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ENHANCING SOIL FERTILITY: INFLUENCE OF INTEGRATED NUTRIENT MANAGEMENT (INM) ON SOIL HEALTH AFTER POTATO HARVEST IN LOAMY SAND SOIL

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ABSTRACT

An investigation was conducted to study the effect of integrated nutrient management on soil nutrient status after potato harvest. The study was carried out at the Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Banaskantha, Gujarat, during the rabi seasons of 2023-24 and 2024-25. The experiment involved combinations of different organic and inorganic sources of nitrogen to evaluate their effects on the soil nutrient status under potato cultivation. The treatments consisted of integrated nutrient management *viz.*, T_1: 100% RDF, T_2: 75% RDF + 20 t FYM ha^{-1}, T_3: 75% RDF + 2 t castor cake ha^{-1}, T4: 50% RDF + 10 t FYM ha^{-1}+ foliar spray of humic acid @ 20 ppm at 30 and 45 DAP + seed inoculation with bio NPK consortium, T_5: 50% RDF + 1 t castor cake ha^{-1} + foliar spray of humic acid @ 20 ppm at 30 and 45 DAP + seed inoculation with bio NPK consortium, T_6: 50% RDF + 10 t FYM ha^{-1} + foliar spray of humic acid @ 40 ppm at 30 and 45 DAP + seed inoculation with bio NPK consortium, T_7: 50% RDF + 1 t castor cake ha^{-1} + foliar spray of humic acid @ 40 ppm at 30 and 45 DAP + seed inoculation with bio NPK consortium and experiment was laid out in a Randomized Block Design (RBD) with three replications to evaluate their effects on the soil nutrient status under potato cultivation. And the result indicated that applying 75% of the recommended dose of fertilizers (RDF) together with 20 t FYM ha^{-1} significantly improved the organic carbon (0.312%), available nitrogen (168.53 kg ha^{-1}), phosphorus (49.54 kg ha^{-1}) and potassium (277.41 kg ha^{-1}) of soil after harvest of potato over rest of the treatments.
***Keywords* :** INM**,** consortium, humic acid, FYM and vermicompost, organic carbon.

Introduction

The low fertility of Indian soils is the main factor preventing this crop from growing and developing. Additionally, the majority of Gujarat's soils have medium to high levels of available phosphorus and potash, but low levels of organic carbon and available nitrogen (Chavda *et al*., 2018). The organic matter content in the soil must be built up with the help of bulky organic manures (*i.e*., FYM, compost etc.), among farmers, using organic manures was well regarded. It is commonly known that adding organic manures has significantly increased crop yields and affected the physical, chemical, and biological characteristics of the soil. Loamy sand soils are of north Gujarat characterized by their low water-holding capacity, rapid drainage, and low nutrient retention. These soil properties pose challenges for sustaining optimal nutrient levels and promoting healthy crop growthFarmers are currently using chemical fertilisers in excess and in an unbalanced manner, which results in a lack of other nutrients and a decrease in the amount of organic carbon. The soil's structure and texture are ruined by careless use of chemical fertilisers. As a result, using chemical fertilisers alone might not be able to maintain soil health over time and sustain productivity. Therefore, improving soil health requires the proper and balanced application of fertiliser and manure. The idea behind Integrated Nutrient Management (INM) is to continuously increase soil productivity over an extended period of time by using organic manures, fertilisers, and biofertilizers for the best possible growth, yield, and quality of various crops and cropping systems in particular agro-ecological conditions. Cakes from various oil businesses, press mud bio-compost from the sugar sector and farm yard manure from the dairy industry are only a few examples of the organic waste or byproduct trash produced by the dominant industry in the area. In light of our current ecological circumstances, this idea has grown in significance. For crops and cropping systems, a sensible mix of chemical fertilisers, organic manures, and biofertilizers should be developed within the constraints of ecology, society, and the economy.

