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Integrated nutrient analysis of soil: Impact on potato haulm and tuber production for sustainable agriculture

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Abstract
The present study was conducted at ICAR-Central Potato Research Institute- RS, research farm Gwalior during winter (*Rabi*) season of 2022-2023. The experiment was laid out using Randomized Design with treatments T_1: Control, T_2: Inorganic practices (standard technology), T_3: NADEP compost @ 25 t/ha + *Azotobacter* @ 1 L/ha + PSB @ 1 L/ha, T_4: T_3+ FYM @ 25 t/ha, T_5: T_3+Vermicompost @ 7.5 t/ha, T_6: T_3+ neem cake @ 5 t/ha + foliar spray of copper oxychloride @ 3 g/L (for management of foliar diseases), T_7: Integrated practice [90% RDF through inorganic sources {urea, SSP, MOP}, 10% RDF through organic sources i.e., FYM @ 25 t/ha. The findings of results reveals that NPK content of haulm (1.77%, 0.47% and 1.86% respectively) and tuber (1.226%, 0.235% and 1.925% respectively) NPK uptake of haulm (43.108, 9.620 and 13.893 kg/ha), NPK uptake of PK (16.47 and 139.49 kg/ha respectively), N_2 use efficiency (32%) and available N_2 (187.778 kg/ha) in soil reported higher in treatment T_7. Higher N_2 uptake by tuber (95.715 kg/ha), higher soil pH (7.053) found higher in treatment T_5. Higher EC (0.333 dSm^{-1}) and available K_2O (442 kg/ha) of soil found in treatment T_3. Higher organic carbon (0.49%) and higher available P_2O_5 (21.045 kg/ha) of soil found in treatment T_4.

Keywords: Compost, EC, FYM, haulm, NPK, OC, pH, potato, tuber

Introduction
"The capacity of a soil to function as a vital living system within ecosystem and land use boundaries to sustain plant and animal production, maintain or enhance water and air quality, and promote plant and animal health" is the definition of soil health given by Doran and Zeiss (2000) [5]. A soil's inherent qualities include its state of health. It is acknowledged as a set of traits that classify and characterize its health. On the other hand, soil quality is an external feature of soils that varies depending on how humans intend to use the soil. It could have to do with the productivity of agriculture and its ability to sustain wildlife, safeguard watersheds, or produce goods for recreational use (Tahat *et al*., 2020) [21].

In the relentless pursuit of sustainable agriculture, the intricate interplay between soil health and crop productivity stands as a linchpin for success. As the global population burgeons, the demand for food escalates, necessitating innovative and environmentally conscious approaches to enhance agricultural yield. Amongst the myriad crops that contribute significantly to our sustenance, the potato (*Solanum tuberosum* L.), an annual crop of the Solanaceae family, is a herbaceous tuber that provides every important nutrient needed to sustain good human health. Nearly half of all people on the planet eat potatoes as a regular diet (Thiele *et al*., 2010) [23]. It is known as a protective food because potato protein is rich in lysine, which is one of the most important amino acid. Its composition is roughly 78% water, 22% dry matter, 20.6% carbs, 2.1% protein, 1.1% crude fiber, 0.9% ash, and 0.3% fat (Zhang *et al*., 2017) [27].

However, the realization of optimal potato yields is contingent upon a nuanced understanding of the soil's nutritional profile. The soil, serving as the natural reservoir for essential nutrients, plays a decisive role in shaping the growth and development of crops. Consequently, the need for integrated nutrient analysis of soil emerges as a focal point in the quest for sustainable agricultural practices.

This research endeavors to unravel the intricate relationships between soil nutrient content and the ensuing impacts on potato haulm and tuber production.

By employing a holistic approach that considers the synergies and antagonisms within the soil nutrient matrix, we aim to delineate a roadmap for sustainable potato cultivation.

