Original research article

Influence of Different Levels Organic and Inorganic Fertilizer Growth and Yield of Potato (*Solanum tuberosum* L.)

Abstract

The global food demand of growing human population and need for eco-friendly strategy for sustainable soil-plant-microbes-environmental system currently a crucial challenge. In conventional farming for increasing the crop yield farmers are using huge amount of chemical fertilizer in the fields. Due to either over or imbalance use of chemical fertilizers in cultivation of crops, degraded the soil fertility and health of soil. Such farming is blamed for land degradation and environment pollution and adversely affecting the human health, plants and animals. Soil degradation contributes to low agricultural productivity. Organic amendments (OAs) have the potentials to reverse soil degradation processes by improving the soil's physical and chemical properties and consequently improve crop growth and yield performance An experiment was carried out during the winter season of 2021- 2022 to know the Effect of different levels of Vermicompost,Neam cake and fertilizer on soil health and yield of Potato (*Solanum tuberosum* L.) ". The experiment was laid out in Randomised Block Design (RBD) with three replicates for each treatment. The fertilizer applied for the crop was NPK and @ 120kg, ha^{-1}, 80kg ha^{-1}, 120kgha^{-1}, Vermicompost 6 and Neem cake 3 t h^{-1}, respectively, showed significant influence on the soil health of Potato . Based on the above research work, it is concluded that application of Vermicompost, Neam cake and fertilizer, treatment T9 [NPK 100% + VC @100% + Neem Cake @ 100% ha^{-1}] was found more beneficial and significantly improved soil, and tuber yield of Potato grown under Allahabad Agro-climatic conditions.

Keywords: Nitrogen, Phosphorus, Potassium, Organic amendments, Soil properties, soil health, yield and potato.

INTRODUCTION

"Potato (*Solanum tuberosum*, L.) is considered as one of the most important vegetable food crops all over the world, As a world crop, it ranks the first most important tuber crop, and next to wheat and rice" (Alam *et al*. 2007). "Potato tubers are an important source of digestible carbohydrates, dietary fiber, vitamin C, and some necessary

minerals" (Sarhan *et al*. 2004). "So, it can use as a staple food, vegetable, source of starch, flour, alcohol, acetone and glucose. Nitrogen (N), Phosphorus (P) and potassium (k) are considered as the most three important elements prerequisite for plant nutrition in large amounts. They play essential roles in overall metabolism of plant enzymes activity, promoting photosynthesis, cell divisive and development of meristematic tissue, nitrogen and water consumption respiration. Since, nitrogen (N) is an essential element for building up protoplasm, proteins and amino acids, which induce cell division and initiate meristematic activity. Also, phosphorus is a part of molecular structure of nucleic acid (DNA and RNP), the energy transfer compounds and phosphor-proteins. Moreover, potassium element is very important in overall metabolism of plant enzymes activity. It is important to serve a vital role in photosynthesis by direct increasing in growth and leaf area and hence CO_2 assimilation" (Gardener *et al*. 1985). The effects of the three mineral fertilizers nitrogen (N), phosphorus (P) and potassium (K) individually or in combination with either one or more of each potato cultivar plants were reported by several investigations such as: Brijlal and Sharma (1995) using K; Danilchenko *et al.* (2005) and Alam *et al*. (2007) using NPK. Since, they found that using such fertilizers reflected significant effects on the vegetative, yield and chemical compositions characters of potato plants.

It is well known that organic manure improved the structure of the soil and this consequently encourage the plant to have a good growth. Moreover, the slow released nutrients contained in organic manure permit the plants to beneficial of it. Organic manures maintain and increase the long-term fertility of soil. They avoid all forms of pollution. Organic manures maintain the genetic diversity of potato and also allow adequate returns and satisfaction to potato growers from their work including a safe working environment. Organic manures act not only as a source of nutrients and organic matter, but also increase microbial diversity and activity in soil, which influence soil structure and nutrients rotation, in addition to improvement in other physical, chemical and biological properties of the soil. All these reasons resulted in improve plant growth. Studies were also made by several researchers on the effects of organic and inorganic fertilizers on vegetative growth, yield, and chemical compositions of potato, such as; Spoil and Fedotova (1987); Das and Banerjee (1996); Eiecharczyk and Malecka (2000); Danilchenko *et al*.(2005) and Singh and Kushwah (2006).

