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# Effect of integrated nutrient management on growth, yield and quality of potato (*Solanum Tuberosum* L.) in northern hill zone of Chhattisgarh

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**Abstract**
A field experiment was conducted during *Rabi* 2021-22 at Potato and temperate fruit research station Mainpat (C.G.) on Effect of integrated nutrient management on growth, yield and quality of potato (Solanum Tuberosum L.) in northern hill zone of Chhattisgarh. The experiment was laid out in randomized block design (RBD) and replicated thrice, and the potato crop variety Kufri Badshah was sown on 17 November, 2021-22. Where treatments were assigned with seven integrated nutrient management *viz*, FYM 5 t ha$^{-1}$ ($T_1$), 100% RDF (150:100:100 kg ha$^{-1}$ NPK) ($T_2$), 100% RDF + Azotobactor ($T_3$), 100% RDF + PSB ($T_4$), 100% RDF + KSB ($T_5$), 100% RDF + Azotobactor + PSB ($T_6$), 100% RDF + Azotobactor + PSB + KSB ($T_7$). Seed rate of 20 q ha$^{-1}$ was taken for sowing having a spacing of 60 cm x 20 cm. Result revealed that among all the treatments significantly maximum fresh weight of tuber plant$^{-1}$, number of tuber plant$^{-1}$, Tuberization efficiency recorded under ($T_7$) 100% RDF + Azotobactor + PSB + KSB. Application of 100% RDF + Azotobactor + PSB + KSB ($T_7$) also resulted in to highest total tuber yield t ha$^{-1}$. Next superior amongst the all-different nutrient management practices was the application of 100% RDF + Azotobactor + PSB ($T_6$) caused significantly fresh weight of tuber plant$^{-1}$, Number of tuber plant$^{-1}$ and Tuberization efficiency. Next highest total tuber yield t ha$^{-1}$ recorded under the application of 100% RDF + Azotobactor + PSB ($T_6$).

**Keywords:** Integrated nutrient management, Azotobactor, Phosphorus solubilizing bacteria, Potassium solubilizing bacteria

## Introduction
Potato (*Solanum tuberosum* L.) is an herbaceous annual plant belongs to family Solanaceae with chromosome number 2n=48. It is commonly known as "King of vegetables" and "poor man's friend". It is the fourth most important food crop in the world after rice, wheat and maize (Anonymous, 2019) [2]. In present scenario, potato is a staple food for many countries of the world and a primary component of world's food supply. Potato is containing 79% water, 17% carbohydrates (88% is starch), 2% protein, fiber, vitamins, minerals, amino acids and contains negligible fat. Generally, 100 g raw potato provides 322 kilojoules (77 kilocalories) of food energy and is a rich source of vitamin B6 and vitamin C (23% and 24% of the Daily Value, respectively) (Potato Wikipedia). Being, an important temperate crop, potato has been well adopted for cultivation under cool regions where the mean temperatures during its growing season, do not usually exceed 18°C. Potato is one of the most important cash crops in India.

Globally, potato is cultivated over an area of 19.3 million hectares in 150 countries of the world with a total production of 308 million tonnes. According to Food Agricultural Organization (FAO), China is the largest producer followed by Russia, Ukraine, Poland and India. India is the second largest producer of potato of world production (contributing 11%) after China with the production of 48.66 million tonnes from an area of 2.06 mha with 23.62 tonnes ha$^{-1}$ productivity (DAC&FC). In India, Uttar Pradesh is the major potato growing states with a 31.26 % share followed by West Bengal, Bihar, Gujarat, Madhya Pradesh, Punjab, and Assam respectively. It accounts for nearly 3/4 of the area and contributes to 82% of total potato production in the country. The maximum area as well as the production of potato was recorded in Uttar Pradesh than in West Bengal (Anonymous, 2020b) [4]. In Chhattisgarh, potato occupies about 42750 hectares with a production of 614056 tones and a productivity of 14.36 tonnes per hectare. The highest area (6742 ha) and production (93065 tonnes) was recorded in Surguja district followed by Balrampur, Bilaspur and Raigarh districts of Chhattisgarh (Anonymous, 2020c) [5].

