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# Response of Potato (*Solanum tuberosum* L.) to Integrated Nutrient Management in Sandy Loam Soils of Punjab

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**ABSTRACT: A field experiment was conducted to study the effect of integrated nutrient management on the vegetative growth, yield and quality of potato cultivar Kufri Chipsona-3 in sandy loam soils of Punjab. The field experiment was laid out in a randomized block design which involved the integrated use of different biofertilizers, organic manures and chemical fertilizers *i.e.*, NPK, FYM (Farm Yard Manure), vermicompost, bio-fertilizers (phosphorus solubilizing bacteria and Vesicular Arbuscular Mycorrhizae) and absolute control to study the yield and quality parameters. The study revealed that maximum yield (27.9 t/ha) was obtained in the treatment which included integrated use of 75% recommended dose of NPK + FYM (Farm Yard Manure) @ 50 t/ha + PSB @ 10 kg/ha as compared to other treatments. The treatment also had positive effect on growth, quality and other yield attributes *viz.* plant height (39.85 cm, 48.73 cm and 51.62 cm at 30, 60 and 90 days after sowing respectively), number of compound leaves (41.84, 46.46 and 49.49 at 30, 60 and 90 days after sowing respectively), dry matter content (20.66%) and specific gravity (1.12 g/cm$^3$) but the treatment had no significant effect on chlorophyll content. The benefit: cost ratio was also higher in the same treatment.**

**Keywords:** Biofertilizers, vermicompost, quality, *Solanum tuberosum*, yield.

## INTRODUCTION

Potato (*Solanum tuberosum* L.) belongs to the nightshade family Solanaceae with chromosome number 2n=48. It was first domesticated in the region of modern-day southern Peru and extreme northwestern Bolivia between 8000 and 5000 BC (Spooner *et al.*, 2005). It is the fourth most important food crop after rice, wheat and maize (Anonymous, 2019). Dry matter provided by potato is 20g/100 g per unit area and time. It contains practically all the essential dietary constituents like carbohydrates, nutrients, protein, vitamins, and minerals (Sriom *et al.*, 2017). It is also a considerable source of carbohydrates (17%), 0.25mg ascorbic acid, 12mg calcium, 0.25mg Pyridoxine, starch (88%), protein (2%), fat (0.09%), fiber (2.2%) and sugar (0.78%) (Khalid *et al.*, 2020).

Potato is widely cultivated throughout the world in an area of 19.03 million hectares and the production is about 388 million tonnes. China is now the largest potato producer having a production of 99.2 million tonnes and almost one-third of all the potato is harvested in China and India (FAOSTAT, 1997). India has 2.1 million hectares area under potato cultivation with 48.60 million tonnes of production and productivity of 23.1 tonnes per hectare (NHB, 2018). In India, the estimated demand of potato in 2050 will be 122 million tons as compared to 48.60 million tons which is 2.5 times more in comparison of current production. So the improvement in potatoes productivity is necessary to meet this requirement (Mohan *et al.*, 2020). Because of the high dry matter production, potato removes large amount of nutrients from the soil per unit area per unit time, and it is difficult for the soils to supply huge amount of nutrients to plants. (Monirul *et al.*, 2013). So, it becomes essential to add nutrients to the soil from the outer sources. Mostly inorganic fertilizers are used as a source of nutrients in potato. The requirement of nitrogen, phosphorus and potassium is very high in potato as it is a heavy nutrient feeder crop. It requires balanced amount of plant nutrients for better growth and development. Nitrogen (N), Phosphorus (P) and Potassium (K) are among the most important elements that are essential for potato productivity (Pervez *et al.*, 2013). So, more or less the same economic yield could be obtained by the integrated use of half of the recommended dose of fertilizers along with bio-fertilizers and organic manures which can save 50% of the inorganic fertilizers (Kumar and Shivay, 2010).

