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P Yongnyu Phom,
Research Scholar, Deptt. of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, Uttar Pradesh, India

Arun Alfred David,
Associate Professor, Deptt. of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, Uttar Pradesh, India

Narendra Swaroop,
Associate Professor, Deptt. of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, Uttar Pradesh, India

Tarence Thomas
Associate Professor, (HOD) Deptt. Of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, Uttar Pradesh, India

Correspondence
Tarence Thomas
Associate Professor, (HOD) Deptt. Of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, Uttar Pradesh, India

Effect of different levels of NPK and fym on the physico-chemical properties of soil growth and yield of potato (*Solanum tuberosum* L.) cv. Kufri Badshah

P Yongnyu Phom, Arun Alfred David, Narendra Swaroop and Tarence Thomas

Abstract
An experiment was carried out at Research Farm of Soil Science and Agricltural Chemistry, (SHUATS) during winter season of 2017- 2018 to know the “Effect of different levels of N P K and FYM on the Physico-chemical properties of Soil, Growth and Yield of Potato (*Solanum tuberosum* L.) cv. Kufri Badshah”. 3×3 Factorial Randomised Block Design (RBD) was arranged with three replication for each treatment. The fertilizer applied for the crop was N P K and FYM @ 120 kg ha$^{-1,}$ 80 kg ha^{-1}, 100 kg ha^{-1} and 15 t ha^{-1} respectively. Based on the research work, it is concluded that application of N P K followed by FYM of treatment T_8 (100% NPK+ 50% t ha^{-1} FYM) was found more beneficial and significantly improved soil, growth and yield of Potato (250.75 Q ha^{-1}). This treatment also showed maximum gross return, net return and benefit: cost ratio) respectively.

Keywords: Soil properties, nitrogen, phosphorus, potassium, FYM, growth, yield and potato

Introduction
The potato is a starchy, tuberous crop from the perennial nightshade *Solanum tuberosum*. The word "potato" may refer either to the plant itself or to the edible tuber. Potato has become a staple food in many parts of the world and an integral part of much of the world's food supply. It is the world's fourth-largest food crop, following maize, wheat, and rice.Depending on the varieties, potato plants grow up to 60 cm high, and are herbaceous perennials. The leaves die back after flowering, fruiting and tuber formation. The flowers of potatoes consist of white, pink, red, blue or purple along with yellow stamens. In general white flowers potato have white skin tuber, while the coloured flower potato tend to have pinkish skins. The pollination in potatoes are mostly cross-pollinated by insects such as bumblebees that carry pollen from other potato plant, although a substantial amount of self-fertilization occurs as well.

In 2014, world production of potatoes was 382 million tonnes, an increase of 4% over 2013 amounts and led by China with 25% of the world total. Other major producers are India, Russia, Ukraine and the United States. India ranks as the world's third largest potato producing nation, with production in 2007 of around 26 million tonnes. This crop is grown throughout the world. Present world production is some 321 million tonnes fresh tubers from 19.5 million hectare. The potato plays a strong role in developing countries with its ability to provide nutritious food for the poor and hungry. The demand for potato is growing as both a fresh and processed food. However, the local importance of potato is variable and rapidly changing. It remains an essential crop in Europe (especially eastern and central Europe), where per capita production is still the highest in the world, but the most rapid expansion over the past few decades has occurred in southern and eastern Asia. In order of importance for food production among twenty major food crops (on fresh weight basis) Potato ranks 6th in the developing countries, 4th in the developed countries and 3rd in India.

Also several international organizations highlighted the potato’s role in world’s food production, in the face of the developing economic problems and cited its potential derived from its status as a low-cost and plentiful crop growing in a wide variety of climates and soils.

Thus, the United Nations officially declared 2008 as the *International Year of Potato,* to raise its profile in the developing nations, calling the crop a "hidden treasure". Citing the potato's health benefits, strong nutrition profile and ability to feed the masses, the designation was approved as a way to help meet its Millennium Development Goals.
(Source:https://www.prweb.com/releases/potato/international/prweb560604.htm)

Nutrients uptake is at its greatest during tuber bulking up. The amount of nutrients removed by a potato crop is closely related to yield. Usually, twice the yield will result twice the removal of nutrients. Nutrients need to be applied as accurately as possible to the zone of uptake, slightly before, or at the time that the crop needs them. Failure to ensure that each plant gets the right balance of nutrients can spoil crop quality and reduce yield.