Vermicompost has been found to effectively enhance the root formation, elongation of

stem and production of biomass in potato crop. Using of vermicompost is now a global movement for the second green revolution that emphasizes on composting. Ghosh *et al.*, (1999) observed that "integration of vermicompost with inorganic fertilizers tends to increase the yield of potato crop". "Vermicompost has higher level of nitrogen (1.6%), phosphorous (0.7%) and potassium (0.8%), calcium (0.2%)" (Buchanan *et al.*, 1988). "The use of vermicompost as long been considered as effective means of improving the structure and fertility of soil" (Haj *et al.*, 2011). "Neem cake organic manure is the by-product obtained in the process of cold pressing of neem fruits and kernels, and the solvent extraction process for neem oil cake. Neem cake organic manure is used directly and/or in blends with urea or with other organic manure like seaweed or farmyard manure to an extent of 15-20% by weight, for higher yields in various corps. Neem Cake Organic Manure has more nitrogen, phosphorous, potassium, calcium and magnesium than the farmyard manures" (Habibi and Thomas 2016**)**. It is rich is sulphur compounds as well as bitter limonoids content of neem cake N-1.5%, P 1.0%, K 1.4%, Ca 0.96% and Na 0.4 %. Therefore, the main objective of this study was to investigate the effects of organic manure and inorganic NPK in soil health and yield of potato plants.

MATERIALS AND METHODS

Two field experiments were carried out during the two consecutive winter seasons of 2020-21 and 2021-22 Research Farm of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad University of Agriculture, Technology and Sciences (U.P.) located at 25^{o}.57$^{'}$ N latitude 81^{o}.57$^{'}$ E longitude and 98m above mean sea level. 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 ^{o}C - 48 ^{o}C and seldom falls below 4 ^{o}C - 5 ^{o}C. The relative humidity ranges between 20-94%. The average rainfall of this area is around 1100mm annually. The treatment combination was laid out as T1- (Control)-NPK 0% Recommended Dose of Fertilizer (RDF) + vermicompost t@ 0t ha^{-1} + Neem cake @ 0t ha^{-1},T2- NPK 0% RDF + + Vermicompost @ 3t ha^{-1} + Neem cake @0.6t ha^{-1}, T3-NPK 0% RDF + vermicompost @ 6t ha^{-1} + Neem cake @ 1.2t ha^{-1}, T4-NPK 50% RDF + Vermicompost @ 0t ha^{-1} + Neem cake @ 0t ha^{-1},T5-NPK 50% + Vermicompost @ 3t ha^{-1} + Neem cake @ 0.6 t ha^{-1},T$_{6}$- NPK 50% RDF + Vermicompost @ 6t ha^{-1} + Neem cake @ 1.2t ha^{-1},

T_7-NPK 100% RDF + Vermicompost @ 0t ha^{-1} + Neem cake @ 0t ha^{-1},T_8-NPK 100%RDF + Vermicompost @ 3t ha^{-1} + Neem cake @ 0.6t ha^{-1}, T9-NPK 100% RDF + Vermicompost @ 6t ha^{-1} + Neem cake @ 1.2t ha^{-1},respectively .

RESULTS AND DISCUSSIONS

Plant height (cm)