Organic and inorganic fertilizers have beneficial effects on both soil properties and its long-term productivity. Many experiments have been conducted to check the

effects of organic and inorganic fertilizers on the soil properties, crop yield and agronomical outcomes under different agro-environmental conditions (Saha *et al*., 2008). Organic products act as sources of plant nutrients as well as beneficial microbes and organic compounds that possess the ability to suppress plant pathogens (Islam *et al.,* 2013, Anonymous, 2004). Yield of potato could be increased up to 50% through proper nutrient management (Grewal and Singh 1992). By using chemical fertilizers only, the maintenance of sustainable crop production is impossible because of decaying soil environment like physical and biological (Khan *et al*., 2008). So, stability in crop production and improvement in fertility status of soil can be achieved through integrated nutrient management (Islam *et al*. 2011, Sood, 2007, Singh and Lal, 2006). Optimal exploitation from these sources not only affects on soil properties positively, but also useful in terms of economic, social, and environmental aspects and it may serve as a suitable substitute for chemical products (Hassani *et al.*, 2015, Gosling *et al.,* 2006; Kennedy *et al.*, 2004).

*Soil Conditions*

The soil of experimental field was sandy loam with adequate drainage and ideal water holding capacity. Analysis of soil was done before the trial was conducted. The details of soil properties of the field are given below:

| Sr. No. | Particulars | Values (0-30 cm depth) | Method employed |
|---|---|---|---|
| **Physical properties** | | | |
| 1 | Coarse sand (%) | 62% | International pipette method (Piper, 1996) |
| 2 | Silt (%) | 7% | |
| 3 | Clay (%) | 31% | |
| **Chemical properties** | | | |
| 1 | pH | 7.7 | Buckmorich meter (Piper, 1996) |
| 2 | EC ($ds/m^{-1}$) | 0.28 | Jackson (1973) |
| 3 | Available OC (%) | 0.55 | Wet oxidation method (Jackson, 1958) |
| **Available nutrient status** | | | |
| 1 | Available Nitrogen (kg/ha) | 224 | Alkaline per magnate method (Subbaiah and Asija,1956) |
| 2 | Available Phosphorus (kg/ha) | 14.8 | Olsen's method (Jackson,1958) |
| 3 | Available Potassium (kg/ha) | 272.4 | Flame photometer method (Jackson,1958) |

## MATERIALS AND METHODS

The research work was conducted at the Horticulture Research Farm of Lovely Professional University, Phagwara, Punjab from November 2018 to February 2019. This University is geographically situated at a latitude 31˚ 22'31. 81'N and 75˚23'03. 02 E longitude with altitude of 252 m above the mean sea level, which falls under the central plain zone of Punjab.

The experiment was carried out by using potato variety Kufri Chipsona-3. The experimental trial has been conducted in complete randomized block design with three replications. The planting of tubers was done at a spacing of 60 cm × 20 cm on individuals beds having size of 1.8 x 1.6 m during November 2018. The number of treatments were eight [$T_1$- 100% recommended dose of NPK, $T_2$- 100% recommended dose of NPK + FYM (Farm Yard Manure) @ 50 t/ha, $T_3$- 100% recommended dose of NPK + vermicompost @ 13 t/ha, $T_4$- 75% recommended dose of NPK + FYM (Farm Yard Manure) @ 50 t/ha + PSB @ 10 kg/ha, T5- 75% recommended dose of NPK + FYM (Farm Yard Manure) @ 50 t/ha + VAM (Vesicular-Arbuscular Mycorrhiza) @ 10 kg/ha, $T_6$- 75% recommended dose of NPK + vermicompost @ 13 t/ha + PSB @ 10 kg/ha, $T_7$- 75% recommended dose of NPK + vermicompost@ 13 t/ha + VAM (Vesicular-Arbuscular Mycorrhiza) @ 10 kg/ha and $T_8$- absolute control]. Five plants in each plot were used for taking the observations. The yield and quality parameters were recorded after harvesting and growth parameters like plant height and the number of compound leaves/plant were recorded at 30, 60 and 90 days after planting, respectively. Data were analysed using one way analysis of variance (ANOVA) to evaluate the differences among treatments while the means were separated using the critical differences (CD) test at 5% level of significance using OPSTAT and Microsoft office excel.