Potato crop is a heavy nutrients feeder crop, the crop demands huge amount of nitrogen, phosphorus and potassium although it is well responsive crop to applied fertilizers. Chemical fertilizers are not only in restricted supply but also expensive in developing countries like India. Integrated nutrient management (INM) is a better approach for supplying nutrition to the crop by including organic and inorganic sources of nutrients (Arora, 2008) [6]. Integrated nutrient management (INM) involving combination of organic manure. Bio fertilizers also are important substances of organic sources in INM which contains living microorganisms and play a major role in supplementing the crop nutrients through biological nitrogen. Biofertilizers like phosphorus solubilizing bacteria (PSB) and Azotobacter may be useful for improving P and N nutrition in potato. Integrated use of all sources of plant nutrients (Chemical fertilizer, organic manures, biofertilizer) to be important not only for increasing crop productivity but also for improving soil health essential for sustaining the crop productivity in a long term (Shubha *et al.*, 2018) [13] and on the other hand a judicious combination of organic and inorganic sources of nutrient might be helpful to obtain a good economic return with strong soil health (Alam *et al.*, 2007) [1].

## Materials and Methods

The experiment was conducted at Potato & Temperate Fruit Research Station, Mainpat, Surguja, (C.G.) during *Rabi* season of 2021-22. The experimental site graphically situated at 22°46'00"N latitude, 83°18'39"E longitude and 1061 m, above mean sea level in Eastern plateau and hill region (Agro-climatic Zone-7) of India. The average annual rainfall with 1200 mm with lowest temperature of 4 ˚C during winter and maximum temperature of 43 ˚C during summer. The soil was sandy clay loam medium in organic carbon (0.55%), acidic in reaction (pH 6.15), low in nitrogen (214.4 kg ha$^{-1}$), and medium in phosphorous (13.72 kg ha$^{-1}$) and medium in available potassium (243.4 kg ha$^{-1}$). The experiment was laid out in Randomized Block Design (RBD) and replicated thrice consisted of seven treatments *viz.* FYM 5 t ha$^{-1}$ ($T_1$), 100% RDF (150:100:100 kg ha$^{-1}$ NPK) ($T_2$), 100% RDF + Azotobactor ( $T_3$), 100% RDF + PSB ($T_4$), 100% RDF + KSB ($T_5$), 100% RDF + Azotobactor + PSB ($T_6$), 100% RDF + Azotobacter + PSB + KSB ($T_7$). The recommended dose of fertilizers 150:100:100 kg N, $P_2O_5$ and $K_2O$ ha$^{-1}$ were applied in the experiment through urea, single super phosphate and murate of potash. Half dose of nitrogen with full dose of single super phosphate and murate of potash were applied as basal dose at the time of planting and remain dose of nitrogen was applied in two equal splits. The potato variety Kufri Badshah was planted on 17$^{th}$ November 2021-22 at 60 × 20 cm spacing and crop was harvested on 15$^{th}$ March 2022.

## Results and Discussion

### Yield attributing characters

In The present investigation on different attributing character *viz*. number of tuber plant$^{-1}$, fresh weight of tubers plant$^{-1}$ (g), tuberization efficiency (tuber: haulm) are presented in Table 1and grade wise tuber yield (< 50g, 50-100g, > 100g) (t ha$^{-1}$) and tuber yield (t ha$^{-1}$) significantly influenced by various nutrient management practices are presented in Table 2.