The data pertaining in table 1 reveals that the effect of different level of vermicompost, Neem cake and fertilizers on plant height at 30, 60 and 90 DAS were significantly differ among the treatment in both the years. At 30 DAS, the maximum plant height was observed in T9 (26.28cm and 27.75 cm) followed by T8 (25.67 and 27.20) while minimum plant height was recorded in T1 (17.45 and 17.82) in the both years. At 60 DAS, maximum plant height was observed in T9 (37.23 cm and 41.16 cm) followed by T8 (34.63 and 39.23) T7 (33.19 and 36.63) while minimum plant height was recorded in T1 (22.73 and 24.83) in the both years. At 90 DAS, maximum plant height was observed in T9 (43.97 and 48.63 cm) followed by T8 (43.21 and 46.21), while minimum plant height was recorded in T1 (28.47) in the both years. Pooled data of two years, plant height were significantly increased over the control in three DAS (30,60 and 90 DAS) and maximum plant height was observed in T9 (27.02,39.20 and 46.30 cm) followed by T8 (26.44,36.93 and 44.71) while minimum plant height was recorded in T1 (17.64, 23.78 and 28.47) respectively. Appropriate fertilization was reported to increase the average fresh tuber, plant height, leaf number and tuber; weight per plant responded positively application and Leaf area increased (Kandil *et al*., 2011).Similar finding were also observed by Habibi and Thomas (2016),Gulam and David (2019), Lanunpiuia *et al*., (2019), Taha.*et al* (2019) and Dey *et al.,* (2015).

Table 1: Influence of Vermicompost, Neem cake and Inorganic Fertilizers on Plant Height (cm) of Potato

	(2020-21)			(2021-22)			Pooled		
Treatments	**30 DAS**	**60 DAS**	**90 DAS**	**30 DAS**	**60 DAS**	**90 DAS**	**30 DAS**	**60 DAS**	**90 DAS**
T_1	17.45	22.73	28.47	17.82	24.83	28.47	17.64	23.78	28.47
T_2	17.78	24.83	30.03	18.89	25.45	30.03	18.34	25.14	30.03
T_3	19.18	25.45	32.64	19.03	27.56	32.64	19.11	26.51	32.64
T_4	20.6	27.56	34.97	20.93	29.13	34.97	20.77	28.35	34.97
T_5	22.89	31.13	37.22	25.36	34.13	40.22	24.13	32.63	38.72

T_6	24.31	32.13	39.33	26.12	35.19	42.33	25.22	33.66	40.83
T_7	24.92	33.19	40.79	26.52	36.63	43.79	25.72	34.91	42.29
T_8	25.67	34.63	43.21	27.2	39.23	46.21	26.44	36.93	44.71
T_9	26.28	37.23	43.97	27.75	41.16	48.63	27.02	39.20	46.30
F – test	S	S	S	S	S	S	S	S	S
CD @ 5%	0.65	1.59	2.22	1.15	1.74	2.25	0.90	1.67	2.24
S. Ed. (±)	0.3	0.75	1.04	0.53	0.82	1.06	0.42	0.79	1.05

Number of leaves plant^{-1}

The data pertaining in table 2 reveals that the effect of different level of vermicompost, Neem cake and fertilizers on Leaves plant^{-1} at 30,60 and 90 DAS were significantly differ among the treatment in both the years.. At 30 DAS the maximum plant height was observed in T9 (15.20 cm and 17.10 cm) followed by T8 (14.67 and 16.57) while minimum Leaves plant^{-1}was recorded in T1 (9.33 and 10.50) in the both years. At 60 DAS maximum Leaves plant^{-1}was observed in T9 (23.53 cm and 28.03 cm) followed by T8 (22.53 and 27.03) T7 (21.47 and 25.97) while minimum Leaves plant^{-1}was recorded in T1 (15.27 and 19.77) in the both years. At 90 DAS, maximum Leaves plant^{-1} was observed in T9 (37.86 and 42.36 cm) followed by T8 (33.65 and 38.15), while minimum Leaves plant^{-1} was recorded in T1 (19.91 and 24.74)in the both years. Pooled data of two years, leaves plant^{-1} were significantly increased over the control in three DAS(30,60 and 90 DAS) and maximum leaves plant^{-1} was observed in T9 (16.15,25.78 and 40.11 cm) followed by T8 (15.62,24.78 and 35.90 cm) while minimum Leaves plant^{-1} was recorded in T1 (9.92,17.52 and 22.33) respectively in the both years. Appropriate fertilization was reported to increase the average fresh tuber, plant height, leaf number and tuber; weight per plant responded positively application and Leaf area increased (Kandil *et al*., 2011).Similar finding were also observed by Habibi and Thomas (2016), Gulam and David (2019), Lanunpiuia *et al.*, (2019),Taha.*et al*.,2019) and Dey *et al.*, (2015).

