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Research Article

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Effect of Integrated Method of Nitrogen Application on Growth and Yield of Potato (*Solanum tuberosum* L. var. Kufri Jyoti) in Mid-Hill of Garhwal

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ABSTRACT

An experiment was conducted at the Vegetable Demonstration and Research Block, Department of Vegetable Science, College of Horticulture, VCSG Uttarakhand University Horticulture and Forestry, Bharsar, during summer season; to study the effect of integrated method of nitrogen application through different method i.e. foliar, top dress and basal dose. The experiment was under taken ten treatment combinations of nitrogen level with application method consisting of RDF basal, topdress (100%, 25%, 50%, 75%) and foliar application (1%, 0.25%, 0.50%, 0.75%) were evaluated in randomized complete block design with three replications. Results showed that among the all the treatment nitrogen application T_4 (50% recommended dose of N as basal+50% top dress at 30 and 45 DAP) found to be most effective in term of plant height, total number of stems per plant, number of haulms per plant (at 45, 60, 75 DAP and de-haulming), tuber diameter, tuber length and yield.

Keywords: *Nitrogen, Method of application, Growth, Potato and De-haulming.*

INTRODUCTION

Potato (*Solanum tuberosum* L.) is fourth most important staple food crop after rice, wheat and maize. It is an important tuberous vegetable crop which has been adopted well for cultivation under sub-tropical conditions during winter season or *Rabi* season. In Uttarakhand, productivity of potato is very low because of various factors involves to reduces its productivity; imbalanced use of nutrients is one of them. The application of inorganic and organic fertilizers is considered essential to produce high tuber yield (Bose & Som, 1993).

To improve productivity, potato plant requires a balanced dose of NPK along with adequate amount of micronutrients. Micronutrients are essential for plant survival and needed only in small quantities (Kanwar & Youngdahl, 1985). Fertilization is an important factor in potato production technology to achieve better growth, yield and quality of tubers. Nutrients requirement of potato is high. However, it is a heavy feeder vegetable crop because it needs high amount of nitrogen, phosphorus, potassium, magnesium and calcium, as well as other micro elements.

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Nitrogen is important in fuelling growth and providing high yield. It is largely needed during leaf formation and then for tuber growth and yield, when it ensures optimal photosynthesis production in the leaves. Nitrogen fed at an early stage of crop development will help built the overall size of the leaf canopy, whereas at later stages of growth, nitrogen use helps to maintain the greenness of the canopy and maximize yield. Potato yield and quality are highly dependent on an adequate supply of nitrogen (Errebhi et al., 1998). Nitrogen increases the tuber yield by improving the size as well as the number of tubers per plant. In the event of nitrogen deficiency, lower leaves become yellow and later the whole of plants gives a yellowish appearance and growth of plant is stunted. Hence, standardization of fertilizer dose for a particular variety at particular region becomes essential for deciding the success of potato cultivation. Nitrogen is the first limiting factor for potato crop which improves vegetative growth and number of tubers per plant, size of tuber (Ananda & Krishnappa, 1999, Li et al., 1999) and ultimately increase the total tuber yield or productivity of crop. Since nitrogen is highly mobile, its use and demand is continuously increasing as it is subjected to high loss from the soil plant system. This is present in both organic and inorganic forms in soil. The organic nitrogen *viz*., ammonical and nitrate form of nitrogen contributes to plant growth and development. At the time of planting, nitrogen must be available in adequate quantity to stimulate root growth in the seed tuber. Quick availability of nitrogen in the soil accelerates shoot and root growth. Inadequate N fertilization leads to poorer potato growth and yield, while excessive N application leads to delayed maturity, poor tuber quality and occasionally a reduction in tuber yield (Cerny et al., 2010). Nitrogen deficiency usually results in poor growth and low yield while excessive nitrogen leads to poor tuber quality, delayed crop maturity and excessive nitrate leaching (Chare et al., 1990). Even under best management practices, approximately 30-50% of applied nitrogen is lost through different agencies and hence, the farmer is compelled to apply more than what the crop needs to compensate for losses through leaching, volatilization and denitrification making the nutrient unavailable during the critical stages of crop growth (Hyatt et al., 2010). The nitrogen losses can be minimized by using appropriate method of its application. Foliar spray of nutrients is an important substitute for soil fertilization and a good tool in crop management to maximize yield of crops. Foliar application of urea is more beneficial as it depends less on soil conditions and in saline or dry soils when root nitrogen uptake is impaired, plants can easily take nitrogen from foliar application (Gooding & Davies, 1992). Foliar application of urea can enhance yield of tuber as it provides an opportunity to fertilize the crop late in the season (Millard & Robinson, 1990). Many previous studies have shown that nitrogen application can increase dry matter content, protein content of potato tubers, total and/or marketable tuber yield (Zelalem et al., 2009). Therefore, present investigation have been planned to study the "Effect of integrated method of nitrogen application on growth, yield and quality of potato crop (*Solanum tuberosum* L. var. Kufri Jyoti)". The objective of the present investigation was to assess the proper method of nitrogen applications.

