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EFFECT OF NITROGEN LEVELS ON YIELD, NITROGEN UPTAKE AND EFFICIENCY OF POTATO VARIETIES UNDER TARAI REGION OF UTTARAKHAND

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ABSTRACT

In order to know the marketable yield and nitrogen use efficiency of potato, five nitrogen levels and two potato varieties were replicated thrice in the experiment at Vegetable Research Station, GBPUAT Pantanagar. It was observed from the study that variety Kufri Surya performs better than Kufri Sadabahar in relation to marketable yield, nitrogen uptake, nitrogen use efficiency and nitrogen apparent recovery. Maximum marketable yield (43.87 t/ha), nitrogen content in tuber (1.17 %) and total nitrogen uptake (193.94 kg/ha) were recorded with application of 150 kg N/ha (N_2), while nitrogen use efficiency (141.60 kg tuber/kg N) and nitrogen apparent recovery (67 %) were observed maximum with application of 75 kg N/ha (N_1). Interaction effect of variety Kufri Surya and 150 kg N/ha (V_2N_2) gave maximum marketable tuber yield (45.75 t/ha) and total nitrogen uptake (199.05 kg/ha) among all treatments. The maximum nitrogen use efficiency was recorded (152.80 kg tuber/kg N) with treatment combination V_2N_1. It can be concluded that the variety Kufri Surya with application of 150 kg/ha nitrogen was best among all other treatments for potato production.

INTRODUCTION

Potato belongs to genetically diverse genus *Solanum* which contains about 2,000 species of which, 235 are tuber bearing species. It is rich source of carbohydrates, proteins, phosphorus, calcium, vitamin C and carotene (Reshi *et al.*, 2013). It produces more protein (524 kg/ha) as compared to wheat (254 kg/ha) (Sajid and Aftab, 2009). Potato tuber contains about 80 % water and the rest is dry matter. Starch is the principal constituent of the dry matter accounting for approximately 70 % of the total solids (Lokendrajit *et al.*, 2013). Potato is highly responsive to nitrogen nutrition and it is usually the most limiting essential nutrient for activity of potato growth and development. Nitrogen supply also plays an important role in the balance between vegetative and reproductive growth of potato plant. It is a vital nutrient for the activity of plant organs (Najm *et al.*, 2013).

Nitrogen uptake by potato crop is a function of yield potential and variety. The period of nitrogen uptake in potato plant begins about the time of rapid biomass accumulation and it is completed long before the crop reaches maturity. Nitrogen uptake on per day basis is some time even more than 1.5 kg/ha when only active growth period is considered (Sullivan *et al.*, 1999). It's important, for two reasons, to know the nitrogen demand in potato crop. First is the excessive use of nitrogen nutrition increases economical cost and second is the negative effects on environments, as problems associated with leaching and runoff (Rahemi *et al.*, 2005). The efficiency of nitrogen fertilizer management is influenced by many factors including source, form, placement, application rate and timing of the nitrogen fertilizer in addition to soil and environmental conditions. Nitrogen leaching is the primary mechanism for nitrogen loss in potato production (Zebarth and Rosen, 2007). Improved nitrogen fertilizer management will reduce the risk of NO_3 leaching and N_2O emissions during the growing season and will also reduce residual soil nitrate at harvest. In humid environments, where significant NO_3 leaching and N_2O emissions occur either before or after the crop growth period, reduced residual soil nitrate is an important factor in limiting environmental nitrogen losses (Cambouris *et al.*, 2008). Thus keeping this in mind the present investigation was carried out to know the effect of nitrogen fertilizer on yield, nitrogen uptake and nitrogen use efficiency of potato varieties.

MATERIALS AND METHODS

The present investigation was undertaken at Vegetable Research Centre of G.B.P.U.A. and T. Pantnagar, Uttarakhand, during Rabi season of 2012-13 and 2013-14. The experiment consists of five levels of nitrogen fertilizer *viz.*, 0 (N_0), 75 (N_1), 150 (N_2), 225 (N_3) and 300 kg/ha (N_4) and two variety *viz.* Kufri Sadabahar (V_1) and Kufri Surya (V_2), which were replicated thrice in factorial randomize block design. The half of the each level nitrogen apply as basal and remaining half amount top dressed after 30 days of planting. The source of nitrogen was urea (46% N). The potato crop was de-haulmed at 90

days after planting. Rest of the agronomic package of practices was adopted as per crop requirement. After harvest, tubers were categorized according to their weight and above 25 g tubers were taken as marketable tubers. The nitrogen content in plant and tuber were calculated by Microkjeldal method. The nitrogen use efficiency for each treatments were determine by method given by Janseen, 1998 and nitrogen apparent recovery were calculated by method given by Niu *et al.*, 2011. The observed data were then subjected to statistical analysis of variance (Sukhatme and Amble, 1995).