Materials and Methods

The experiment was carried in the ICAR-Central Potato Research Institute-RS, research farm in Gwalior which is located at 26º13' North latitude, 78º14' East longitude and 206 meters above mean sea level in the North tract of M.P. Gwalior's climate is subtropical, with summer temperatures reaching up to 48 °C and minimum temperature as low as 4.0 °C during the winter season. The annual rainfall ranges between 750 and 800 mm, with the majority falling between the end of June and end of September, with only a few showers in the winter months. According to meteorological data the total rainfall received during the crop growth period was 17.4 mm. during the crop growing period the average maximum and lowest temperature were 8 °C and 10 °C, respectively. The relative humidity ranged from 37.2% to 73.4%.

Treatment details

T_1: Control, T_2: Inorganic practices (standard technology), T_3: NADEP compost @ 25 t/ha + *Azotobacter* @ 1L/ha + PSB @ 1L/ha, T_4: T_3+ FYM @ 25 t/ha, T_5: T_3+Vermicompost @ 7.5 t/ha, T_6: T_3+ neem cake @ 5 t/ha + foliar spray of copper oxychloride @ 3 g/L (for management of foliar diseases), T_7: Integrated practice [90% RDF through inorganic sources {urea, SSP, MOP}, 10% RDF through organic sources i.e., FYM @ 25 t/ha].

Observations taken

NPK content (%) and uptake (kg/ha) by potato haulm and tuber

Preparation of plant samples

Following harvest, oven dried plant samples of haulm and tuber were collected for chemical analysis. The samples were ground to a fine powder in a Willey mill fitted with stainless steel blades. Nutrient analysis was performed on the powdered plant samples.

Digestion of samples

Wet digestion was used on plant samples to estimate different nutrients in the tuber and haulm. The plant sample was digested in a di-acid combination of HNO_3 and perchloric acid (9:4) for nutrients other than N. This combination was used to estimate P and K. In a 50 ml flask, one gramme of processed material was inserted in a low heat digesting chamber (160 °C). The mixture was then heated to a higher temperature (210 °C) until the formation of crimson NO_2 fumes stopped. The contents were then evaporated until the volume was decreased to 3 to 5 ml but not to dryness, indicating that digestion was complete. After chilling the flask, the solution was diluted with glass-distilled water to a volume of 100ml volumetric flask. P and K were determined using aliquots of this solution. Nitrogen concentration was evaluated in haulm and tuber using a modified Kjeldahl technique (Prasad *et al*., 2006) [28].

Nutrient content (%)

The nitrogen, phosphorus, and potassium content of tuber and haulm were determined on a dry weight basis during harvesting using the standard protocols outlined in table 1.

Table 1: Method employed in estimation of nutrient content in plant

Nutrient	Analytical method	Method employed
Nitrogen	Modified Kjeldahl method	Prasad *et al*., 2006 [28]
Phosphorus	Vanado molybdate yellow colour method	Koeing and Johnson, 1942 [10]
Potassium	Flame-photometric method	Black (1965) [3]

Nutrient uptake by potato haulm and tuber

Nutrient intake was estimated by multiplying the nutritional content of the leaf sample by the dry weight of the haulm and tuber, dividing by hundred, and expressing the result as kg per hectare.

$$\text{Nutrient uptake by haulm (kg/ha)} = \frac{\text{nutrient content in haulm(\%)}}{\text{dry haulm weight(kg/ha)}} \times 100$$

Nutrient use efficiency

N use efficiency

$$\text{NUE} = \frac{total\ N\ uptake(\text{kg/ha})\ in\ fertilized\ plot - total\ N\ uptake(\text{kg/ha})\ in\ control\ plot}{N\ dose\ applied(\text{kg/ha})} \times 100$$

P use efficiency

$$\text{PUE} = \frac{total\ P\ uptake(\text{kg/ha})\ in\ fertilized\ plot - total\ P\ uptake(\text{kg/ha})\ in\ control\ plot}{P\ dose\ applied(\text{kg/ha})} \times 100$$