Nitrogen is a first limiting nutrient in potato production thus has a great influence on crop growth, tuber yield and its quality. A mature crop of potato yielding 25-30 t ha^{-1} tubers removes 120-140 kg N ha^{-1}. The Indian soils are generally deficient in organic matter thus unable to release N at the rate required to maintain adequate supply to the growing plant. Therefore, application of nitrogen in form of fertilizers and manures becomes indispensable to meet the needs of the crop. Trehan *et al.* (2008) [18].

Phosphorus is important for early root and shoot development, providing energy for plant processes such as ion uptake and transports. Roots absorb phosphate ion only when they are dissolved in the soil water. P deficiencies can occur even in soils with abundant available P, if drought, low temperatures, or disease interfere with P diffusion to the root, through the soil solution. These deficiencies will result in stunt root development and inadequate function.

Phosphorus is one the most essential elements for plant growth after nitrogen. However, the availability of this nutrient for plants is limited by different chemical reactions especially in arid and semi-arid soils. Phosphorus plays a significant role in several physiological and biochemical plant activities like photosynthesis, transformation of sugar to starch, and transporting of the genetic traits Mehrvarz *et al.* (2008) [9].

Potato plants take up large quantities of potassium throughout the growing season, since this nutrient is crucial to metabolic functions such as the movement of sugars from the leaves to the tubers and the transformation of sugar into potato starch. K has an important role in the Control of the plant water status and internal ionic concentration of the plant tissues, with a special focus on the stomatal functioning. K requirements of potato tubers during the bulking stage are very high as they are considered to be luxury consumers of K. K deficiencies reduce the yield, size, and quality of the potato crop. It also impair the crop's resistance to disease and its ability to tolerate stresses such as drought and frost.
(Source:http://www.haifagroup.com/files/Guides/Potato.pdf)

Farm Yard Manure (FYM) is a bulky organic manure which is rich in nutrient and supply nutrients required by the plants, however with low quantity. FYM also supplies macro and micro nutrients and maintains healthy positive nutrient balance besides being a source of organic matter; and further it emphasizes the need for integrated and balance nutrient management in potato Sharif *et al*. (2014) [16]. The chemical composition of FYM is nitrogen - 0.5%, phosphate - 0.4 %, potassium - 0.5 %. (Source: Fertilizer statistics 2007-2008). FYM, despite its nutrient content it also act as buffering agent which reduces the toxicity of excessive acid, alkali or salts present in the soil.

Materials and Methods

The field experiment was conducted to study the effect of different levels of N P K and FYM on the Physico-chemical properties of soil, growth and yield of Potato. The Physico-chemical analysis was carried out by conducting laboratory experiment. The field experiment was carried out during the Rabi season 2017-2018 at the research farm of Department of Soil Science and Agricultural Chemistry, Naini Agriculture Institute, Sam Higginbottom University of Agriculture, Technology and Sciences (U.P.) located at 25°.57' N latitude 81°.57' E longitude and 98m above mean sea level.

Soil sample were taken from 0-15cm depth of soil randomly prior to tillage operations, air dried and passed through 2 mm sieve. Then the composite sample was taken for mechanical and chemical analysis. BOUYOUCOS HYDROMETER METHOD (1957) was used for the mechanical analysis of soil to determine sand, silt and clay percentage in the sample.

Chemical analysis of the soil showed a neutral pH (7.29), 0.41 dSm^{-1} EC, 0.90% Organic carbon, 270 kg ha^{-1} Nitrogen, 20.22 kg ha^{-1} Phosphorus, and 107.01 kg ha^{-1} exchangeable Potassium. Recommended dose of N, P and K (120:80:100 kg N, P_2O_5 and K_2O ha^{-1}) were applied. Full dose of P and K were applied along with 50 per cent of N at the time of planting. The remaining 50 per cent N was applied at time of earthling up.

Agro climatically, Allahabad district represents the subtropical belt of the South East of Uttar Pradesh, and is endowed with extremely hot summer and fairly cold winter. The maximum temperature of the location ranges between 46° C - 48° C and seldom falls below 4° C - 5° C. The relative humidity ranges between 20-94%. The average rainfall of this area is around 1100mm annually.

