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Effect of Split Application of Nitrogen and Potassium on Growth and Yield of Potato (*Solanum tuberosum* L.)

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A B S T R A C T

A field experiment was carried out during *rabi* season of 2013-14at Instructional Farm, Bidhan Chandra Krishi Viswavidyalaya, Jaguli, Mohanpur, Nadia, West Bengal to study the effect of different doses of nitrogen and potassium fertilizer on growth and yield of potato. The experiment was conducted under randomized block design replicated thrice. Two different doses of $N:P_2O_5:K_2O$ i.e. 300:150:150 and 200:150:150 kg ha^{-1}respectively were applied. Further $N:P_2O_5:K_2O$-200:150:150 kg ha^{-1}were split in nitrogen and potassium fertilizer at basal, 28 and 42 DAP along with full dose of phosphatic fertiliser at basal and altogether ten treatments were tested under the experiment. Results revealed that highest growth attributes and yield namely plant height (36.17 cm), LAI (3.12), CGR (40.04g ma^{-2} day^{-1}), NAR (6.04g ma^{-2} day^{-1}) and LAD (132.53 days) and tuber yield (28.917 t ha^{-1}) were recorded in case of the treatment where N and K_2O applied as basal + 1/4 at 28 and 42 DAP @ 200:150:150 $N:P_2O_5:K_2O$ kg ha^{-1}. Amongst the ten treatments adopted in the experiment, the highest net return ha^{-1} (Rs.78860.31) and highest return per rupee investment (1.83) were obtained from the treatment where N and K_2O were applied as basal + $1/4^{th}$ at 28 and 42 DAP @ 200:150:150 $N:P_2O_5:K_2O$ kg ha^{-1}.

Introduction

Potato (*Solanum tuberosum* L.) is an important member of the family Solanaceae. It is grown and consumed all around the world and is one of the main vegetable cash crop. Potato is an integral part of human diet. The area and production of potato in the country during 2016-17was estimated around 21.64 lakhs ha and 465.46lakhs MT respectively (Hort. Stat., 2017). The major potato growing states are Uttar Pradesh, West Bengal, Punjab, Bihar, Haryana, Madhya Pradesh, Gujarat and Maharashtra. West Bengal ranks second in potato production after Uttar Pradesh, in the country. In West Bengal, it is grown in 0.42 million ha area with the production of 11.05 million tones during 2016-17(Hort. Stat., 2017). Potatoes require high amounts of potassium (K) and

nitrogen (N) fertilizers for optimum growth, production and tuber quality. In the eastern plains severe imbalance in the N: P: K application ratio and unbalanced fertilization in favour of N and lack of potash application is quite common among farmers (Singh and Rai, 2011). Nitrogen and Potassium are important essential macronutrients which play important role in growth and development of potato crop. Inadequate N fertilization leads to poor 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). With rising environmental concerns for N fertilizer management practices, efficient N use is important for the economic sustainability of cropping systems (Shrestha *et al.,* 2010).In addition to N and P, potato is a heavy remover of soil potassium and its response to potassium varies with variety, source and method of potassium fertilizer application (Sharma and Sud, 2001; Kumar *et al.,* 2007).

Materials and Methods

The experiment was carried out during *rabi* season of 2013-14at the Instructional Farm, Bidhan Chandra Krishi Viswavidyalaya, Jaguli, Nadia, West Bengal. The farm was situated at $22^0 93^/$N latitude and 83^0 $59^/$ E longitude at an elevation of 9.75 m above mean sea level. This zone falls under the sub-tropical humid climate where summer and winter both are short and mild/moderate. So, this zone is not subjected to condition of extreme winter. The total rainfall received during the winter months (Nov-Feb) i.e., experimental period was 19.4 mm and that occurred in the month of February. The maximum and minimum temperature during this period ranged from 23.6-28^{0}C and 10.1-15.9^{0}C respectively (Table 1). During the investigation period, the maximum and minimum relative humidity varied from 95.4-97.3% and 52.1-61.4% respectively and very low rainfall (9.7 mm, respectively) occurred in the month of February (Table 1). The experiment was laid out in randomized block design with ten treatments and three replications. The dose $N:P_2O_5:K_2O$ was 300:150:150 (kg ha^{-1}) for T_1 (farmer's practice) treatment where fertilisers applied as 1/2 N as basal + 1/2 N at 28 DAP and full K as basal. For rest nine treatments $N:P_2O_5:K_2O$ dose was 300:150:150 (kg ha^{-1}). These treatments are T_2- 1/2 N as basal + 1/2 N at 28 DAP and full K as basal, T_3- 1/2 N as basal + 1/4 N at 28 DAP +1/4 N at 42 DAP and full K as basal, T_4- 1/3 N as basal + 1/3 N at 28 DAP + 1/3 N at 42 DAP and full K as basal, T_5- 1/2 N as basal +1/2 N at 28 DAP and 1/2 K as basal + 1/2 K at 28 DAP, T_6- 1/2 N as basal + 1/4 N at 28 DAP + 1/4 N at 42 DAP and 1/2 K as basal + 1/2 K at 28 DAP, T_7- 1/3 N as basal + 1/3 N at 28 DAP + 1/3 N at 42 DAP and1/2 K as basal + 1/2 K at 28 DAP, T_8-1/2 N as basal +1/2 N at 28 DAP and1/2 K as basal + 1/4 K at 28 DAP + 1/4 K at 42 DAP, T_9- 1/2 N as basal + 1/4 N at 28 DAP + 1/4 N at 42 DAP and 1/2 K as basal + 1/4 K at 28 DAP + 1/4 K at 42 DAP, T_{10}($N:P_2O_5:K_2O$ kg ha^{-1}- 200:150:150)- 1/3 N as basal + 1/3 N at 28 DAP + 1/3 N at 42 DAP and 1/3 K as basal + 1/3 K at 28 DAP + 1/3 K at 42 DAP.