Material and Method

Geographically, Sardarkrushinagar is situated at 24º19' North latitude and 72 º 19' East longitude with an elevation of 154.42 m above the mean sea level. It is situated in the North Gujarat Agro-climatic Zone - IV. The zone is characterized by arid and semi-arid climate with moderately cold winter, while summer is quite hot and dry. The monsoon commences by the middle of June and retreats by the middle of September. Most of the precipitation is received from south-west monsoon. The regular winter starts from the middle of October and it continues till the end of February. The December and January are the coldest months of the year. The temperature starts rising from February and reaches the maximum in the month of June. This was carried out during *rabi* and summer season of 2023-24 and 2024-25 at the Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Banaskantha, Gujarat. The treatments consisted of integrated nutrient management *viz.,* T_1: 100% RDF, T_2: 75% RDF + 20 t FYM ha^{-1}, T_3: 75% RDF + 2 t castor cake ha^{-1}, T4: 50% RDF + 10 t FYM ha^{-1}+ foliar spray of humic acid @ 20 ppm at 30 and 45 DAP + seed inoculation with bio NPK consortium, T_5: 50% RDF + 1 t castor cake ha^{-1} + foliar spray of humic acid @ 20 ppm at 30 and 45 DAP + seed inoculation with bio NPK consortium, T_6: 50% RDF + 10 t FYM ha^{-1} + foliar spray of humic acid @ 40 ppm at 30 and 45 DAP + seed inoculation with bio NPK consortium, T_7: 50% RDF + 1 t castor cake ha^{-1} + foliar spray of humic acid @ 40 ppm at 30 and 45 DAP + seed inoculation with bio NPK consortium to potato crop in *rabi s*eason and replicated three times in Randomized Block Design. In experimental year of 2023 and 2024, analyzed soil data indicated that the soil of the experimental field was loamy sand in texture, low in organic carbon available nitrogen and DTPA - extractable Fe medium in available phosphorus, and available potash and DTPA - extractable Zn. EC was normal showing that the soil was free from salinity hazard. Walkley and Black's (1965) rapid titration method was used to determine the percentage of organic carbon in the soil, while Subbiah and Asija's (1956) alkaline $KMnO_4$ method was used to estimate the amount of available nitrogen. In accordance with Olsen's method described by Olsen *et al*. (1954), soil available phosphorus was extracted using 0.5 M sodium bicarbonate (1:20), whereas available potassium was measured using the flame photometric method (Jackson, 1974) and micronutrients (Fe and Zn) were analyzed with Atomic Absorption Spectrophotometric Method (Lindsay and Norvell, 1978). Urea and SSP fertilizer received the necessary amounts of as per calculation of treatment required, while organic fertilizers such as farm yard manure, vermicompost and castor cake were applied in the appropriate plots according to the treatments and mixed into the soil 15 days prior to crop sowing. Following the harvest of the crop, various soil nutrient status components were noted. The conventional analysis of variance method was applied to the data (Panse and Sukhatme,1967). At the $P<0.05$ level of significance, the mean treatments were compared.

Result and Discussion

Organic carbon

The data presented in Table 1 shows that the soil organic carbon (O.C.) percentage after the harvest of potato was significantly influenced by the application of different integrated nutrient management (INM) treatments during both cropping seasons (2023-24 and 2024-25), as well as in the pooled mean. The data explicit that significantly the highest organic carbon (0.308, 0.317 and 0.312 % in 2023-24, 2024-25 and in pooled result respectively) in soil were found under the treatment of 75% RDF + FYM 20 t ha^{-1} (T_2). the lower organic carbon (0.239, 0. 245 and 0.242 % in 2023-24, 2024-25 and in pooled result respectively) content was observed under the application of 50% RDF + 1 t castor cake ha^{-1} + foliar spray of humic acid @ 40 ppm at 30 and 45 DAP + seed inoculation with bio NPK consortium (T_7). Application of FYM resulted in improved soil fertility might be due to fact that FYM add organic matter in soil which in turns increase the organic carbon content in soil. The present findings are also in close conformity with the findings of Sing *et al*. (2008) and Rao *et al*. (2019).

