77	23.64	49.32	81.9	3.68	69.09	3.37	69.09	10.58	23.64
T_6	240	80	150	29.25	25.23	52.23	83.95	3.95	68.43	3.64	68.43	11.64	25.23
T_7	300	80	150	28.57	24.63	51.09	83.05	3.83	68.9	3.56	68.9	11.12	24.63
T_8	240	0	150	23.65	17.05	36.07	65.05	2.76	63.86	1.86	63.86	9.65	17.05
T_9	240	40	150	24.79	20.18	39.9	71.1	3.04	66.98	2.39	66.98	9.95	20.18
T_{10}	240	120	150	30.83	26.53	55.74	85.5	4.33	69.12	3.92	69.12	11.85	26.53
T_{11}	240	80	0	22.25	16.45	35.7	61.43	2.7	63.83	1.71	63.83	9.32	16.45
T_{12}	240	80	50	24.11	19.85	37.6	67.06	2.96	66.97	2.05	66.97	9.79	19.85
T_{13}	240	80	100	26.86	23.17	47.54	77.65	3.42	68.89	3.1	68.89	10.47	23.17
SEm (±)				0.73	0.8	1.43	0.93	0.11	0.17	0.07	1.95	0.42	0.93
LSD (p=0.05)				2.13	2.34	4.18	2.69	0.34	0.48	0.2	NS	1.24	2.69

planting. Additionally, it was shown that increasing fertiliser levels caused a delay in the development of tubers [5]. The same conclusions were reached Marthha *et al*. [6] and Barman *et al.* [7]. The height of the dominant (44.27cm) plant was measured in treatment T_{10} (240N, $120P_2O_5$ $150K_2O$ kg ha^{-1}) at several growth stages. Statistics showed that treatment T_{10} was comparable at par with T_7 (300N, $80P_2O_5$ $150K_2O$ kg ha^{-1}) but in T_6 (240N, $80P_2O_5$ $150K_2O$ kg ha^{-1}) at only 60 days after planting at par with T_{10}. This is due to the fact that applying a relatively large amount of nitrogen causes the plant to develop quickly [5] similar findings was documented by Thirupal *et al.* [8]. The maximum shoot's (5.60) number $plant^{-1}$ was recorded with T_{10} (240N, $120P_2O_5$ $150K_2O$ kg ha^{-1}) it is statistically at par with treatment T_6 (240N, $80P_2O_5$ $150K_2O$ kg ha^{-1}) deliberately more than remained treatments When applying different chemical fertiliser dosages to potatoes, the number of shoots per plant did not alter significantly Marthha *et al*. [6] These kinds of results as reported Singh and Gupta [9] and Kumar *et al.* [10]. Number of leaves $plant^{-1}$ (56.3) are affected by different level of fertilizers markedly varied between treatments respectively the maximum leaves number $plant^{-l}$ was found in $T_{10.}$ It was statistically similar with T_6 and T_7. The response of different potato level to NPK treatment varies significantly, demonstrating a significant interaction between varieties and Application of NPK based on the number of leaves at distinct development stages. The greatest and smallest leaf counts per plant were measured using the application of NPK Thirupal *et al.* [8] The current findings were similar to research conclusions of Marthha *et al*. [6].

3.2 Yield Components

As shown in Table (2), in the most cases treatment T_{10} (240N, $120P_2O_5$ $150K_2O$ kg ha^{-1}) exhibited high significant increases of yield components included Dry matter accumulation (g $plant^{-1}$), Bulking rate (g day^{-1} $plant^{-1}$), Harvest index (%) haulm yield, (t ha^{-1}) and Tuber yield (t ha^{-1}) tested seasons compared to control treatment. Dry matter accumulati0n (g $plant^{-1}$) was recorded maximum (85.5) with T_{10} and it was statistically similar with treatment T_5 (81.90 g $plant^{-1}$), T_6 (83.95 g $plant^{-1}$) T_7 (83.05 g $plant^{-1}$). The total DMA rose as crop ages increased, while the total DMP was significantly influenced by NPK levels (Banerjee *et al.*2016). Chemical fertilizer supply plant nutrients easily that can be quite significant in photosynthetic activity of and dry matter accumulation activity of plants. These research's conclusions concur with those of Kushwah *et al.* [11] Alam *et al.* [12] Lal and Khurana [13] and Patel [14]. tuber bulking rate difference that is statistically significant between all of the treatments The bulking rate was registered maximum (7.87) at 60 DAP with treatment T_{10} and lowest (0.97) bulking rate at 75DAP was observed with T_1 (control). This was primarily caused by plants satisfying dosages diverting more sugars and photosynthates for cr0p growth and development, increasing the amount of radiation captured, an increase in the production of photosynthates. this outcome comparable to the end of Meena *et al.* [15] and Banerjee *et al.* [16]. The observed mean data for harvest index showed that, despite statistical analysis of the no effects of various fertilizers level on various treatments, The partitioning of photosynthates to sink and the greater photosynthetic rate during the tuberization stage may be to blame for this. This result was supported by Nag [17] and Patel [14]. The quintessential haulms yields were considered and recorded maximum (11.85 t ha^{-1}) with T_{10} (240N, $120P_2O_5$ $150K_2O$ kg ha^{-1}). These are statistically at par with treatments T_6 and $T_{7.}$ finding of Shaaban and Kisetu [18] and Uzatunga *et al.* [19]. the key factor contributing to the rise in the haulms yield seems to be the availability of nitrogen at increasing at a particular level. The tuber yield (t ha^{-l}) data gathered showed that different level of fertilizes treatments had a significant impact on the tuber yield (t ha^{-1}). best tuber yield (26.53) with all possible treatments was produced with treatment $T_{10.}$ Higher growth and production may be attributable to the crop's improved nutrient availability, which may have raised the plant's photosynthetic capacity and metabolic activity with an up to a particular amount of NPK dose increase. Adhikari [5] the current research finding conform to findings of Sharma and Singh [20] and Rykbost *et al.* [21].

4. CONCLUSION

Out of thirteen treatments tested during the research work, treatment T_{10} (240N, $80P_2O_5$ $150K_2O$ kg ha^{-1}) was showed that the higher number of leaves, shoots, dry matter accumulati0n, plant height, tuber bulking rate and tuber, haulm yield and harvest index. However, variety *Kufri Lalit* responded significantly to the levels of NPK application and resulted better responses and trends were observed with the use of 240N, $80P_2O_5$ $150K_2O$ level of fertilizer. The germination percentage at 30 days after planting and harvest index showed no discernible variation between the treatments. at several growth stages, including 45, 60, 75 and at harvest the number of leaves, shoots, plant height dry matter accumulati0n, tuber bulking rate on a plant was significantly impacted by different treatments.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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