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The Effect of Integrated Nutrient Management (INM) and Zn Fertilization on Yield of Potato

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The present investigation was carried out at Student Instructional farm Narendra Deva University of Agriculture and Technology Narendra Nagar Kumarganj, Ayodhya (U.P.) during *Rabi* season 2017-2018. To evaluate the Effect of nutrient management practices on the performance of potato (*Solanum tuberosum* L.) and soil fertility. The five treatments comprised with various levels of 75% and 100% recommended doses of NPK, $ZnSO_4$ (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 KufriBaadshah was taken a test crop. Results revealed that the integrated use of 75% recommended doses of NPK fertilizers (180:80:100), 25% nitrogen by Farm yard manure as well as 20kg ha^{-1} $ZnSO_4$ in potato was found superior for higher plant growth, productivity and better marketable quality of tubers. The availability of NPK nutrients, organic carbon, moisture retention capacity of soil increased while bulk density, soil pH, and electrical conductivity decreased at higher rate by applying 75% recommended doses of NPK and 20kg ha^{-1} $ZnSO_4$ fertilizers with Farm yard manure as compared to 100% recommended doses of NPK fertilizers alone. The application of 75% recommended doses of NPK, 20 kg ha^{-1} $ZnSO_4$ fertilizers and 25% Nitrogen by Farm yard manure provided highest net returns (Rs. 193639) and cast benefit ratio (2.48). It was concluded that application of 75% RDF, 20 kg ha^{-1} $ZnSO_4$ fertilizers and 25% nitrogen by Farm yard manure may be recommended for higher productivity and returns, and build up soil fertility.

Introduction

Potato (*Solanum tuberosum* L.) is herbaceous annual plant and belongs to the family Solanaceae. The edible part of potato is modified underground stem. It is originated in South America and brought to India in 16th century by the Portuguese. 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.

Potato can be compared only with rice, wheat and maize for its contribution towards securing the food and nutrition and avoiding poverty and hunger especially in developing countries, where food is perpetually on demand to feed increasing population living with inherent social and political conflict. It is also utilized in preparation of readymade products like fried items (Dices, vanies, flakes, granules, starch, gravy thicker, potato custard etc.) and canned potato. 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 tones 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). Where as in India, total area is 21.24 m ha and production is 50.30m tones with 23.9 tones productivity. The contribution of U.P. alone in area and production is 0.614 million ha and 15.56 million tones with 22.77/ha productivity (NHB, 2017-18), respectively. Nitrogen is the most limiting in potato production and has a great influence on crop growth, tuber yield and quality. A mature crop of potato yielding 25-30 tonnes tuber/ha consumes 120-140 kg N/ha .The Indian soils generally deficient in organic matter and are thus unable to release N at the desired rate, required to maintain adequate supply to the growing plant. Therefore, application of N in the form of fertilizer and manures becomes necessary to meet the crop needs.

The deficiency of N leads to pale-green colouration of leaf margins at the initial stage; turning to pale-yellow foliage in case of acute deficiency. The symptoms first appear at lower leaves. However, excess of N delays tuber initiation and onset of linear phase of tuber growth, ultimately resulting in lower yield. The economic response of potato in alluvial soils of north-western and central Indo-Gangetic plains in India has been reported upto 180 kg N/ha.

In potato crop, application of N at proper time is important for getting full benefit of applied N. In general, for plains where growth period is short (100-120 days), application of N in two split doses, i.e. half at planting and rest at the time of earthing up gives higher yields and results in higher N recovery than applying entire dose at planting. This reduces leaching and other losses and gives better utilization of applied N. Phosphorus is the most important nutrient for plant.

However, Indian soils test generally low to medium in available phosphorus and not more than 30 per cent of applied phosphate is available to current crop, remaining parts gets converted into relatively unavailable form. Potassium has an important role in control of the plant water status and ionic concentrations inside plant tissues, including stomata. as a result of improved cell strength that potassium provides in potatoes stress such as frost can be tolerated.

