International Journal of Plant & Soil Science

Volume 36, Issue 11, Page 301-310, 2024; Article no.IJPSS.126543
ISSN: 2320-7035

Influence of INM on Yield, Quality of Potato and Soil Status

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/ijpss/2024/v36i115145

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/126543

Original Research Article

Received: 10/09/2024
Accepted: 13/11/2024
Published: 20/11/2024

ABSTRACT

An experiment was carried out to study the Influence of INM on yield, quality of potato and soil status at Horticulture Research Farm, College of Horticulture, AAU, Anand during the three consecutive years 2020-21, 2021-22 and 2022-23. The experiment was laid out in Randomized Block Design with three replications and ten treatments *viz.,* T_1: 100 % RDF (220:110:220), T_2: 20 t FYM + 100 % RDF (220:110:220), T_3: 75 % RDF + 25 % RDN through FYM, T_4: 75 % RDF + 25 % RDN through VC, T_5: 50 % RDF + 50 % RDN through FYM, T_6: 50 % RDF + 50 % RDN through VC, T_7: 50 % RDF + 50 % RDN through FYM + 1 L Bio NPK consortium/ha, T_8: 50 % RDF + 50 %

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Cite as: *Raval, C. H., B. N. Satodiya, D. R. Pardva, and A. J. Patel. 2024. "Influence of INM on Yield, Quality of Potato and Soil Status". International Journal of Plant & Soil Science 36 (11):301-10. https://doi.org/10.9734/ijpss/2024/v36i115145.*

RDN through VC + 1 L Bio NPK consortium/ha, T_9: 25 % RDF + 50 % RDN through FYM + 1 L Bio NPK consortium/ha + KMB 1 L/ha, T_{10}: 25 % RDF + 50 % RDN through VC + 1 L Bio NPK consortium + KMB 1 L/ha. The treatment T_2 [20 t FYM + 100 % RDF (220:110:220] recorded maximum tuber weight per plant (487.13 g), tuber yield (434.8 q/ha) and grade "A" tuber (378.9 q/ha) in pooled analysis. Treatments T_7 to T_{10} received inoculation of Bio NPK consortium showed higher microbial population. Whereas, grade "B" tuber, TSS and soil status after harvest were found non-significant in pooled data.

Keywords: FYM; tuber weight; grade "A" tuber; microbial count.

1. INTRODUCTION

Potato (*Solanum tuberosum* L.) belongs to family Solanaceae. Peru- Bolivian region in the Andes (South America) is the centre of origin of potato. 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. India produces about 60.14 MT of potato from an area of 2.30 Mha with productivity of 27.31 metric tonnes (Anonymous, 2022-23[b]). Uttar Pradesh is the leading potato producing state and other important states are West Bengal, Bihar, Gujarat, Madhya Pradesh and Punjab. In Gujarat its production is 39.83 MT from an area of 131503 ha with productivity of 30.29 metric tonnes (Anonymous, 2022-23[a]).

Farm yard manure (FYM) influences the physico-chemical as well biological properties of the soil, which in turn improves the soil fertility, provide excellent soil structure, porosity, aeration, drainage, water retention capacity and prevent soil degradation.

Potato is a heavy feeder crop so its mostly depend on supply of nutrients (nitrogen, phosphorus, potassium *etc.*) through chemical fertilizers (Pandit *et al.,* 2018). However, with the increment of the price of these chemical fertilizers as well as its issues about environmental hazards, potato cultivation is now required to be shifted to a promising alternative of inorganic nutrition, called integrated nutrient management (INM). INM involves supplies of nutrients from various sources (inorganic and organic) to achieve balanced nutrition covering benefits and curtailing limitations of both the sources. Specifically, it addresses the adverse effects of chemical fertilizers on soil health and crop qualities as well as incorporates the benefits of organic manures to improve soil fertility and crop performance (Keupper and Gegner, 2019. Nevertheless, a lot of integrated approach have been made for pushing up the production of vegetable crops, however, work done on potato crop is meagre. Therefore, the present investigation was carried out to study the influence of integrated nutrient management on yield, quality of potato and soil status.