K use efficiency

$$\text{KUE} = \frac{total\ K\ uptake(\text{kg/ha})\ in\ fertilized\ plot - total\ K\ uptake(\text{kg/ha})\ in\ control\ plot}{K\ dose\ applied(\text{kg/ha})} \times 100$$

Initial and post-harvest soil analysis

Soil sampling: Soil samples were gathered using a Khurpi (Spud) from each plot of the above-mentioned treatments reflecting the plough layer (0-15 cm) for the current investigation. For each treatment, composite representative soil samples were produced from these samples. Each Composite sample was made up of three sub-samples taken from different locations on each plot in order to get a representative sample of the plot chosen for sampling. Using the quartering approach, the bulk of each collected sample was decreased to roughly 500 g. These dirt samples were dried by air. The samples were smashed with a wooden pestle and mortar, then sieved through a 2 mm stainless steel sieve and kept in polythene bags at room temperature for analysis.

pH: A glass electrode pH meter was used to measure soil pH in a 1:2.5 soil water suspension (Jackson, 1973) [9].

Organic Carbon: Walkley and Black's fast titration technique was used to determine the organic carbon level (Jackson, 1973) [9].

EC: The pH determination soil suspension was allowed to settle, and the conductivity of the supernatant liquid was assessed using a conductivity meter (Jackson, 1973) [9], with the values represented in ds/m at 25 °C.

Available Nitrogen in soil
The alkaline permanganate technique of Subbiah and Asija (1956) [20] was used to determine available nitrogen in soil**.**

Available phosphorus (P) in soil
The phosphorus content of soil was determined using the extraction method reported by Olsen *et al*., (1954) [14]. After 10 minutes, the absorbance of blue colour was measured using a spectrophotometer with a wavelength of 660 nm.

Available potassium (K) in soil
The available potassium was extracted using a flame photometer and neutral normal ammonium acetate (Jackson, 1973) [9].

Statistical analysis
The treatment's importance is assessed using critical difference (C.D.). The data from each character's set of observations were submitted to "Analysis of Variance" as proposed by Panse and Sukhatme (1985) [16].

Results and Discussion

1. NPK content in haulm
NPK content in haulm has been presented in the table 1. Highest NPK content (1.770%, 0.470%, 1.860% respectively) is recorded in treatment T_7. This is due to more and continuous availability of nutrients. Findings are supported by Eshu (2014) [6].

2. NPK content in tuber
NPK content in tuber has been presented in the table 2. Highest NPK content (1.226%, 0.263%, 1.925% respectively) is recorded in treatment T_7. This is due to more and continuous availability of nutrients. Findings are supported by Eshu (2014) [6].

3. NPK uptake of potato haulm
NPK uptake in haulm has been presented in the table 2. Highest NPK uptake (43.108, 9.620, 13.893 kg/ha respectively) is recorded in treatment T_7. This is due to more and continuous availability of nutrients. Findings are supported by Gupta *et al*. (2017) [7] and Singh *et al*. (2020) [19]. Qadri *et al*. (2015) [17] reported that application of nutrients as foliar gave the best results in nitrogen content in plant which strength from source to sink. These results are in close conformity with the findings Kumar *et al*. (2017) [13] and Pandey *et al*. (2018) [15].

4. NPK uptake in potato tuber
NPK uptake in tuber has been presented in the table 3. Highest NPK uptake (95.715, 16.47, 139.49 kg/ha respectively) is recorded in treatment T_7. This is due to more and continuous availability of nutrients. Findings are supported by Gupta *et al*. (2017) [7] and Singh *et al*. (2020) [19]. Kumar *et al*. (2009) [11] revealed that nutrient (nitrogen, phosphorus and potassium) uptake of the potato crop significantly increased with integrated use of 75 or 100 per cent NPK and poultry manure (@ 7.5 t ha^{-1}) or farmyard manure (@ 30 t ha^{-1}) as compared with inorganic fertilizers alone (control). Islam *et al*. (2013) [8] results showed that the N, P and K uptake by the potato increased significantly due to addition of organic manure and inorganic fertilizers with the highest N, P and K uptake by PM + reduced RDF treatment (N135P20K135S10 kg ha^{-1}).

