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Research Article

Influence of Integrated Nutrient Management Practices On Soil Properties and Yield of Potato (*Solanum tuberosum*. L) in an Inceptisol of Khajura, Banke

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Abstract

Field experiment was conducted at the research farm of Regional Agriculture Research Station (RARS), Khajura to evaluate the influence of integrated nutrient management options that could enhance the properties of soil and yield of potato under the different climatic conditions of Khajura. The experiment was started in November 2016 in randomized complete block design with different seven treatments of nutrients using Farm yard manure (FYM), Poultry manure (PM) Vermicompost (VC). Available N, P and K status in the soil increased gradually due to the application of inorganic and organic fertilizers. The plots receiving 50 % RDNPK through inorganic fertilizers and remaining 50% RDN through PM registered the highest available N, P and K status in the soil. The highest pH (6.3) content in soil was found in plots treatments with poultry manure and inorganic fertilizers. Potato plots treated with FYM and inorganic fertilizers produced higher SOM content in soil after harvest (2.38%) as compared to control plots (2.09%). The treatments integrated with FYM show less bulk density than the control plot. Organic manures treated plots produce taller plants as compared plots receiving inorganic fertilizers only. Integrated use of 50 % recommended dose of NPK through inorganic fertilizers and remaining 50% RDN through PM produced higher numbers of tubers per plot (304 tubers per plot) and total tuber yield (22.86 tha^{-1}).

Keywords: Inorganic fertilizers; organic manures; integrate

Introduction

Agriculture is the major sector of Nepalese economy. It provides employment opportunities to 65.6 percent of the total population and contributes about 28 percent in the GDP. Therefore, the development of agriculture sector is key for the growth of the national economy (MoAD, 2016). Potato (*Solanum tuberosum* L.) is an annual, herbaceous, tuber crop of family Solanaceae that contains all the essential food ingredients required for maintaining proper health. Potato is the world's leading vegetable crop and grown under tropical and temperate climate with wide range of climatic variations. The crop is known to perform well under loamy and sandy loam soil with pH range 5-6. It is second to maize in terms of the number of producing countries and fourth after wheat, maize and rice in global

tonnage. In Nepal potato is grown in area the of 1,90,896 ha with the production of 25,51,739 mt maintaining productivity around 13.36 (MoAD, 2016). The average composition of the potato is about 80% water, 2% protein, and 18% starch. As a food, it is one of the cheapest and easily available sources of carbohydrates and proteins and contains an appreciable amount of vitamins B and C as well as some minerals. Potato is one of the important crops in the food security program in Nepal since it gives the highest dry matter per unit time and area. It plays a vital role in food security and nutrition. The potato produces more nutritious food more quickly, on less land, and in a harsher climate than any other major crop - up to 85 percent of the plant is edible human food, compared to around 50% in cereals (IYP, 2008).

Inceptisol soils are in the beginning stages of soil profile development. The differences between horizons are just beginning to appear. Some color changes may be evident between the emerging horizons, and the beginnings of a B horizon may be seen with the accumulation of small amounts of clay, salts, and organic material. These soils show more profile development than Entisols, but have not developed the horizons or properties that characterize other soil orders. Inceptisols are commonly found throughout the world, and are prominent in mountainous regions. The natural productivity of these soils varies widely, and is dependent upon clay and organic matter content, and other edaphic (plant-related) factors. They are widely distributed and occur under a wide range of environmental settings. They are often found on fairly steep slopes, young geomorphic surfaces, wet sites, and on resistant parent materials. They form quickly through alteration of parent material. They have no accumulation of clays, Fe, Al or organic matter.