The application of organic manures particularly FYM or compost is recommended for potato crop. Organic manure not only supply nutrients to the crop but also improves physical conditions of soils, such as texture and its water holding capacity. In potatoes, Zinc deficiency symptoms are variable.

In general, the leaves are smaller and the plants are stunted in growth. The leaves fold inwards giving a fern like appearance, grayish brown to bronze colored Blotches appears first on the middle leaves and latest on all leaves. Yield responses to zinc can be expected in crops grown on soils with a low or high pH if the Zinc levels are low.

Therefore, the Zinc plays an important role in potato production. Zinc maintains active state of auxin and alck of it leads to excessive destruction of auxin due to an increase in oxidation. Zinc is also essential for the function and structure of aldolases, dehydrogenases, phosphatases, aspartate transcarbamylase and isomerase (Auld, 2001).

Protein synthesis is markedly influenced through some action of Zinc and also influenced in photosynthesis by the speedy release of respiratory CO_2. Zinc is essential for carbohydrate and phosphorus metabolism and synthesis of RNA and chlorophyll formation (Pandey and Sinha, 2006).

So the Zinc is key factor of potato production. Farm yard manure is organic matter and refers to the well-decomposed mixture of dung, urine, farm litter (bedding material).In FYM found richest nutrients and directly available to the plants.

Though single nutrient source may supply the respective required nutrients for plant but integrated use of all source (Organic and inorganic) is required for balanced plant nutrient (Arora 2008).

Materials and Methods

A field experiment was conducted during the winter season of 2017-18 at Experiment farm of Narendra Deva University of Agriculture & Technology, Narendra Nagar (Kumarganj), Ayodhya (Faizabad) (U.P.) India, which is located 42 km away from Faizabad on Faizabad-Raibarelly road.

Geographically, this experimental site falls under humid, sub-tropical climate and is located at 26.47^0 N latitude and 82.12^0E longitude on an elevation of about 113 meters above mean sea level in the Indo- Gangetic alluvial plain of eastern Uttar Pradesh. Ayodhya region receives a mean annual precipitation of about 1200 mm.

Growth attributes

Observation on various growth parameters viz., plant height, number of physiological active leaves and leaf area index/plant was made at 30,60 and 90 days after sowing (DAS) and at harvest of the crop.

Emergence percentage

Plant population of each treatments were counted after 30 days of planting from three randomly selected rows in each plot and figure were converted into per cent to compute emergence percentage.

Number of haulms per hill

Numbers of haulms per hill were counted at 60 days after planting. For this purpose five plants were selected in each plot at random and they were tagged and then numbers of haulms per hills were counted. The average numbers of haulms were calculated in order to know the average number of haulms per plant.

Plant height (cm)

Plant height was measured at 60 days after planting. Plants selected for number of haulm per plant were used for this purpose. Plant heights were measured in centimeter with the help of meter scale. Height was measured from the surface of the ridge to the apex of the plants and then average height of plants were finally calculated and presented.

Yield and quality of tubers

Gradation of tubers:

For determining the size of tuber, the produce of each plots was graded and weighted separately. The tubers above 75 g were counted in A grade, 50-75g were placed in B grade, 25-50g were kept in C grade respectively.

Weight of A, B, and C grade tubers per plot

Each plot was harvested separately and tubers weight of A, B, and C grade recorded in kg per plot.

Tuber yield (q/ha)

After harvesting, the yield of total tubers per plot were recorded in Kilograms separately and converted in to q/ha.