The experiment was carried out at RBD (Randomised Block Design) with three replication for each treatment. The inorganic source of fertilizers was satisfied with Urea, MOP, DAP (as N, P, k) and organic source as FYM (Farm Yard Manure) which had a significant effects on the growth and yield of Potato. The treatment combination was laid out as T_0-Control, T_1-0% NPK + 25 t ha^{-1} FYM, T_2- 0% NPK + 50 t ha^{-1} FYM, T_3-50% NPK + 0 t ha^{-1} FYM, T_4-50% NPK + 25 t ha^{-1} FYM, T_5- 50% NPK + 50 t ha^{-1} FYM, T_6-100% NPK + 0 t ha^{-1} FYM, T_7-100% NPK + 25 t ha^{-1} FYM, T_8-100% NPK + 50 t ha-1 FYM respectively.

Result and Discussion

Plant height (cm)

The effect of different level of N P K and FYM on plant height at 30 DAS was found significant. The maximum plant height (23.00cm) was of treatment T_8 (100% NPK + 50% t ha^{-1}FYM) followed by treatment T_7 (100% NPK + 25% t ha^{-1}FYM) (19.88cm) whereas, the minimum was recorded 11.88cm in treatment T_0 (Control). At 60 DAS the maximum plant height of 40.33cm was observed at treatment T_8 (100% NPK + 50% t ha^{-1}FYM) followed by T_7 (100% NPK + 25% t ha^{-1}FYM) (36.22cm) and the lowest of 17.11cm was recorded in treatment T_0 (Control). The plant height at 90 DAS was found maximum at treatment T_8 (100% NPK + 50% t ha^{-1}FYM) (50.67cm) and the lowest of 23.67cm was in treatment T_0 (Control).

This may be due to the fact that relatively higher dose of nitrogen application results in increase in cell size, elongation and enhancement of cell division which ultimately increased vigorous growth of the plant. Nitrogen fertilization has been reported to increase the plant height Kandil *et al.* (2011) [7]. Application of K increases plant height, crop vigour and imparts resistance against drought, frost and diseases. Similar findings were also reported by Sharif *et al.* (2014) [16] and Ram (2009) [11]. Inclusion of organic manures with inorganic fertilzers positively influenced the soil reaction and improved the efficiency of N utilization by the plant. These results tally with the findings of Raghav *et al.* (2008) [13].

Number of branches plant^{-1}

The effect of different level of N P K and FYM on number of branches at 30 DAS was found significant. The maximum number of branches (4.17) was of treatment T_8 (100% NPK + 50% t ha^{-1}FYM) followed by treatment T_7 (100% NPK + 25% t ha^{-1}FYM) (3.77) whereas, the minimum was recorded 2.30 in treatment T_0 (Control). At 60 DAS the maximum number of branches of (8.00) was observed at treatment T_8 (100% NPK + 50% t ha^{-1}FYM) followed by T_7 (100% NPK + 25% t ha^{-1}FYM) (7.00) and the lowest (5.11) was recorded in treatment T_0 (Control). The maximum number of branches (12.89) at 90 DAS recorded with treatment T_8 (100% NPK + 50% t ha^{-1}FYM) which was closely followed by (11.44) in treatment T_7 (100% NPK + 25% t ha^{-1}FYM), whereas the minimum number of leaves (8.67) was obtained in T_0 (Control). The similar finding were also reported by Ghulam *et al.* (2016) [6].

Number of leaves plant^{-1}

The effect of different level of N P K and FYM on number of leaves at 30 DAS was found significant. The maximum number of leaves (12.40) was of treatment T_8 (100% NPK + 50% t ha^{-1}FYM) followed by treatment T_7 (100% NPK + 25% t ha^{-1}FYM) (10.96) whereas, the minimum was recorded 9.00 in treatment T_0 (Control). At 60 DAS the maximum number of leaves of (39.55) was observed at treatment T_8 (100% NPK + 50% t ha^{-1}FYM) followed by T_7 (100% NPK + 25% t ha^{-1}FYM) (34.44) and the lowest (23.87) was recorded in treatment T_0 (Control). The maximum number of leaves (74.78) at 90 DAS recorded with treatment T_8 (100% NPK + 50% t ha^{-1}FYM) which was closely followed by (71.67) in treatment T_7 (100% NPK + 25% t ha^{-1}FYM), whereas the minimum number of leaves (45.79) was obtained in T_0 (Control).

Potassium increases leaf expansion particularly at early stages of growth and extends leaf area duration by delaying leaf shedding near maturity. The application of potassium activates a number of enzymes involved in photosynthesis, carbohydrate and protein metabolism; and assists in the translocation of carbohydrates from leaves to tubers Sharif *et al.* (2014).

