Use of Chemical Fertilizers on Potatoes in Sandy Loam Soil under Humid Sub-Tropical Condition of Chitwan[1]

Ram C Adhikari*[2] and Moha D Sharma[3]

[2]Potato Research Program, NARC, Khumaltar, Lalitpur
[3]Department of Horticulture, IAAS, Rampur, Chitwan

ABSTRACT

An experiment was conducted at Rampur, Chitwan to study the effects of N, P_2O_5 and K_2O on tuber yield, quality and leaf nutrient status of potato cv. Kufri Sinduri and Desiree. The highest potato tuber yields (35.7 and 21.1 t ha $^{-1}$) were obtained with 150:100:100 and 100:100:100 of N:P_2O_5:K_2O kg ha^{-1} respectively of Kufri Sinduri and Desiree. The optimum dose of N, P_2O_5 and K_2O was 100:50:50 kg ha^{-1} for both cultivars. Regression of N, P_2O_5 and K_2O doses on Kufri Sinduri and Desiree explained 78 and 31% variation, respectively, in the tuber yield. Leaf N alone accounted for maximum variation (76% and 43% by linear in Kufri Sinduri and Desiree, respectively). Leaf N, P and K, respectively 5.04, 0.29 and 3.97% dry matter was critical for potato production under humid sub-tropical condition of Chitwan. Present findings suggest that Nitrogen, Phosphorous and Potassium fertilizers management should be based on leaf analysis for balanced application of mineral nutrients in potato crops.

Key words: Desiree, Kufri Sinduri, nutrients, potato, tuber yield

INTRODUCTION

Soil fertility is one of the major factors that affect the yield and quality of the potato. Several studies describe relationships between fertilizer applications, leaf nutrient concentrations, potato (*Solanum tuberosum* L.) tuber yield and tuber quality (Jackson and Carter 1976, Singh 1987, Krishnappa and Gowda 1988, Rykbost et al 1993). Potato cv. Desiree and Kufri Sinduri were the focus cultivars for this study due to its dominance in the farmers' field particularly in lower hills and terai. The primary objective of this experiment was to ascertain the nutrient status of the standing crop, by leaf analysis. This method has been found useful in potato to recommend fertilizers for optimum tuber yield and quality. Indiscriminate fertilizers use adds costs to growers and enhances environmental pollution.

The present tuber yields of these cultivars in Chitwan are very low. The main reasons are unbalanced and inadequate use of nutrients. It is important to standardize the optimum dose of major nutrients. As potato cultivation practices change and yield increase, fertilizer application may require adjustment. Desiree with NPK in Chitwan valley produced a maximum tuber yield of 16.89 t ha^{-1} (Basnet et al 1998-1999). The objectives of this study were to quantify the N, P and K doses on tuber yield and quality of Desiree and Kufri Sinduri and compare leaf nutrient concentrations with critical nutrient concentrations.

MATERIALS AND METHODS

The experiment was conducted at the Horticulture Farm, Institute of Agriculture and Animal Science, Rampur, Chitwan during 1999/2000 in split plot design with four

[1] A part of MSc thesis submitted by the first author to the Institute of Agriculture and Animal Science, Rampur, Chitwan, Nepal in 2000 for partial fulfillment of the degree.

replications. Two released cultivars, Desiree and Kufri Sinduri included were considered as the main plot treatment and fertilizer doses as the sub-plot treatment. Seven level of fertilizers, ie 0:0:0, 50:50:50, 100:50:50, 100:75:50, 100:75:100, 100:100:100 and 150:100:100 kg ha^{-1} of $N:P_2O_5$, K_2O were included in the sub plot. The sources of fertilizers were di-ammonium phosphate (18:46:0), urea (46:0:0) and muriate of potash (0:0:60). One kg of surface soil sample (up to 20 cm depth) was collected before planting the potato crop. The soil was analyzed for total nitrogen, phosphorous and potassium available by modified Kjeldahal distillation, modified Olsen's method and Flame photometer, respectively. The experimental plot was characterized by having sandy loam soil with pH range from 4.8 to 5.2 and organic matter from 2.55 to 3.22%. The NPK contents in the soil were 2400-2800, 96.54-108.58 and 211.87-277.76 kg ha^{-1}, respectively.