**Following observations were recorded:**

i. Plant height (cm)
ii. Number of compound leaves/plant
iii. Dry matter content (%)
iv. Specific gravity ($g/cm^3$)
v. Yield (t/ha)

## RESULTS AND DISCUSSION

*A. Growth parameters*

The highest plant height (39.85 cm, 48.73 cm and 51.62 cm) at 30, 60 and 90 days after planting was recorded in treatment $T_4$ (75% RDF of NPK + FYM (Farm Yard Manure) @ 50 t/ha + PSB @ 10 kg/ha) which was found to be statistically significant over the other treatments, while the minimum plant height (13.28 cm, 24.27 cm and 27.41 cm) at 30, 60 and 90 days after sowing was recorded in treatment $T_8$ (absolute control) (Table 1).The maximum number of compound leaves (41.84, 46.46 and 49.49) at 30, 60 and 90 days after planting was recorded in treatment $T_4$ (75% RDF of NPK + FYM (Farm Yard Manure) @ 50 t/ha + PSB @ 10 kg/ha) which was found significant over other treatments, while the minimum number of compound leaves (30.14, 35.75 and 38.49) at 30, 60 and 90 days after planting was recorded in $T_8$ (absolute control). The maximum values for plant height and compound leaves were recorded in treatment $T_4$ (75% RDF of NPK + FYM (Farm Yard Manure) @ 50 t/ha + PSB @ 10 kg/ha) which might be due to the integrated use of

organic manures, bio-fertilizers and inorganic fertilizers that enhanced the plant's nitrogen utilization ability (Raghav *et al.,* 2008). Moreover, bio-fertilizers like PSB makes available necessary nutrients to plants because of the microorganism present in them that colonizes the rhizosphere and therefore increase the growth of the plant. Similar results were also reported in earlier studies (Nandekar *et al*., 2006).

The highest chlorophyll index (50.33) was recorded in treatment $T_3$ (100% RDF of NPK + vermicompost @ 13 t/ha) which was at par with the treatment $T_1$-100% RDF of NPK (47.56) while the minimum chlorophyll index was found in treatment $T_5$[75% recommended dose of NPK + FYM (Farm Yard Manure) @ 50 t/ha + VAM (Vesicular-Arbuscular Mycorrhiza) @ 10 kg/ha]. The highest value of chlorophyll index in $T_3$might be due to the application of vermicompost with a higher dose of nitrogen that supplies plant growth regulating substances which directly increases the plant growth. Similar results have also been reported (Koodi *et al*, 2017).

