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Integrated effect of humic acid, biofertilizers and inorganic fertilizers on growth and yield of potato (*Solanum tuberosum* L.) var. Kufri Chandramukhi

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Abstract

The current study entitled “Integrated effect of humic acid, bio-fertilizers and inorganic fertilizers on growth and yield of potato (*Solanum tuberosum* L.) Var. Kufri Chandramukhi” was conducted at Horticulture Research Farm, College of Agriculture, RVSKVV, and Gwalior (M.P.). Potato (*Solanum tuberosum* L.) is an annual herbaceous plant belonging to family *Solanaceae*. Being a cool-season vegetable crop, potatoes are well suited in temperate locations where the average temperature of their growth typically does not exceed 18°C. Potato is a high yielding crop but depletes nutrients from the soil quickly and has a short growing season. Relying too heavily on inorganic fertilizers, can cause imbalances in nutrients and harm the physical, chemical, and biological properties of soil. Biofertilizers such as *Azotobacter*, PSB, and KSB have been identified as affordable alternatives for enhancing soil fertility and maximizing crop yield. Application of natural resources like humic acid along with NPK fertilizers led to a reduction in the leaching of nitrogen and potassium to lower soil layers, while also increasing the availability of phosphorus. Three replications of the experiment were set up in the RBD. Each replication was comprised of thirteen treatments consisting different doses of humic acid as foliar spray, bio-fertilizers like *Azotobacter*, PSB, and KSB, with different quantity of inorganic fertilizers. The treatment T₁₃ [N (75%) + P (75%) + K (75%) + *Azotobacter*+ PSB+KSB+ Humic acid (2%)] was found best among all treatments and it also gave the maximum growth, yield, and economic parameters.

Keywords: Potato, bio-fertilizers and humic acid, inorganic fertilizer

Introduction

Potato (*Solanum tuberosum* L.), an annual herbaceous plant with the chromosome number $2n=4x=48$, is a member of *Solanaceae* family. The Potato is known as “King of Vegetables”. Potatoes, a staple food in many regions of the world, are crucial to the world’s food supply. Potato has 79% water content, 17% carbohydrate content (of which 88% is starch), 2% protein content, and very little fat. Essentially, 100 gram of fresh potatoes have 77 calories and are good source of vitamins B₆ and C. Since potatoes are an important food crop, they thrive in temperate climates where the average temperature during their growth normally does not exceed 18°C. (Kumar and Rathiya, 2022) [9]. The area and production in India, respectively, are 2203 thousand hectares and 56.17 mt (Anonymous, 2021) [2]. In Madhya Pradesh, there are 156.39 thousand hectares and 3.66 million tons of potatoes produced (Anonymous, 2021) [2]. Relying too heavily on inorganic fertilizers can cause imbalances in nutrients and harm the physical, chemical, and biological properties of soil. In developing countries like India, availability of inorganic fertilizers is not only limited but also expensive. Biofertilizers such as *Azotobacter*, PSB, and KSB have been identified as affordable alternatives for enhancing soil fertility and maximizing crop yield. Combining fertilizers is crucial for promoting long-term soil health and sustaining crop productivity (Hensh *et al.* 2020) [8]. The application of humic substances along with NPK fertilizers led to a reduction in the leaching of nitrogen and potassium to lower soil layers and increases the availability of phosphorus. These results in improved tuber yield, quality, and nutritional content of potato organs (Harfoush *et al.* 2017) [7]. Hence, an effort has been made to study the growth and yield variation in potato crop as affected by integrated use of humic acid and biofertilizers with inorganic fertilizers.