2. MATERIALS AND METHODS

The field experiment entitles "Influence of INM on yield, quality and soil status of potato" was laid out during the three consecutive years 2020-21, 2021-22 and 2022-23 at Horticultural Research Farm, College of Horticulture, Anand Agricultural University, Anand, Gujarat, India, during the *Rabi* season. The experiment was laid out with ten treatments *i.e.* T_1: 100 % RDF (220:110:220), T_2: 20 t FYM + 100 % RDF (220:110:220), T_3: 75 % RDF + 25 % RDN through FYM, T_4: 75 % RDF + 25 % RDN through VC, T_5: 50 % RDF + 50 % RDN through FYM, T_6: 50 % RDF + 50 % RDN through VC, T_7: 50 % RDF + 50 % RDN through FYM + 1 L Bio NPK consortium/ha, T_8: 50 % RDF + 50 % RDN through VC + 1 L Bio NPK consortium/ha, T_9: 25 % RDF + 50 % RDN through FYM + 1 L Bio NPK consortium/ha + KMB 1 L/ha, T_{10}: 25 % RDF + 50 % RDN through VC + 1 L Bio NPK consortium + KMB 1 L/ha in a Randomized Block Design with three replications and plot size of 2.70 × 3.20 m. The experiment soil was light alluvial having sandy loam texture with 7.68 pH, 0.46 % organic carbon, 240.00 kg/ha available N, 23.70 kg/ha available P_2O_5, 340.00 kg/ha available K. Potato tuber of Kufri Kyati variety was planted at spacing of 45 × 20 cm. Application of 50 % Nitrogen, 100 % P_2O_5 and 50 % K_2O and all organic manures and Bio NPK consortium with organic manures were applied as basal while 50 % Nitrogen and 50 % K_2O was applied 30 DAP and while KMB was applied at 45 DAS with irrigation.

For yield observation five plant were randomly tagged. Tubers per plants were weighed by weighing balance and after that the average value was calculated. Yield of tuber were recorded in kg per plot separately and converted into q/ha. The quality parameters *i.e.,* TSS estimated by digital refractometer from tuber at final harvest. Potato tuber grade desiced according weight of tuber (grade A: >75g, grade B: 25-75g and grade C: <25g). Soil fertility status and microbial count of soil measured at initial and after harvest of the crop. The pooled analysis was conducted in accordance with Panse and Sukhatme (1989) to examine the average effect of various treatments over time.

3. RESULTS AND DISCUSSION

3.1 Yield Parameters of Potato

3.1.1 Tuber weight per plant (g)

The data pertaining to tuber weight per plant is presented in Table 1. The result showed significant effect during 2020-21, 2021-22 and 2022-23 as well as in pooled analysis. Maximum tuber weight per plant (487.13 g) was recorded with treatment T_2 [20 t FYM + 100 % RDF (220:110:220)] which was at par with treatment T_3, T_4, T_8, T_7 and T_6 in the pooled data.

This might be due to the usage of both organic and inorganic chemical fertilizers, as an organic fertilizer promoted aeration in the soil, focalized root advancement and boosted microbes and biological production in the rhizosphere which also increased the nutrient use efficiency through modification of soil physical condition and resulted in higher total uptake of nutrients because of better root penetration leading to better absorption of nutrients and moisture that ultimately increase tuber weight of plant. Similar result also found by Solanke *et al.* (2009) and Jaipaul *et al.* (2011).

3.1.2 Tuber yield (q/ha)

The data pertaining to tuber yield (q/ha) is presented in Table 1. The result showed significant effect during 2020-21, 2021-22 and 2022-23 as well as in pooled analysis. Maximum tuber yield (434.8 q/ha) was observed with treatment T_2 [20 t FYM + 100 % RDF (220:110:220)] but it was at par with T_3 and T_4 in pooled analysis.

This could be ascribed to the use of organic manure and chemical fertilizer, which altered the physical characteristics of the soil to enhance the efficiency of nutrient use and led to a larger total uptake of nutrients due to better root accessibility, which increased nutrient and moisture absorption in plant that lead to more photosynthates in plant [Khurana *et al.* (2005). Resulted increase tuber weight per plant and ultimately increased total yield of potato tuber. Similar observations have been noted by Kushwah and Banafar (2003), Raghav and Chandra (2005) and Singh and Rai (2007) and Singh *et al*. (2018).

3.2 Quality Parameters of Potato

3.2.1 Grade “A” tuber (q/ha)

The data pertaining to grade “A” tuber yield by effect of different integrated treatments during three consecutive years 2020-21, 2021-22, 2022-23 and in pooled data are presented in Table 2. The data regarding grade “A” tuber was found significant in three consecutive years and in pooled analysis. Maximum grade “A” tuber yield (378.9 q/ha) was observed with treatment T_2 [20 t FYM + 100 % RDF (220:110:220)] in pooled data and it was found statistically at par with treatment T_3 and T_4 in the pooled data.