Specific gravity

For determining specific gravity the five tubers were selected at random from each plot. Tubers were weighed separately and then they were placed into measuring cylinder containing water. Thus, water which was replaced by the tubers was measured and specific gravity was calculated adopting the formula:

$$\text{Specific gravity} = \frac{\text{Weight of tuber (g)}}{\text{Volume of water replaced by the tuber (ml/cc)}} X100$$

Results and Discussion

Growth parameter

The plant emergence was found statistically at par with the application of 100% RDF and 75%RDF+ 25% FYM-N the plant growth parameters viz., plant height and number of haulms hill^{-1} were influenced significantly due to application of RDF 75%+ 25% FYM-N along with the successive increment doses of $ZnSO_4$ *viz*., 20, 30 and 40kgha^{-1} . This might be due to application of fertilizers in combination with organic manure which increased the nutrient-use efficiency through modification of soil physical condition, and resulted in higher total uptake of nutrients because of better root penetration leading to better absorption of nutrients and moisture (Yadav *et al.*, 2013a; Kushwah *et al.*, 2005). This increase in growth parameters might be due to increase in uptake of nitrogen, phosphorus and potassium. The growth parameters such as number of leaves and leaf area have the direct association with photosynthetic efficiency of a crop and this might be the reason for higher plant height, halums hill^{-1} of a potato crop. Similar results were also corroborated with the findings of Pandey *et al.*, (2008), Thakare *et al.*, (2007) (Table 1–3).

Effect of nutrient management on tuber grades and tuber yield

The application of farm yard manure along inorganic fertilizers and $ZnSO_4$ increased the tuber grades. The treatments receiving farm yard manure and inorganic fertilizers (N P K) along with $ZnSO_4$ increased the size of tubers (A grade- 12.13kg plot^{-1} to 12.65 kg plot^{-1}, B grade-19.48kg plot^{-1} to 20.26 kg plot^{-1} and C grade- 17.26 kg plot^{-1} to 18.20 kg plot^{-1})

which was significantly as compared to 100% recommended doses of NPK fertilizers alone. The lowest quantity of A, B and C grade tubers were recorded in treatment 100% recommended dose of fertilizers (NPK) and 75% RDF+ 25% FYM-N. The overall grade wise tubers yield data showed that application of farm yard manure and inorganic fertilizers along with $ZnSO_4$) significantly increased the quantity of large size (>50g) marketable tubers as compared to treatment T_1 100% recommended dose of fertilizers (NPK) alone.

The increasing levels of $ZnSO_4$ (20, 30 and 40kg/ha) increased the quantity of large size of tubers but it was statistically at par. On the other side application of 100% recommended doses of NPK fertilizers alone and 75% recommended doses of NPK fertilizers and 25% FYM-N recorded lower quantity of small size tubers (>25g) as compared to 75% recommended doses of fertilizers (NPK) and 25% farm yard manure along with $ZnSO_4$ (20, 30 and 40kg/ha) treatments respectively (Raghav *et al.*, 2009). Similar observations have also been noted by Singh *et al.*, (2008) and Islam *et al.*, (2013). Thind *et al.*, (2007) also observed that the percent contribution of larger size tubers towards yield was more in FYM plots than other organic manures. The pooled yield data showed that application of 75% recommended doses of fertilizers (NPK) and 25% FYM-N along with successive increment doses of $ZnSO_4$ (20, 30 and 40kg/ha) fertilizers increased the tuber yield significantly as compared to 100% recommended doses of fertilizers (NPK) alone.

Das *et al.*, (2009) reported that the integrated nutrient management by application of both inorganic fertilizers and organic manures increase the different grades tuber production. The increasing level of 75% recommended doses of fertilizers (NPK) and farm yard manure (9 t/ha) along with $ZnSO_4$ (20, 30 and 40kg/ha) fertilizers increased the tuber yield significantly.

This might be due to the increase in photosynthetic activity by zinc application which improves the vegetative growth of potato plant leading to increase in total tuber yield. Similar results were also supported with the finding of Joshi and Raghav (2007), Tiwari and Dwivedi (1991) and Sahota (1985) (Table 4–6).