The plot size was 4.2- × 2.5-m having seven rows; each row consisting of 10 plants. A half dose of N and full dose of P_2O_5 and K_2O were applied in furrows and mixed thoroughly at planting time. The remaining half of N was top dressed at the time of earthing up after 5 weeks of planting. Disease free tubers of Kufri Sinduri and Desiree weighing approximately 40-50 g were planted at a spacing of 60 cm between rows and 25 cm between the plants. Two rows were left for borders in between two plots. The crop was irrigated after 45 days of planting through furrow method. Two sprays of mancozeb (Dithane M-45) and one spray of metalaxyl (Krilaxyl) were alternatively used to control late blight disease of the crop during the first fortnight of January, when the environment was conducive for late blight pathogens. Weeding, earthing up and other cultural practices were carried out as per recommendation. Potato tubers of both cultivars were planted on 2 November 1999. Desiree and Kufri Sinduri were harvested on 3 Feb and 28 Feb 2000 respectively. The central three rows were net harvested for tuber yields.

Three plants were randomly selected from each plot at 45 day after planting. The fourth leaves from the growing tip were collected, chopped separately, dried at 70°C for 72 hours and ground to pass through a 40 mesh (0.368 mm) screen. Modified Kjeldhal, modified Olsen's and Flame photometer methods determined total N, P and K in leaf samples, respectively. Percent N, P and K content in the leaves were recorded. The results were analyzed using MSTAT program as described by Gomez and Gomez (1984). Duncan Multiple Range Test (DMRT) was used for mean separation.

RESULTS AND DISCUSSION

Regression of NPK on tuber yield showed that the accumulation of N, P and K in leaf had a definite bearing on tuber yield (Table 1). In both cultivars, total Nitrogen explained the maximum variation in yield were 77% and 42.8% linear, and 78.0% and 40.6% quadratic in Kufri Sinduri and Desiree, respectively.

Critical concentrations

Effect of N application on leaf N and tuber yield was calculated by grouping all treatment combinations with same levels of N together (Table 2). Similarly, effects of P and K application on leaf P and K respectively and tuber yield were calculated (Table 3 and 4). Kufri Sinduri had significantly higher tuber yield than Desiree (Table 2). Application of 100 kg N ha^{-1} yielded significantly more than 50 kg N ha^{-1}. However, 100 and 150 kg N ha^{-1} levels were at par. Increases in leaf N was significant up to 150 kg N ha^{-1}.

Table 2. Effect of level of nitrogenous fertilizers on N-composition of leaf and tuber yield of potato at Rampur, Chitwan, 1999/2000

Treatment	Leaf N, %	Tuber yield, t ha^{-1}
Variety (V)		
Kufri Sinduri (KS)	4.82	31.85a†
Desiree (De)	4.96	17.42b
F test	ns	**
Nitrogen, kg ha^{-1}		
0	4.47c	20.31c
50	4.86b	23.19b
100	4.96b	27.21a
150	5.21a	27.81a
F test	**	**
Interaction		
KS × 0	4.37	25.68

KS × 50	4.78	31.62
KS × 100	4.92	34.83
KS × 150	5.22	35.27
De × 0	4.57	14.95
De × 50	4.93	14.76
De × 100	4.99	19.60
De × 150	5.20	20.36
F test	ns	ns

** Significant at 0.01. ns, Non significant. †Figures within column bearing the same letter(s) are not significantly different at 5% level of significance.