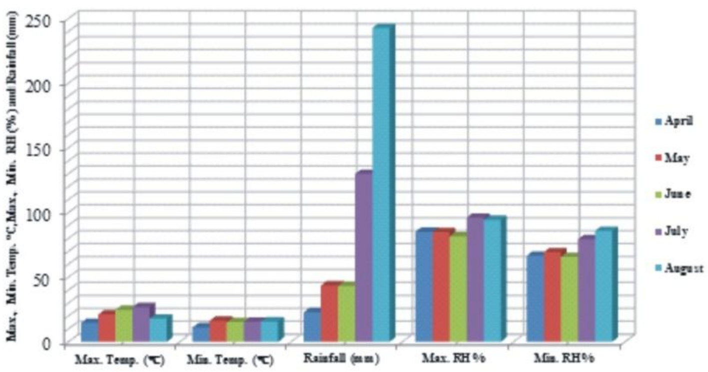

Fig. 1: Mean monthly meteorological data for crop season of the year 2017

MATERIAL AND METHODS

The experiment was conducted at the Vegetable Demonstration and Research Block, Department of Vegetable Science, College of Horticulture, VCSG Uttarakhand University of Horticulture and Forestry Bharsar during April-August 2017. The site of experiment is geographically located at latitude of 30.056^o N and longitude 78.99^o E and at an elevation of 1900-2200 meters above mean sea level. The climate of this zone is typically sub-humid, sub-temperate and mid-hill zone of Uttarakhand. The climatological data graphically depicted in Fig. 1. The soil textural class at the site was sandy loam. The experiments was laid out in randomized complete block design with three replications conducted were taken total ten different nitrogen modules comprising RDF basal and topdress (100%, 25%, 50%, 75%) and foliar application (1%, 0.25%, 0.50%, 0.75%) during *summer* season of the year 2017. At planting, hills were created with a between-row distance of 60 cm and a within-row plant distance of 20 cm. Each subplot had five rows with 10 hills per row. Therefore, each subplot had an area of 3 m×2 m=6m^2. Cultivar "Kufri Jyoti" of Potato was chosen for the present study. Well sprouted seed tuber each of 30g- 50g weight were used for planting. Intercultural operation like weeding, earthing up, irrigation and effective plant protection measures were done as and when necessary. Data on 5 randomly selected plants per plot were recorded during the crop growth period and also at harvest. The crops were harvested at 120 days after planting. Data were recorded on days required to 50% emergence, plant height, number of stems, number of haulms per plant, tuber length and diameter. The details of the treatments are given as for potato. Ten different methods of Nitrogen application were used as follows: T_1-No application of nitrogen (control), T_2 -100% recommended dose of nitrogen as basal, T_3-75% recommended dose of N as basal + foliar spray of 0.5 % urea (30 and 45 DAP), T_4 -50% recommended dose of N as basal + 50% top dress (30 and 45 DAP), T_5 -Foliar spray 0.75% urea (30 and 45 DAP), T6-25% recommended dose of N as basal + 75% top dress (30 and 45 DAP), T_7-50% recommended dose of N as basal + foliar spray of 0.25% urea(30 and 45 DAP), T_8-25% recommended dose of N as basal + foliar spray of 1% urea (30 and 45 DAP), T_9-Foliar spray of 0.5% urea (30 and 45 DAP) and T_{10}-Foliar spray of 1% urea (30 and 45 DAP). After proper demarcation of the plots a basal application of 135 kg P_2O_5 (full) and 95 kg K_2O (full) per hectare in the form of single superphosphate (SSP) and muriate of potash (MOP) respectively, were applied uniform to all experimental plots at the time of sowing and it was mixed with soil. The data were analyzed as per the standard procedure for Analysis of Variance (ANOVA) as described by Pense and Sukhamate (1967). The significance of treatments was tested by 'F' test. The difference in the treatment mean was tested by using critical difference (CD) at 5% level of probability. Standard error of mean (SEm±) was also computed in all cases.

