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RESPONSE OF POTATO TO NITROGEN APPLICATION METHODOLOGIES

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A promising red potato variety Symphonia was taken to explore for various nitrogen application techniques like broadcast (BC), side dressing (SD) and foliar application. Optimal recommended dose of nitrogen (250 kg ha^{-1}) were supplied from urea applied at planting and later on. Tuber emergence percentage, number of aerial stems, leaves $plant^{-1}$, plant height, number of tubers, foliage and tuber fresh and dried weight $plant^{-1}$ and tuber yield ha^{-1} were found to be better in case of T_{10} = BC+SD, followed by T_7 = BC+BC, T_{11} = SD+BC and T_4 = SD after 30 days of planting. Similarly, some of the tuber qualitative characters like TSS, specific gravity, dry matter contents were also better comparatively in case of initially broadcasted or later on side dressed nitrogen as compared to full basal dose (broadcasted or side dressed) and foliar application of nitrogen. On the other hand some qualitative characteristics like tuber's moisture, nitrogen, phosphorus, potassium and crude protein contents were improved in case of foliar application of nitrogen, followed by initially side dressed or full basal single dose of nitrogen as compared to better performing treatments for all other quantitative characters.
Key words: *Solanum tuberosum,* urea, nutrient, placement, broadcast, foliar.

INTRODUCTION

Potato is grown on an area of 18.63 million hectare in the world, providing an annual production of 327.62 million tons (FAO, 2004). While in Pakistan, it is being cultivated on an area of 115.8 thousand hectares, providing an estimated annual production of 1.95 x 10^6 tons, averaging 16.81 tons ha^{-1} (Govt. of Pakistan, 2004) which is very low as compared to leading potato growing developed countries like Netherlands, France, Germany, USA, U.K., Switzerland and Sweden, getting 46.43, 45.44, 44.22, 43.77, 42.86, 35.91 and 31.10 tons ha^{-1} yield of potato, respectively.

Potato is a short duration, high yielding and exhaustive crop. So, use of balanced fertilizers becomes more necessary and pre-requisite for getting better and higher yields of this crop. For optimum growth and development of potato crop, all essential elements need to be available in sufficient amounts. All these nutrients are present in the soil in varying quantities. However, some nutrients do not exist in sufficient amount and must be added from external sources. Practically, all cultivated soils in Pakistan are deficient in nitrogen. Continuous crop production further depletes these nutrients from the soil reservoir, so, they have to be replenished, especially nitrogen which is lost quickly due to leaching and volatilization (Malik, 1995).

In Pakistan, farmers follow different practices for the production of potato crop in various localities. They apply different types of manures and fertilizers from various sources at different times in different doses, through various techniques like broadcasting, placement, side or top dressing, fertigation and foliar application.

Keeping in view, the existing practices of the farmers in Pakistan, a red promising variety Symphonia was selected through varietal trial and current research studies were undertaken regarding nitrogen (urea) application methodologies to glean important findings of commercial importance for further uses in future for farming community to adopt and improve their existing old practices for better yields and returns.

MATERIALS AND METHODS

Present research project was carried out in the Vegetable Research Area, Institute of Horticultural Sciences, University of Agriculture, Faisalabad during 2001-2003. Materials used and methods employed may now be summarized below:

Five samples of soils at the depth of 15 and 30 cm each were taken, report was obtained from Ayub Agri., Res. Inst. Faisalabad (Table 3) and then this experiment was conducted to observe the effect of different methods of nitrogen application.

Whole potato tubers of Symphonia variety were sown and NPK fertilizers were supplied @ 250:125:125 kg ha^{-1} as Urea, SSP and SOP in three repeats.

Total amount of phosphorus and potash was applied at the time of sowing whereas, nitrogen was applied at different times through broadcast, placement and foliar methods.

Following eleven treatments were included in this experiment:

T_1 = Full dose of nitrogen at planting as broadcast method.

T_2 = Full dose of nitrogen at planting as placement method.