Materials and Methods

The study was conducted at the experimental field of Horticulture department in College of Agriculture, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, and Gwalior in the years 2022 and 2023, under Northern Madhya Pradesh field conditions. The size of the plot was kept of size 3 m x 2 m, Variety Kufri Chandramukhi was selected for the study; the tubers were planted at a spacing of 45 cm x 20 cm. The experiment was statically replicated thrice and was set up in RBD (Randomized block design). Each replication comprised thirteen treatments viz., T₁- Control (only 100% RDF), T₂- N(75%) + P(75%)+K(100%)+Azotobacter+PSB, T₃-N(75%) + P(100%)+ K(75%)+ Azotobacter + KSB, T₄- N(100%)+ P(75%) + K(75%)+ PSB + KSB, T₅- N75%+ P(75%)+ K(75%)+ Azotobacter + PSB+ KSB, T₆- N(75%)+ P(75%)+K(100%)+ Azotobacter +PSB+Humic acid(1%), T₇- N(75%)+ P(100%)+ K(75%)+ Azotobacter+KSB+Humic acid (1%), T₈-N(100%)+ P(75%)+ K75%+ PSB + KSB+ Humic acid (1%), T₉- N(75%)+ P(75%)+ K(75%)+ Azotobacter + PSB+ KSB+ Humic acid (1%), T₁₀- N(75%)+ P(75%)+ K(100%)+ Azotobacter + PSB+ Humic acid (2%), T₁₁-N(75%)+ P(100%)+ K(75%)+ Azotobacter + KSB+ Humic acid (2%), T₁₂- N(100%)+ P(75%)+ K(75%)+ PSB + KSB+ Humic acid (2%) and T₁₃- (N75%)+ P(75%)+ K(75%)+ Azotobacter +PSB+ KSB+ Humic acid (2%). Medium sized tubers, ranging from 35 to 45 mm diameter weighing 45 to 50 g, were used for planting at a rate of 30 to 35 quintals per hectare. These tubers were treated with Azotobacter (8g/kg tuber), PSB (8g/kg tuber) and KSB (8g/kg tuber) as per treatment. Using a pickaxe manually, shallow furrows were created at a spacing of 6 cm apart, and the tubers were dibbled into the soil on 2nd November 2022, with a spacing of 45 x 20 cm. After seven days of planting, gap filling was carried out to maintain the desired plant population. Right after planting, the initial irrigation was provided to ensure the successful establishment of sprout. Following that, additional irrigations were given at intervals of 15 days until January, and 10 days intervals throughout February. Urea, Single Super Phosphate, and Muriate of Potash were used to apply nitrogen, phosphorus, and potassium, respectively. The recommended dose of fertilizers (RDF) at ratio of 150:60:100 kg/ha was applied as the basal dose in control (100%) and in other treatment as specified above. Additionally, after the potato plants emerged, foliar application of humic acid was done at concentrations of 1% and 2%. Earthing-up and weeding of potato crop was carried out with the emergence of weeds, preferably when potato plant reached a height of 8 to 10 cm, which was around 25 days after planting. The crop was sprayed with Imidachloropid 0.2% to keep the crop pest-free throughout the crop growth phase and to reduce aphids and jassids. On February 27th, 2023, the crop was harvested in a controlled manner, dividing it into different treatments. At different stages of growth, observations were made for the experiments.

Results and Discussion

Morphological parameters

Most of the plant growth characteristics of potato were found to be highly impacted by integrated use of humic acid, biofertilizers and inorganic fertilizers (Table 1). The result clearly showed that treatment T₁₃[N (75%) + P (75%) + K (75%)

+ Azotobacter+ PSB+KSB+ Humic acid (2%)] was significantly better than the others (Table 1). The maximum effect on morphological parameters viz. days taken to emerging sprouts, plant height at 30 and 60 DAP, number of compound leaves per plant at 30 and 60 DAP and number of haulms per plant at 30 and 60 DAP was recorded under treatment T₁₃[N (75%) + P (75%) + K (75%) + Azotobacter+ PSB+KSB+ Humic acid (2%)] and it was discovered to be noticeably better than other treatments, the lowest effect on morphological parameters were observed in treatment T₁[Control (only 100% RDF)]. This may be attributed to the fact that humic acid contains growth regulators, hormones, and nutrients, and because of biofertilizers like PSB, KSB and Azotobacter boost plant growth and nutrient uptake. Similar findings for majority of characteristics were noted by Choudhary *et al.* (2010) [3], Dash and Zena (2015) [5], Al-Zubaidi (2018) [1], Harfoush *et al.* (2019) [7] and Patel *et al.* (2022) [11].