RESULTS AND DISCUSSION

I. Effect on growth attributes

Data regarding the effect of various integrated nitrogen application on growth attributes have been presented in Table 1 revealed that the days to 50% emergence, plant height, number of stems and number of haulms were significantly influenced by different levels of nitrogen. The application of nitrogen didn't have any impact on days to 50% emergence of potato tubers. It was manifested that the minimum days to 50% emergence 22 days were observed in treatment T_7 (50% recommended dose of N as basal + foliar spray of 1% urea at 30 and 45 DAP). The poor emergence was mainly due to late planting and low night temperature (below 10^{o}C) prevailed during the time of observation. Similar result was observed by Brajesh and Ezekiel (2010). Maximum days was recorded 28 days in treatment T_8 (25% recommended dose of N as basal + foliar spray of 1% urea at 30 and 45 DAP). It might be probably due to the fact that food material already stored in the seed tubers gave initial boost to the emerging plants. The emergence percentage showed non- significant effect of nitrogen (Singh & Lal, 2012). The plant height was significantly influenced by different levels of nitrogen application. Maximum plant height of 35.46 cm, 49.78 cm, 65.94 cm and 68.41 cm was recorded at different stages 45 DAP, 60 DAP, 75 DAP and at de-haulming, respectively. The results indicated that recommended dose (basal+ top dress) of nitrogen gave better response than that of recommended practice *i.e.* recommended dose of (Top dress and foliar spray). Nitrogen being an important constituent of amino acids, proteins and protoplast directly influences the plant growth and development through better utilization of photosynthates (Singh & Lal, 2012). Potato varieties for various nitrogen application techniques like basal and top dress were found to be better in case of plant height (Ayyub, et al., 2006). The plant height significantly increased with the increase in nitrogen dose up to 180 kg N/ha. (Kumar et al., 2008). The present finding has been also supported by Bose et al., (2008), Abu-Zinada (2009), Najm et al., (2010). The significantly maximum number of stems *i.e*. 46.13, 51.93, 55.93 and 59.26 were recorded at 45 DAP, 60 DAP, 75 DAP and at de-haulm stage, respectively. Number of stems per plant increased with an increase in nitrogen levels (Banjare et al., 2014). Rizk et al. (2013), found that potato plant growth characters greatly affected by urea application. However, urea as foliar spray at 3 % level caused an increase the number of stem in potato plant. Nitrogen application didn't have any impact on number of haulms of potato. The split application of nitrogen *i.e.* basal + top dress + spray didn't have any significant impact on number of haulms per plant of potato tubers at any stages of crop growth. The number of haulms per plant character mainly depends on the cultivar, seed size and its physiological stage of the seed tuber rather than the fertility of the soil (Ananda & Krishnappa, 1999, Chowdhury, et al., 2002). Our results are in close conformity with Singh & Lal (2012). The application of nitrogen significantly increases the tuber diameter. Treatment T_4 (50% recommended dose of N as basal+50% top dress at 30 and 45 DAP) recorded maximum tuber diameter of 4.73 cm. The different treatments, showed significant variation with respect to tuber length. In the present investigation, maximum tuber length (6.78 cm) was recorded in treatment T_4. The increased tuber diameter and tuber length was also reported with the application of basal and top dress of nitrogen. Application of nitrogen significantly increased the potato size (Singh & Gupta, 2005).