Available nitrogen

According to the data presented in Table 1 that the soil available N after the harvest of potato was significantly influenced by the application of various integrated nutrient management (INM) treatments during both cropping seasons (2023–24 and 2024–25), as well as in the pooled mean. An application of 75% RDF + FYM 20 t ha^{-1} (T_2) gave significantly higher available nitrogen (166.51, 170.54 and 168.53 kg ha^{-1} in 2023-24, 2024-25 and in pooled respectively) content in soil after harvest of potato, which was remained at par with 75% RDF + 2 t castor cake ha^{-1} (T_3) during the both year of experimentation and in pooled results. The lowest soil available nitrogen of 144.20, 146.19 and 145.20 kg ha^{-1} in 2023-24, 2023-24 and in pooled results respectively, under the application of 50% RDF + 1 t castor cake ha^{-1} + foliar spray of humic acid @ 20 ppm at 30 and 45 DAP + seed inoculation with bio NPK consortium (T_5).

The application of 20 tonnes FYM per hectare along with 75% of the recommended dose of fertilizers (RDF) in the preceding potato crop enhances the available nitrogen content in the soil due to multiple beneficial effects. FYM is a rich source of organic nitrogen, which undergoes slow mineralization, thereby continuously releasing plant-available nitrogen (ammonium and nitrate) even after the potato crop is harvested. The present findings are also in conformity with the findings of Singh and Lal, (2015), Yadav (2016) and Patel (2017).

Available Phosphorus

A perusal of data on available phosphorus (kg ha^{-1}) in soil after harvest of potato as influenced by various treatments are exhibited in Table 2 An assessment of data revealed that available phosphorus (49.06, 50.03 and 49.54 kg ha^{-1} in 2023-24, 2024-25 and in pooled result, respectively) obtained in soil after harvest of potato crop was significantly higher under treatment 75% RDF + 20 t FYM ha^{-1} (T_2), which was statistically remained at par with 100% RDF (T_1), 75% RDF + 2 t castor cake ha^{-1} (T_3), 50% RDF + 10 t FYM ha^{-1}+ foliar spray of humic acid @ 20 ppm at 30 and 45 DAP + seed inoculation with bio NPK consortium (T_4) and 50% RDF + 10 t FYM ha^{-1} + foliar spray of humic acid @ 40 ppm at 30 and 45 DAP + seed inoculation with bio NPK consortium (T_6) during the both the individual years and 75% RDF + 2 t castor cake ha^{-1} (T_3) and 50% RDF + 10 t FYM ha^{-1} + foliar spray of humic acid @ 40 ppm at 30 and 45 DAP + seed inoculation with bio NPK consortium (T_6) in pooled results. The minimum soil available phosphorus (42.70, 43.37and 43.04 kg ha^{-1} in 2023-24, 2024-25 and in pooled results, respectively) were recorded under the application of 50% RDF + 1 t castor cake ha^{-1} + foliar spray of humic acid @ 40 ppm at 30 and 45 DAP + seed inoculation with bio NPK consortium (T_7).

FYM contains moderate amounts of organic phosphorus and, more importantly, enhances the activity of phosphate-solubilizing microorganisms (PSMs). These microbes release organic acids and enzymes like phosphatase, which help in converting insoluble forms of phosphorus into plant-available forms. The present findings are also in close conformity with the findings of Singh. and Lal, (2015), Yadav (2016) and Patel (2017).

Available Potassium

An appraisal of data with respect to available potash (kg ha^{-1}) in soil after harvest of potato crop are presented in Table 2.