Kufri Sinduri and Desiree were not significantly different on leaf N. Therefore, the mean leaf N of 4.48% at 50 kg N ha^{-1} was considered as deficient while N of 5.21% at 150 kg N ha^{-1} as sufficient. The midpoint (5.04%) of these two leaf N values can be classified as critical. The critical level of nutrient is that concentration in a specific plant part at a specific stages of growth at which a 5 or 10% reduction in yield occurs, or that concentration which is associated with the breaking point of the nutrient response curve or that concentration which is at the midpoint of the nutrient response curve or that concentration which is at the midpoint of the traditional zone between deficiency and sufficiency level (Ulrich and Hills 1973). Singh (1987) reported a similar value of 5.37% as critical leaf N concentration for potato in Jalandhar, India.

Leaf P increased significantly with P application up to 100 kg P_2O_5 ha^{-1} (Table 3). Kufri Sinduri had significantly higher leaf P than Desiree (Table 3). Application of 50 kg P_2O_5 ha^{-1} significantly increased the tuber yield over control. In Kufri Sinduri application of P_2O_5 above 50 kg ha^{-1} did not show significant different in tuber yield. Similarly, the application of 50 kg P_2O_5 ha^{-1} in Desiree produced statistically the same yield as with control. Leaf P of 0.27% obtained without P application could be taken as deficient, while leaf P of 0.31% at 100 kg P_2O_5 ha^{-1} as sufficient and the mid point (0.29%) as critical. Singh (1988) described similar critical P value on leaf.

Leaf K was affected significantly by K application (Table 4). Kufri Sinduri and Desiree had similar leaf K. Application of 100 kg K_2O ha^{-1} significantly increased the tuber yield over control (Table 4). Significant interaction between variety and K application was obtained in tuber yield. Potassium more than 50 kg ha^{-1} did not show significant different in tuber yield in both cultivars. Leaf K of 3.57% was obtained without K application, while leaf K of 4.37% at 100 kg ha^{-1} as sufficient and midpoint (3.97) as critical. Singh (1987) reported a similar value of 3.62% as critical leaf K concentration for potato in Jalandhar, India.

Tuber yield

Kufri Sinduri had significantly higher tuber yield than Desiree (Table 5). Mean tuber yield increased significantly up to the application of 100:50:50 kg $N:P_2O_5:K_2O$ ha^{-1}, beyond which there was no proportionate increase in tuber yield. Tuber yield ranged from 25.7 to 35.7 and 14.9 to 21.1 t ha^{-1} in Kufri Sinduri and Desiree, respectively. The highest tuber yield (35.3 and 21.1 t ha^{-1}) was obtained at 150:100:100 and 100:100:100 $N:P_2O_5:K_2O$ kg ha^{-1}, respectively. Among the three nutrients, response of N was consistent and significant up to 150 kg N ha^{-1} irrespective of P_2O_5 and K_2O levels. Responses of P and K were significant only at lower level fertilization. The increase in tuber yield of potato with increase N and P has been reported by Gurung et al (1977) and that with N, P and K application by Sharma and Singh (1988) and Rykbost et al (1993).

Soil samples before planting and after harvesting contained a high amount of organic matter, Nitrogen and Phosphorus and medium amount of Potassium. The value above 1.29% organic matter more than 543:22:333 kg ha^{-1} the available $N:P_2O_5:K_2O$ respectively was considered as rich soils (Arora et al 1979). In the experimental plot, Nitrogen and Phosphorous were higher than these values. High nutrient status of the experimental plot played a significant role in increasing the fertility status of the soils.

Specific gravity

Specific gravity is considered an important quality character particularly for chips and flour making industries. Kufri Sinduri had higher specific gravity than Desiree (Table 5). It generally tended to decrease with increasing rate of N fertilizer across the entire range. The highest

specific gravity (1.086) was associated with control treatment followed by 50:50:50 $N:P_2O_5:K_2O$ kg ha^{-1} (1.082) in both cultivars. The treatment 150:100:100 $N:P_2O_5:K_2O$ kg ha^{-1} had the lowest specific gravity (1.076) in both cultivars. Interaction effect between fertilizer levels and cultivars on specific gravity was highly significant. The fertilizer levels 100:50:50; 100:75:50; 100:75:100 and 100:100:100 $N:P_2O_5:K_2O$ kg ha^{-1} did not show significant different on specific gravity in both cultivars. Increasing levels of Nitrogen and Potassium decreased specific gravity in both cultivars. Tubers from plants receiving highest Nitrogen and Potassium doses had lower specific gravity (Maier et al 1994, Westermann et al 1994, Smith 1968, Lauer 1986, Beukema and Vander Zaag 1990). High levels of P relatively did not influence specific gravity. This finding corroborates those of Dubetz and Bole (1975).