All phosphatic fertiliser was applied as basal to all plots. The source of nitrogen, phosphorus and potassium were Urea, SSP and MOP respectively. The potato variety used for the experiment was *Kufri Jyoti*. The tubers of potato were planted on 22nd November, 2013 with 50 cm X 20 cm spacing. Seed tuber was treated with Dithane M-45 @ 2.5 g l^{-1} of water before sowing. Irrigation was given as per requirement of the crop. The treatments were allocated randomly to different plots with the help of random number table (Fisher, R. A., 1958) and the data were analysed by ANOVA, and ranked by using the critical differences (CD) at 5% level.

Results and Discussion

Application of both nitrogen and potassium influenced the growth attributes and yield components of potato. In case of height of potato plant, during 80 DAP the maximum height (36.17 cm) was observed by the treatment T_9 where both N and K applied in three splits i.e. 1/2 as basal + 1/4 at 28 DAP + 1/4 at 42 DAP. These results supported by the finding of Ahmed *et al.,* (2017). The leaf area index (LAI) recorded highest value (3.12) under the same treatment.

Marton (2001) and Saha *et al.,* (2001) also observed increased foliage and LAI with N and K application. The treatment with three splitting of nitrogen and potassium (1/2 as basal + 1/4 at 28 DAP + 1/4 at 42 DAP) also maintained the highest value of CGR (40.04 g m^{-2} day^{-1}) and tuber bulking rate (43.17 g m^{-2} day^{-1}) between 60-80 DAP.

The highest leaf area duration (132.53 days) and net assimilation rate (6.04 g m^{-2} day^{-1}) was recorded in T_9 within 60-80 DAP. Moshileh *et al.,* (2005) reported that splitting N rates into three doses improved plant growth characters. A similar finding was also reported by Rizk *et al.,* (2013) (Table 2).

Regarding the grade wise yield, the maximum (4.68 t ha^{-1}) yield of less than 25 g size was recorded in the treatment T_9 where both N and K applied in three splits (1/2 as basal + 1/4 at 28 DAP + 1/4 at 42 DAP). The highest yield (6.27 t ha^{-1}) of 25-50 g size tubers was recorded under same treatment (Table 3).

For 51-75 g size tuber, the maximum yield (8.17 t ha^{-1}) was obtained from treatment T_{10} where both N and K was applied in three splits (1/3 as basal + 1/3 at 28 DAP + 1/3 at 42 DAP). Production of large size tubers (greater than 75 g) was recorded maximum value (9.98 t ha^{-1}) in treatment T_9 and lowest yield (7.93 t ha^{-1}) was observed in treatment T_1 (farmer's practice).Singh and Lal (2012) reported improved tuber size by increasing the large and medium grade yield and decreasing the small and very small sized tuber with N and K application. These results supported by the finding of Kumar and Trehan (2012).

The total tuber yield was recorded highest in case of treatment T_9(28.91 t ha^{-1}) where both N and K applied in three splits (1/2 as basal + 1/4 at 28 DAP + 1/4 at 42 DAP) and it was closely followed by treatment T_{10} (27.61 t ha^{-1}) where both N and K was applied in three splits (1/3 as basal + 1/3 at 28 DAP + 1/3 at 42 DAP). The lowest tuber yield (22.14 t ha^{-1}) was recorded in treatment T_1 (farmer's practice) where N (300 kg ha^{-1}) applied in two splits (1/2 as basal + 1/2 at 28 DAP) and full K (150 kg ha^{-1}) as basal (Table 3).

