Effect of integrated nutrient management on yield and nutrient uptake of potato (*Solanum tuberosum* L.)

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Abstract

A field experiment was conducted during the *Rabi* season of the year 2017-18 on potato with variety *Kufri Ashoka* to test the recommended dose of fertilizers (RDF) levels (0, 50, 75, 100, 125, 150%) with two organic manures (vermicompost 5 t/ha and mustard oil cake 2.5 t/ha) at research farm of Tirhut college of Agriculture Dholi, Muzaffarpur, Bihar. The experiment was carried out in randomized block design (RBD) with twelve treatments and replicated thrice. The soil of experimental plot was *Entisols*, sandy loam in texture under low available in N, P and K with pH 8.3. Among the yield, nutrient uptake and available nutrient in soil after harvesting of potato were recorded higher with the application of treatment T11 - 150% RDF + 5.0 t/ha vermicompost which was significantly superior over T1 - absolute control, T2 - 100% RDF, T3 - 50% RDF + 5.0 t/ha vermicompost, T4 - 50% RDF + 2.5 t/ha mustard oil cake, T5 - 75% RDF + 5.0 t/ha vermicompost and T6 - 75% RDF + 2.5 t/ha mustard oil cake but was statistically at par with treatments, T7 - 100% RDF + 5.0 t/ha vermicompost, T8 - 100% RDF + 2.5 t/ha mustard oil cake, T9 - 125% RDF + 5.0 t/ha vermicompost, T10 - 125% RDF + 2.5 t/ha mustard oil cake and T12 - 150% RDF + 2.5 t/ha mustard oil cake.

Keywords: Recommended dose of fertilizers, vermicompost, mustard oil cake, yield, nutrient uptake, available nutrient in soil and *Kufri Ashoka*

Introduction

Potato (*Solanum tuberosum* L.) belongs to family Solanaceae. Peru-Bolivian region in the Andes (South America) is the centre of origin of potato and it has introduced to India in 17th century by Portuguese traders or the Britishers and gradually become a commercial crop of all over India. Potato is one of the major vegetable crops of the India and occupies an important position among food crops and provides staple food stuff for millions of people of many part of the world. It is grown as a cash crop and capable in producing more food per unit area and time than cereals in short span of life. Potato (*Solanum tuberosum* L.) is a staple food crop of the world and it ranks next to rice, wheat and maize. It is highly amenable to adjustment and fits well in various cropping systems. Potato is well known for highest food value in the world. It has a high nutritive value, rich in contents like carbohydrates 20.6%, protein 2.1%, fat 0.3% and crude fiber 1.1%. It is the cheapest source of nutrition for the rural mass hence it is called as “poor man’s friend”. The per capita consumption of potato in India is only 16 kg per annum but other countries the consumption of potato per capita is quite high thus the use of cereals should be substituted by potato in Indian scenario.

India is the second largest potato producing country in the world after China. In India, during 2015-16, potato is grown over an area of 2.11 million hectare with an annual production of 43.41 million tonnes with an average yield of 20.5 t/ha. Almost 85% of total production comes from north India plain viz. Uttar Pradesh, West Bengal and Bihar. In world scenario, India has got second position after China with respect to production. Bihar is the third largest potato producer state of the country, occupying 5% area of total cultivated land i.e. 0.31 million hectare with a production of 6.34 million tonnes and productivity 19.88 t/ha (Horticultural statistics at a glance 2017). The productivity of potato can be increased and sustained by adoption of integrated nutrient management. Keeping this point in view the present...
investigation has been carried out. The main constituents of potato cultivation are lack of quality seed, new cultivar and inappropriate doses of fertilizers (Kumar and Trehan, 2012) [9]. This high rate of dry matter production results in large amounts of nutrients removed per unit time, which generally most of the soils are not able to supply. Hence, nutrient application from external sources as fertilizers becomes essential. High yields can only be sustained through the application of optimal NPK doses in balanced proportion. Integrated use of sources of plant nutrients (chemical fertilizer and organic manures) is important not only for increasing crop productivity but also for improving soil fertility essential for sustaining the crop productivity.