5. N use efficiency
N use efficiency has been presented in the table 3. Highest N use efficiency (32.0%) is recorded in treatment T_7. This is due to more and continuous availability of nutrients. Findings are supported by Gupta *et al*. (2017) [7]. Agronomic efficiency of N more than threefold was reported by Banerjee *et al*. (2015) [4] from the lower levels of N fertilization as compared to the higher levels. This was due to the fact that input-output relationship follows the law of diminishing return as far as the relationship between N and yield is concerned (Das *et al*., 2015) [4]. In the manner AE of N was reported by Das *et al*. (2015) [4] and Trehan (2009) [24] from the experiments of different dose of N fertilization. In the current study, the observed differences at application of the same N rate might be due to the improvement in N efficiency (yield production per unit N supply) might be the amendments effect from balanced fertilization.

6. pH, EC and OC of soil
pH and EC of soil has been found non-significant. But OC is recorded maximum in T_7. This is due to continuous availability of nutrients. This finding is supported by Shubha *et al*. (2018) [18]. Taye (2011) [22] reported that highest organic carbon content after harvest was recorded with the application of 100% equivalent N through FYM + 25 tonnes of FYM ha^{-1} (1.08%).

7. Available NPK in soil
Available NPK is presented in the table 3. Highest available NPK (187.778, 18.543, 427.000 kg/ha respectively) is recorded in treatment T_7. This is due to more and continuous availability of nutrients. Findings are supported by Yadav *et al*. (2017) [25]. Kumar *et al*. (2009) [11] observed significantly improved post-harvest soil fertility with the application of 100 per cent N through farmyard manure which was however comparable with 100 per cent N through sheep manure or poultry manure in baby corn. Similar favourable effect of integrated nutrient management involving inorganic fertilizers and organic manures on increasing the available N, P and K contents in soil have been noticed by Kumar *et al*., (2008) [12] and Baishya (2010) [1]. Zaman *et al*., (2011) [26] also reported that FYM @ 30 t/ha along with biofertilizers recorded maximum soil fertility build-up after harvest of the crop. Biofertilizers treatments did not exert significant effect on available N, P and K status of the soil under the study.

Table 2: Effect of treatments on NPK content of potato haulm and tuber and NPK uptake of potato haulm at harvest

Treatments	NPK content of potato haulm			NPK content (%) of potato tuber			NPK uptake (kg/ha) of potato haulm at harvest		
	N (%)	P (%)	K (%)	N (%)	P (%)	K (%)	N	P	K
T_1	1.668	0.310	1.750	1.126	0.210	1.760	25.510	3.625	8.668
T_2	1.748	0.453	1.840	1.196	0.230	1.920	40.705	9.493	11.823
T_3	1.723	0.425	1.793	1.151	0.213	1.878	26.238	9.043	9.960
T_4	1.720	0.413	1.818	1.153	0.215	1.870	29.425	3.728	9.242
T_5	1.713	0.328	1.813	1.138	0.216	1.860	29.533	7.355	10.673
T_6	1.720	0.413	1.805	1.178	0.213	1.798	30.930	8.498	9.338
T_7	1.770	0.470	1.860	1.226	0.235	1.925	43.108	9.620	13.893
S.Em.±	0.011	0.011	0.011	0.019	0.010	0.012	0.762	0.921	0.925
CD at 5%	0.034	0.032	0.034	0.058	0.031	0.035	2.282	2.756	2.771

Table 3: Effect of treatments on NPK uptake of potato tuber, N use efficiency, pH, EC, OC and available NPK of soil after harvesting