Data revealed that effect of various treatments on available potash in soil after harvest of potato crop exhibited significant effect during both the years of investigation. An application of 75% RDF + 20 t FYM ha^{-1} (T_2) gave significantly higher available potash (275.86, 278.96 and 277.41 kg ha^{-1}) during 2023-24, 2024-25 and in pooled results, respectively over rest of the treatments but it was remained at par with 75% RDF + 2 t castor cake ha^{-1} (T_3) during both the individual years. The minimum soil available potash (240.97, 243.62 and 242.22 kg ha^{-1} in 2023-24, 2024-25 in pooled result, respectively) was recorded under the application of 50% RDF + 1 t castor cake ha^{-1} + foliar spray of humic acid @ 40 ppm at 30 and 45 DAP + seed inoculation with bio NPK consortium (T_7).

Table 1: Effect of INM on organic carbon and available nitrogen content of soil after harvest of potato

Treatments	Organic carbon (%)			Available nitrogen (kg ha^{-1})		
	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled
T_1:100% RDF	0.248	0.261	0.255	148.55	149.62	149.08
T_2:75% RDF + 20 t FYM ha^{-1}	0.308	0.317	0.312	166.51	170.54	168.53
T_3:75% RDF + 2 t castor cake ha^{-1}	0.266	0.290	0.278	161.61	167.11	164.36
T_4:50% RDF + 10 t FYM ha^{-1}+ foliar spray of humic acid @ 20 ppm at 30	0.248	0.250	0.249	151.42	153.09	152.25

and 45 DAP + seed inoculation with bio NPK consortium						
T_5:50% RDF + 1 t castor cake ha^{-1} + foliar spray of humic acid @ 20 ppm at 30 and 45 DAP + seed inoculation with bio NPK consortium	0.239	0.245	0.242	144.20	146.19	145.20
T_6:50% RDF + 10 t FYM ha^{-1} + foliar spray of humic acid @ 40 ppm at 30 and 45 DAP + seed inoculation with bio NPK consortium	0.244	0.250	0.247	153.39	153.02	153.20
T_7:50% RDF + 1 t castor cake ha^{-1} + foliar spray of humic acid @ 40 ppm at 30 and 45 DAP + seed inoculation with bio NPK consortium	0.237	0.246	0.242	150.37	152.80	151.59
S.Em.±	0.008	0.008	0.005	4.34	4.04	2.48
C. D. at 5%	0.026	0.023	0.016	12.80	11.92	8.28
Interaction (Y X T)						
S.Em.±	-	-	0.008	-	-	4.02
C. D. at 5%	-	-	NS	-	-	NS
C.V. %	5.36	5.89	5.41	4.50	4.88	4.50

The increase in available potassium (K) in the soil following the application of 20 tonnes FYM per hectare along with 75% RDF in the preceding potato crop is mainly due to the direct contribution of potassium from FYM and its influence on soil physical and biological properties. Unlike nitrogen and phosphorus, potassium does not form organic complexes, so it remains in the exchangeable and water-soluble forms. The present findings are also in conformity with the findings of Singh and Lal (2015), Yadav (2016) and Patel (2017).

Table 2 : Effect of INM on available phosphorus and potash content of soil after harvest of Potato

Treatments	Available phosphorus (kg ha^{-1})			Available potash (kg ha^{-1})		
	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled
T_1:100% RDF	46.65	47.32	46.98	253.76	259.60	256.68
T_2:75% RDF + 20 t FYM ha^{-1}	49.06	50.03	49.54	275.86	278.96	277.41
T_3:75% RDF + 2 t castor cake ha^{-1}	47.70	48.35	48.02	260.09	266.71	263.40
T_4:50% RDF + 10 t FYM ha^{-1}+ foliar spray of humic acid @ 20 ppm at 30 and 45 DAP + seed inoculation with bio NPK consortium	45.89	46.76	46.33	247.15	255.70	251.42
T_5:50% RDF + 1 t castor cake ha^{-1} + foliar spray of humic acid @ 20 ppm at 30 and 45 DAP + seed inoculation with bio NPK consortium	43.63	44.28	43.95	247.77	248.46	248.11
T_6:50% RDF + 10 t FYM ha^{-1} + foliar spray of humic acid @ 40 ppm at 30 and 45 DAP + seed inoculation with bio NPK consortium	47.29	47.94	47.61	252.82	256.40	254.68
T_7:50% RDF + 1 t castor cake ha^{-1} + foliar spray of humic acid @ 40 ppm at 30 and 45 DAP + seed inoculation with bio NPK consortium	42.70	43.37	43.04	240.97	243.62	242.22
S.Em.±	1.23	1.32	0.86	7.10	6.23	4.54
C. D. at 5%	3.63	3.89	2.52	20.96	18.38	13.28
Interaction (Y X T)						
S.Em.±	-	-	1.22	-	-	6.42
C. D. at 5%	-	-	NS	-	-	NS
C.V. %	4.87	4.63	4.57	4.23	4.78	4.34