Field experimental was laid out in Randomized Block Design with twelve treatments viz., T1 - absolute control, T2 - 100% RDF, T3 - 50% RDF + 5.0 t/ha vermicompost, T4 - 50% RDF + 2.5 t/ha mustard oil cake, T5 - 75% RDF + 5.0 t/ha vermicompost, T6 - 75% RDF + 2.5 t/ha mustard oil cake, T7 - 100% RDF + 5.0 t/ha vermicompost, T8 -100% RDF + 2.5 t/ha mustard oil cake, T9 - 125% RDF + 5.0 t/ha vermicompost, T10 - 125% RDF + 2.5 t/ha mustard oil cake oil cake, T11 - 150% RDF + 5.0 t/ha vermicompost and T12 - 150% RDF + 2.5 t/ha mustard oil cake and replicated thrice.

Description of experimental variety

Kufri Ashoka - Kufri Ashoka developed through clonal selection from the segregating population of the hybrid EM/C-1021 x CP-1468. Central Potato Research Institute, Shimla, released this variety in 1996.

Results and discussion

Tuber and vine yield
Mean data given in (Table 2.) revealed that different treatments had significant effect on nitrogen content and yield values. The highest tuber (276.15 q/ha) and vine yield (118.45 q/ha) was recorded with 150% recommended dose of fertilizer along with vermicompost which was significantly higher than other treatments but was at par with treatments T7, T9, T10, T11, and T12. Higher yield obtained with application of higher dose of fertilizers (NPK) might be due to positive response of potato crop to the nutrients like nitrogen, phosphorus and potassium. The beneficial response of organic manure to increase the crop yield might also be attributed to the availability of sufficient amounts of plant nutrients throughout the growth period and especially at critical growth periods of crops resulting its better uptake, plant vigour and superior yield attributes. These results are in conformity with the finding of Sarkar et al. (2011), Banjare (2012), Patel (2013) and Kumar et al. (2017).

Nitrogen content in tuber and vine (% of potato)

Citation of the data regarding nitrogen content in tuber and vine revealed that potato crop grown through integrated use of organic and inorganic source of nutrients had shown a significant effect in Table 3. Among all treatment, T11 - 150% RDF + 5.0 t/ha vermicompost indicated maximum nitrogen content and minimum under treatment T1 - absolute control (0.89%). Treatments, T7 - 100% RDF + 5.0 t/ha vermicompost, T9 - 125% RDF + 5.0 t/ha vermicompost, T10 - 125% RDF + 2.5 t/ha mustard oil cake and T12 - 150% RDF + 2.5 t/ha mustard oil cake was found statistically at par with T11 regarding nitrogen content in potato tuber and vine.

Nitrogen uptake by tuber, vine and total uptake (kg/ha) of potato

Perusal of mean data revealed that different treatments had significant effect on total nitrogen uptake by potato crop in Table 3. Among all treatments, T11 - 150% RDF + 5.0 t/ha vermicompost recorded highest Nitrogen uptake by tuber, vine and total nitrogen uptake which was significantly superior over treatments T1 - absolute control, T2 - 100% RDF, T3 - 50% RDF + 5.0 t/ha vermicompost, T4 - 50% RDF + 2.5 t/ha mustard oil cake, T5 - 75% RDF + 5.0 t/ha vermicompost and statistically at par to treatments. T7 - 100% RDF + 5.0 t/ha vermicompost, T8 - 100% RDF + 2.5 t/ha mustard oil cake oil cake, T9 - 125% RDF + 5.0 t/ha vermicompost, T10 - 125% RDF + 2.5 t/ha mustard oil cake and T12 - 150% RDF + 2.5 t/ha mustard oil cake. This might be due to narrow C: N ratio, continuous release of nutrients through the crop period and release of organic acids, which would have aided in the solubilization of minerals and change over from non-exchangeable to exchangeable form of nutrients which led to direct and early absorption of nitrogen, phosphorus and potassium resulting in better uptake of nutrients (Sasani et al., 2003). This result is conformity with the findings of Kumar et al. (2011) [14] and Baishya (2009) [1].