RESULTS AND DISCUSSION

Marketable yield

The data pertaining to marketable tuber number and yield as affected by varieties, nitrogen levels and their interaction has been presented in table 1. The number of tubers per hectare was non-significantly affected by varieties but yield of tubers was showed significant variation. Tuber yield was recorded higher (36.34 t/ha) with variety Kufri Surya (V_2) than variety Kufri Sadabahar (V_1) having 34.09 t/ha. Ravikant and Chadha (2009), and Sandhu *et al*. (2010) also recorded significant variation among varieties with respect to total potato yield.

The number and yield of potato tubers were significantly varied with application of different nitrogen levels. The number of tuber and yield were increase (43.70 % and 47.23 %, respectively) with increase in nitrogen levels upto treatment N_2 (150 kg N/ha) over treatment N_0 (without nitrogen) and after this level of nitrogen, it was decreased. Maximum number of tubers (1023.27 thousand/ha) and marketable yield (43.87 t/ha) were recorded with treatment N_2 and minimum (576.08 thousand/ha and 23.15 t/ha, respectively) with treatment N_0 (without nitrogen application). These findings are also in agreement with the results of Chandra *et al*. (2015) and Keisham *et al*. (2015). This might be attributed to better growth and development of the plant and formation of larger tuber due to better availability and efficient use of nitrogen by the plant. The decreased yield with application of above 150 kg N/ha might be due to the fact that in such conditions, vegetative growth of the areal parts can be increased and hence, it prevents the transferring of photosynthetic matters in to storage parts *i*.e. tuber. Singh *et al*. (2008) and Mehdi *et al*. (2008) also recorded similar types of results.

The interaction of variety and nitrogen were also affect significantly to the number and yield of potato tuber. It was observed that both varieties respond similarly to different nitrogen levels as both the varieties gave highest number (995.51 and 1051.03 thousand/ha with variety Kufri Sadabahar and Kufri Surya, respectively) and yield (42.03 and 45.72 t/ha in variety Kufri Sadabahar and Kufri Surya, respectively) of tuber with application of 150 kg N/ha and beyond this both varieties show reduction in number and yield of tuber. These findings are also in agreement with the observation of Takalign and Hammes (2005).

Nitrogen content in potato plant and tuber

Nitrogen content in plants showed non-significant variation

Table 1: Effect of varieties, nitrogen levels and their interaction on yield and plant analytical characters of potato.

Treatments	Number of marketable tubers per ha	Yield of marketable tuber (t/ha)	N content in plant (%)	N content in tuber (%)	Nitrogen uptake by potato crop (kg/ha)			Nitrogen use efficiency (kg tuber /kg N)	Nitrogen apparent recovery (%)
Variety					N uptake by haulms	N uptake by tuber	Total nitrogen uptake		
V_1	845.6	34.09	2.59	1.07	74.18	78.21	152.43	71.32	40.27
V_2	846.33	36.34	2.52	1.08	86.76	79.82	166.58	82.72	36.63
S.Em±	1.85	0.65	0.1	0.3	0.58	1.29	1.14	0.78	0.66
CD at 5%	NS	1.94	NS	NS	1.73	NS	3.4	2.32	1.96
Nitrogen									
N_0	576.08	23.15	2.23	0.94	50.04	49.37	99.4	-	-
N_1	864.71	33.84	2.54	1.04	71.83	78.38	150.2	141.6	67.81
N_2	1023.27	43.87	2.82	1.17	84.66	109.2	193.94	135.7	62.97
N_3	883.03	40.17	3.05	1.16	96.31	90.65	186.96	71.96	38.93
N_4	882.73	35.04	2.83	1.07	99.5	67.5	167	35.86	22.54
S.Em±	2.92	1.03	0.16	0.48	0.92	2.05	1.81	1.23	1.04
CD at 5%	8.69	3.06	0.49	0.14	2.74	6.09	5.37	3.66	3.09
Interaction (VxN)									
V_1N_0	560.7	22.79	2.1	0.93	41.98	46.28	88.27	-	-
V_1N_1	924.57	32.65	2.34	0.98	62.58	76.08	138.66	130.4	67.33
V_1N_2	995.51	42.03	2.67	1.16	77.84	110.83	188.83	125.53	66.94
V_1N_3	875.53	39.19	2.54	1.2	92.86	89.57	182.43	68.09	41.87
V_1N_4	871.7	33.82	2.79	1.12	95.66	68.31	163.96	32.6	25.23
V_2N_0	591.46	23.52	2.36	0.96	58.1	52.46	110.53	-	-
V_2N_1	804.85	35.03	2.74	1.1	81.09	80.68	161.75	152.8	65.23
V_2N_2	1051.03	45.72	2.97	1.19	91.48	107.55	199.05	145.87	59.01
V_2N_3	890.53	41.15	3.06	1.13	99.76	91.73	191.5	75.84	35.99
V_2N_4	893.77	36.27	2.87	1.02	103.36	66.68	170.05	39.13	19.84
S.Em±	4.14	1.46	0.23	0.68	1.3	2.9	2.56	1.74	1.47
CD at 5%	12.29	4.33	0.7	NS	3.87	NS	7.6	5.18	4.37