**Table 4.2.1:** Number of tuber plant$^{-1}$, fresh weight of tubers plant$^{-1}$ (g) and tuberization efficiency (tuber: haulm) of potato as influenced by different integrated nutrient management

| Treatment | Number of tuber plant$^{-1}$ | Fresh weight of tubers plant$^{-1}$ (g) | Tuberization efficiency (Tuber: Haulm) |
|---|---|---|---|
| $T_1$ - FYM 5 t ha$^{-1}$ | 7.78 | 214.89 | 1.67 |
| $T_2$ - 100% RDF (150:100:100 NPK kg ha$^{-1}$) | 8.33 | 393.44 | 1.77 |
| $T_3$ - 100% RDF + Azotobactor | 8.67 | 514.11 | 1.80 |
| $T_4$ - 100% RDF + PSB | 9.45 | 541.89 | 2.01 |
| $T_5$ - 100% RDF + KSB | 9.00 | 522.11 | 1.84 |
| $T_6$ - 100% RDF + Azotobactor + PSB | 10.33 | 578.56 | 2.18 |
| $T_7$ - 100% RDF + Azotobactor + PSB +KSB | 10.44 | 620.33 | 2.29 |
| S.E.M± | 0.51 | 4.53 | 0.01 |
| CD ($p$ = 0.05) | 1.57 | 13.95 | 0.05 |

**Table 4.2.2:** Grade wise tuber yield and total tuber yield (t ha$^{-1}$) of potato influenced by different integrated nutrient management practices

| Treatment | Grade wise tuber yield (t ha$^{-1}$) | | | Total tuber yield (t ha$^{-1}$) |
|---|---|---|---|---|
| | (< 50 g) | (50-100 g) | (> 100 g) | |
| $T_1$ - FYM 5 t ha$^{-1}$ | 4.17 | 6.80 | 7.70 | 18.67 |
| $T_2$ - 100% RDF (150:100:100 NPK kg ha$^{-1}$) | 5.36 | 7.40 | 7.80 | 20.56 |
| $T_3$ - 100% 0RDF + Azotobactor | 5.59 | 7.58 | 7.90 | 21.08 |
| $T_4$ - 100% RDF + PSB | 5.86 | 7.80 | 8.10 | 21.76 |
| $T_5$ - 100% RDF + KSB | 5.76 | 7.60 | 7.92 | 21.28 |
| $T_6$ - 100% RDF + Azotobactor + PSB | 6.06 | 7.75 | 8.13 | 21.94 |
| $T_7$ - 100% RDF + Azotobactor + PSB +KSB | 6.46 | 8.60 | 9.40 | 24.46 |
| S.E.M± | 0.06 | 0.06 | 0.07 | 0.15 |
| CD ($p$ = 0.05) | 0.20 | 0.18 | 0.21 | 0.47 |

### Number of tubers plant$^{-1}$

Among all the integrated nutrient management practices, significantly maximum number of tuber plant$^{-1}$ was recorded with the application of 100% RDF + Azotobactor + PSB +KSB ($T_7$) (10.44) which was statistically at par with 100% RDF + Azotobactor + PSB ($T_6$), (10.33), 100% RDF + PSB ($T_4$) (9.45) and 100% RDF + KSB ($T_5$) (9.00) as compared to other treatments. However, lower number of tuber plant$^{-1}$ was recorded under the treatment FYM 5 t ha$^{-1}$ ($T_1$), (7.78). The increased numbers of tubers plant$^{-1}$ with 100% RDF + Azotobactor + PSB +KSB ($T_7$) could be attributed to increased availability of nutrients including bio fertilizers in

the soil which led to enhanced absorption of nutrients by the crop resulting in increased tuber production. Narayan (2010) [12] revealed that the application of 75% recommended dose of fertilizer with 8 t ha$^{-1}$ vermicompost + Azotobacter and PSB significantly increased the number of tubers plant$^{-1}$ over other nutrition management treatments