Protein content in tuber (%) on dry weight basis

The data regarding protein content revealed that the maximum protein content content (12.69%) recorded under treatment T9 - 125% RDF + 5.0 t/ha vermicompost which was statistically at par with T7 - (12.38%), T8 - (12.06%), T9 - 125% RDF + 5.0 t/ha vermicompost (12.56%), T10 - (12.31%) and T12 - (12.56%) and significantly superior over rest of the

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**Table 1: Initial chemical properties of experimental soil**

| S.N. | Particulars                        | Values  | Method adopted                  |
|------|-----------------------------------|---------|---------------------------------|
| 1.   | Organic carbon (%)                | 0.45    | Walkley and Black method (1934) |
| 2.   | pH (1:2.5)                        | 8.30    | Buckman pH meter (Jackson, 1967) |
| 3.   | Electrical conductivity (m. mhos /cm at 25 °C) | 0.34 | Systronics electrical conductivity meter (Richards, 1954) |
| 4.   | Available Nitrogen (kg N/ha)      | 220.40  | Alkaline permanganate method (Subbiah and Asija, 1956) |
| 5.   | Available Phosphorus (kg P2O5/ha) | 17.88   | Olsen’s method (0.5 NaHCO3 extractable) (Olsen et al., 1954) |
| 6.   | Available Potassium (kg K2O/ha)   | 120.02  | Flame photometric method (Jackson, 1967) |

**Materials and Methods**

The field experiment was laid out during Rabi season in year 2017-18 at the research farm of Tirhut College of Agriculture, Dholi (Muzaffarpur) which is situated on the southern bank of the river Burhi Gandak at an altitude of 52.18 meter above mean sea level and lies at 25°.98’ N latitude and 85°.6’ E longitude. The soil of experimental field was sandy-loam in reaction with pH 8.3 and EC 0.43 m. mhos /cm. It was moderately fertile being low in organic carbon (0.45%), available nitrogen (220.4 kg N ha⁻¹), phosphorous (17.8 kg P₂O₅ ha⁻¹) and potassium (120.02 kg K₂O ha⁻¹). The spacing row to row 60cm and plant to plant 20cm and cultivar ‘Kufari Ashoka’ was taken as a test crop.

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treatments. The minimum protein content (9.38) was estimated under treatment T1 - absolute control on dry weight basis. It might be due to increased involvement of nitrogen in accumulation of amino acid. Amino acid is an important constituent of protein thus increased protein content at higher dose of nitrogen applied. Thus result shows similarity with idea of Rai et al. (2004) [12] and Chopra et al. (2006) [13].

**Phosphorus uptake by tubers, vine and total uptake of Phosphorus (kg/ha) of potato**

Perusal of mean data revealed that different treatments had significant effect on Phosphorus uptake by tubers, vine and total Phosphorus uptake in Table 4. Among all treatment T11 - 150% RDF + 5.0 t/ha vermicompost recorded highest Phosphorus uptake by tubers, vine and total Phosphorus uptake which was significantly superior over remaining treatments and statistically at par to treatments, T7 - 100% RDF + 5.0 t/ha vermicompost, T8 - 100% RDF + 2.5 t/ha mustard oil cake, T9 - 125% RDF + 5.0 t/ha vermicompost, T10 - 125% RDF + 2.5 t/ha mustard oil cake and T12 - 150% RDF + 2.5 t/ha mustard oil cake, while minimum Phosphorus content was recorded under treatment T1 - absolute control.