II. Effect on yield attributes

The data presented in table 2 revealed that yield and Yield attributes were significantly affected by different levels of nitrogen. The results indicated that there is an increase in aggregate number of tuber with mode of application (50% recommended dose of N as basal+50% top dress). The highest numbers of tuber per plot with size less than 25 g grade tubers was obtained in treatments T_3 (252.66) and 25-50 g tuber was obtained maximum with treatment T_4 (249.33) whereas, maximum numbers of tubers with grade 50-75 g and at de-haulmimg were obtained with T_4 (272.00 and 291.33, respectively). Maximum number of grade wise tuber per hectare were obtained as 234.34, 230.91, 252.41 and 270.41 thousand/ha. This might be due to the application of different nitrogen form (basal + top dress). Nitrogen application improves the tuber size by increasing the large (>75g) and medium grade (25-50 g and 50-75 g) tuber yield and decrease small size tuber (<25g) (Singh & Lal, 2012, Kumar et al., 2008). The grade wise increase in number of tubers may be due to increased photosynthetic activity and translocation of photosynthates to the roots which might help in the initiation of more stolon in potato (Ananda & Krishnappa, 1999). These results are supported by the finding of Chowdhury et al. (2002) and Kumar and Trehan (2012). These results are also confirmed by the finding of Osaki et al. (1992), Patel et al. (2000), and Singh and Gupta (2005). The present study revealed significant differences among treatments with respect to total tuber yield per plot and per hectare. Maximum tuber yield was recorded with the application of T_4 (50% recommended dose of N as basal+50% top dress at 30 and 45 DAP) whereas, minimum tuber yield was reported in the plots receiving no application of nitrogen (control). The improvement in yield of tubers might be due to better growth and development of plant and larger tuber formation that were resulted due to better availability and efficient use of nitrogen by plant (Chowdhury et al., 2002). Qadri et al. (2015) concluded that potato supplied with foliar nitrogen, increased leaf nitrogen contents, thus accelerates photosynthesis and develop a strong source sink relationship. Hence mode of fertilizer application also matters a lot specifically when plants need quick access to nutrients. They also observed that fertilizer dose for foliar application is too low than soil applied nitrogen. So, in another way it enhances fertilizer use efficiency and reduced nutrients loses. These results are supported by the findings of Chowdhury et al. (2002) and Correa et al. (2017) The results indicated that the marketable yield were influenced by nitrogen application (50% recommended dose of N as basal + 50% top dress) over control. The increase in marketable tuber yield might be due to increase in number and yield of large and medium sized tubers. The results are also in agreement with the findings of Moshileh et al. (2005), Getachew et al. (2012) and Zelalem et al. (2009).

Table 1: Influence of different application method of nitrogen levels on growth attributes

Treatments	Days to 50% emergence	Plant height (cm)				Number of stems				Number of haulms				Tuber diameter (cm)	Tuber length (cm)
		45 DAP	60 DAP	75 DAP	At de-haulming	45 DAP	60 DAP	75 DAP	At de-haulming	45 DAP	60 DAP	75 DAP	At de-haulming		
T_1	26.66	26.73	33.06	40.98	47.28	26.86	38.86	39.33	42.93	1.60	1.62	2.32	2.39	4.03	6.12
T_2	26.33	33.97	47.90	62.86	68.41	46.06	51.93	55.26	57.80	1.66	1.81	2.90	3.23	4.46	6.59
T_3	26.00	33.34	42.46	55.72	61.30	35.53	42.66	47.06	50.66	1.46	1.79	2.65	2.93	4.08	6.29
T_4	23.66	35.46	49.78	65.94	68.38	46.13	51.66	55.93	59.26	2.00	2.33	2.61	3.05	4.73	6.78
T_5	25.00	29.94	34.74	56.43	60.26	30.93	34.86	42.53	45.86	1.80	2.22	3.17	3.66	4.06	6.24
T_6	23.00	28.99	43.23	50.13	52.49	31.20	38.13	42.73	47.13	1.86	1.95	2.78	2.98	4.49	6.38
T_7	22.00	31.98	41.33	54.30	57.98	33.73	40.66	45.13	48.60	1.80	2.11	2.42	2.90	4.69	6.43
T_8	28.00	26.88	33.76	47.53	49.74	35.93	43.26	48.00	51.13	1.66	1.87	2.83	3.07	4.55	6.66
T_9	26.66	33.13	40.10	44.14	53.71	43.40	49.53	55.73	58.60	1.86	2.14	2.65	2.88	4.46	6.68
T_{10}	23.33	30.92	39.46	55.81	60.31	33.20	40.86	45.20	48.06	1.93	2.08	2.65	2.89	4.50	6.32
±S.E.(d)	1.97	2.38	3.24	2.14	3.92	4.79	4.44	4.62	4.63	0.29	0.33	0.43	0.33	0.19	0.18
$C.D._{(0.05)}$	3.41	5.04	6.87	4.54	8.30	10.14	9.41	9.79	9.80	0.50	0.57	0.74	0.57	0.41	0.38