to varieties, while it was significantly affected by nitrogen levels. It was found that nitrogen content in plant increases with the increase in nitrogen levels upto treatment N_3 (225 kg N/ha) which gave 26.88 % higher nitrogen content in plants than treatment N_0 (without nitrogen application). Maximum nitrogen content in plant was recorded (3.05 %) with treatment N_3 (225 kg N/ha) which was statistically at par with treatment N_4 (2.83 % N) and N_2 (2.83 % N). The minimum nitrogen content in plant was observed (2.23 %) with treatment N_0 (without nitrogen application). Interaction effects of varieties and nitrogen levels also showed significant response to nitrogen content of potato plant. Maximum nitrogen content in plant was recorded (3.06 %) with treatment V_2N_3 (Kufri Surya with 225 kg N/ha) and minimum (2.10 %) with treatment V_1N_0 (Kufri Sadabahar without nitrogen application). Chopra *et al*. (2010) reported significant enhance in plant nitrogen content with application of nitrogen fertilizer upto 250 kg/ha.

In variety Kufri Surya the nitrogen content in tubers was recorded 1.08 % higher than variety Kufri Sadabahar (V_1) having 1.07 %, however, the variation in nitrogen content of tuber for varieties was non-significant. The tuber nitrogen content responds significantly to applied nitrogen levels. Highest nitrogen content in tuber (1.17 %) was recorded with treatment N_2 (150 kg N/ha), which was statistically at par with all other treatments, except N_0 (0.94 %), having lowest tuber nitrogen content. Nitrogen content in tuber was increase gradually with the increase in nitrogen levels upto N_2 (150 kg N/ha) and after that it decreased. The higher nitrogen content in tubers might be due to the reason that, nitrogen applied at this level was found to be beneficial since hydrolysis of urea have made more nitrogen easily available to the plant roots which in turn resulted in higher nitrogen concentration in tuber. Majic *et al*. (2008) and Yassen *et al*. (2011) were also reported the increased nitrogen level in potato tubers with increasing nitrogen fertilizer application.

Nitrogen content in tuber was recorded highest (1.20 %) with treatment V_1N_3 (Kufri Sadabahar and 225 kg N/ha) and lowest (0.93 %) with V_1N_0 (Kufri Sadabahar without application of nitrogen), however, interaction effect of varieties and nitrogen levels did not show any remarkable influence on nitrogen content in tuber.

Nitrogen uptake by plant and tuber

A significant effect of varieties was recorded on nitrogen uptake in potato plant in pooled analysis over the years. The higher nitrogen uptake in plant was observed with Kufri Surya (V_2) having 86.76 kg/ha, which showed 14.50 % increase over Kufri Sadabahar (V_1) *i.e.* 74.18 kg/ha. Badr *et al*. (2012) also reported significant difference between varieties for nitrogen uptake in potato plant. Nitrogen uptake in potato plant enhance with increasing nitrogen levels and was maximum (99.50 kg/ha) with treatment N_4 (300 kg N/ha), followed by N_3 (225 kg N/ha) which uptake 96.31 kg N/ha. Guhar and Raghav (2007) also reported that the nitrogen uptake increase with increasing levels of nitrogen fertilizer. Variation in nitrogen uptake with different nitrogen levels might be due to the variation in dry matter yield of potato plant. Higher nitrogen content at higher level of nitrogen application together with higher dry matter production resulted higher nitrogen uptake (Singh and Lal, 2012). Minimum nitrogen uptake was observed (50.04 kg/ha) with treatment N_0 (0 kg N/ha). These findings are also supported by results of Poljak *et al*. (2008).

Significant variation was observed in mean nitrogen uptake in plant (table 1) with respect to interaction of varieties and nitrogen levels. The maximum nitrogen uptake in plants were recorded (103.36 kg/ha) with treatment V_2N_4 (Kufri Surya and 300 kg N/ha), followed by V_2N_3 (Kufri Surya and 225 kg N/ha) having 99.76 kg/ha. Minimum nitrogen uptake in plant was recorded (41.98 kg/ha) with treatment V_1N_0 (Kufri Sadabahar and 0 kg N/ha). These results are partially in agreement with the finding of Badr *et al*. (2012).