The application of K to potato along with N is very essential to improve tuber yield and its quality (Singh and Lal, 2012).

Amongst the ten treatments adopted in the experiment, the highest net return ha^{-1} (Rs. 78860.31) and highest return per rupee investment (1.83) were obtained in T_9 treatment where both N and K applied in three splits (1/2 as basal + 1/4 at 28 DAP + 1/4 at 42 DAP). The lowest net return (Rs. 37055.27) and return per rupee investment (1.39) were recorded in treatment T_1 (farmer's practice) where N (300 kg ha^{-1}) applied in two splits (1/2 as basal + 1/2 at 28 DAP) and full K (150 kg ha^{-1}) as basal (Table 3). Therefore, the balanced use of nutrients could be the most accepted treatment to obtain maximum benefit from the potato (Singh *et al.,* 2010).

It can be concluded that split application of nitrogen as well as potassium was found better for giving higher growth, tuber yield and net return.

Table.1 Meteorological data of the experimental site during the period of investigation

Months	Temperature (^{0}C)		Relative humidity (%)		Rainfall (mm)
	Maximum	Minimum	Maximum	Minimum	
November, 2013	28	15.9	96	52.1	0
December, 2013	25.9	12.7	97.3	57.5	0
January, 2014	23.6	10.1	95.4	61.4	0
February, 2014	27.1	13.8	95.4	52.5	9.7

Source: Department of Agricultural Physics and Meteorology, B.C.K.V., Mohanpur, Nadia, W.B.

Table.2 Effect of split application of nitrogen and potassium on plant height, Leaf area index, Crop growth rate, Tuber bulking rate, Leaf area duration and Net assimilation rate of potato

Treatments	Plant height (cm) at 80 DAP	LAI at 80 DAP	CGR (g ma^{-2} day^{-1}) at 60-80 DAP	TBR (g ma^{-2} day^{-1}) at 60-80 DAP	LAD (days) at 60-80 DAP	NAR (g ma^{-2} day^{-1}) at 60-80 DAP
T_1	34.80	2.08	19.37	23.45	71.33	5.43
T_2	32.53	2.54	23.45	25.17	83.07	5.65
T_3	33.03	2.57	24.31	25.43	86.20	5.64
T_4	33.37	2.84	26.66	27.23	90.67	5.89
T_5	32.40	2.85	27.42	27.79	92.87	5.91
T_6	32.73	2.86	27.99	29.17	98.53	5.68
T_7	33.90	2.88	28.07	29.33	100.53	5.59
T_8	32.63	2.92	28.88	34.19	107.13	5.39
T_9	36.17	3.12	40.04	43.17	132.53	6.04
T_{10}	34.50	2.96	33.29	39.60	125.00	5.34
S.Em±	0.421	0.017	0.189	1.341	1.674	0.088
CD at 5%	1.249	0.047	0.564	3.984	4.973	0.263

DAP: Days after planting; LAI: Leaf area index; CGR: Crop growth rate; TBR: Tuber bulking rate; LAD: Leaf area duration; NAR: Net assimilation rate

T_1 (N:P:K kg ha^{-1}- 300:150:150)- 1/2 N as basal + 1/2 N at 28 DAP and full K as basal; T_2 (N:P:K kg ha^{-1}- 200:150:150)- 1/2 N as basal + 1/2 N at 28 DAP and full K as basal; T_3 (N:P:K kg ha^{-1}- 200:150:150)- 1/2 N as basal + 1/4 N at 28 DAP +1/4 N at 42 DAP and full K as basal; T_4 (N:P:K kg ha^{-1}- 200:150:150)- 1/3 N as basal + 1/3 N at 28 DAP + 1/3 N at 42 DAP and full K as basal; T_5 (N:P:K kg ha^{-1}- 200:150:150)- 1/2 N as basal +1/2 N at 28 DAP and 1/2 K as basal + 1/2 K at 28 DAP; T_6 (N:P:K kg ha^{-1}- 200:150:150)- 1/2 N as basal + 1/4 N at 28 DAP + 1/4 N at 42 DAP and 1/2 K as basal + 1/2 K at 28 DAP; T_7 (N:P:K kg ha^{-1}- 200:150:150)- 1/3 N as basal + 1/3 N at 28 DAP + 1/3 N at 42 DAP and1/2 K as basal + 1/2 K at 28 DAP; T_8 (N:P:K kg ha^{-1}- 200:150:150)-1/2 N as basal +1/2 N at 28 DAP and1/2 K as basal + 1/4 K at 28 DAP + 1/4 K at 42 DAP; T_9 (N:P:K kg ha^{-1}- 200:150:150)- 1/2 N as basal + 1/4 N at 28 DAP + 1/4 N at 42 DAP and 1/2 K as basal + 1/4 K at 28 DAP + 1/4 K at 42 DAP; T_{10} (N:P:K kg ha^{-1}- 200:150:150)- 1/3 N as basal + 1/3 N at 28 DAP + 1/3 N at 42 DAP and 1/3 K as basal + 1/3 K at 28 DAP + 1/3 K at 42 DAP.

