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Site Specific Nutrient Management in Potato through Nutrient Omission Plot Technique

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ABSTRACT

A field experiment was conducted during four consecutive winter seasons from 2013-14 to 2016-17 at Patna, Bihar under sandy clay loam soil. The trial on potato was laid out in randomized block design with four replications with objective to develop nutrient omission plot technique in potato. The highest plant height and number of shoot per plant were recorded under 150% recommended dose of fertilizer of NPK. The range of dry matter content in potato tuber varied from 16.1 to 17.7% on dry weight basis. The maximum yield of smallest tuber (0-25g) was recorded under 150% recommended dose of fertilizer of NPK, which was at par to all the nutritional treatments and significantly superior over absolute control plot. The maximum yield of medium, large and very large size tuber was recorded under 150% recommended dose of fertilizer of NPK. However, 150% recommended dose of fertilizers of NPK recorded about 13% higher net return over 100% recommended dose of fertilizers of NPK. The maximum yield reduction was observed in the omitted plot without nitrogen among other nutrients like phosphorus and potassium. Hence, nitrogen was one of the most limiting nutrients for tuber yield of potato.

KEYWORDS

Nutrient, Nutrient omission, Potato, Tuber crop

INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the most important cash crops in India. The productivity of potato in the eastern part of the country is just below the national average. Although the demand for table purpose as well as providing seed to eastern part including the north eastern region of India is quite high. Several constraints are found for low productivity of this region among improper nutrient management which has become more crucial for poor productivity (Singh *et al.*, 2015). Nitrogen, phosphorus and potassium are the most important among the elements that are essential for potato (Zewide *et al.*, 2012). Being a heavy feeder of nutrients, potato requires a high amount of nitrogen, phosphorus and potassium. Chemical fertilizers are the main source of nutrients used for potato cultivation (Narayan *et al.*, 2013). Improper use of sources of the nutrient has jeopardized the profit of farmers and besides increasing the cost of cultivation. Availability of one nutrient may affect directly or indirectly the efficiency of other nutrients in the soil. Singh and Singh, (2014) reported that imbalanced nutrition produces low yields, low fertilizer use efficiency and finally, low farmer profit. It also results in further depletion of the most deficient nutrients in the soil. Once the critical level of a nutrient is reached, the yield of potato tuber falls dramatically even though large aggregate amounts of other nutrients may have been applied. In many potatoes growing area of eastern Indo-Gangetic plain, the imbalances of nutrient application are the root cause of low tuber yield of potato productivity and poor soil fertility status where the majority of farmer's practice has usually ignored P and/or K. Thus, nutrient management for N, P and K have become important in sustainable potato production. This present scenario demands immediate attention to correct the imbalances in nutrient applications to prevent further deterioration of soil fertility. Hence, the importance of balanced fertilization in potato for increasing marketable potato tuber yield must be realized. The omission plot technique in potato is used to estimate actual fertilizer requirements for desire tuber yield. The basic concept of omission plot technique is the adjustment of plant nutrient supply to an optimum level for sustaining the desired potato productivity. Keeping above view in mind an approach of field experiment was initiated to determine the main limiting nutrient in potato production in this region entitled site-specific nutrient management through nutrient omission plot technique in potato.

MATERIALS AND METHODS

The field experiment was conducted during consecutive winter seasons from 2013-14 to 2016-17 at ICAR-Central Potato Research Station, Patna, Bihar India. The trial was laid out in randomized block design with four replications. In omission plot technique adequate amounts of all nutrients are applied except for the nutrient of interest (the omitted nutrient). The yield in such an omission plot is related to the indigenous soil supplying capacity of the omitted nutrient. Each trial has a set of treatment of nutrient management schedule in nutrient omission plots: 50% recommended dose of fertilizer (RDF) of NPK; 100% RDF of NPK; 150% RDF of NPK; Without N fertilizer (PK); Without P (NK); Without K (NP) and Without NPK (Absolute control). Potato cultivar *Kufri Khyati* is a newly released short maturing variety, taken under this experiment. The potato was planted during the first week of November in the net plot of 3x3.6 meters with the spacing of 60x20 cm. The recommended dose of N, P_2O_5 and K_2O was taken as 150, 60 and 80 kg/ha for potato. Nitrogen, phosphorus and potassium were applied in the form of urea, single

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super phosphate and muriate of potash, respectively. Half of N while the whole of phosphate and potash were applied at planting of the crop as per treatments. Rest half of the nitrogen was applied as per the treatments at the time of earthing up. Recommended package and practices for disease and insect management for potato crop were followed.

The seed treated tubers were planted at 20 cm apart in the furrows at 60 cm distance and covered immediately after planting. The earthing up was done at 25-30 days after planting to provide loose soils around the plants for proper development of tubers at the stolen tips. Weeding was also done during earthing up with the help of a small spade. Two sprays of mancozeb and one spraying of Curzate (cymoxanil 8% + mancozeb 64%) were done for controlling late blight of potato.