Treatments	NPK uptake (kg/ha) of potato tuber			N Use Efficiency (%)	pH, EC (dSm^{-1}) and OC (%) of soil			Available NPK (kg/ha) of soil		
	N	P	K		pH	EC (dSm^{-1})	OC (%)	N	P_2O_5	K_2O
T_1	55.195	9.025	88.293	0.00	7.048	0.260	0.348	163.225	19.380	405.000
T_2	70.898	16.46	125.20	17.16	7.038	0.295	0.458	175.470	19.645	430.000
T_3	64.435	11.73	121.66	5.53	7.033	0.333	0.450	185.753	20.888	442.000
T_4	67.965	13.03	108.30	9.26	7.035	0.315	0.490	184.793	21.045	428.500
T_5	95.715	12.39	95.858	11.37	7.053	0.300	0.388	183.810	19.340	407.500
T_6	65.900	13.87	108.59	8.95	7.020	0.303	0.403	187.378	19.368	433.500
T_7	71.643	16.47	139.49	32	7.028	0.298	0.473	187.778	18.543	427.000
S.Em.±	0.924	1.252	5.972	-	0.017	0.017	0.023	2.859	0.654	5.994
CD at 5%	2.766	3.749	10.618	-	N.S	N.S	0.069	8.561	N.S	17.947

Conclusion

The findings of results reveals that NPK content of haulm and tuber, NPK uptake of haulm, NPK uptake of PK, N_2 use efficiency and available N_2 of soil reported higher in treatment T_7. Higher N_2 uptake by tuber, higher soil pH found higher in treatment T_5. Higher EC and available K_2O of soil found in treatment T_3. Higher organic carbon and higher available P_2O_5 of soil found in treatment T_4.

References

1. Baishya LK, Kumar M, Goshi DC. Effect of different proportion of organic and inorganic nutrients on productivity and profitability of potato (*Solanum tuberosum*) varieties in Meghalaya hills. Indian J Agron. 2010;55(3):230-234.
2. Banerjee NC, Singhamahapatra DK. Effect of different organic manures and biofertilizers on growth and yield of potato. Indian Agriculture. 1986;30(2):117-123.
3. Black CA. Methods of Soil Analysis, part 1 and 2, Agronomy Monograph No. 9 in the series. Agronomy American Society of Agronomy Inc., Madison, Wisconsin, USA; c1965.
4. Das SK, Banerjee H, Chakraborty A, Sarkar A. Production Potential of Newly Released Potato (*Solanum tuberosum* L.) Cultivars under Different Nitrogen Levels. SAARC J Agri. 2015;13(2):121-130.
5. Doran JW, Zeiss MR. Soil health and sustainability: Managing the biotic component of soil quality. Appl. Soil Ecol. 2000;15:3-11.
6. Eshu Ku. Studies on integrated nutrient management in potato (*Solanum tuberosum* L.). Ph. D. thesis Submitted to Indira Gandhi Krishi Vishwavidyalaya, Raipur; c2014.
7. Gupta SD, Sarkar A, Chaitanya AK, Saha A, Dey A, Mondal R. Response of Potato Crop to Integrated Nutrient Management in the Indo-Gangetic Alluvial Soils of West Bengal, India. Journal of Experimental Agriculture International. 2017;16(3):1-10.
8. Islam M, Sajeda A, Nik M, Majid J, Ferdous M, Shamshul A. Integrated nutrient management for potato (*Solanum tuberosum*) in grey terrace soil (Aric Albaquipt) Australin J Crop. Sci. 2013;7(9):12351241.
9. Jackson ML. Soil Chemical Analysis, Prentice Hall of India private Limited, New Delhi; c1973. p. 182-260.
10. Koeing R, Johnson C. Colorimetric Determination of Phosphorus in Biological Materials. Ind. Eng. Chem. Anal. 1942;14(2):155-156.
11. Kumar A, Karuna K, Sagar G, Chandrika V, Reddy PM. Influence of integrated nitrogen management on yield, nitrogen uptake, soil fertility status and economics of baby corn. Indian J Agric. Res. 2009;43(3):227-229.
12. Kumar P, Pandey SK, Singh SV, Singh BP, Rawal S, Kumar D. Evaluation of Nutrient management option for potato processing cultivars. Potato Journal. 2008;35(1-2):46-52.
13. Kumar U, Chandra C, Raghav M. Nitrogen management in potato for maximum tuber yield, quality and environmental conservation. Bull. Env. Pharmacol. Life Sci. 2017;6:296-301.
14. Olsen SR, Cole CV, Dean LA. Estimation of available phosphorus in soil by extraction with sodium bicarbonate. In: Black, C.A. ed. Methods of Soil Analysis. Part 2.Am. Soc. Agron., Inc. Madison, USA, 1954, 1044-1046.
15. Pandey P, Raghav M, Bajeli J, Tripathi A. Effect of nitrogen scheduling on growth and yield performance of potato (*Solanum tuberosum* L.). J of Pharm. And Phytochem. 2018;7(6):785-789.
16. Panse VG, Sukhatme PV. Statistical Methods for Agricultural Workers. Indian Council of Agricultural Research Publication, 1985, 87-89.
17. Qadri RWK, Khan I, Jahangir MM, Ashraf U, Samin G, Anwer A, *et al*. Phosphorous and Foliar Applied Nitrogen Improved Productivity and Quality of Potato. American Journal of Plant Sciences. 2015, 06(01).
18. Shubha AS, Srinivasa V, Devaraju Anusha RB, Sharavathi MB. Effect of integrated nutrient management on soil and plant nutrient content in potato (*Solanum tuberosum* L). International Journal of Chemical Studies. 2018;6(5):879-881.