*B. Quality parameters*

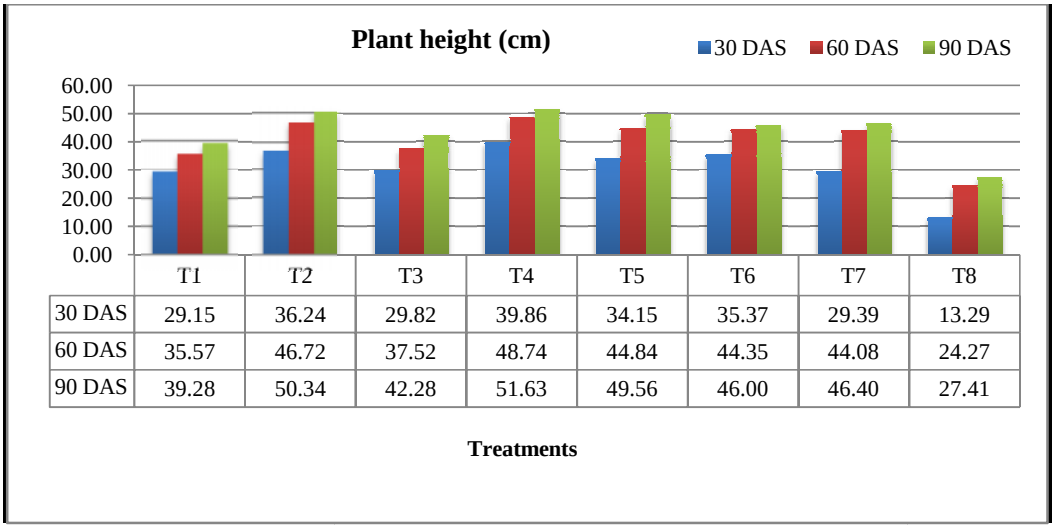
The highest dry matter content (20.66%) and specific gravity (1.12 g/cm$^3$) was recorded in the treatment $T_4$(75 % RDF of NPK + FYM (Farm Yard Manure) @ 50 t/ha + PSB @ 10 kg/ha) which was significant over the other treatments. The minimum value of dry matter (16%) and specific gravity (1.05 g/cm$^3$) was recorded in treatment $T_7$ [75% recommended dose of NPK/ha + vermicompost @ 13 t/ha + VAM (Vesicular-Arbuscular Mycorrhiza) @ 10 kg/ha]. The highest value of dry matter and specific gravity might be due to the combined application of inorganic fertilizers with organic manures like FYM (Farm Yard Manure) which enhanced the microbial activity and led to the greater availability of nutrients, translation of unavailable to available forms and improved properties (physical, biological and chemical) of soil (Singh and Kushwah, 2006).

*C. Yield parameters*

The highest total yield (27.9 t/ha) was recorded in treatment $T_4$(75% RDF of NPK + FYM (Farm Yard Manure) @ 50 t/ha + PSB @ 10 kg/ha) while the minimum yield (7.4 t/ha) was recorded in treatment $T_8$ (absolute control). It was also reported that the integrated use of 50% recommended dose of NPK with FYM (Farm Yard Manure) produced higher tuber bulking rate that ultimately increased the yield/ha of potato (Upadhayay *et al*., 2003). Also, the increase in yield/ha might be since bio-fertilizers provide a better supply of nutrients especially P and N because of greater biological nitrogen fixation, phosphorus solubilization, development of better root system and secretion of plant hormones (Kushwah and Banafar, 2003).

**Table 1: Effect of integrated nutrient management on the growth, yield and quality attributes of potato.**

| Treatments | | Plant height (cm) | | | Number of compound leaves | | | Dry matter (%) | Specific gravity (g/cm$^3$) | Yield (t/ha) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 30 days after sowing | 60 days after sowing | 90 days after sowing | 30 days after sowing | 60 days after sowing | 90 days after sowing | | | |
| T1 | 100% RDF of NPK | 29.14 | 35.57 | 39.28 | 37.74 | 43.64 | 46.53 | 20.00 | 1.11 | 24.01 |
| T2 | 100% RDF of NPK + FYM @ 50 t/ha | 36.24 | 46.71 | 50.34 | 40.57 | 45.82 | 48.94 | 16.00 | 1.05 | 24.36 |
| T3 | 100% RDF of NPK + vermicompost @ 13 t/ha | 29.82 | 37.52 | 42.27 | 38.41 | 44.81 | 47.72 | 20.00 | 1.10 | 20.25 |
| T4 | 75% RDF of NPK + FYM @ 50 t/ha + PSB @ 10 kg/ha | 39.85 | 48.73 | 51.62 | 41.84 | 46.46 | 49.49 | 20.66 | 1.12 | 27.90 |
| T5 | 75% RDF of NPK + FYM @ 50 t/ha + VAM @ 10 kg/ha | 34.15 | 44.84 | 49.56 | 40.23 | 45.64 | 48.62 | 18.66 | 1.08 | 22.96 |
| T6 | 75% RDF of NPK + vermicompost @ 13 t/ha + PSB @ 10 kg/ha | 35.37 | 44.34 | 46.00 | 39.41 | 44.61 | 47.69 | 17.33 | 1.06 | 22.00 |
| T7 | 75% RDF of NPK + vermicompost @ 13 t/ha + VAM @ 10 kg/ha | 29.39 | 44.08 | 46.39 | 40.04 | 45.82 | 48.83 | 16.00 | 1.05 | 18.92 |
| T8 | Absolute control | 13.28 | 24.27 | 27.41 | 30.14 | 35.75 | 38.49 | 18.66 | 1.09 | 7.49 |
| | Grand mean | 30.90 | 40.73 | 49.18 | 38.54 | 44.06 | 47.03 | 18.33 | 1.08 | 20.98 |
| | C.D. @ 5 % | 1.183 | 0.866 | 4.239 | 0.432 | 0.487 | 0.371 | 2.592 | 0.026 | 6.550 |
| | SE(m) | 0.386 | 0.283 | 1.384 | 0.141 | 0.159 | 0.121 | 0.846 | 0.009 | 2.139 |
| | SE(d) | 0.546 | 0.400 | 1.957 | 0.200 | 0.225 | 0.171 | 1.197 | 0.012 | 3.025 |
| | C.V. | 2.165 | 1.202 | 5.434 | 0.634 | 0.625 | 0.446 | 7.960 | 1.366 | 17.649 |




