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Studies on the effect of Zinc fertilization with different nutrient management practices on the soil properties and availability of nutrients under potato (*Solanum tuberosum* L.)

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Abstract
A field experiment was carried out at Student Instructional farm, Acharya Narendra Deva University of Agriculture and Technology, Narendra Nagar, Kumarganj, Ayodhya (U.P.) during *Rabi* season 2017-2018 to evaluate the effect of Zinc fertilization with different nutrient management practices on the soil properties and availability of nutrients under potato (*Solanum tuberosum* L.) crop. The five treatments comprised with various levels of 75% and 100% recommended doses of NPK, ZnSO4 (20, 30and 40 kg ha^{-1}) and 25% Nitrogen by Farm yard manure were tested against 100% NPK fertilizers alone were replicated four time in randomized block design (RBD) potato crop the variety Kufri Baadshah was taken a test crop. The result revealed that there was improvement in the soil physico-chemical properties and increase in the availability of nutrients in all the treatments wherever organics were the components of the treatments. Among all the treatments, treatment consisting of 75% recommended dose of NPK fertilizers with 25% nitrogen by the farm yard manure as well as 40 kg/ha $ZnSO_4$ (T_5) was found most superior in improving the physicochemical properties of the soil as well as increasing the availability of nutrients.

Keywords: organic manure, soil property, available nutrients

Introduction
Potato (*Solanum tuberosum* L.) is herbaceous annual plant and belongs to the family Solanaceae. Potato is the 4th major food crop after rice, wheat and maize of the world. Potato is rich source of energy and produces more food per unit area and time than all major food crops. Potato is one of the most efficient food crop which produce more dry matter, dietary fiber, quality protein, minerals and vitamin than wheat, maize and rice per unit area and time is considered as a balanced and nutritive food. India is the second largest producer of potato contributing 10-11% of the world potato production after China with the production of 50.33 million tons from an area of 1.843 million ha. The total area in world under potato cultivation is 193.03 mha and total production is 388.19 m tones with 20.11 tones productivity (FAOSTAT 2017) [8]. Potato is the one of the most important vegetable crops in India. It removes large amount of nutrients from soil in a very short time scale for supporting faster biomass production (Singh *et al.* 1997) [26]. Moreover, its' root system is shallow and poorly developed (Dey *et al.* 2015) [7]. Thus farmers are forced to apply huge amount of inorganic fertilizer for profitable return in terms of yield. Ever-increasing cost of inorganic fertilizer and its increasing use resulted in high cost of cultivation and soil health deterioration, and decline in crop production in long run (Khan *et al.* 2008). On the other hand, excessive nitrogen fertilization reduces starch, dry matter and sugar contents in tubers, compromising tuber quality (Baniuniene *et al.* 2008) [4]. Thus, it is necessary to develop techniques for sustainable crop production which is not only cheap and affordable, but also helps to restore soil health. The gradual shift to use of high analyzed chemical fertilizers instead of organic and conventional plant nutrients like FYM, composts etc. also another contributing factor to this problem (Murmu *et al.* 2014) [15]. Hence, micronutrient management needs greater attention in crop production systems to combat with wide spread deficiency of micronutrients (mainly Zn) in many potato growing areas, as 49% soils of India is deficient in available Zn (Singh, 2001)

[27]. Zinc is considered as the most important micronutrient for potato, and low recovery of applied Zn is the main limitation in enhancing the yield of potato crop (Singh *et al.* 2014) [28]. Zinc is involved in the synthesis of growth promoting hormones and the reproductive process of many plants (Ram *et al.* 2014) [20]. Zinc plays an important role as a metal component of enzymes (alcohol dehydrogenase, superoxide dismutase, carbonic anhydrase and RNA polymerase) or as a functional, structural or regulator cofactor of a large number of enzymes. Keeping these facts in view, the present investigation was done to evaluate the effect of Zinc fertilization with different nutrient management practices on the soil properties and availability of nutrients under potato (*Solanum tuberosum* L.) crop.

Materials and methods

The present investigation was carried out at Student Instructional farm of Acharya Narendra Deva University of Agriculture and Technology, Narendra Nagar Kumarganj, Ayodhya (U.P.) during *Rabi* season 2017-2018 to evaluate the effect of Zinc fertilization with different nutrient management practices on the soil fertility under potato (*Solanum tuberosum* L.) crop. The five treatments comprised with various levels of 75% and 100% recommended doses of NPK, ZnSO4 (20, 30and 40 kg ha-1) and 25% Nitrogen by Farm yard manure were tested against 100% NPK fertilizers alone were replicated four time in randomized block design (RBD) potato crop the variety Kufri Baadshah was taken a test crop. The experiment was comprised with five treatments *viz.* T_1-RDF 100%, T_2- RDF 75% + 25% FYM-N, T_3 -RDF 75% + 25% FYM-N + ZnSO4 @ 20 kg ha^{-1}, T_4-RDF 75% + 25% FYM-N + ZnSO4 @ 30 kg ha^{-1}, T_5- RDF 75% + 25% FYM-N + ZnSO4 @ 40 kg ha^{-1}. To assess the various treatment effects, soil sample were collected after harvest of the crop from each plots. Soil pH and EC were determined by following Chopra and Kanwar (1991). Soil organic carbon was determined by Walkley and Black (1934) [32] rapid titration procedure. Soil available N was determined following Subbiah and Asija (1956) [31]. Available P was determined by Olsen *et al.* (1954) [17] method. Available K was determined by following Jackson (1973) [9] and DTPA extractable Zn (Lindsay and Norwell, 1978) [11] by atomic absorption spectrophotometer following the procedure outlined in Sparks (1996) [30].