Table 2: Influence of Vermicompost Neem cake and Inorganic Fertilizers on Number Leaves Plant^{-1} of Potato

Treatments	**(2020-21)**			**(2021-22)**			**Pooled**		
	30	**60**	**90**	**30**	**60**	**90**	**30**	**60**	**90**

	DAS	DAS	DAS	DAS	DAS	DAS	DAS	DAS	DAS
T_1	9.33	15.27	19.91	10.50	19.77	24.74	9.92	17.52	22.33
T_2	9.67	15.6	22.55	11.13	20.10	27.05	10.40	17.85	24.80
T_3	10.67	16.07	22.79	13.43	21.13	27.29	12.05	18.60	25.04
T_4	13.13	18.87	26.21	15.53	23.37	30.71	14.33	21.12	28.46
T_5	14.6	20.2	27.29	16.9	24.7	31.79	15.75	22.45	29.54
T_6	14.2	19.53	30.43	17.43	24.77	34.93	15.82	22.15	32.68
T_7	14.40	21.47	31.08	16.3	25.97	35.58	15.35	23.72	33.33
T_8	14.67	22.53	33.65	16.57	27.03	38.15	15.62	24.78	35.90
T_9	15.20	23.53	37.86	17.1	28.03	42.36	16.15	25.78	40.11
F - test	S	S	S	S	S	S	S	S	S
CD @ 5%	1.02	1.72	3.34	1.13	1.75	3.35	1.08	1.74	3.35
S.Ed. (±)	0.48	0.81	1.57	0.53	0.82	1.56	0.51	0.82	1.57

Number of Tubers Plant^{-1}

Number of Tubers Plant^{-1} presented in table 3 reveals that effect of different level of vermicompost, neem cake and fertilizers when subjected to statistical analysis indicated that there was a significantly difference among the treatments during the both year. Comparatively maximum Number of Tubers Plant^{-1}was observed in treatment T_9 (8.81 and 9.14) followed by T_8 (8.23 and 8.37) while minimum Number of Tubers Plant^{-1}was recorded in T_1 (6.57and 6.91) in the both years. Pooled data of two years shows that Number of Tubers Plant^{-1} significantly increased over the control and maximum Number of Tubers Plant^{-1}was observed in T_9 (8.98) followed by T8 (8.43) while minimum Number of Tubers Plant^{-1} was recorded in T1 (6.74) respectively in the both years. Appropriate fertilization was reported to increase the average fresh tuber, plant height, leaf number and tuber; weight per plant responded positively application and Leaf area increased (Kandil *et al*., 2011). Similar finding was also observed by Habibi and Thomas (2016), Gulam and David (2019), Lanunpiuia *et al.,* (2019), Taha.*et al* (2019) and Dey *et al.,* (2015).

Table 3: Influence of Vermicompost Neem cake and Inorganic Fertilizers on Number of Tubers Plant^{-1} of Potato

Treatments	(2020-21)	(2021-22)	Pooled
T_1	6.57	6.91	6.74

T_2	6.81	7.14	6.98
T_3	7.06	7.33	7.20
T_4	7.22	7.49	7.36
T_5	7.31	7.7	7.51
T_6	7.89	8.09	7.99
T_7	8.03	8.37	8.20
T_8	8.23	8.63	8.43
T_9	8.81	9.14	8.98
F – test	S	S	S
CD @ 5%	0.82	0.46	0.64
S. Ed. (±)	0.38	0.22	0.30

Tuber Yield (t ha^{-1})