Table 2: Influence of different application method of nitrogen levels on yield of tubers

Treatment	Grade wise number of tubers per plot ± SE(m)				Tuber yield per plot (kg) ± SE(m)	Tubers yield per hectare (q) ± SE(m)	Marketable yield (q) ± SE(m)
	<25 g	25-50 g	50-75 g	>75 g			
T_1 control	155.33 ± 1.20	134.33 ± 0.88	83.33 ± 0.88	70.66 ± 0.88	12.11 ± 0.35	171.23 ± 0.31	169.13 ± 0.52
T_2	213.00* ± 1.15	197.00* ± 0.57	194.33* ± 0.88	204.33* ± 0.33	15.50* ± 0.60	219.50* ± 0.63	217.27* ± 0.51
T3	252.66* ± 0.88	189.33* ± 0.88	167.33* ± 0.88	117.00* ± 0.57	15.47* ± 0.42	219.23* ± 0.43	218.26* ± 0.60
T_4	184.33* ± 0.88	249.33* ± 0.33	272.00* ± 0.57	291.33* ± 0.88	19.36* ± 0.61	274.20* ± 0.55	271.30* ± 0.39
T_5	168.33* ± 0.88	161.33* ± 0.88	239.00* ± 0.56	260.66* ± 0.66	17.53* ± 0.40	248.30* ± 0.57	246.21* ± 0.56
T_6	165.33* ± 0.88	177.33* ± 0.88	241.33* ± 0.88	263.33* ± 0.88	13.90* ± 0.32	196.43* ± 0.62	194.63* ± 0.53
T_7	197.00* ± 0.57	216.00* ± 0.57	186.00* ± 0.57	193.00* ± 0.57	17.44* ± 0.65	247.43* ± 0.72	245.66* ± 0.80
T_8	233.67* ± 1.85	227.66* ± 0.66	178.00* ± 0.57	162.66* ± 1.20	14.99* ± 0.50	212.60* ± 0.64	210.36* ± 0.63
T_9	232.33* ± 0.88	206.66* ± 1.20	181.00* ± 0.57	183.33* ± 0.88	14.59* ± 0.63	206.63* ± 0.80	202.10* ± 0.62
T_{10}	173.33* ± 0.88	168.33* ± 0.88	183.33* ± 1.45	180.33* ± 0.33	15.73* ± 0.77	222.26* ± 0.96	220.56* ± 0.67
±S.E.(d)	1.44	0.80	1.16	1.06	0.32	0.31	0.15
$C.D._{(0.05)}$	3.05	1.69	2.47	2.26	0.68	0.66	0.33

CONCLUSION

From the result of this study, it may be concluded that integrated nitrogen application method increased growth, yield and yield attributing traits in potato. The overall results suggest that application of nitrogen T_4 (50% recommended dose of N as basal+50% top dress at 30 and 45 DAP) found to be most effective in term of plant height, total number of stems per plant, number of haulms per plant at (45, 60, 75 DAP and at de-haulming), tuber diameter, tuber length and yield.

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