The imbalance uses of chemical fertilizers created many environmental and health problems. The soil fertility status of Nepalese soils is deteriorating which is one of the most serious problems in crop production. Although the national average of the chemical fertilizer consumption is low but the amount of its use in commercial farm and pocket areas has exceeded to a maximum extent. In this situation many constraints are derived from the effect of soil fertility status in cultivation of different horticultural commodities including potato. These constraints include the low multiplication rates of seed tubers, technical difficulties, cost associated with maintaining seed quality through successive multiplications, owing to the potato's susceptibility to soil and seed-borne insect pests and diseases. INM is one of the burning reference in all these contexts but there needs a systematic cultivation of potato by rural farmers in our Nepalese condition. So the integrated use of different fertilizer and nutrient management should be given due consideration so that the sustainability of the soil fertility and soil productivity can be duly addressed by focusing towards the sustainable type of agriculture. Integrated nutrient management (INM) is the combined use of mineral fertilizers with organic resources such as cattle manures, crop residues, urban/rural wastes, composts, green manures and bio-fertilizers. Its basic concept is sustaining soil and crop productivity through optimization of all possible sources of plant nutrients in an integrated manner. In this system, all aspects of mineral and organic plant nutrient sources are integrated into the crop production system and are utilized in an efficient and judicious manner for sustainable crop production. It contributes in attaining agronomically feasible, economically viable, environmentally sound and sustainable high crop yields in cropping systems by enhancing nutrient use efficiency and soil fertility, increasing carbon sequestration, reducing nitrogen losses due to nitrate leaching and emission of greenhouse. Over applications of inorganic fertilizers lead nutrient imbalances, inefficiency and environmental contamination while insufficient application of nutrients causes soil fertility depletion. This problem drives the use of organic manures, which supply balanced micro and macro nutrients to the current crop and also leave a substantial residual effect on the succeeding crops in different cropping systems. But it is required in bulk as it contains nutrients in small proportion. Hence its availability is scarce for large farms. Therefore, to eliminate both excessive and inadequate applications, judicious use of integrated nutrient management is the best alternative for sustainable crop production while maintaining soil fertility status in different agricultural cropping systems. Low use of fertilizers and serious imbalances in the N:P:K application ratio is partially responsible for this low yield. Supplementing the nutrient requirement of crops through organic manures e.g. vermicompost, farm yard manure etc., especially plays a key role in sustaining soil fertility and crop productivity, reducing the use of fossil fuels and restoring overall soil quality. These sources are often cheaper and more efficient than inorganic compounds. Organic materials hold great promise as a source of multiple nutrients because of their ability to improve soil characteristics. Intensive land use with the continuous use of higher doses of inorganic fertilizers significantly influences soil health and crop growth. But this has raised concerns about the potential long-term adverse effects on soil health and environmental quality (Kumar et al., 2012). However, the use of organic manure is limited by the huge quantities needed to meet crop nutritional needs, while the use of chemical fertilizers is limited by cost and scarcity. Complementary use of organic and inorganic fertilizers may be beneficial for achieving a sustainable crop production. Therefore, this study was carried out with the main objective enhance soil properties and yield of potato through Integrated nutrient management.

Materials and Methods

A field experiment was started in randomized complete block design with different seven treatments of nutrients integrations i.e., First treatments (T1), control (full recommended dose NPK through FYM, urea, DAP & MOP), second treatments (T2) with 50% recommended dose of Nitrogen through PM+50 % through inorganic fertilizers, third treatments (T3) with 50% recommended dose of nitrogen through VC+50 % through inorganic fertilizers, fourth treatments (T4) with 50% recommended dose of Nitrogen through FYM+50 % through inorganic fertilizers, fifth treatment (T5) with 50% recommended dose of Nitrogen through PM+50 % through inorganic fertilizers+ tuber treated with urea and sodium bicarbonate both 1% solution. Sixth treatments with 50% recommended dose of Nitrogen through VC+50 % through inorganic fertilizers+ tuber treated with urea and sodium bicarbonate both 1% solution. Seventh treatments with 50% recommended dose of Nitrogen through FYM+50 % through inorganic fertilizers+ tuber treated with urea and sodium bicarbonate both 1% solution. The Potato variety namely Kufri Jyoti was selected for the study which is grown mainly in the winter season. The average duration of crop was 110 days. Potato tubers were treated with 1% urea and 1% sodium bicarbonate solution for three different treatments T5, T6 and T7. Urea and sodium bicarbonate solution was prepared using 100gm urea and sodium bicarbonate in 10 liters of water. After tuber treatment tubers were kept under shaded region to dry moisture. Sowing of tubers was done with a distance of 50×20cm geometry (Table 1).

Result and Discussion

Effect of Organic Manure and Inorganic Fertilizers On Yield Contributing Characters and Yield of Potato

Integrated use of 50% recommended dose of NPK through inorganic fertilizers and remaining 50% RDN through organic sources produced higher numbers of tubers per plot and total tuber yield than application of 100% RDNPK through inorganic fertilizers. Integrated use of 50 % recommended dose of NPK through inorganic fertilizers and remaining 50% RDN through PM produced higher numbers of tubers per plot (304 tubers per plot) and total tuber yield (22.86 tha^{-1}) which were at par with the crop receiving 50 % RDNPK through inorganic fertilizers and remaining 50% RDN through FYM or VC or 100% RDNPK through inorganic fertilizers. The supply of 100% nutrients through only organic manure is not helpful also due to slow mineralization of organic manures under low temperature condition, so this integration is effective in maximum nutrient supplement in cultivation of different vegetables crops (Table 2).