**Potassium uptake by tubers, vine and total Potassium uptake (kg/ha) of potato**

Perusal of mean data revealed that different treatments had significant effect on Potassium uptake by tubers, vine and total Potassium uptake in Table 5. Among all treatment T11 - 150% RDF + 5.0 t/ha vermicompost recorded highest Potassium uptake by tubers, vine and total Potassium uptake which was significantly superior over remaining treatments and statistically at par to treatments, T7 - 100% RDF + 5.0 t/ha vermicompost, T8 - 100% RDF + 2.5 t/ha mustard oil cake, T9 - 125% RDF + 5.0 t/ha vermicompost, T10 - 125% RDF + 2.5 t/ha mustard oil cake and T12 - 150% RDF + 2.5 t/ha mustard oil cake, while minimum Potassium uptake by tubers, vine and total Potassium uptake was obtained under treatment T1 - absolute control (without NPK and organic manure). It might be due to the more availability of potassium by the mechanism and mineralization of organic compost and solubilisation of fixed potassium in the soil. This result is conformity with the findings of Kumar and Singh (2016) [7] and Kumar et al. (2008) [8].

**Table 2: Effect of different treatments on fresh tuber and vine yield of potato (q/ha)**

| Treatments | Fresh tuber yield (q/ha) | Yield of vine (q/ha) | Yield of biomass (q/ha) |
|------------|--------------------------|---------------------|------------------------|
| T1         | 111.28                   | 72.20               | 183.47                 |
| T2         | 233.30                   | 106.69              | 339.98                 |
| T3         | 210.24                   | 100.68              | 310.92                 |
| T4         | 207.02                   | 99.45               | 306.47                 |
| T5         | 237.23                   | 106.48              | 343.72                 |
| T6         | 235.58                   | 105.59              | 341.18                 |
| T7         | 262.00                   | 115.96              | 377.96                 |
| T8         | 259.67                   | 116.72              | 376.39                 |
| T9         | 272.45                   | 117.26              | 389.71                 |
| T10        | 269.23                   | 117.15              | 386.38                 |
| T11        | 276.15                   | 118.45              | 394.66                 |
| T12        | 273.87                   | 118.21              | 392.09                 |
| S Em (+)   | 8.24                     | 3.48                | 12.37                  |
| CD(p=0.05) | 24.16                    | 10.19               | 36.28                  |

**Table 3: Effect of different treatments on protein content and N- content and uptake in potato**

| Treatments | N-content in tuber (%) | N-content in vine (%) | Protein content (%) | N-uptake by tuber (kg/ha) | N-uptake by vine (kg/ha) | Total uptake (kg/ha) |
|------------|------------------------|-----------------------|--------------------|---------------------------|-------------------------|---------------------|
| T1         | 1.50                   | 0.89                  | 9.38               | 33.43                     | 8.04                    | 41.47               |
| T2         | 1.80                   | 1.18                  | 11.25              | 84.12                     | 15.76                   | 99.89               |
| T3         | 1.69                   | 1.05                  | 10.56              | 71.18                     | 13.24                   | 84.41               |
| T4         | 1.66                   | 1.01                  | 10.38              | 68.94                     | 12.59                   | 81.53               |
| T5         | 1.78                   | 1.16                  | 11.13              | 84.66                     | 15.48                   | 100.13              |
| T6         | 1.71                   | 1.13                  | 10.69              | 80.69                     | 14.94                   | 95.63               |
| T7         | 1.98                   | 1.26                  | 12.38              | 103.96                    | 18.30                   | 122.26              |
| T8         | 1.93                   | 1.22                  | 12.06              | 100.43                    | 17.84                   | 118.27              |
| T9         | 2.01                   | 1.32                  | 12.56              | 109.77                    | 19.39                   | 129.17              |
| T10        | 1.97                   | 1.29                  | 12.31              | 106.19                    | 18.91                   | 125.11              |
| T11        | 2.03                   | 1.35                  | 12.69              | 112.28                    | 20.02                   | 132.30              |
| T12        | 2.01                   | 1.33                  | 12.56              | 110.31                    | 19.69                   | 130.00              |
| S Em (+)   | 0.06                   | 0.04                  | 0.37               | 5.77                      | 1.04                    | 6.81                |
| CD(p=0.05) | 0.17                   | 0.11                  | 1.07               | 16.92                     | 3.05                    | 19.97               |
Table 4: Effect of different treatments on P- content and uptake in potato