| | T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 |
|---|---|---|---|---|---|---|---|---|
| 30 DAS | 29.15 | 36.24 | 29.82 | 39.86 | 34.15 | 35.37 | 29.39 | 13.29 |
| 60 DAS | 35.57 | 46.72 | 37.52 | 48.74 | 44.84 | 44.35 | 44.08 | 24.27 |
| 90 DAS | 39.28 | 50.34 | 42.28 | 51.63 | 49.56 | 46.00 | 46.40 | 27.41 |

**Fig. 1.** Mean data of plant height (cm).

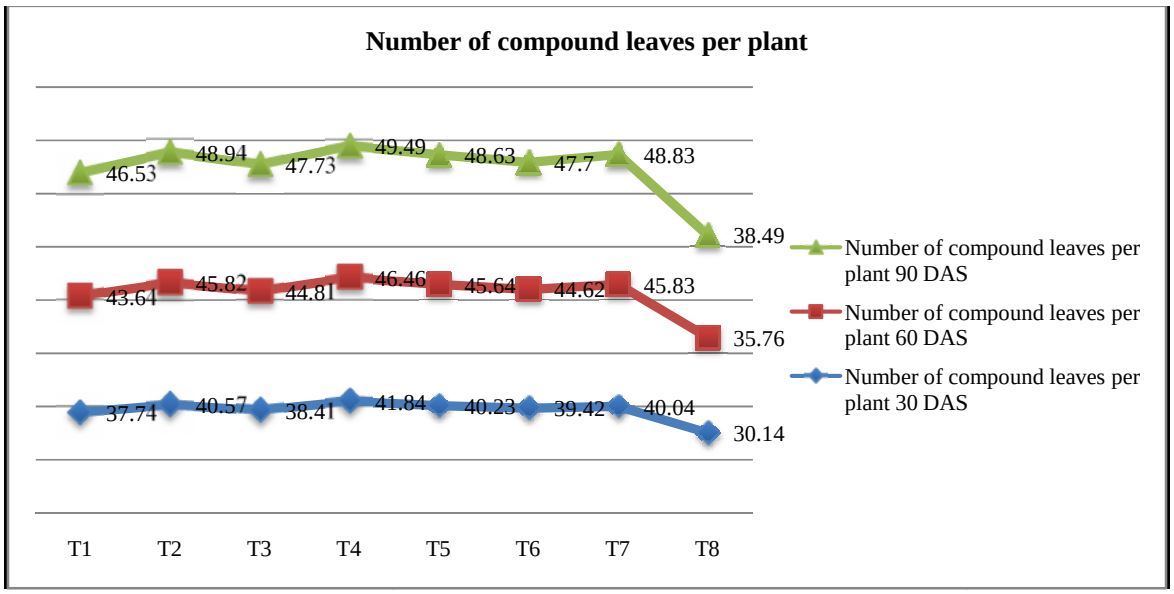



**Fig. 2.** Mean data of number of compound leaves per plant.

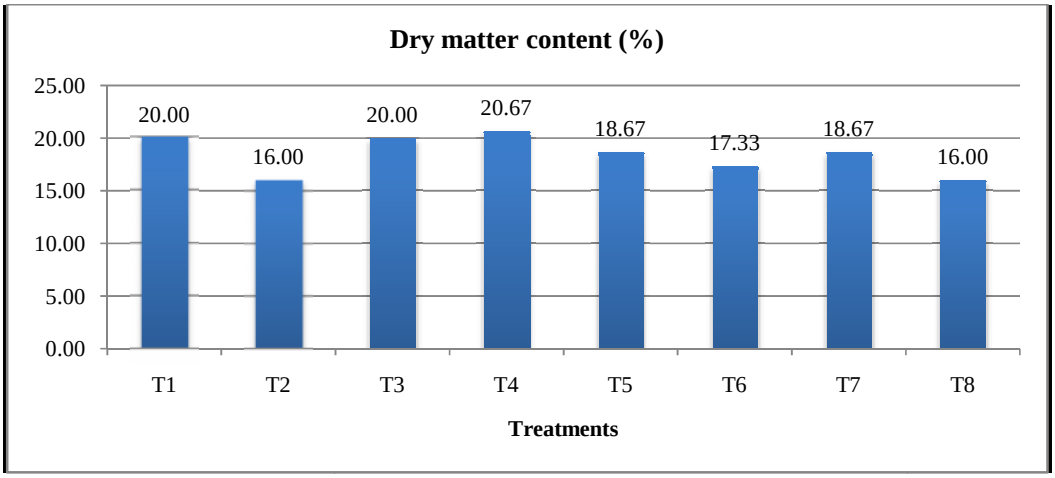