Yield parameters

There was significant effect of integrated use of humic acid, biofertilizers and inorganic fertilizers on yield parameters of potato (Table 2 and Fig 1). Application of humic acid and biofertilizers in combination with different doses of inorganic fertilizers increased the tuber yield as compared to control. However, the highest effect on yield parameters viz. tuber yield per plot (kg), tuber yield per hectare (q), biological yield per hectare (q) and harvest index (%) was recorded in treatment T₁₃[N (75%) + P (75%) + K (75%) + Azotobacter+ PSB+KSB+ Humic acid (2%)] and it was noticeably better than other treatments, and in treatment T₁[Control (only 100% RDF)] the lowest effect on yield parameters was noted. The increase the yield of potato tubers might be due to effect of humic acid, Azotobacter, PSB, and KSB that might significantly have improved. In addition to an increase in tubers per plant and tuber weight, which may have been brought on by humic acid's beneficial effects on plant foliage, the availability of natural and applied macro and micronutrients, vitamins, enzymes, antibiotics, growth hormones, and insoluble nutrients to plants also has a positive effect on overall yield characteristics. The findings are in authorization with the result attained by Verma *et al.* (2011) [16], Narayan *et al.* (2013) [10], Singh *et al.* (2013) [15], Ramandeep *et al.* (2018) [13], Al-Zubaidi (2018) [1], Shubha *et al.* (2019) [14], Ekin (2019) [6], Harfoush *et al.* (2019) [7], Hensh *et al.* (2020) [8], Patel *et al.* (2021) [11], Congera *et al.* (2022) [4] and Kumar and Rathiya (2022) [9].

Economic parameters

Economics of the treatments is presented in Table 3. It was recorded that integrated use of humic acid, biofertilizers and inorganic fertilizers significantly influenced different economical parameters of potato. It was found that the maximum net return (108790 ₹/ha), gross return (200040 ₹/ha) & B:C ratio (2.19) was recorded in treatment T₁₃ [N (75%) + P (75%) + K (75%) + Azotobacter+ PSB+KSB+ Humic acid (2%)] whereas T₁ [Control (only 100% RDF)] recorded the minimum net return (80612 ₹/ha) and gross return (168552 ₹/ha). Similar results were also reported by Singh (2013) [15], Dash and Jena (2015) [5].

Table 1: Integrated effect of humic acid, bio-fertilizers and inorganic fertilizers on growth parameters of potato