Tuber Yield (t ha^{-1}) of Potato presented in table 4 reveals that effect of different level of vermicompost, neem cake and fertilizers when subjected to statistical analysis indicated that there was a significantly difference among the treatments during the both years. Comparatively maximum Tuber Yield (t ha^{-1})was observed in treatment T_9 (32.13 and 34.24) followed by T_8 (21.62 and 23.88) while minimum Tuber Yield (t ha^{-1})was recorded in T_1 (7.88 and 8.07) in the both year. Pooled data of two years shows that Tuber Yield (t ha^{-1})significantly increased over the control and maximum Tuber Yield (t ha^{-1})was observed in T_9(33.19) followed by T_8 (22.75) while minimum Tuber Yield (t ha^{-1})was recorded in T_1 (7.98) respectively in the both years. Appropriate fertilization was reported to increase the average fresh tuber, plant height, leaf number and tuber; weight per plant responded positively application and Leaf area increased (Kandil *et al*., 2011). Similar finding were also observed by Habibi and Thomas, (2016), Gulam and David (2019), Lanunpiuia *et al.*, (2019), Taha.*et al*.,(2019) and Dey *et al*., (2015).

Table 4: Influence of Vermicompost Neem cake and Inorganic Fertilizers onTuber Yield (t ha^{-1}) of Potato

Treatments	(2020-21)	(2021-22)	Pooled
T_1	7.88	8.07	7.98
T_2	12.68	12.73	12.71
T_3	21.09	22.31	21.70
T_4	12.68	13.02	12.85

T_5	19.17	20.4	19.79
T_6	26.37	27.73	27.05
T_7	15.82	17.56	16.69
T_8	21.62	23.88	22.75
T_9	32.13	34.24	33.19
F – test	S	S	S
CD @ 5%	4.53	5.55	5.04
S.Ed. (±)	2.07	2.64	2.36

Haulm Yield (t ha^{-1})

Haulm Yield (t ha^{-1}) of Potato presented in table 5 reveals that effect of different level of vermicompost, neem cake and fertilizers when subjected to statistical analysis indicated that there was a significantly difference among the treatments during the both years. Comparatively maximum Haulm Yield (t ha^{-1}) was observed in treatment T_9 (3.23 and 3.3) followed by T_8 (2.99 and 3.05) while minimum Number of Tubers Plant^{-1}was recorded in T_1 (1.56and 1.63) in the both year. Pooled data of two were on haulm yield (t ha^{-1}) showed significant in both the years and maximum haulm yield (t ha^{-1}) was observed in T_9(3.27) followed by T8 (3.02) while minimum Haulm Yield (t ha^{-1})was recorded in T1 (1.60) respectively in the both years. Appropriate fertilization was reported to increase the average fresh tuber, plant height, leaf number and tuber; weight per plant responded positively application and Leaf area increased (Kandil *et al*., 2011).Similar finding were also observed by Habibi and Thomas, (2016), Gulam and David, (2019), Lanunpiuia *et al.,* (2019), Taha.*et al* .,(2019) and Dey *et al.,* (2015).

Table 5 : Influence of Vermicompost Neem cake and Inorganic Fertilizers on Haulm Yield (t ha^{-1}) of Potato

Treatments	(2020-21)	(2021-22)	Pooled
T_1	1.56	1.63	1.60
T_2	1.75	1.82	1.79
T_3	2.03	2.1	2.07
T_4	2.33	2.4	2.37
T_5	2.56	2.63	2.60
T_6	2.44	2.5	2.47
T_7	2.61	2.67	2.64

T_8	2.99	3.05	3.02
T_9	3.23	3.3	3.27
F – test	S	S	S
CD @ 5%	0.35	0.31	0.33
S.Ed. (±)	0.12	0.14	0.13

CONCLUSION

The findings of present study concluded that among nine treatment combination the best results were obtained with treatment T_9 [RDF @ 100 % + Vermicompost @ 6 t ha^{-1}+ Neem cake @ 1.2 t ha^{-1}] followed by treatment T_8[RDF @ 100 % + Vermicompost @ 3 t h^{-1}+ Neem cake @ 0.6 t ha^{-1}]. It proved that T_9 gave significantly higher result in respect to plant height, number of branches, potato tuber and haulm yield than other treatments. Hence it is being recommended to farmers for higher benefits and maintaining soil health.

Disclaimer (Artificial intelligence)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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