19. Singh SP, Sharma SK, Dua VK, Sharma J, Sadawarti MJ, Roy S, *et al*. Potato productivity and nutrient use efficiency as influenced by NPK fertilizer omissions in Central India. Potato Journal. 2020;47(2):202-209.
20. Subbiah BV, Asija GL. A rapid procedure for the estimation of available nitrogen in soils. Curr. Sci. 1956;25:259-260.
21. Tahat MM, Alananbeh KM, Othman YA, Leskovar DI. Soil Health and Sustainable Agriculture. Sustainability. 2020;12(12):4859.
22. Taye M. Integrated nutrient management studies in potato (*Solanum tuberosum* L.). M. Sc. (Ag.) thesis submitted to the University of Agricultural Sciences, Dharwad; c2011.
23. Thiele G, Theisen K, Bonierbale M, Walker T. Targeting the poor and hungry with potato science. Potato Journal. 2010;37:75-86
24. Trehan, SP. Improving Nutrient Use Efficiency By Exploiting Genetic Diversity of Potato. Potato Journal. 2009;36(3-4):121-135.
25. Yadav SK, Srivastava AK, Bag TK. Effect of Integration of Fertilizers and FYM on Productivity and Soil Health of Rainfed Potato. Journal of Agri Search. 2017;4(1):23-26.
26. Zaman A, Sarkar A, Sarkar S, Devi WP. Effect of organic and inorganic sources of nutrients on productivity, specific gravity and processing quality of potato (*Solanum tuberosum*). Indian Journal of Agricultural Sciences. 2011;81(12):1137-42.
27. Zhang You-Liang, Wang Feng-Xin, Shock Clinton Cleon, Yang Kai-Jing, Kang Shao-Zhong, Qin Jing-Tao, *et al*., Effects of plastic mulch on the radiative and thermal conditions and potato growth under drip irrigation in arid Northwest China, Soil & Tillage Research. 2017;172:1-11.
28. Prasad AM, Iverson LR, Liaw A. Newer classification and regression tree techniques: Bagging and random forests for ecological prediction. Ecosystems. 2006 Mar;9:181-99.