**Fig. 3.** Dry matter content (%).

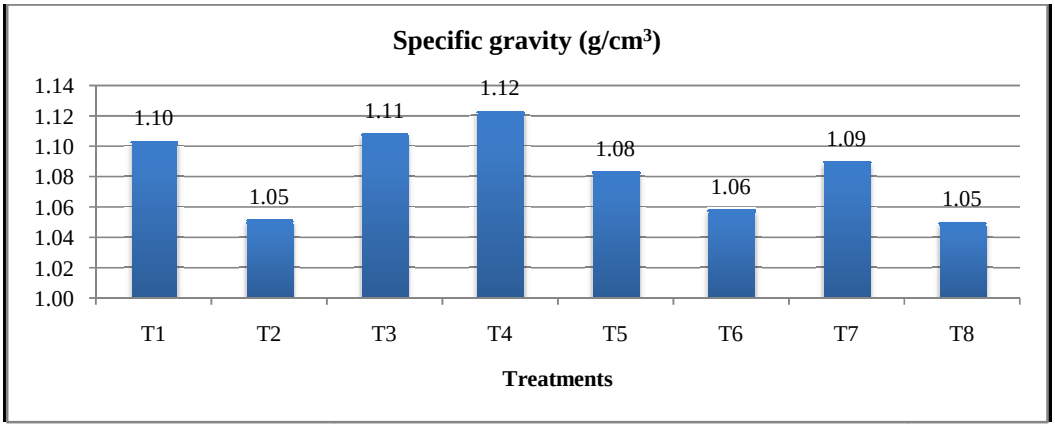



**Fig. 4.** Specific gravity (g/cm$^3$).

**Benefit: Cost ratio of potato production under integrated nutrient management**

The Higher money value of produce and less cost of management are desirable traits for getting higher returns. Hence, the economics of the treatments was worked out. The Price of inputs used, the total cost of cultivation and economics of different treatments is depicted in Table 2, 3 and 4 respectively.