DTPA- extractable Fe and Zn

A perusal of data with respect to DTPA-extractable Fe and Zn content (mg kg^{-1}) in soil after harvest of potato crop are presented in Table 3 Data indicated that effect of various treatments on DTPA-extractable Fe and Zn in soil after harvest of potato crop were found non-significant during both the years of investigation but numerically higher Fe content (4.303, 4.341 and 4.321 mg kg^{-1} in 2023-24, 2024-25 and in pooled result, respectively) and the higher Zn content (0.305, 0.308 and 306 mg kg^{-1} in 2023-24, 2024-25 and in pooled result, respectively) in soil after harvest of potato crop were recorded under treatment T_2 (75% RDF + 20 t FYM ha^{-1}). Integrated Nutrient Management (INM) showed a non-significant effect on soil Fe and Zn availability, likely due to their slow mobilization and fixation in soil matrices (Singh & Prasanna, 2020).

Table 3 : Effect of INM on DTPA extractable Fe and Zn of soil after harvest of potato

Treatments	DTPA-Fe (mg/kg)			DTPA-Zn (mg/kg)		
	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled
T_1:100% RDF	4.175	4.185	4.180	0.291	0.292	0.292
T_2:75% RDF + 20 t FYM ha^{-1}	4.303	4.341	4.321	0.305	0.308	0.306
T_3:75% RDF + 2 t castor cake ha^{-1}	4.301	4.317	4.310	0.303	0.306	0.304
T_4:50% RDF + 10 t FYM ha^{-1}+ foliar spray of humic acid @ 20 ppm at 30 and 45 DAP + seed inoculation with bio NPK consortium	4.215	4.214	4.215	0.298	0.298	0.298
T_5:50% RDF + 1 t castor cake ha^{-1} + foliar spray of humic acid @ 20 ppm at 30 and 45 DAP + seed inoculation with bio NPK consortium	3.863	4.126	3.995	0.294	0.295	0.295
T_6:50% RDF + 10 t FYM ha^{-1} + foliar spray of humic acid @ 40 ppm at 30 and 45 DAP + seed inoculation with bio NPK consortium	4.185	4.191	4.188	0.300	0.298	0.299
T_7:50% RDF + 1 t castor cake ha^{-1} + foliar spray of humic acid @ 40 ppm at 30 and 45 DAP + seed inoculation with bio NPK consortium	3.962	3.926	3.944	0.294	0.295	0.294
S.Em.±	0.154	0.130	0.09	0.013	0.012	0.08
C. D. at 5%	NS	NS	NS	NS	NS	NS
Interaction (Y X T)						
S.Em.±	-	-	0.13	-	-	0.012
C. D. at 5%	-	-	NS	-	-	NS
C.V. %	6.37	5.86	5.65	7.46	7.22	7.05

Conclusion

After two years of experimentation, it was observed that applying 75% of the recommended dose of fertilizers (RDF) together with 20 t FYM ha^{-1} significantly enhanced soil organic carbon and the availability of nitrogen, phosphorus, and potassium. The levels of DTPA-extractable Fe and Zn also showed an increasing trend, though the changes were not statistically significant.

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