- *Full dose of phosphorus applied as basal.*

Table.3 Effect of split application of nitrogen and potassium on Yield and Economics rate of potato

Treatments	Grade wise yield (t ha^{-1})				Total yield (t ha^{-1})	Total cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C ratio
	<25 g	25-50 g	51-75 g	>75 g					
T_1	3.000	4.833	6.373	7.933	22.140	95784.73	132840	37055.27	1.39
T_2	3.007	5.500	6.473	8.133	23.113	94474.69	138678	44203.31	1.47
T_3	0.793	4.783	6.587	8.100	23.263	94474.69	139578	45103.31	1.48
T_4	2.900	4.900	7.317	8.720	23.837	94474.69	143022	48547.31	1.51
T_5	3.997	4.813	7.300	8.167	24.277	94474.69	145662	51187.31	1.54
T_6	3.863	5.640	7.023	8.237	24.763	94474.69	148578	54103.31	1.57
T_7	3.730	5.457	7.320	8.567	25.073	94641.69	150438	55796.31	1.59
T_8	3.620	5.823	6.733	8.973	25.150	94641.69	150900	56258.31	1.59
T_9	4.687	6.277	7.967	9.987	28.917	94641.69	173502	78860.31	1.83
T_{10}	4.203	5.673	8.173	9.567	27.617	94641.69	165702	71060.31	1.75
S.Em±	0.0991	0.1416	0.1687	0.1897	0.3875	-	-	-	-
CD at 5%	0.2944	0.4208	0.5013	0.5635	1.1514	-	-	-	-

T_1 (N:P:K kg ha^{-1}- 300:150:150)- 1/2 N as basal + 1/2 N at 28 DAP and full K as basal; T_2 (N:P:K kg ha^{-1}- 200:150:150)- 1/2 N as basal + 1/2 N at 28 DAP and full K as basal; T_3 (N:P:K kg ha^{-1}- 200:150:150)- 1/2 N as basal + 1/4 N at 28 DAP +1/4 N at 42 DAP and full K as basal; T_4 (N:P:K kg ha^{-1}- 200:150:150)- 1/3 N as basal + 1/3 N at 28 DAP + 1/3 N at 42 DAP and full K as basal; T_5 (N:P:K kg ha^{-1}- 200:150:150)- 1/2 N as basal +1/2 N at 28 DAP and 1/2 K as basal + 1/2 K at 28 DAP; T_6 (N:P:K kg ha^{-1}- 200:150:150)- 1/2 N as basal + 1/4 N at 28 DAP + 1/4 N at 42 DAP and 1/2 K as basal + 1/2 K at 28 DAP; T_7 (N:P:K kg ha^{-1}- 200:150:150)- 1/3 N as basal + 1/3 N at 28 DAP + 1/3 N at 42 DAP and1/2 K as basal + 1/2 K at 28 DAP; T_8 (N:P:K kg ha^{-1}- 200:150:150)-1/2 N as basal +1/2 N at 28 DAP and1/2 K as basal + 1/4 K at 28 DAP + 1/4 K at 42 DAP; T_9 (N:P:K kg ha^{-1}- 200:150:150)- 1/2 N as basal + 1/4 N at 28 DAP + 1/4 N at 42 DAP and 1/2 K as basal + 1/4 K at 28 DAP + 1/4 K at 42 DAP; T_{10} (N:P:K kg ha^{-1}- 200:150:150)- 1/3 N as basal + 1/3 N at 28 DAP + 1/3 N at 42 DAP and 1/3 K as basal + 1/3 K at 28 DAP + 1/3

Regarding total as well as grade wise yield, application of nitrogen (200 kg ha^{-1}) and potassium (150 kg ha^{-1}) in three splits i.e. 1/2 as basal + 1/4 at 28 DAP + 1/4 at 42 DAP was found to give satisfactory results as compared to application of N (300 kg ha^{-1}) in two splits i.e. 1/2 as basal + 1/2 at 28 DAP and full K (150 kg ha^{-1}) as basal which is normally followed by most of the farmers. Application of nitrogen (200 kg ha^{-1}) and potassium (150 kg ha^{-1}) in three splits i.e. 1/2 as basal + 1/4 at 28 DAP + 1/4 at 42 DAP proved to be more remunerative than any other split application schedule.

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