3.2.2 Grade “B” tuber (q/ha)

The data pertaining to effect of different integrated treatment on grade “B” tuber yield during three consecutive years 2020-21, 2021-22, 2022-23 and in pooled data are presented in Table 2. The data regarding grade “B” yield was found non-significant result in three consecutive years and in pooled data.

3.2.3 Grade “C” tuber (q/ha)

The data pertaining to grade “C” tuber yield by effect of different integrated treatment during three consecutive years 2020-21, 2021-22, 2022-23 and in pooled data are presented in Table 2. The data regarding grade “C” tuber was found significant in three consecutive years and in pooled analysis. Maximum grade “C” tuber yield (18.3 q/ha) was observed with treatment T_{10} [20 t FYM + 100 % RDF (220:110:220)] in pooled data and was found at par with T_9 in pooled analysis.

3.2.4 Total soluble solids (^{0}Brix)

The data on total soluble solids (^{0}Brix) influenced by different treatments is presented in Table 3 and results revealed that effect of different treatments on total soluble solids (^{0}Brix) was found non-significant during the years 2020-21, 2021-22, 2022-23 and in pooled analysis.

Table 1. Influence of INM on yield parameters of potato

Treatments	Tuber weight per plant (g)				Tuber yield (q/ha)			
	2020-21	**2021-22**	**2022-23**	**Pooled**	**2020-21**	**2021-22**	**2022-23**	**Pooled**
T_1	435.46 ab	426.86	432.20	431.51 bcd	332.9abc	320.2 bc	369.9 a	341.0 d
T_2	488.93 a	493.06	479.40	487.13 a	423.6a	432.1 a	448.6 a	434.8 a
T_3	456.40 ab	486.06	474.06	472.17 ab	395.4ab	421.3 a	424.3 a	413.7 ab
T_4	462.13 a	459.86	466.20	462.73 abc	384.6 ab	393.5 ab	414.3 a	397.5 abc
T_5	432.20 ab	416.66	417.33	422.06 cd	320.6 bc	368.8 ab	380.4 a	356.6 cd
T_6	439.46 ab	449.86	439.20	442.84 abc	321.3 bc	367.2 ab	381.9 a	356.8 cd
T_7	446.53 ab	440.53	448.20	445.08 abc	366.5 ab	376.1 ab	371.9 a	371.5 bcd
T_8	452.33 ab	473.80	456.13	460.75 abc	378.8 ab	365.3 ab	391.5 a	378.6 bcd
T_9	346.86 c	357.00	357.66	353.84 e	262.7 c	277.39 c	279.3 b	273.1 e
T_{10}	369.26 bc	399.333	400.000	389.533 de	332.9 c	320.22 c	369.9 b	341.0 e
SEm (T)	26.27	33.08	28.55	14.96	26.74	25.56	27.96	15.45
SEm (Y X T)	-	-	-	29.43	-	-	-	26.77
F Test (T)	Sig.	NS	NS	Sig.	79.44	75.93	83.06	43.82
F (Y X T)	-	-	-	NS	-	-	-	NS
C V %	10.51	13.01	11.32	11.67	13.47	12.38	12.98	12.94

Note: *Treatment means with the letter/letters in common are not significant by Duncan's New Multiple Rang Test at 5% level of Significance*