The present study indicated that, among the various treatments the benefit: cost ratio was higher in treatment $T_4$having 75% recommended dose of NPK + FYM @ 50 t/ha + PSB @ 10 kg/ha (2.21) followed by $T_1$ having 100% recommended dose of NPK (2.13). Similar findings were obtained in previous studies (Sharma and Singh, 2017) (Allolli *et al*., 2011) by the use of chemical fertilizers with organic manures.

**Table 2: Price of inputs used.**

| S. No. | | Amount | Price | Total cost (Rs.) |
|---|---|---|---|---|
| 1. | **Organic manures and Bio-fertilizers (Rs.)** | | | |
| **a.** | **Vermicompost** | 13 t/ha | Rs. 6/kg | Rs. 78000 |
| **b.** | **FYM** | 50 t/ha | Rs. 300/ton | Rs. 15000 |
| **c.** | **PSB** | 10 kg/ha | Rs. 100/kg | Rs. 1000 |
| **d.** | **VAM** | 10 kg/ha | Rs. 100/kg | Rs. 1000 |
| **2.** | **Inorganic fertilizers** | | | |
| **a.** | **Urea** | 187.5 kg/ha | Rs. 350/50 kg | Rs. 1312 |
| **b.** | **DAP** | 62.5 kg/ha | Rs. 1175/50 kg | Rs. 1468 |
| **c.** | **MOP** | 62.5 kg/ha | Rs. 560/50 kg | Rs. 700 |
| **3.** | **Total Cost of cultivation** | | | Rs. 1,11,505 |
| **4.** | **Market price of potato** | | | Rs.15/kg |

**Table 3: Treatment wise total cost of cultivation (Rs. /ha)**

| S. No. | Treatments | Fertilizer cost (Rs./ha) | Fixed cost + Variable cost (Rs./ha) | Total cost (Rs./ha) |
|---|---|---|---|---|
| **1.** | $T_1$ | 3,480 | 1,11,505 | 1,14,985 |
| **2.** | $T_2$ | 18,480 | 1,11,505 | 1,29,985 |
| **3.** | $T_3$ | 81,480 | 1,11,505 | 1,92.985 |
| **4.** | $T_4$ | 18,610 | 1,11,505 | 1,30,115 |
| **5.** | $T_5$ | 18,610 | 1,11,505 | 1,30,115 |
| **6.** | $T_6$ | 81,610 | 1,11,505 | 1,93,115 |
| **7.** | $T_7$ | 81,610 | 1,11,505 | 1,93,115 |
| **8.** | $T_8$ | 0 | 1,11,505 | 0 |

**Table 4: Benefit: Cost ratio of different treatments.**

| Treatments | Total cost of cultivation (Rs.) | Yield (t/ha) | Gross returns (Rs/ha) | Net returns (Rs/ha) | Benefit: cost ratio |
|---|---|---|---|---|---|
| T1 | 1,14,985 | 24.01 | 3,60,150 | 2,45,165 | 2.13 |
| T2 | 1,29,985 | 24.36 | 3,65,400 | 2,35,415 | 1.05 |
| T3 | 1,92,985 | 20.25 | 3,03,750 | 110765 | 0.57 |
| T4 | 1,30,115 | 27.90 | 4,18,500 | 2,88,385 | 2.21 |
| T5 | 1,30,115 | 22.96 | 3,44,400 | 2,14,285 | 1.64 |
| T6 | 1,93,115 | 22.00 | 3,30,000 | 136885 | 0.70 |
| T7 | 1,93,115 | 18.92 | 2,83,800 | 90685 | 0.46 |
| T8 | 1,11,505 | 7.49 | 1,12,350 | 845 | 0.007 |

## CONCLUSION

Based on results obtained from the present investigation it may be concluded that application of 75% recommended dose of NPK + FYM (Farm Yard Manure) @ 50 t/ha + PSB @ 10 kg/ha increased the vegetative growth parameters [plant height (51.62 cm), number of compound leaves/plant (49.49)], quality parameters [dry matter (20.66%) and specific gravity (1.12 g/cm$^3$)] and total yield (27.90 t/ha) of potato.

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**Conflict of intrest.**

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