Nitrogen fertilization has been reported to increase leaf number per plant Kandil *et al.* (2011) [7]. The similar findings were also reported by Amana *et al.* (2016).

Soil pH

The highest pH (7.40) was recorded with treatment T_0 (Control) followed by treatment T_7 (100% NPK + 25 t ha^{-1} FYM), (7.37). Whereas the lowest value was observed with treatment combination T_8 (100% NPK + 50 t ha^{-1} FYM), (7.27). The decrease in soil pH may be due to formation of bicarbonate and ammonium nitrate by the application of urea that react with H^+ ions and caused to reduce acidity. Slight decrease in pH may also be related with the application FYM due to formation of humic and carbonic acids. Release of organic acids during the mineralization of FYM helps to decrease soil pH. Similar findings also reported by Roshan *et al.* (2014).

Bulk density (g cm^{-3})

The effect of different levels of NPK and FYM showed non-significant on bulk density in soil after harvest of potato. The maximum bulk density was recorded highest at T_0 (Control) with value 1.15 and the lowest value 1.09 was recorded at T_8 (100% NPK + 50 t ha-1 FYM). As compared to pre-harvest soil bulk density of 1.30, the bulk density of post-harvest soil decreases. Decrease in BD might be due to higher accumulation of organic carbon and improvement in soil structure. Similar results were also reported by Moharana *et al.* (2017) and Rudrappa *et al.* (2006).

Particle density (g cm^{-3})

The effect of treatment combination of NPK and FYM at different levels on particle density after harvest was found significant. The particle density of soil significantly increased with increase in levels of NPK and FYM. The maximum particle density value 2.78 g cm^{-1} was found at treatment T_8 (100% NPK + 50 t ha-1 FYM) and minimum particle density 2.25 g cm^{-1} was recorded in treatment T_0 (Control). The similar findings were also reported by Ghulam *et al.* (2016) [6].

Pore Space (%)

The % pore space of soil significantly increased with increase in levels of NPK and FYM. The maximum % pore space (57.19 %) was found in treatment T_8 (100% NPK + 50 t ha-1 FYM) and the minimum % pore space (50.78 %) was recorded in T_0 (Control). The findings proved that the effect of NPK and FYM was significant with respect to % pore space. Ghulam *et al.* (2016) [6] also reported the similar findings.

Electrical Conductivity (d Sm^{-1})

The maximum electrical conductivity value 0.66 dsm^{-1} was found at treatment T_8 (100% NPK + 50 t ha-1 FYM) and minimum electrical conductivity 0.53 dsm^{-1} was recorded in treatment T_0 (Control). The application of various fertilizers raised the EC of the soils to different levels, and the highest was recorded at treatment receiving full dose of inorganic and organic fertilizers *i.e.*, T_8 (100% NPK + 50 t ha-1 FYM). On the other hand FYM improve soil physical properties like structure and EC and buffering action in soil reaction.

Ghulam *et al.* (2016) [6] and Esawy *et al*. (2009) observed that the maximum EC value under higher dosed of Inorganic and organic fertilizer, which is in agreement with the present findings.

Available Organic carbon (%)

The result shows that soil Organic carbon (%) increases with increased in levels of NPK and FYM. The maximum soil O.C. (%) of 0.53 % was observed in treatment T_8 (100% NPK + 50 t ha-1 FYM), and the minimum soil O.C. (%) of 0.45 % was recorded in T_0 (Control). Similar findings have also been reported by Moharana *et al*. (2017), Rudrappa *et al*. (2006) and Ghulam *et al*. (2016) [6].

Available Nitrogen (kg ha^{-1})

The maximum available N of 246.00 kg ha^{-1} was recorded at treatment T_8 (100% NPK + 50 t ha-1 FYM), which was followed by 243.44 kg ha^{-1} at treatment T_7 (100% NPK + 25 t ha^{-1} FYM). And the minimum available N was recorded at T_0 (Control) with 202.44 kg ha^{-1}.

The application of organic or inorganic fertilizers is widely known to ameliorate soil N status Ajebesone *et al.* (2011), this explains why plots that received NPK and FYM had higher N. The increase in available N may be due to application of FYM, which is the major source of nitrogen and the soil physic-chemical characteristics are very much benefited by FYM. The increased in available N have also been reported by Shuh *et al.* (2015) and Ghulam *et al.* (2016) [6].