Table.1 Effect of integrated nutrient management on plant emergence at 30 days after planting

Treatment	Emergence Percentage at 30 DAP
T_1RDF 100%	91.50
T_2RDF 75% + 25% FYM-N	93.20
T_3RDF 75% + 25% FYM-N+ $ZnSO_4$ @20kgha^{-1}	92.70
T_4RDF 75% + 25% FYM-N+ $ZnSO_4$ @30kgha^{-1}	93.00
T_5RDF 75% + 25% FYM-N+ $ZnSO_4$ @40kgha^{-1}	94.20
SEm±	2.61
CD at 5%	NS

Table.2 Effect of nutrient management on number of haulms hill^{-1} at 60 days after planting

Treatment	Number of haulms hill^{-1}at 60 DAP
T_1 RDF 100%	5.20
T_2 RDF 75% + 25% FYM-N	5.40
T_3 RDF 75% + 25% FYM-N+$ZnSO_4$@ 20kgha^{-1}	5.80
T_4 RDF 75% + 25% FYM-N+$ZnSO_4$@ 30kgha^{-1}	6.00
T_5 RDF 75% + 25% FYM-N+$ZnSO_4$@ 40kgha^{-1}	6.10
SEm±	0.16
CD at 5%	0.50

Table.3 Effect of nutrient management on plant height at 60 days after planting

Treatment	Plant height (cm) at60 DAP
T_1 RDF 100%	50.20
T_2 RDF 75% + 25% FYM-N	51.50
T_3 RDF 75% + 25% FYM-N+$ZnSO_4$@ 20kgha^{-1}	57.60
T_4 RDF 75% + 25% FYM-N+$ZnSO_4$@ 30kgha^{-1}	58.90
T_5 RDF 75% + 25% FYM-N+$ZnSO_4$@ 40kgha^{-1}	59.00
SEm±	1.57
CD at 5%	4.83

Table.4 Effect of nutrient management on gradation of potato crop

Treatment	C-grade (25-50g)Yield (kg plot^{-1})	B-grade (51-75 g) Yield (kg plot^{-1})	A-grade (> 75 g) Yield (kg plot^{-1})
T_1 RDF 100%	15.83	18.09	11.34
T_2 RDF 75% + 25% FYM-N	16.06	18.68	11.73
T_3 RDF 75% + 25% FYM-N+$ZnSO_4$@ 20kgha^{-1}	17.26	19.48	12.13
T_4 RDF 75% + 25% FYM-N+$ZnSO_4$@ 30kgha^{-1}	17.86	19.98	12.49
T_5 RDF 75% + 25% FYM-N+$ZnSO_4$@ 40kgha^{-1}	18.20	20.26	12.65
SEm±	0.47	0.43	0.26
CD at 5%	1.47	1.30	0.82

Table.5 Effect of nutrients management on total yield of potato (qha^{-1})

Treatment	Tuber Yield (qha^{-1})
T_1 RDF 100%	251.39
T_2 RDF 75% + 25% FYM-N	258.17
T_3 RDF 75% + 25% FYM-N+$ZnSO_4$@ 20kgha^{-1}	271.50
T_4 RDF 75% + 25% FYM-N+$ZnSO_4$@ 30kgha^{-1}	279.64
T_5 RDF 75% + 25% FYM-N+$ZnSO_4$@ 40kgha^{-1}	283.97
SEm±	7.58
CD at 5%	23.61

Table.6 Effect of nutrient management on specific gravity of potato

Treatment	Specific gravity (g/cm^3)
T_1RDF 100%	1.009
T_2RDF 75% + 25% FYM-N	1.016
T_3RDF 75% + 25% FYM-N+$ZnSO_4$@ 20kgha^{-1}	1.018
T_4RDF 75% + 25% FYM-N+$ZnSO_4$@ 30kgha^{-1}	1.019
T_5RDF 75% + 25% FYM-N+$ZnSO_4$@ 40kgha^{-1}	1.020
SEm.±	0.004
CD at 5%	NS

Effect of nutrient management on specific gravity of potato

Specific gravity of tubers increased by applying 75% recommended dose of N P K fertilizers with 25% nitrogen by farm yard manure along with successive increment doses of $ZnSO_4$ (20, 30 and 40kg ha^{-1}) fertilizer compared to 100% recommended dose of NPK fertilizers respectively.

However, no significant variations were observed among the various nutrient management treatment. These results may be supported with the findings of Baishya *et al.*, (2011) and Mandal *et al., (*1986).

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