Results and discussion

Bulk density

The bulk density of surface soil was reduce (1.38g cm^{-3}) with the application of 75% recommended dose of NPK fertilizers with 25% nitrogen by the farm yard manure compared to other treatments (Table-1). However, no significant variations were observed among the various nutrient management treatment. Mathur, (1997) [12] Similar results have been reported by Appavee (1999) [2], Ray and Gupta, (2001) [21].

Moisture content near to field capacity

The application of 75% recommended dose of NPK fertilizers with 25% nitrogen by the farm yard manure along with $ZnSO_4$ (20, 30 and 40kg ha^{-1}) fertilizers increased the moisture retention capacity of soil as compared to 100% recommended dose of NPK fertilizers alone (Table 1). The quantity of moisture content did not varied significantly with the application of farm yard manure and inorganic fertilizers. 75% recommended dose of NPK fertilizers with 25% nitrogen by the farm yard manure along increment doses of $ZnSO_4$ (20, 30 and 40kg ha^{-1}) was found more effective to increase moisture retention capacity of soil than 100% recommended dose of NPK fertilizers, but not to the extent of significance. Similar results have been reported by Yadav *et al.*, (2013) [33].

Soil pH

Reduction in soil pH (8.35) with the application of 75% recommended dose of NPK fertilizers with 25% nitrogen with the farm yard manure (Table-1). The minimum reduction in soil pH (8.40) was recorded in treatment T_1 100% recommended dose of NPK fertilizers alone. The maximum reduction of pH with organic manure (FYM) might be due to formation of organic acids, during decomposition of FYM which neutralized the sodium salts present in soil and increased the hydrogen ion concentration. Prasad and Singhania (1989) [19]. Sarkar and Singh (1997) [22] also reported that the application of organic matter (FYM) alone decreased the soil pH. Mehdi *et al.* (2011) also reported that the long-term application of organic manures reduced the soil pH rapidly as various acid and acid forming compounds were released during decomposition of organic materials.

Electrical conductivity

The application of 75% recommended dose of NPK fertilizers with 25% nitrogen by the farm yard manure reduced the electrical conductivity (0.26) compared to 100% recommended dose of NPK fertilizers. The minimum reduction in electrical conductivity was found (0.28) by the application of 100% recommended dose of NPK fertilizers (Table-1). However, non-significant variations were observed among the various nutrient management treatments. The results are in conformity with findings of Kumar *et al.* (1995). Bellakki *et al.* (1998) [5] also reported that use of organic materials lowered the electrical conductivity of over chemical fertilizers. Sarkar and Singh (1997) [22] also reported that the application of organic matter (FYM) alone decreased the soil EC.

Organic carbon

Results (Table-1) revealed that application of 75% recommended dose of NPK fertilizers with 25% nitrogen by the farm yard manure increased the organic carbon (0.40) as compared to 100% recommended dose of NPK fertilizers of organic carbon (0.38). This could be attributed to direct addition of organic substances in soil and due to better root growth, more plant residues after crop harvest and their indirect influence on physic-chemical characteristics of the soil (Biswas *et al.*, 1970; Kaushik *et al*., 1984 and Ojha *et al.*, 2009) [6, 10, 16]. Mishra and Sharma (1997) [14] also reported the application of FYM alone promote the organic carbon content in soil while, it reduced the soil bulk density.

Available Nitrogen

The application of 75% recommended dose of NPK fertilizers with 25% nitrogen by the farm yard manure along with $ZnSO_4$ (20, 30 and 40kg ha^{-1}) fertilizers increased available nitrogen as compared with 100% recommended dose of NPK fertilizers alone. Data depicted in the Table-2 shows that maximum (160.50 kg/ha) available nitrogen observed in treatment T_5 75% recommended dose of NPK fertilizers with 25% nitrogen by the farm yard manure as well as 40 kg/ha $ZnSO_4$ and the minimum available nitrogen in treatment T_1 100%RDF (154.50 kg/ha) respectively. The increase in soil nitrogen might be due to direct addition of N through fertilizer and organic materials and greater multiplication of soil microbes, which converts organically bound nitrogen to inorganic form (Bellakki and Badanur, 1997). The application of organic manures could reduce N losses and conserve soil N by mineralization, thus maintaining a continuous availability of N in entire life cycle of rice plant (Pandey and Sarkar 2008) [18].