| Treatments | P-content in tuber (%) | P-content in vine (%) | P-uptake by tuber (kg/ha) | P-uptake by vine (kg/ha) | Total uptake (kg/ha) |
|------------|------------------------|-----------------------|---------------------------|--------------------------|---------------------|
| T1         | 0.31                   | 0.25                  | 6.91                      | 2.26                     | 9.17                |
| T2         | 0.38                   | 0.32                  | 17.76                     | 4.27                     | 22.03               |
| T3         | 0.34                   | 0.29                  | 14.32                     | 3.66                     | 17.97               |
| T4         | 0.33                   | 0.27                  | 13.70                     | 3.37                     | 17.07               |
| T5         | 0.37                   | 0.32                  | 17.60                     | 4.27                     | 21.87               |
| T6         | 0.36                   | 0.31                  | 16.99                     | 4.10                     | 21.09               |
| T7         | 0.40                   | 0.34                  | 21.00                     | 4.94                     | 25.94               |
| T8         | 0.39                   | 0.33                  | 20.30                     | 4.82                     | 25.12               |
| T9         | 0.42                   | 0.36                  | 22.94                     | 5.29                     | 28.23               |
| T10        | 0.40                   | 0.35                  | 21.56                     | 5.13                     | 26.69               |
| T11        | 0.43                   | 0.37                  | 23.78                     | 5.49                     | 29.27               |
| T12        | 0.41                   | 0.36                  | 22.50                     | 5.33                     | 27.83               |
| S Em (±)   | 0.01                   | 0.01                  | 1.20                      | 0.28                     | 1.47                |
| CD (p=0.05)| 0.04                   | 0.03                  | 3.51                      | 0.83                     | 4.31                |

Table 5: Effect of different treatments on K- content and uptake in potato

| Treatments | K-content in tuber (%) | K-content in vine (%) | K-uptake by tuber (kg/ha) | K-uptake by vine (kg/ha) | Total uptake (kg/ha) |
|------------|------------------------|-----------------------|---------------------------|--------------------------|---------------------|
| T1         | 1.83                   | 0.98                  | 40.78                     | 8.86                     | 49.64               |
| T2         | 2.16                   | 1.16                  | 100.95                    | 15.50                    | 116.44              |
| T3         | 2.08                   | 1.06                  | 87.60                     | 13.36                    | 100.96              |
| T4         | 2.04                   | 1.04                  | 84.72                     | 12.97                    | 97.69               |
| T5         | 2.14                   | 1.15                  | 101.78                    | 15.34                    | 117.12              |
| T6         | 2.10                   | 1.13                  | 99.10                     | 14.94                    | 114.03              |
| T7         | 2.23                   | 1.29                  | 117.09                    | 18.74                    | 135.82              |
| T8         | 2.20                   | 1.27                  | 114.87                    | 18.57                    | 133.05              |
| T9         | 2.26                   | 1.32                  | 123.43                    | 19.39                    | 142.82              |
| T10        | 2.24                   | 1.29                  | 120.75                    | 18.91                    | 139.66              |
| T11        | 2.31                   | 1.34                  | 127.76                    | 19.87                    | 147.63              |
| T12        | 2.28                   | 1.33                  | 125.12                    | 19.69                    | 144.81              |
| S Em (±)   | 0.07                   | 0.04                  | 6.70                      | 1.05                     | 7.75                |
| CD (p=0.05)| 0.20                   | 0.11                  | 19.65                     | 3.08                     | 22.73               |

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