Table 2. Influence of INM on grade A, B and C of potato

Treatments	**Grade "A"(q/ha)**				**Grade "B"(q/ha)**				**Grade "C"(q/ha)**			
	2020-21	**2021-22**	**2022-23**	**Pooled**	**2020-21**	**2021-22**	**2022-23**	**Pooled**	**2020-21**	**2021-22**	**2022-23**	**Pooled**
T_1	268.9^{bc}	268.5^{bc}	313.2^{a}	283.6^{d}	54.4	42.0	44.3	46.9	9.6^{b}	9.6^{b}	12.3^{b}	10.5^{b}
T_2	369.9^{a}	373.8^{a}	392.7^{a}	378.9^{a}	43.6	46.6	46.6	45.6	10.0^{b}	8.8^{b}	9.2^{c}	9.3^{b}
T_3	340.2^{ab}	366.9^{a}	369.9^{a}	359.1^{ab}	45.1	44.3	44.3	44.6	10.0^{b}	9.2^{b}	10.0^{bc}	9.7^{b}
T_4	329.4^{ab}	337.5^{ab}	356.4^{a}	341.2^{abc}	45.9	47.8	47.8	47.2	9.2^{b}	8.4^{b}	10.0^{bc}	9.2^{b}
T_5	266.9^{bc}	314.8^{ab}	326.5^{a}	302.8^{cd}	44.7	43.7	43.7	44.1	8.8^{b}	9.6^{b}	10.0^{bc}	9.5^{b}
T_6	259.6^{bcd}	305.5^{ab}	319.8^{a}	295.0^{d}	52.0	51.7	51.7	51.8	9.6^{b}	10.0^{b}	10.4^{bc}	10.0^{b}
T_7	312.8^{ab}	324.4^{ab}	319.0^{a}	318.8^{bcd}	43.9	43.2	43.2	43.4	9.6^{b}	8.4^{b}	9.6^{c}	9.2^{b}
T_8	329.4^{ab}	314.4^{ab}	338.7^{a}	327.5^{bcd}	39.7	40.5	40.5	40.2	9.6^{b}	10.0^{b}	12.3^{b}	10.6^{b}
T_9	195.2^{cd}	210.2^{b}	212.5^{b}	206.0^{e}	49.3	50.5	50.5	50.1	18.1^{a}	16.9^{a}	16.2^{a}	17.1^{a}
T_{10}	187.5^{d}	190.2^{b}	207.1^{b}	195.0^{e}	44.7	43.6	43.6	43.9	18.9^{a}	18.1^{a}	18.1^{a}	18.3^{a}
SEm (T)	23.90	27.06	28.00	15.23	4.40	4.28	4.28	2.50	0.68	0.93	0.75	0.46
SEm (Y X T)	-	-	-	26.38	-	-	-	4.32	-	-	-	0.79
F Test (T)	71.00	80.39	83.19	43.18	NS	NS	NS	NS	2.01	2.76	2.21	1.29
F (Y X T)	-	-	-	NS	-	-	-	NS	-	-	-	NS
C V %	14.47	15.59	15.36	15.19	16.45	16.34	16.24	16.34	10.32	14.67	10.90	12.02

Note: Treatment means with the letter/letters in common are not significant by Duncan's New Multiple Rang Test at 5% level of Significance

Table 3. Influence of INM on TSS of potato

Treatments	**TSS (°Brix)**			
	2020-21	**2021-22**	**2022-23**	**pooled**
T_1	0.83	0.80	0.83	0.82
T_2	0.87	0.77	0.80	0.81
T_3	0.87	0.80	0.87	0.84
T_4	0.80	0.77	0.87	0.81
T_5	0.77	0.83	0.87	0.82
T_6	0.83	0.87	0.80	0.83
T_7	0.83	0.80	0.83	0.82
T_8	0.87	0.83	0.80	0.83
T_9	0.73	0.80	0.80	0.78
T_{10}	0.83	0.83	0.87	0.84
SEm (T)	0.04	0.04	0.05	0.03
SEm (Y X T)	-	-	-	0.04
F Test (T)	NS	NS	NS	NS
F (Y X T)	-	-	-	NS
C V %	8.84	9.29	9.61	9.25

Table 4. Soil microbial count (CFU/g soil) influenced by different integrated nutrient management treatments after harvest