Available phosphorus

Data presented in the Table 2 revealed that application of 75% recommended dose of NPK fertilizers with 25% nitrogen by the farm yard manure along with increment doses of $ZnSO_4$ (20, 30 and 40kg ha^{-1}) fertilizers increased available phosphorus as compared with 100% recommended dose of NPK fertilizers alone. The maximum (16.20 kg/ha) available phosphorus observed in treatment T_5 75% recommended dose of NPK fertilizers with 25% nitrogen by the farm yard manure as well as 40 kg/ha $ZnSO_4$ and the minimum available phosphorus in treatment T_1 100%RDF (15.56 kg/ha) respectively.

Selvamani *et al*. (2011) [23] it might could be the phosphorus content in soil increased with the application of organics and bio-inoculants. Organic acids released during decomposition of organic manures increased availability of phosphorus. The organic materials forms a protective cover on sesquoxide and thus also reduce the phosphate fixing capacity of soil and hence, increase available P status of soil (Singh *et al*., 2006) [29].

Available potassium

Data depicted in the Table-2 revealed that the application of 75% recommended dose of NPK fertilizers with 25% nitrogen by the farm yard manure along with increment doses of $ZnSO_4$ (20, 30 and 40kg ha^{-1}) fertilizers increased available potassium as compared with 100% recommended dose of NPK fertilizers alone. The maximum (231.40 kg/ha) available potassium was found with 75% recommended dose of NPK fertilizers with 25% nitrogen by the farm yard manure and $ZnSO_4$ up to 40$kgha^{-1}$ and the minimum available potassium in treatment T_1 100%RDF (225.00 $kgha^{-1}$). The organic manure have greater capacity to hold K in available form and reduced K-fixation due to interaction of organic matter with clay besides direct addition of potassium to the available pool of soil (Mathur, 1997) [12]. Selvamani *et al.* (2011) [23].

Available zinc

Data presented in the Table-2 revealed that application of 75% recommended dose of N P K fertilizers with 25% nitrogen by farm yard manure along with $ZnSO_4$ (20, 30 and 40kg ha^{-1}) fertilizer increased available zinc significantly as compared to than other treatments. Application of potassium, FYM and Zn significantly increased Zn content of soil. Similar results were reported by Singh and Bansal (2000) [25]. Sharif *et al*. (2014) [24] reported advantageous effect due to application of FYM in combination with K as it improves soil physical properties and also maintaining a positive nutrient balance and also helps in keeping quality of the tubers.

Conclusion

From the above it may be concluded that the application of (T_5) RDF 75% + 25% FYM-N + $ZnSO_4$ @ 40 $kgha^{-1}$ showed maximum response in reduction of bulk density, pH, EC and buildup of organic carbon, available N, P, K and Zn. Hence, this combination of treatment may be opted for sustaining soil fertility, and improved soil health.

Table 1: Effect of different nutrients management treatments on soil parameters

Treatments	Bulk density	Moisture at field capacity (%)	Soil pH	EC (dSm^{-1})	OC (g kg^{-1})
T_1 RDF 100%	1.41	27.15	8.40	0.28	3.8
T_2 RDF 75% + 25% FYM-N	1.38	29.27	8.35	0.26	4.0
T_3 RDF 75% + 25% FYM N+$ZnSO_4$@ 20$kgha^{-1}$	1.39	30.17	8.36	0.27	3.9
T_4 RDF 75% + 25% FYM-N+$ZnSO_4$@ 30$kgha^{-1}$	1.39	30.28	8.36	0.27	3.9
T_5 RDF 75% + 25% FYM-N+$ZnSO_4$@ 40$kgha^{-1}$	1.40	30.36	8.37	0.27	3.9
SEm ±	0.01	0.37	0.14	0.01	0.01
CD at 5%	NS	1.16	NS	NS	NS

Table 2: Effect of different nutrients management treatments on availability of nutrients

Treatments	Available nutrients			
	N ($kgha^{-1}$)	**P** ($kgha^{-1}$)	**K** ($kgha^{-1}$)	**Zn** (ppm)
T_1 RDF 100%	154.50	15.56	225.00	0.52
T_2 RDF 75% + 25% FYM-N	156.70	15.70	226.80	0.53
T_3 RDF 75% + 25% FYM-N+$ZnSO_4$@ 20$kgha^{-1}$	158.90	15.90	229.50	0.64
T_4 RDF 75% + 25% FYM-N+$ZnSO_4$@ 30$kgha^{-1}$	160.10	16.00	230.00	0.67
T_5 RDF 75% + 25% FYM-N+$ZnSO_4$@ 40$kgha^{-1}$	160.50	16,20	231.40	0.69
SEm.±	2.40	0.27	3.77	0.01
CD at 5%	NS	NS	NS	0.02

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