T_3 = Full dose of nitrogen 30 days after planting as broadcast method.
T_4 = Full dose of nitrogen 30 days after planting as placement method.
T_5 = Full dose of nitrogen 30 to 45 days after planting as foliar application of Urea @ 2% spray for 16 days regularly.
T_6 = Half dose of nitrogen at planting as placement method + half dose of nitrogen 30 days after planting as placement method.
T_7 = Half dose of nitrogen at planting as broadcast method + half dose of nitrogen 30 days after planting as broadcast method.
T_8 = Half dose of nitrogen at planting as broadcast method + half dose of nitrogen 30-37 days after planting as foliar application of Urea @ 2% spray for 8 days regularly).
T_9 = Half dose of nitrogen at planting as placement method + half dose of nitrogen 30-37 days after planting as foliar application of Urea @ 2% spray for 8 days regularly.
T_{10} = Half dose of nitrogen at planting as broadcast method + half dose of nitrogen 30 days after planting as placement method.
T_{11} = Half dose of nitrogen as placement method + half dose of nitrogen 30 days after planting as broadcast method.

Whole potato tubers of medium sized were sown on 29th September, 2001 at a distance of 15 cm on ridges, made 75 cm apart. Each ridge contained 35 tubers whereas, 70 tubers were sown in case of two ridges of each treatment. Length of the sub-plot measured was 5.71 m alongwith 1.5 m width, having 8.565 m^2 area. Irrigation was applied immediately after sowing and subsequent irrigations were given according to the need of the crop. Treatmental plots were separated by wats to avoid mixing of the inputs. At early stages of the crop, Imidaclorprid was sprayed twice against aphids and whiteflies. Similarly, at later stages Dithene M-45 was sprayed twice as a preventive measure against blight disease. All other cultural practices performed for all the treatments were uniform and same. Finally, crop was harvested on 21st January, 2002 to collect the data for various yield parameters. Experiment was repeated next year.

Various growth parameters; total emergence percentage, plant height, number of tubers and tuber weight $plant^{-1}$ were collected from five randomly selected plants and average was computed. Whereas, tuber yield ha^{-1} was obtained from tuber yield $plot^{-1}$. 350 g tuber weight from each treatment was taken, sliced, treated and dried adopting procedure reported by Srivastava and Sanjeev (2002) and converted to tuber dry weight $plant^{-1}$ basis. Tuber specific gravity and dry matter percentage was noted using potato hydrometer. Tuber nitrogen, phosphorus and potash contents on dry matter basis were estimated from dried and grinded samples following procedure as reported by Chapman and Pratt (1961). Tuber crude protein contents were obtained by multiplying nitrogen percentage by 6.25 as stated by AOAC (2000).

Data collected separately for both the years from individual treatments laid in RCBD, were analysed statistically through **analysis of variance over year's techniques** and tables of variance were constructed. Averages of significant treatments were compared in accordance with Duncan's Multiple Range Test (DMR) at 5% probability level (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Total emergence percentage varied significantly (Table 1), for which T_7 (BC+BC) and T_{10} (BC + SD) performed better with 94.05 and 93.10% of tuber emergence, respectively. Whereas, it was minimum (80.72%) with foliar application (T_9). Emergence depends upon genetic make up and micro climate. So, initially side

Table 1. Effect of nitrogen application methodologies on quantitative characters of potato

Treatments	Total emergence (%)	Plant height (cm)	No. of tubers $plant^{-1}$	Tuber fresh wt. $plant^{-1}$ (g)	Tuber dry wt. $plant^{-1}$ (g)	Tuber yield ha^{-1} (kg)
T1	86.67cd	45.30b	6.87cde	290.30d	66.64de	15679.09d
T2	85.95cd	43.23c	6.43ef	277.65d	62.57e	14709.51d
T3	88.33c	44.10bc	7.0bcd	345.17c	75.78c	16160.70cd
T4	90.95b	45.53b	7.53b	489.63b	114.36b	18208.76b
T5	84.52de	41.20d	6.13f	135.58f	30.72g	10834.88f
T6	90.72b	47.40a	7.0bcd	296.13d	68.56d	15907.74d
T7	94.05a	48.13a	7.13bcd	352.38c	74.78c	17581.21bc
T8	82.38ef	45.20b	6.60def	221.95e	49.55f	13207.80e
T9	80.72f	43.57bc	6.40ef	221.90e	47.61f	12739.43e
T10	93.10ab	47.73a	8.30a	572.60a	131.17a	20193.58a
T11	91.90ab	45.30b	7.27bc	355.88c	78.21c	17571.48bc

dressed full dose of nitrogen might have hurted to tender growing points. Similarly, due to unavailability of nutrients, plants might have faced stress in case of foliar application of nitrogen. Similar trend was observed for plant height, for which initially broadcasted plus broadcasted or side dressing later on behaved significantly better, producing taller plants as compared to initial full doses or foliar application (Table 1). Jongoo *et al.* (1996) support our results partially that plant height was increased with two nitrogen applications as compared to single basal application of nitrogen.