Treatment	**Total microbial count (CFU/g soil)**			
Initial Count: 6.7 X 10^3	**2020-21**	**2021-22**	**2022-23**	**Pooled**
T_1: 100 % RDF (220:110:220)	4.46^d (3.5×10^4)	4.42^d (2.6×10^4)	4.87^d (7.5×10^4)	4.58^d (4.5×10^4)
T_2: 20 t FYM + 100 % RDF (220:110:220)	4.63^d (5.3×10^4)	4.53^d (4.1×10^4)	4.88^d (7.6×10^4)	4.68^d (5.7×10^4)
T_3: 75 % RDF + 25 % RDN through FYM	4.57^d (3.7×10^4)	4.68^d (4.9×10^4)	4.86^d (7.2×10^4)	4.70^d (5.3×10^4)
T_4: 75 % RDF + 25 % RDN through VC	4.52^d (3.5×10^4)	4.60^d (4.3×10^4)	4.92^d (8.2×10^4)	4.68^d (5.4×10^4)
T_5: 50 % RDF + 50 % RDN through FYM	6.69^b (4.9×10^6)	6.66^b (4.8×10^6)	6.75^b (5.6×10^6)	6.70^b (5.1×10^6)
T_6: 50 % RDF + 50 % RDN through VC	5.68^c (5.0×10^5)	5.63^c (4.4×10^5)	5.75^c (5.6×10^5)	5.69^c (5.0×10^5)
T_7: 50 % RDF + 50 % RDN through FYM + 1 L Bio NPK Consortium/ha	8.76^a (5.8×10^8)	8.71^a (5.3×10^8)	8.67^a (4.7×10^8)	8.71^a (5.2×10^8)
T_8: 50 % RDF + 50 % RDN through VC + 1 L Bio NPK Consortium/ha	8.30^a (2.0×10^8)	8.32^a (2.3×10^8)	8.70^a (5.1×10^8)	8.44^a (3.1×10^8)
T_9: 25 % RDF + 50 % RDN through FYM + 1 L Bio NPK Consortium/ha + KMB 1 L/ha	8.79^a (6.1×10^8)	8.74^a (5.6×10^8)	8.57^a (4.7×10^8)	8.70^a (5.5×10^8)
T_{10}: 25 % RDF + 50 % RDN through VC + 1 L Bio NPK Consortium + KMB 1 L/ha	8.55^a (3.5×10^8)	8.55^a (3.6×10^8)	8.64^a (5.3×10^8)	8.58^a (4.1×10^8)
S. Em. ±	0.108	0.103	0.105	0.072
CD (P=0.05)	Sig.	Sig.	Sig.	Sig.
CV %	2.89	2.75	2.72	2.28
Interaction Y x T	-	-	-	NS

Note: Data subjected to Log transformation. Figures in parentheses are means of original values. Treatment means with the letter/letters in common are not significant by Duncan's New Multiple Range Test at 5% level of significance

Table 5. Effect of INM on soil status (OC, P, K, pH, EC and BD) after harvest

Treatment	Organic Carbon (%)	Av. Phosphorus (P_2O_5) kg/ha	Av. Potassium (K_2O) kg/ha	Soil pH	Soil EC (dS m-1)	BD (g/cc)
INITIAL	**0.46**	**23.7**	**340**	**7.68**	**0.40**	**1.37**
T_1	0.50	35.20	350	7.79	0.40	1.35
T_2	0.56	35.14	369	7.75	0.40	1.35
T_3	0.51	33.63	379	7.83	0.40	1.29
T_4	0.56	35.34	352	7.73	0.40	1.29
T_5	0.54	33.10	368	7.74	0.39	1.31
T_6	0.51	30.53	355	7.71	0.39	1.32
T_7	0.53	36.11	372	7.81	0.40	1.31
T_8	0.51	37.65	359	7.74	0.38	1.31
T_9	0.51	36.34	357	7.81	0.39	1.33
T_{10}	0.54	35.65	357	7.69	0.38	1.31
S.Em.±	0.03	1.49	13.82	0.05	0.01	0.02
C.D. at 5%	NS	NS	NS	NS	NS	NS
C.V. (%)	8.46	7.40	6.61	1.13	3.76	3.27

3.3 Soil Microbial Count after Harvest of Potato

The data pertaining to effect of different integrated treatments on total microbial count (CFU/g soil) after harvest during three consecutive years 2020-21, 2021-22, 2022-23 and in pooled data are presented in Table 4. The result showed that treatments having application of 1 L Bio NPK Consortium/ha + KMB 1 L/ha significantly increased soil microbial count after harvest *i.e.* in treatment T_7 to T_{10} as compared to rest of the treatments in all the years as well as in pooled result.

The increment of soil microbial population after application of RDF with biofertilizers might be due to favorable rhizospheric micro-environment developed due to root exudates, soil aggregation, decomposition of root cells and organic matter, availability of plant nutrients, and other physical-biochemical processes resulting a higher microbial abundance in soil.

3.4 Soil Status after Harvest of Potato

The data pertaining to soil status after harvest of crop (OC, P, K, pH, EC and BD) as influenced by different integrated nutrient management treatment are presented in Table 5. The data concerning to the effect of integrated nutrient management treatments on soil status after harvest of crop was found non-significant.

4. CONCLUSION

From the pooled result of three years, it can be concluded that application of 20 t FYM + 100 % RDF (220:110:220) or 75 % RDF + 25 % RDN through FYM or 75 % RDF + 25 % RDN through Vermicompost gave the higher tuber weight per plant, tuber yield and grade “B” tuber with increase microbial population in the soil.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

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

ACNOWLEDGEMENTS

The Authors are highly thankful to the Anand Agricultural University, Gujarat for firm support, funds and facilities provided.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/126543