**Fresh weight of tubers plant$^{-1}$**

The highest fresh weight of tubers plant$^{-1}$ was obtained under the treatment of 100% RDF + Azotobactor + PSB + KSB ($T_7$) (620.33g) but was statistically at par with 100% RDF + Azotobactor + PSB ($T_6$) (578.56g) as compared to other treatments. However, the lowest fresh weight of tuber plant$^{-1}$ was recorded under the treatment of (214.89) FYM 5 t ha$^{-1}$ ($T_1$). Higher fresh weight of tubers plant$^{-1}$ was under 100% RDF + *Azotobactor* + PSB +KSB ($T_7$) might be due to adequate supply of nutrients with *Azotobactor*, PSB and KSB, it was improving the efficient interception of sunlight and other growth factors, which ultimately leads to enhanced the production of photosynthates and translocation from leaf to tubers. Similar result also reported by Kate *et al*. (2005) [10]. 100% RDF + *Azotobactor* + PSB + KSB ($T_7$) may also be attributed to the synergistic interactions between bio fertilizers and inorganic fertilizers which in turn helps in improvement of soil physical conditions and in turn helps to increase the yield.

**Tuberization efficiency**

Higher tuberization efficiency was recorded with 100% RDF + Azotobactor + PSB +KSB ($T_7$), (2.29) followed by application with 100% RDF + Azotobactor + PSB ($T_6$) (2.18) as compared to over other treatments. On contrary, the lowest tuberization efficiency was noted with the application of (1.67) FYM 5 t ha$^{-1}$ ($T_1$). Higher tuberization efficiency under 100% RDF + Azotobactor + PSB + KSB ($T_7$) might be due to application of chemical fertilizer along with bio fertilizers that helps in abundant availability of nutrient throughout the crop season that helped to plant in attaining higher number of leaves, thick, wide and active leaf caused maximum accumulation of photosynthates (carbohydrates) resulting higher tuberization efficiency was recorded under this treatment.

**Grade wise tuber yield t ha$^{-1}$ (< 50g, 50-100g, > 100g)**

Grade wise tuber yield i.e. < 50g, 50-100g, > 100g (6.46, 8.60, 9.40 t ha$^{-1}$) was recorded significantly higher with 100% RDF + Azotobactor + PSB + KSB ($T_7$) followed by application with 100% RDF + Azotobactor + PSB (T6) and 100% RDF + PSB ($T_4$) as compared to other integrated nutrient management treatments. However, lowest all grade wise tuber yield i.e. < 50g, 50-100g, > 100g (4.17, 6.80, 7.70 t ha$^{-1}$) were recorded under FYM 5 t ha$^{-1}$ ($T_1$). Nag (2006) also found that beneficial effect of the application of crop residue incorporation along with bio fertilizers (PSB + Azotobactor) which may give the highest grade wise yield of tubers per plot in potato.

**Tuber yield (t ha$^{-1}$)**

Among all the integrated nutrient management practices, significantly higher tuber yield (24.46 t ha$^{-1}$) was obtained with application of 100% RDF + Azotobactor + PSB + KSB ($T_7$) closely followed by (21.94 t ha$^{-1}$) 100% RDF + Azotobactor + PSB ($T_6$) but was at par with 100% RDF+ PSB (T4) as compared to other integrated nutrient management treatments. However, lowest tuber yield (18.67 t ha$^{-1}$) was observed under FYM 5 t ha$^{-1}$.This result was conformity with earlier researcher Choudhary *et al*. (2010) [8] who observed that application of vermicompost doses @ 20 or 30 t ha$^{-1}$ as well as bio-fertilizers alone or in combination with bio fertilizers increased tuber yield.

**Conclusion**

Among all integrated nutrient management practices 100% RDF + Azotobactor + PSB + KSB (T7) recorded considerably higher value for major yield parameters as well as higher tuber yield production (24.46 t ha$^{-1}$) as compare to other integrated nutrient management practices. Economics revealed that lowest cost of cultivation was calculated under FYM 5 t ha$^{-1}$ ($T_1$) of ₹ 89331 ha$^{-1}$, but 100% RDF + Azotobactor + PSB +KSB ($T_7$) recorded significantly higher gross return (₹391307 ha$^{-1}$), net return (₹281651 ha$^{-1}$) and B:C ratio (2.57) compared to other integrated nutrient management treatments and was the most profitable practice.

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