Table 1: Treatment combination of organic manure and chemical fertilizers.

Treatment no	Combination of organic manure and chemical fertilizers
T1	Control (100% recommended dose of NPK and FYM)
T2	50% RDN through PM + 50% through inorganic fertilizers
T3	50% RDN through VC + 50% through inorganic fertilizers
T4	50% RDN through FYM + 50% through inorganic fertilizers
T5	50% RDN through PM + 50% through inorganic fertilizers +TT
T6	50% RDN through VC + 50% through inorganic fertilizers +TT
T7	50% RDN through FYM + 50% through inorganic fertilizers +TT

100% RDF for potato(MOAD,2016)
RDF: Recommended dose of fertilizers, PM: Poultry manure, VC: Vermicompost
RDN: Recommended dose of Nitrogen, FYM: farm yard manure
TT: Tubers treated with 1% urea and1% sodium bicarbonate solution

Table 2: Plant emergence count(30DAS), Plant height(60DAS), Tuber number and yield after harvest as affected by different treatments.

Treatments	Growth parameters			Yield parameters	
	Emergence count	Plant height(cm)	No of stems/plant	No of tubers / plot	Tuber yield(ton/ha)
T1	45.66	34.94	2.20	290.67	19.55
T2	45.66	39.06	2.66	304.00	21.58
T3	46.66	37.83	4.13	295.67	20.76
T4	46.33	38.07	2.53	292.00	21.34
T5	47.00	39.49	2.46	302.67	22.86
T6	46.66	37.38	2.20	296.00	20.22
T7	49.66	39.48	3.20	298.33	20.23
CV	6.5	5.51	28.23	1.98	4.57

Nutrient Uptake

The highest nitrogen uptake was found in treatment five, which was statistically identical to third treatment but significantly higher than the other treatments. The lowest N uptake was found in the control. It was observed that poultry manure in combination with inorganic fertilizer showed superiority over VC, FYM plus inorganic fertilizer. The highest uptake P and K by tubers were noticed with the application of 50% RDNPK through inorganic fertilizers and remaining 50% RDN through PM, it was statistically similar with those obtained from the crop receiving 50% RDNPK through inorganic fertilizers and remaining 50% of RDN through VC and FYM.

Influences on Soil Properties

The influence of integrated nutrient management practices on bulk density of soil after the cultivation of potato was seen non-significant. Although the treatments integrated with organic manures show less bulk density (1.21gcm^{-3}) than the control plot which were not treated with organic manures. Minimum bulk density was found in the treatments integrated with farm yard manure and chemical fertilizers. The control plot showed the maximum bulk density followed by others treatments. The higher bulk density on the control plot may be due to very low organic matter content in soil and formation of compact layer. It was viewed by Islam et al. (2006). Mathur, (1997) reported that organic matter incorporation into the soil decreased bulk density from 1.46 to 1.40gcm^{-3} which is similar to present findings (Table 3).

The available N, P and K contents in the soil increased gradually after the application of recommended dose of nutrients either through inorganic fertilizers or through integrated application of inorganic fertilizers and organic manures. The plots receiving 50% RDNPK through inorganic fertilizers and remaining 50% RDN through PM registered the highest available N, P and K status in the soil and it was closely followed by the plots receiving 50 % RDNPK through inorganic fertilizers and remaining 50% RDN through VC or FYM, but was markedly higher than those of the plots receiving 100% RDNPK through only inorganic fertilizers only. Application of 100% RDNPK through only inorganic fertilizers also increased the available N, P and K status in the soil over its initial values. The results emphasized the need for integrated nutrient management practices through inorganic fertilizers and organic sources (particularly PM or VC) for enhancing the available N, P and K contents in soil. The highest pH content in soil was found in plots of treatments with poultry manure and inorganic fertilizers 6.30 (nearly neutral) and lowest pH content of soil was found in control plot (6.13) plots. The soil receiving only recommended dose of fertilizers showed low pH showing an increase in acidity. Among the organic treatments the PM treatment resulted in the highest pH value because the poultry manure content varying amount of calcium carbonate. Potato treated with FYM and inorganic fertilizers produced higher SOM content in soil after harvest (2.38) as compared to control plots (2.09). Troeh and Thompson, (2005) also reported that organic residues of plant and animal waste are the parent materials of organic matter and humus, which make up the nutrient supplies of microorganisms and plant root.