Available Phosphorus (kg ha^{-1})

The maximum available P of 22.96 kg ha^{-1} was recorded at treatment T_8 (100% NPK + 50 t ha-1 FYM), which was followed by 22.61 kg ha^{-1} at treatment T_7 (100% NPK + 25 t ha^{-1} FYM). And the minimum available P was recorded at T_0 (Control) with 16.48 kg ha^{-1}.Phosphorus fertilizers and manure in the soil increase phosphorus uptake by plants, through favouring production of carbonic acid, the acid that increases solubility of phosphate compounds. Phosphorus is the second most important macro nutrient after nitrogen that plays significant role in physiological and biochemical reactions such as photosynthesis and transfer characteristics Mehrvarz *et al.* (2008) [9]. Das *et al.* (1991) reported that application of FYM resulted in tremendous increase in available P status of soil which might be attributed to the build-up of available P owing to the formation of fulvic acid and other chelating agents which form soluble complexes with native P in soils. The increased in available P have also been reported by Shuh *et al.* (2015) and Ghulam *et al.* (2016) [6].

Available Potassium (kg ha^{-1})

The soil available potassium (kg ha^{-1}) increased significantly with increase in levels of NPK and FYM. The maximum available K of 172.00 kg ha^{-1} was recorded at treatment T_8 (100% NPK + 50 t ha-1 FYM. And the minimum available K was recorded at T_0 (Control) with 130.41 kg ha^{-1}. The increase in available K may be due to higher application of NPK along with FYM which is advantageous as it improve soil physical properties, also due to availability of more nutrients as compared to their individual effects. FYM also supplies macro and micro nutrients and maintains healthy positive nutrient balance besides being a source of organic matter; and further it emphasizes the need for integrated and balance nutrient management in potato. It is also suggested that continuous application of NP without K depletes soil K and may pose problem in crop production Sharif *et al.* (2014) [16]. The results are conformity with the finding of Ghulam *et al.* (2016) [6].

Tuber Diameter (cm)

The maximum tuber diameter of 5.11 cm was found at treatment T_8 (100% NPK + 50 t ha-1 FYM), and the minimum was recorded at T_0 (Control) with 2.81 cm. all the treatment combination showed significant increase over Control. The maximum tuber diameter with treatment T_8 could be due to availability of different nutrients organic manure and added availability of Nitrogen to plant. Mojtaba *et al.* (2013) reported that increasing nitrogen rates up to 150 kg ha^{-1} increased tuber diameter, which confirmed the present findings.

Tuber length (cm)

From the field experiment it was observed that the maximum tuber length of 7.98 cm was found at treatment T_8 (100% NPK + 50 t ha-1 FYM), and the minimum was recorded at T_0 (Control) with 3.81 cm, all the treatment combination showed significant increase over Control. The maximum tuber length with treatment T_8 could be due to availability of different nutrients from organic manure and inorganic fertilizers, which contributed significantly to growth of crop. The effects of manures and fertilizers has significant impact on the growth, yield and physiological properties of potato. Shiferaw Boke (2014).

Tuber yield (Q ha^{-1})

It has been recorded that the maximum number yield of 250.75 Q ha^{-1} was found in treatment T_8 (100% NPK + 50 t ha-1 FYM), followed by treatment T_7 (100% NPK + 25 t ha^{-1} FYM) with 240 Q ha^{-1}. And the minimum tuber yield was found in treatment T_0 (Control) with 79.2 Q ha^{-1}. Application of both NPK and FYM resulted significantly higher tuber yield as compared Control. The higher benefits from combined applications might be attributed, in part, to enhanced fertilizer recovery (increased uptake) due to increased soil physical and chemical properties as a result of increased soil organic matter. Besides increasing soil physical and chemical properties, by providing macro and micronutrient organic manure improved crop production. The results are in partial agreement with reports of Sharif *et al.* (2014) [16] who also reported that combined application of K with FYM significant increase in tuber yield, also suggested that K as a major yield limiting factor for optimum production of potatoes

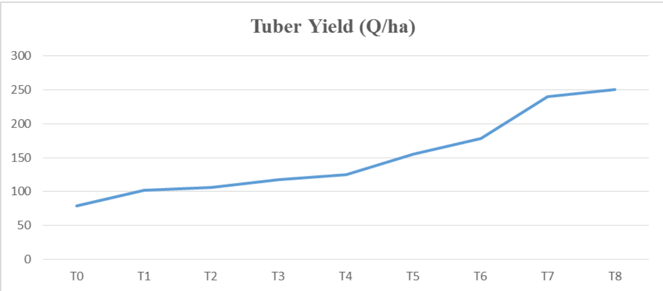

Fig 1: Effect of different level of N P K and FYM on Tuber Yield (Q ha^{-1}) of potato.

