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

Purnendu Sekhar Bera¹, Priyanka Das¹, Champak Kumar Kundu¹*, Utpal Biswas¹, Hirak Banerjee¹ and Pratap Kumar Dhara²

¹Department of Agronomy, Faculty of Agriculture, ²Department of Soil and Water Conservation, Faculty of Agriculture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal- 741252, India

*Corresponding author

**A B S T R A C T**

A field experiment was carried out during *rabi* season of 2013-14 at 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:P₂O₅:K₂O i.e. 300:150:150 and 200:150:150 kg ha⁻¹ respectively were applied. Further N:P₂O₅:K₂O-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 fertilizer 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 (40.04 g m⁻² day⁻¹), NAR (6.04 g m⁻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 K₂O applied as basal + 1/4 at 28 and 42 DAP @ 200:150:150 N:P₂O₅:K₂O 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 K₂O were applied as basal + 1/4th at 28 and 42 DAP @ 200:150:150 N:P₂O₅:K₂O kg ha⁻¹.

**K e y w o r d s**

Nitrogen, Potassium, Tuber yield, Potato

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**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 2016-17 was estimated around 21.64 lakhs ha and 465.46 lakhs 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

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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 2013-14 at the Instructional Farm, Bidhan Chandra Krishi Viswavidyalaya, Jaguli, Nadia, West Bengal. The farm was situated at 22°93'N latitude and 83°59' E longitude at an elevation of 9.75 m above mean sea level. This zone falls under the subtropical 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°C and 10.1-15.9°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:P₂O₅:K₂O was 300:150:150 (kg ha⁻¹) for T₁ (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:P₂O₅:K₂O dose was 300:150:150 (kg ha⁻¹). These treatments are T₂- 1/2 N as basal + 1/2 N at 28 DAP and full K as basal, T₃- 1/2 N as basal + 1/4 N at 28 DAP +1/4 N at 42 DAP and full K as basal, T₄- 1/3 N as basal + 1/3 N at 28 DAP + 1/3 N at 42 DAP and full K as basal, T₅- 1/2 N as basal +1/2 N at 28 DAP and 1/2 K as basal + 1/2 K at 28 DAP, T₆- 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, T₇- 1/3 N as basal + 1/3 N at 28 DAP + 1/3 N at 42 DAP and 1/2 K as basal + 1/3 K as basal + 1/2 K at 28 DAP, T₈- 1/3 N as basal + 1/3 N at 28 DAP + 1/3 N at 42 DAP and 1/3 K as basal + 1/2 K at 28 DAP + 1/2 K as basal + 1/2 K at 28 DAP, T₉- 1/2 N as basal + 1/2 N at 28 DAP + 1/2 N at 42 DAP and 1/2 K as basal + 1/2 K at 28 DAP, T₁₀(N:P₂O₅:K₂O 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).

The highest 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 (°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 |
|------------|-----------------------------|---------------|---------------------------------|---------------------------------|------------------------|---------------------------------|
| T₁         | 34.80                       | 2.08          | 19.37                           | 23.45                           | 71.33                  | 5.43                            |
| T₂         | 32.53                       | 2.54          | 23.45                           | 25.17                           | 83.07                  | 5.65                            |
| T₃         | 33.03                       | 2.57          | 23.45                           | 25.43                           | 90.67                  | 5.89                            |
| T₄         | 33.37                       | 2.84          | 24.31                           | 27.23                           | 92.87                  | 5.91                            |
| T₅         | 32.40                       | 2.85          | 24.31                           | 27.79                           | 98.53                  | 5.68                            |
| T₆         | 32.73                       | 2.86          | 27.99                           | 29.17                           | 100.53                 | 5.59                            |
| T₇         | 33.90                       | 2.88          | 28.07                           | 29.33                           | 107.13                 | 5.39                            |
| T₈         | 32.63                       | 2.92          | 28.88                           | 34.19                           | 132.53                 | 6.04                            |
| T₉         | 36.17                       | 3.12          | 40.04                           | 43.17                           | 125.00                 | 5.34                            |
| T₁₀        | 34.50                       | 2.96          | 33.29                           | 39.60                           | 1.674                  | 0.088                           |
| S.Em⁺      | 0.421                       | 0.017         | 0.189                           | 1.341                           | 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

T₁(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; T₂(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; T₃(N:P:K kg ha⁻¹ - 200:150:150) - 1/2 N as basal + 1/4 N at 28 DAP and 1/2 N at 42 DAP and full K as basal; T₄(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; T₅(N:P:K kg ha⁻¹ - 200:150:150) - 1/2 N as basal + 1/4 N at 28 DAP and full K as basal + 1/4 K at 28 DAP; T₆(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; T₇(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; T₈(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; T₉(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; T₁₀(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.

- 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 | 23.837 | 94474.69 | 143022 | 48547.31 | 1.51 |
| T\(_4\)    | 2.900 | 4.900 | 7.317 | 8.720 | 23.263 | 94474.69 | 145662 | 51187.31 | 1.59 |
| T\(_5\)    | 3.997 | 4.813 | 7.300 | 8.167 | 24.763 | 94474.69 | 150438 | 54103.31 | 1.57 |
| T\(_6\)    | 3.863 | 5.640 | 7.023 | 8.237 | 25.073 | 94474.69 | 150900 | 56258.31 | 1.59 |
| T\(_7\)    | 3.730 | 5.457 | 7.320 | 8.567 | 25.150 | 94474.69 | 153502 | 78860.31 | 1.83 |
| T\(_8\)    | 3.620 | 5.823 | 6.733 | 8.973 | 25.150 | 94474.69 | 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)- 1/4 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; \(T_6\) (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 1/2 K as basal + 1/2 K at 28 DAP; \(T_7\) (N:P:K kg ha\(^{-1}\) - 200:150:150)- 1/4 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; \(T_8\) (N:P:K kg ha\(^{-1}\) - 200:150:150)- 1/4 N as basal + 1/4 N at 28 DAP + 1/4 K at 28 DAP + 1/4 K at 42 DAP; \(T_9\) (N:P:K kg ha\(^{-1}\) - 200:150:150)- 1/4 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; \(T_{10}\) (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.
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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