It is concluded that NPK application increases the potato yield significantly. However, the significant higher yield was obtained with the use of NPK in the ratio of 100:50:50 kg ha^{-1} under the soil conditions prevailing in sandy loam soil of Chitwan valley.

REFERENCES

Arora BR, IM Chhibba and GS Sekhon. 1979. *Practical manual soils and waters testing for BSc. (Agric.) honors in soils*. Department of Soils, Punjab Agricultural University, Ludhiana, India. 136pp.

Basnet KB, MD Sharma and RC Adhikari. 1998-1999. Response of potato to mineral fertilization under humid sub-tropical condition of Chitwan. *J. Insti. Agric. Anim. Sci.* 19-20:91-96.

Beukema HP and DE Vander Zaag. 1990. *Introduction to potato production*. Pudock Wageningen, The Netherlands. 208pp.

Dubetz, S and JB Bole. 1975. Effect of nitrogen, phosphorus, and potassium fertilizers on yield components and specific gravity of potatoes. *American Potato J.* 52:399-405.

Gomez KA and A Gomez. 1984. *Statistical procedure for agricultural research*. 2nd ed. John Willy and Sons, New York. 680pp.

Gurung SB, OP Gupta and N Kunwar. 1977. Response of unirrigated potato (*Solanum tuberosum*) to NPK application at Rampur, Chitwan. *J. Inst. Agric. Anim. Sci.* 1:111-118.

Jackson TL and GE Carter. 1976. Nutrient uptake by Russet Burbank potatoes as influenced by fertilization. *Agron. J.* 68: 9-12.

Krishnappa KS and MC Gowda. 1988. NPK uptake by Kufri Jyoti Potato (*Solanum tubersum* L.) in sandy loam soil. *J. Indian Potato Assoc.* 15(3 & 4):153-158.

Lauer DA. 1986. Russet Burbank yields response to sprinkler applied nitrogen fertilizer. *American Potato J.* 63(2):61-69.

Maier NA, AP Dahlenburg and CM J Williams. 1994. Effects of nitrogen, phosphorous and potassium on yield, specific gravity, crisp color and tuber chemical composition of potato (*Solanum tubersum* L.) cv. Kennebec. *Australian J. Expt. Agric.* 34(6):813-824.

MSTAT. 1986. *A microcomputers program for the design, management and analysis of agronomic research experiments*. East Lansing, Michigan State University.

Rykbost KA, NW Christensen and J Maxwell. 1993. Fertilization of Russet Burbank in short-season environment. *American Potato J.* 70:699-708.

Sharma UC and K Singh. 1988. Response of potato to NP and K in acidic hill soil of Meghalaya. *J. Indian Potato Assoc.* 15(1 & 2):40-44.

Singh JP. 1987. Leaf analysis of balanced nutrition of potato. *J. Indian Potato Assoc.* 14(3 & 4):88-91.

Singh JP. 1988. Role of phosphorus and potassium content of leaf in maximizing potato yield. *Indian J. Agric. Sci.* 57 (8):565-566.

Smith O. 1968. *Potatoes: Production storing processing*. The AVI publishing company, Inc., Westport, Connecticut, USA. 605pp.

Ulrich A and FJ Hills. 1973. Plant analysis as an aid in fertilizing sugar crops Part I, Sugarbeets. In: *Soil testing and plant analysis* (LM Walsh and JD Beaton, eds). Soil Sci. Soc. America, Madison. Pp. 271-288.

Westermann DT, TA Tindall, DW James and RL Hurst. 1994. Nitrogen and potassium fertilization of potatoes: Yield and specific gravity. *American. Potato J.* 71(7):417-431.