had positive effect on tuber yield ha^{-1}. Results for tuber dry weight $plant^{-1}$ were almost same as in above cases, that initially broadcasted plus side dressing later on (T_{10}) remained better and foliar application (T_5) performed poorly (Table 1). These results are partially supported by the findings of Payton (1990) who reported that split nitrogen application increased tuber dry weight.

Data for tuber dry matter percentage (Table 2) indicated significant differences which were quite narrowed. T_3 (BC) and T_{10} (BC+SD) performed better whereas, T_5 (foliar) and T_4 (SD) showed poor results.

Table 2. Effect of nitrogen application methodologies on qualitative characters of potato

Treatments	Dry matter (%)	Specific gravity	N contents (%)	P contents (%)	K contents (%)	Crude protein contents (%)
T1	22.0ab	1.090bc	1.40NS	0.208ab	1.72bcd	8.75NS
T2	22.37a	1.092abc	1.63	0.209ab	1.80b	10.21
T3	22.67a	1.094a	1.52	0.208b	1.72bcd	9.48
T4	22.33a	0.092abc	1.28	0.114c	1.62de	8.02
T5	21.13a	1.087d	1.75	0.210a	1.95a	10.94
T6	22.53a	1.093ab	1.28	0.208b	1.72bcd	8.02
T7	22.33a	1.092abc	1.28	0.114c	1.72bcd	8.02
T8	22.20a	1.091abc	1.63	0.208b	1.78bc	10.21
T9	21.97ab	1.090c	1.63	0.208b	1.78bc	10.21
T10	22.63a	1.093ab	1.28	0.111d	1.53e	8.02
T11	22.43a	1.092abc	1.28	0.115c	1.65cde	8.02

Number of tubers per $plant^{-1}$ were maximum (8.30) in T_{10} (BC + SD) and minimum (6.134) in case of foliar application (T_5) of nitrogen (Table 1). Wintek (1999) concluded that number of tubers were increased through foliar nitrogen application. These differences could be attributed to consecutive number of foliar nitrogen applications (present studies) which might have caused toxicity and ultimately stress to plants. Weight of tubers $plant^{-1}$ were maximum (572.6 g) in case of T_{10} (BC+SD), other treatments fell in between whereas, foliar application (T_9, T_5) showed poor results (Table 1). These findings are in agreement partially with the results of Payton (1990) who reported that split nitrogen application increased tuber fresh weight as compared to basal single nitrogen application. Similar trend was observed for tuber yield ha^{-1} (Table 1). T_{10} (BC+SD), T_4 (SD later on), T_9 (SD + Foliar) and T_5 (foliar) produced a yield of 20193.58, 18208.76, 12739.43 and 10834.88 kg ha^{-1}, respectively. These results are in agreement with the findings of Hodjankowa (1998) that band application of nitrogen proved to be better than broadcast method. Similarly, results reported by Maidl *et al.* (2002) support these findings that split application and placement of nitrogen

As for as concerned this parameter of study, different researchers have reported differently; Singh and Singh (1994) reported that basal dressing cum foliar application had a significant effect on tuber dry matter. On the other hand, Trawczynski (2001) concluded that methods of nitrogen application had no significant effect on tuber dry matter. Data in connection to tuber specific gravity (Table 2) showed narrowed significant differences. Any how, T_3 remained at top, other treatments remained in between whereas, T_9 and T_5 got the last two positions. These results are supported by Giroux (1984) who reported that nitrogen application to foliage reduced tuber specific gravity.