Plants samples were selected randomly to determine the height and number of shoot per plant at the peak growth stage. Three plants were harvested from the earmarked area outside the net plot and brought to the laboratory. The plants were separated into tubers, green leaves and haulms and their dry weights were recorded after drying in a hot air oven at 75^0C till constant weights were obtained. All the plants from net plot area were harvested manually at maturity. All the tubers were dried and graded in the shade and their weight and number were recorded as large (>75 g), medium (50-75 g), small (25-50 g) and very small (< 25 g). The tuber yield of different plots were estimated and converted into tonnes per hectare.

All observations for each character were subjected to statistical analysis according to the standard method (Panse and Sukhatme, 1978). The calculated values of the treatments and error variance ratio were compared with Fisher and Yates F table at 5% level of significance. The differences between significant treatments means were tested against C.D. at 5 percent probability.

RESULTS AND DISCUSSION

Growth attributes

The pooled data over four years presented in Table 1 show that the maximum plant emergence was recorded with fertilization of nitrogen and phosphorus without potassium. Dubey *et al.* (2012) also reported that higher plant emergence in potato due to increasing the nitrogen fertilization in potato. Similarly, the lowest emergence was recorded under the fertilization of nitrogen and potassium without phosphorus. The percent range of plant emergence was varying from 96.2 to 97.9%. However, plant emergence was found non-significant among different treatments. Plant growth attributes such as plant height and number of shoot per plant are presented in Table 1. It revealed that the maximum plant height and number of shoot per plant was recorded under 150% recommended dose of fertilizers which was significantly superior over most of the treatments except 100% recommended dose of fertilizer of NPK. The Maximum reduction in plant height and number of shoot per plant was due to N omission over-fertilization plots. High dose of fertilizer, particularly of N, seems to favour better uptake of N by the haulm, resulting in the bigger canopy for the heavily fertilized crop (Kumar *et al.*, 2008). However, the minimum plant height and number of shoot per plant were recorded under the control plot followed by fertilization of phosphorus and potassium without nitrogen.

Table 1: Growth attributes potato (Pooled over four years)

Treatments	Emergence (%)	Plant height (cm)	No. of shoots/plant
50% RDF of NPK	96.8	49.6	3.61
100% RDF of NPK	96.7	52.8	4.29
150% RDF of NPK	96.4	53.2	4.64
Without N fertilizer (PK)	97.4	41.6	3.55
Without P (NK)	96.2	47.2	4.07
Without K (NP)	97.9	46.9	4.15
Without NPK (Control)	96.5	38.3	3.51
SE±	0.61	2.97	0.28
CD at ± 5%	1.28	6.02	0.57

Dry matter

Dry matter content in tuber is one of the most important parameter to decide the final yield of potato. Based on the pooled data over four years presented in Table 2 revealed that there was no significant difference between dry matter per cent on tuber and haulm of potato was recorded. However, the range of dry matter content in percent in tuber was varying from 16.1 to 17.7% on dry weight basis. While the dry matter percent in haulm in percentage basis were recorded between 12.8 to 13.7% during the course of study. In contrast to dry matter content in potato tuber and haulm, the dry matter yield per unit area in potato tuber was recorded the maximum under 150% recommended dose of fertilizers of NPK which was at par to 100% recommended dose of fertilizers of NPK. However, the application of 150% recommended dose of fertilizers over 100% of NPK fertilization recorded significant variation in dry matter yield potato haulm. Earlier studies showed that excess N causes more development of stem and leaves at the cost of tubers (Mozumder *et al.*, 2014). The highest reduction in total dry matter production by potato crop per unit was recorded under fertilization without nitrogen as compared to fertilization of two other major nutrients (P&K). This might be due to that poor vegetative growth of crops in nitrogen omission treatments, resulting in lower dry weight. The dry matter production in tuber and haulm is directly proportional to the plant biomass yield including tuber and haulm at the harvest (Kavvadias *et al.*, 2012).

Table 2: Dry matter yield of potato biomass (Pooled over four years)

Treatments	Dry matter yield (%)		Dry matter yield (t/ha)	
	Potato	haulm	Potato	haulm
50% RDF of NPK	16.7	13.5	4.1	3.19
100% RDF of NPK	16.4	12.8	5.0	3.84
150% RDF of NPK	16.1	13.3	5.4	4.40
Without N fertilizer (PK)	17.1	13.7	3.3	2.55
Without P (NK)	17.2	13.6	4.9	3.74
Without K (NP)	16.6	13.4	4.8	3.81
Without NPK (Control)	16.7	12.9	2.9	2.17
SE±	0.57	0.46	0.33	0.26
CD at ± 5%	NS	NS	0.70	0.55

Potato tuber yield

Different size of potato tuber has been presented in Table 3. It revealed that the maximum number of small tuber (0-25g) was recorded under 150% recommended dose of fertilizers of NPK which was at par to all the nutritional treatments and significantly superior over absolute control treatment. The distribution of medium size tuber (25-50g) was found the maximum under the treatment 150% recommended dose of fertilizers of NPK followed by fertilization of NK without P. The maximum yield of larger and very large size tuber was recorded under 150% recommended dose of fertilizers of NPK treatment which was significantly superior over other treatment under study.