Varieties did not show any significant effect on nitrogen uptake in potato tuber. Pooled data over the years show significant variation in nitrogen uptake in tuber for different nitrogen levels and was recorded maximum (109.20 kg/ha) with treatment N_2 (150 kg N/ha), followed by N_3 (90.65 kg/ha). Minimum nitrogen uptake (49.37 kg/ha) was observed with treatment N_0 (0 kg N/ha). The increased nitrogen uptake in tubers with increasing nitrogen levels were also reported by Guhar and Raghav (2007). Interaction of varieties and nitrogen levels showed non-significant effect in nitrogen uptake by potato tuber.

Total nitrogen uptake

Varieties show significant effect on total nitrogen uptake in potato plants. Variety Kufri Surya (V_2) showed 8.49 % increased total nitrogen uptake over Kufri Sadabahar (V_1). Total nitrogen uptake was recorded higher (166.58 kg/ha) with Kufri Surya (V_2) than Kufri Sadabahar (V_1) *i.e.* 152.43 kg/ha. These results were supported by results of Kumar *et al*. (2008).

Pooled analysis over the years indicates that the nitrogen levels significantly affect the total nitrogen uptake of plant and was recorded highest (193.94 kg/ha) with treatment N_2 (150 kg N/ha), followed with treatment N_3 (186.96 kg/ha). The lowest total nitrogen uptake was observed (99.40 kg/ha) in plants with no nitrogen application. The higher nitrogen content in plant and tuber might be due to the reason that the nitrogen applied at adequate level was found beneficial, since hydrolysis of urea have made more nitrogen easily available to plant roots which in turn resulted in higher nitrogen concentration in haulms and tubers. The results were in agreement with finding of Sharma and Dubey (2000), and Shanmugasundaram and Savithri (2000). Highest total nitrogen uptake was recorded (199.05 kg/ha) with treatment combination V_2N_2 (Kufri Surya and 150 kg N/ha) and minimum (88.27 kg/ha) with treatment V_1N_0 (Kufri Sadabahar without nitrogen application).

Nitrogen use efficiency

Data shows higher nitrogen use efficiency in plant with variety Kufri Surya (V_2) having 82.72 kg tuber/kg N, which was 13.78 % higher over variety Kufri Sadabahar (V_1) having 71.32 kg tuber/kg N. This higher nitrogen use efficiency with variety Kufri Surya (V_2) was might be due to its higher tuber yield per hectare. Kumar and Trehan (2012) also reported the significant variation in nitrogen use efficiency potato plants in different varieties. Maximum nitrogen use efficiency was recorded (141.60 kg tuber/kg N) with treatment N_1 (75 kg N/ha), followed by treatment N_2 (150 kg N/ha) having 135.70 kg tuber/kg N and minimum (35.86 kg tuber/kg N) with treatment N_4 (300 kg N/ha). It was observed that nitrogen use efficiency of potato plants showed 74.67% decrease as nitrogen levels increases

from treatment N_1 to N_4. These results partially supported by results of Singh and Lal (2012). Interaction of varieties and nitrogen levels were show highest nitrogen use efficiency of plant (152.80 kg tuber/ kg N) with treatment V_2N_1 (Kufri Surya and 75 kg N/ha) and minimum (32.60 kg tuber/kg N) with V_1N_4 (Kufri Sadabahar with 300 kg N/ha). These results were also in agreement with finding of Kumar *et al*. (2006).

Nitrogen apparent recovery

The nitrogen apparent recovery in plants was recorded higher (40.27 %) in Kufri Sadabahar (V_1) which was 9.04 % higher over Kufri Surya (V_2) having 36.63 %. Pooled data show significant response of nitrogen levels to nitrogen apparent recovery in plant and was recorded maximum (67.81 %) with treatment N_1 (75 kg N/ha), followed by 62.97 % with treatment N_2 (150 kg N/ha). The minimum nitrogen apparent recovery was recorded (22.54 %) with treatment N_4 (300 kg N/ha). The proportion of fertilizer recovered in tubers clearly declined with increased nitrogen supply was also reported by Mustonen *et al*. (2010) and Badr *et al*. (2012). The recovery of applied fertilizer nitrogen by the potato crop is generally low. This low efficiency has been attributed to the limited and shallow root system of the crop (Cambouris *et al*., 2008). Pooled analysis over the years shows significant response of interaction of varieties and nitrogen levels on nitrogen apparent recovery in potato plant. Maximum nitrogen apparent recovery in plant was observed (67.33 %) with treatment V_1N_1 (Kufri Sadabahar and 75 kg N/ha), followed by treatment V_1N_2 (Kufri Sadabahar and 150 kg N/ha application) having 66.94 % and minimum (19.84 %) with treatment V_2N_4 (Kufri Surya and 300 kg N/ha).

On the basis of experimental results it can concluded that the variety Kufri Surya was better for yield, nitrogen uptake and nitrogen use efficiency. Among various nitrogen levels, 150 kg N/ha found to be best for both the varieties, but yield potential of variety Kufri Surya was 8.07 % higher than Kufri Sadabahar.

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