Tuber nitrogen contents were found to be non-significant (Table 2). Anyhow, T_5 (1.75%) remained at top where more nitrogen was retained within tubers due to growth dilution factor of nitrogen whereas, T_{11} (SD+BC) remained at last position with 1.28% nitrogen contents. These results are supported by Millard and Robinson (1990) who reported that foliar spray of Urea slightly increased tuber nitrogen contents. Similarly, Maidl *et al.* (2002) concluded that when nitrogen fertilizer was applied in split doses, the effect of nitrogen placement became negligibly small. These

Table 3. Soil analysis

S.No.	Depth (cm)	TSS (%)	pH	Organic matter (%)	Available P (ppm)	Available K (ppm)	Saturation (%)	Texture	Gypsum (t ha^{-1})
14423	0-15	0.07	8.5	0.97	10.8	230	38	Loam	Nil
14424	15-30	0.07	8.4	0.83	10.6	210	37	"	"
14425	30-45	0.06	8.4	0.69	9.8	-	39	"	"
14426	0-15	0.07	8.3	1.24	12.7	-	39	"	"
14427	15-30	0.07	8.2	0.97	11.5	-	38	"	"
14428	30-45	0.06	8.2	0.83	11.3	-	38	"	"
14429	0-15	0.31	8.0	1.10	12.8	-	43	"	"
14430	15-30	0.07	8.2	0.83	12.6	145	41	"	"
14431	30-45	0.07	8.5	0.69	19.3	130	40	"	"
14432	0-15	0.09	8.3	0.97	11.2	-	39	"	"
14433	15-30	0.06	8.3	0.55	10.5	-	39	"	"
14434	30-45	0.06	8.3	0.42	10.4	-	38	"	"
14435	0-15	0.07	8.2	1.24	13.5	200	39	"	"
14436	15-30	0.06	8.2	0.97	13.3	170	37	"	"
14437	30-45	0.06	8.3	0.55	12.0	-	38	"	"

results are further strengthened by the findings of Trawczynski (2001) that row fertilization of nitrogen decreased nitrogen contents in tubers. Observations for tuber phosphorus contents revealed significant but narrowed variations (Table 2). Anyhow, T_5 remained at top with more phosphorus contents due to growth dilution factor of phosphorus, followed by T_1, T_2 and other treatments (T_3, T_6, T_8, T_9) which remained in between whereas, T_4, T_7, T_{10} and T_{11} occupied the last positions. These results are in line partially with the findings of Kalembasa and Symanowicz (1998) that single fertilizer application increased tuber phosphorus contents. On the other hand, Trawczynski (2001) reported that method of nitrogen application had no significant effect on phosphorus contents of tubers. Tuber potassium contents showed significant but again narrowed differences (Table 2). Mean values indicated supremacy of T_5 (foliar) over other treatments, followed by T_2 (SD at planting), T_8 (BC+ foliar) and T_9 (SD+ foliar) whereas, T_{11} (SD+BC) ,T_4(SD later on) and T_{10} (BC + SD) occupied the last three positions where less potassium was retained within tubers because of its proper utilization. These results are partially supported by the findings of Kalembasa and Symanowicz (1998) that single fertilizer application increased potassium contents in tubers. Whereas, Trawczynski (2001) reported that method of fertilizer application had no significant effect on potassium contents of tubers. As for as concerned tuber crude protein contents, non-significant results were observed (Table 2). As this data was derived from tuber nitrogen percentage so, same trend in this case was observed. Mean values showed that poor performer treatments for vegetative or quantitative parameters (T_2, T_5, T_8, T_9) had comparatively more crude protein contents. On the other hand, better performer treatments for yield (T_{10}, T_{11}, T_7, T_4) retained less protein within the tubers. These results are supported by the findings of Tranwzynski (2001) that row fertilization decreased tuber nitrogen contents which ultimately represent tuber protein contents. Similarly, Trawczynski and Grzeskiewicz (2000) reported that partly application of Urea to foliage had no influence on chemical composition of the tubers, which support our results indirectly as non-significant results with minor variations are being presented in the present study.

REFERENCES

AOAC. 2000. Official methods of analysis. 15th Ed. Association of Official Chemists, Arlington 22200, Virginia, USA.

Chapman, H.D. and P.F. Pratt. 1961. Determination of NPK. Methods of Analysis of Soils, Plants and Waters, Pvt. Div. Agri. Univ. California, USA. PP.150-179.

Chaudhary, M.I. 1994. Soils and fertilizers in Horticulture. M.N. Malik (Ed.). National Book Foundation, Islamabad. P-269.

FAO. 2004. Stat database. Access date 23.08.05. www.fao.org.statistics

Giroux, M. 1984. Effect of application of urea to the soil and foliage on yields, specific weight and nitrogen nutrition of potato. Naturaliste Candien 111(2): 157-166 (Potato Absts., 10(8): 1086, 1985).