Table 1: Analysis of soil before sowing of Potato.

Parameters	Result
Sand (%)	70.10
Silt (%)	17.20
Clay (%)	12.70
Texture of Soil	Sandy Loam
Bulk density (g cm^{-3})	1.30
Particle density (g cm^{-3})	2.54
Pore space (%)	53.33
Soil colour	Light yellowish brown
P^H	7.29
EC (dSm^{-1})	0.41
OC (%)	0.90
Available Nitrogen (kgha^{-1})	270.00
Available Phosphorus (kgha^{-1})	20.22
Available Potassium (kgha^{-1})	107.01

Table 2. Effect of NPK and FYM on growth parameters, yield and economics of Potato.

Treatment combination	Plant height (cm)	Number of branches plant^{-1}	Number of leaves plant^{-1}	Tuber Diameter (cm)	Tuber length (cm)	Tuber yield (Q ha^{-1})
T_0	23.67	8.67	45.79	2.81	3.81	79.20
T_1	32.56	8.89	53.11	3.56	4.79	102.22
T_2	32.78	10.00	60.44	3.66	5.54	106.51
T_3	39.56	9.89	63.56	3.12	4.04	117.50
T_4	43.44	10.89	67.44	3.60	4.26	125.00
T_5	46.33	12.56	65.11	4.02	7.66	155.75
T_6	49.44	12.56	62.89	4.41	7.00	178.75
T_7	45.22	11.44	71.67	4.63	7.21	240.00
T_8	50.67	12.89	74.78	5.11	7.98	250.75
Mean	40.40	10.86	62.75	3.88	5.81	150.63
F-Test	S	S	S	S	S	
SE.d (±)	2.26	0.78	3.27	0.42	0.49	
C. D. at 5%	4.79	1.65	6.94	0.89	1.04	

Note: Av= Available

Table 3. Effect of NPK and FYM on soil properties after harvest of Potato.

Treatment combination	Soil pH	Bulk density (g cm^{-3})	Particle density (g cm^{-3})	Pore Space (%)	EC (dSm^{-1})	OC (%)	Av. Nitrogen (kg ha^{-1})	Av. Phosphorus (kg ha^{-1})	Av. Potassium (kg ha^{-1})
T_0	7.40	1.15	2.25	50.78	0.53	0.45	202.44	16.48	130.41
T_1	7.27	1.13	2.53	52.41	0.53	0.48	227.50	22.2	140.36
T_2	7.27	1.11	2.28	52.74	0.56	0.47	202.43	20.23	142.44
T_3	7.37	1.14	2.47	53.82	0.59	0.51	218.25	22.59	143.22
T_4	7.30	1.13	2.57	55.08	0.62	0.49	226.17	19.53	172.41
T_5	7.33	1.11	2.55	52.59	0.61	0.48	228.82	21.09	167.89
T_6	7.27	1.09	2.55	56.16	0.61	0.51	237.78	18.65	165.86
T_7	7.37	1.11	2.64	55.04	0.63	0.48	243.44	22.61	161.88
T_8	7.27	1.09	2.78	57.19	0.66	0.53	246.00	22.96	172.00
F-test	S	NS	S	S	S	S	S	S	S
SE.d (±)	0.11	0.53	0.12	1.41	0.03	0.03	2.14	2.07	1.78
C. D. at 5%	0.23	0.12	0.26	2.99	0.07	0.06	4.53	16.48	3.76

Conclusions

The findings of the experiment concluded that the application of NPK (@ 120 kg ha^{-1}, 80 kg ha^{-1}, 100 kg ha^{-1} and FYM @ 15 t ha^{-1} had significant effects on the soil, growth and yield of Potato which makes the combined application of NPK and FYM a beneficial approached towards an important source of plant nutrients and superior to all other treatments and profitable.

Results indicated that there was a great differences in the plot treated with fertilizers and plot with zero fertilizer, hence the combined use of NPK and FYM could be recommended as important nutrient management and sustainable potato production.

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