Table 3: Effect of nutrient omission on the economic yield of potato tuber (Pooled over four years)

Treatments	Grade wise tuber yield (t/ha)				Total yield (t/ha)	Marketable yield (t/ha)
	0 - 25g	25 - 50g	50 - 75g	>75g		
50% RDF of NPK	1.76	3.80	7.63	11.2	24.4	22.6
100% RDF of NPK	1.52	4.62	8.66	15.7	30.5	29.0
150% RDF of NPK	1.84	5.43	9.84	16.6	33.7	31.9
Without N fertilizer (PK)	1.61	3.38	6.74	7.50	19.2	17.6
Without P (NK)	1.70	4.57	8.64	13.8	28.6	26.9
Without K (NP)	1.59	4.55	8.76	14.1	29.0	27.4
Without NPK (Control)	1.40	3.28	5.61	6.78	17.1	15.7
SE±	0.19	0.58	0.67	1.51	1.96	1.85
CD at ±5%	0.40	1.23	1.62	3.17	4.12	3.89

The recommended dose of fertilization of NPK showed a positive effect on the productivity of potato with an increasing dose of NPK from 50 to 150 %. A similar relationship was also recorded by Banerjee et al. (2016). Although about 10.5% yield enhancement in total tuber yield was recorded due to application of 150% recommended dose of NPK over the recommended dose of NPK. However, no significant differences in total and marketable tuber yield of potato were recorded between 100% and 150% recommended dose of fertilizers of NPK, but both the treatment were found significantly superior over rest of the treatments. This might be due to that maintaining adequate or higher amount of major elements, i.e. nitrogen phosphorus and potassium availability in the soil throughout crop growth to bulking stage to satisfy the crop nutrient requirement to achieve higher tuber yield. Similar finding was also reported by Alva *et al.* (2011).

Data on tuber yield presented in Table 3 revealed that nitrogen was one of the most limiting nutrients for both total potato and marketable tuber yield of potato. Because of the maximum yield reduction was observed without nitrogen, among other nutrients like phosphorus and potassium in this experiment. A similar result was also recorded by Jatav *et al.* (2013). The second most limiting nutrient was phosphorus followed by potassium. However, no significant difference in yield of total potato tuber was recorded between phosphorus and potassium omission.

Economics of developed nutrient management technology

The economics, including cost of cultivation, net return and net benefit cost ratio are presented in Table 4. The maximum cost of cultivation was recorded under 150 percent recommended dose of fertilizers of NPK followed by 100 percent recommended dose of fertilizers of NPK. Although the general cost of seed for all the treatment remain the same except the cost of fertilizer and cultivation. The lowest total cost of cultivation (73.9 x10^3 Rs/ha) was recorded in absolute control treatment, followed by 50% recommended dose of fertilizers of NPK. The maximum cost of cultivation was recorded under 150% recommended dose of fertilizers of NPK followed 100% recommended dose of fertilizer of NPK.

Table 4: Economics of different weed management practices in potato (×10^3 Rs/ha)

Treatments	Seed	Fertilizers	Cultivation	Total cost	Net return	B:C ratio
50% RDF of NPK	45.0	4.9	30.8	80.7	114.4	1.42
100% RDF of NPK	45.0	9.8	31.2	86.0	158.1	1.84
150% RDF of NPK	45.0	14.7	31.6	91.3	178.6	1.96
Without N fertilizer (PK)	45.0	7.4	30.8	83.2	70.6	0.85
Without P (NK)	45.0	5.4	30.8	81.2	147.2	1.81
Without K (NP)	45.0	6.8	30.8	82.6	149.1	1.80
Without NPK (Control)	45.0	0.0	28.9	73.9	62.7	0.85

Similarly, data in Table 3 represent that the maximum net return (178.6 x10^3 Rs/ha) and net benefit-cost ratio (1.96) were noticed under the application of 150% recommended dose of fertilizers of NPK followed by 100% recommended dose of fertilizers of NPK. 150% recommended dose of fertilizers of NPK recorded about 13% higher net return over 100% recommended dose of fertilizers of NPK during investigations. The lowest net return among nutrients (NPK) was recorded without application of nitrogen followed by without phosphorus application to potato.

CONCLUSION

It may be concluded that the total tuber yield increased with increasing recommended dose of fertilizers of NPK. There were no significant variations in marketable as well as total tuber yield were recorded between 150% and 100% recommended doses of fertilizers of NPK. However, 150% recommended dose of fertilizers of NPK recorded about 13% higher net return over 100% recommended dose of fertilizers of NPK during investigations. Nitrogen was found one of the most limiting nutrients for potato due to maximum reduction in total tuber yield. The second most limiting nutrient was phosphorus followed by potassium.

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