Economic Analysis

The economic return was calculated considering the prevailing market prices of tubers. The cost of cultivation was calculated considering the prevailing market prices of various farm inputs (fertilizers, seeds, manures, irrigation expenses, labors). The highest tuber yield (22.86) was observed in plots cultivated with the integration of poultry manure and inorganic fertilizers. Similar trend in benefit-cost ratio was observed among the various plots treatments ranging from (1.23) poultry manure and inorganic fertilizers treated plots to least (1.06) in plots receiving inorganic fertilizers only (Table 4).

Table 3: Effect of INM on soil properties as influenced by different treatments

Treatments	B.D.(gcm^{-3})	pH	SOM(%)	Total N(kg/ha)	Available P(ppm)	Available K(kg/ha)
T1	1.38	6.13	2.09	116.90	10.92	128.78
T2	1.27	6.18	2.30	161.28	12.9	140.26
T3	1.28	6.28	2.27	156.05	10.79	112.77
T4	1.24	6.18	2.34	122.45	9.82	137.07
T5	1.26	6.30	2.16	176.21	16.07	132.16
T6	1.24	6.18	2.19	146.34	8.22	124.49
T7	1.21	6.27	2.38	144.85	12.00	137.48
CV	8.78	3.41	13.13	11.37	18.66	6.95

Table 4: Economic analysis of treatment applications during the course of experiment

Treatments	Net yield (ton ha^{-1})	Total return (Rs ha^{-1})(A)	Cost of cultivation (Rs ha^{-1})(B)	Net return (Rs ha^{-1})(A-B)	Benefit-cost ratio (A/B)
T1	19.55	586500	549000	37500	1.06
T2	22.86	685800	555555	130245	1.23
T3	21.58	647400	552500	94900	1.17
T4	21.34	640200	551400	88800	1.16
T5	20.76	622800	550900	71900	1.13
T6	20.23	606900	550500	56400	1.10
T7	20.22	606600	549000	37500	1.06

Conclusion

Poultry manure treated plots had a good vegetative growth imparted by soil moisture, organic matters and nutrient content as compared to inorganic fertilizers condition. Yield attributes varied significantly due to application of different rate of organic manure and inorganic fertilizers. Stems per plant, late blight count, SPAD value and specific gravity were significantly influenced by the different treatments. Emergence count and vigour index were not influenced by the treatments due to good favorable condition of soil and environment. Plots treated with organic sources (PM, FYM &VC) and chemical fertilizers produced higher numbers of tubers per plot and total tuber yield than application of 100% RDNPK through inorganic fertilizers. Higher economic gain was also found in those treatments which were integrated with organic manures and inorganic fertilizers. The highest Benefit cost ratio was obtained in treatments integrated with poultry manure and inorganic fertilizers. Economic analysis concluded the positive effects of integration in increasing yield and economy of farmers.

Thus, we came to a conclusion that the integration of different organic and inorganic manures can greatly contribute towards the yield of potato cultivation, yielding attributes and different properties of soil. INM also reduces heavy burden of costly fertilizers application and their more hazardous environmental effects.

Author's Contribution

Chandeshwar Parsad Shriwastav designed the research plan; Madan Marasini performed experimental works & collected the required data. Kishor Kafle analysed the data; All authors prepared the manuscript, critically revised and finalized the manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest with present publication.

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References

Islam MM, Khan MS, Rahman MJ, Mallik SA & Ferdous J (2006) Effect of tillage practices and crop residue on wheat-fallow-T. aman rice cropping pattern. *Bangladesh J Agric Environ* **2**: 1-7.

IYP (2008) International year of the potato. Potato world. Retrieved on March 28, 2008 from http://www.potato2008.org/en/world/asia.html

Kumar M, Baishaya LK, Ghosh DC, Gupta VK, Dubey SK, Das A & Patel DP (2012). Productivity and soil health of potato (Solanum tuberosum L.) field as influenced by organic manures, inorganic fertilizers and biofertilizers under high altitudes of eastern Himalayas. *Journal of Agricultural Science* **4**(5): 223.

Mathur GM (1997) Effect of long-term application of fertilizers and manures on soil properties and yield under cotton-wheat rotation in north-west Rajashtan. *J Indian Soc Soil Sci* **45**: 288-292.

MoAD (2016) Nepalese Agriculture and population. Government of Nepal, Ministry of Agriculture Development, Agribusiness and Statistics Division, Kathmandu, Nepal.

Troeh FR & Thompson LM (2005). Soils and Soil Fertility. 6theds. Blackwell Publishing, Ames, Iowa.