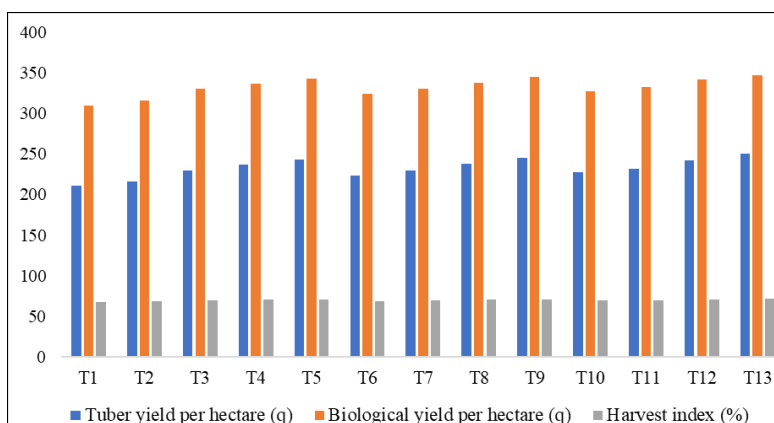
Treatment	Days taken to emerging sprouts		Plant height (cm)		Number of compound leaves per plant		Number of haulms per plant	
	1 st emergence	50% emergence	30 DAP	60 DAP	30 DAP	60 DAP	30 DAP	60 DAP
T ₁	13.70	20.60	14.17	31.47	26.13	30.80	3.32	4.63
T ₂	12.22	17.60	15.63	33.91	28.30	34.70	3.57	5.00
T ₃	10.43	15.70	18.90	39.70	32.17	43.70	4.04	6.03
T ₄	8.74	14.27	21.20	44.07	35.17	46.17	4.50	7.17
T ₅	7.27	12.77	23.73	47.40	38.37	48.90	5.11	8.00
T ₆	11.41	16.73	16.75	36.14	30.07	35.77	3.82	5.34
T ₇	9.64	14.73	19.24	41.72	33.20	44.13	4.12	6.47
T ₈	8.21	13.93	21.70	45.12	36.17	47.60	4.89	7.43
T ₉	7.23	12.60	25.13	48.67	38.74	49.86	5.37	8.13
T ₁₀	10.80	16.27	17.52	37.50	31.07	37.87	3.97	5.83
T ₁₁	9.40	14.58	20.15	42.38	34.08	44.86	4.26	6.60
T ₁₂	7.80	13.57	22.74	46.43	37.84	47.78	5.10	7.87
T ₁₃	7.10	12.51	26.47	53.30	40.59	50.80	5.67	8.40
S.Em ±	0.360	0.537	0.819	1.602	1.542	1.566	0.215	0.323
CD 5%	1.053	1.567	2.392	4.677	4.503	4.573	0.627	0.785

Table 2: Integrated effect of humic acid, bio-fertilizers and inorganic fertilizers on yield parameters of potato

Treatment	Tuber yield per plot (kg)	Tuber yield per hectare (q)	Biological yield per hectare (q)	Harvest index (%)
T ₁	14.27	210.69	310.09	67.70
T ₂	15.11	216.06	315.73	68.38
T ₃	16.01	230.07	330.07	69.69
T ₄	16.43	236.72	336.72	70.28
T ₅	17.55	242.89	342.89	70.83
T ₆	15.15	223.80	323.80	69.07
T ₇	16.28	230.10	330.10	69.70
T ₈	16.83	238.06	338.06	70.40
T ₉	17.67	245.18	345.18	71.02
T ₁₀	15.55	227.72	327.72	69.47
T ₁₁	16.36	232.21	332.21	69.88
T ₁₂	17.02	241.63	341.63	70.71
T ₁₃	18.56	250.05	346.93	72.31
Sem±	0.46	5.98	5.96	0.55
CD 5%	1.34	17.46	17.40	1.62

Table 3: Integrated effect of humic acid, bio-fertilizers and inorganic fertilizers on economic parameters of potato

Treatment	Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio
T ₁	87940	168552	80612	1.91
T ₂	87710	172848	85138	1.97
T ₃	87870	184056	96186	2.09
T ₄	87580	189376	101796	2.16
T ₅	87610	194312	96390	2.10
T ₆	89525	179040	89515	1.99
T ₇	89685	184080	94395	2.05
T ₈	89395	190448	101053	2.13
T ₉	89600	196144	106544	2.18
T ₁₀	91340	182176	90836	1.99
T ₁₁	91500	185768	94268	2.03
T ₁₂	91210	193304	102094	2.11
T ₁₃	91250	200040	108790	2.19

**Fig 1:** Integrated effect of humic acid, bio-fertilizers and inorganic fertilizers on yield parameters of potato

Conclusion

Based on the result outcome, it may be said that integrated use of humic acid, biofertilizers and inorganic fertilizers significantly influenced different growth and yield parameters of potato. The treatment T₁₃ [N (75%) + P (75%) + K (75%) + *Azotobacter*+ PSB+KSB+ Humic acid (2%)] gave the maximum growth and yield parameters. The integrated use of humic acid biofertilizers and inorganic fertilizers is a promising approach for improving the growth, yield, and quality of potatoes. Together, these inputs create a synergistic effect that boosts potato productivity, reduces environmental impact, and promotes sustainable agricultural practices.

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