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Effect of integrated nutrient management on soil properties and soil fertility under in sweet corn-potato cropping sequence in vertisols of Deccan plateau of India

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Abstract
An experiment was conducted at Mahatma Phule Krishi Vidyapeeth (MPKV), Rahuri a representative place for the vertisols of Deccan plateau of India to study the effect of integrated nutrient management in sweet corn-potato cropping sequence on crop yield and soil physical, chemical and biological properties in the sweet corn-potato cropping sequence. There were seven treatments applied sweet corn and each plot of *rabi* potato was equally divided into two parts to potato. Results revealed that the application of the INM treatments, the various fertilizer levels to preceding sweet corn crop T_7 - 125% RDN + 25% N through VC significantly higher cob yield in sweet corn, however it was at par T_6 – 125% RDN + 25% N through FYM. Potato registered significantly higher tuber yield and sweet corn equivalent yield in residual fertility of 100% GRDF to preceding sweet corn, however it was at par with in T_6 – 125% RDN + 25% N through FYM. The soil physical, chemical and biological properties determined at the end of two crop cycles were improved due to the application of FYM in combination with chemical fertilizers. The data recorded for two years indicated that available nutrient (N, P and K) under integrated nutrient management in *kharif* sweet corn and *rabi* potato during both years was significantly increased as influenced by 100% GRDF to preceding sweet corn in the main plot, 100% GRDF to *rabi* potato in the subplot while interactions showed non significant differences concerning the previous parameters.

Keywords: Cropping sequence, Farmyard manure, INM, potato, Soil properties, Sweet corn, Vermicompost, Vertisols

1. Introduction

In India, vertisols cover an area of about 72.9 million ha, constituting roughly 22.2% of the total geographic area of the country. (Hati *et al*. 2006) [20]. In India, these soils are predominantly found in Deccan plateau of Maharashtra. These soils are dominated by as mectite group of clay minerals, leading to expansion and shrinkage on wetting and drying. From the viewpoint of crop production, low organic matter is one of the major constraints in addition to low plant available nutrients, particularly nitrogen (N), phosphorus (P), and zinc (Zn), thus affecting the productivity of these soils (Blaise *et al*., 2005) [8]. During the green revolution, the strategy of intensive external input oriented agriculture has depleted soil fertility considerably in all major agricultural production systems. This has led to stagnation of food production in spite of consistent increment in food production. Moreover, intensive farming has led to over-production associated with environmental consequences largely affecting the soil health arising from long-term use of inorganic fertilizers in large quantities. Therefore time has come to focus on organic farming, to create a balance between soil organisms, plants, animals and humans. Organic manures are responsible for improving chemical, physical and physiochemical properties of soil. In Maharastra, the productivity of potato is only 100 q ha^{-1} which is very low in terms of per ha yield as compared to all-India average. This is mainly due to the series of long term fertilizer application, which increases the crop yield in the initial year but adversely affect the sustainability at a later stage. Moreover conjunctive use of manures along with chemical fertilizers reduces the decline in organic carbon and gap between potential yield and actual yield is bridged to a large extent (Tolanur and Badanur, 2003). The use of only chemical fertilizers alone may not keep pace with time in maintaining the soil health and sustaining the productivity. It is also detrimental to human health and the environment (Arisha and Bardisi, 1999) [4].

So, it is desirable to develop a sustainable production system that gives optimum productivity with minimum environmental pollution by using organic manure as an alternative practice to mineral fertilization (Naeem *et al*., 2006). Use of organic manure offers the twin benefits of soil quality and fertility enhancement while meeting a part of nutrient needs of crops (Choudhary *et al*., 2011) [10]. Organic manure improves soil structure and water holding capacity, resulting in more extensive root development and enhanced soil micro flora and fauna activity, which results in availability of micronutrients available to plants (Zeidan, 2007) [59]. Therefore fertilizers are to be integrated with organic sources to replenish the continuous removal of plant nutrients. In the present study, an effort was made to evaluate the long term effect of integration of Urea with FYM and Vermicompost, a component of integrated plant nutrition system, applied to potato during *Rabi* season.

Materials and Methods

Site Description

Field experiment was conducted during 2014-1 and 2015-16 at Mahatma Phule Krishi Vidyapeeth (MPKV), Rahuri, Dist. Ahmednagar, Maharashtra, India to find effect of integrated nutrient management on yield and soil physical, chemical and biological properties in sweet corn-potato cropping sequence under in Mula river command area. A field experiment was conducted from 2014 to 2015 at the Post Graduate Institute Research Farm, of Mahatma Phule Krishi Vidyapeeth, Rahuri is lies between 19^0 48'N and 19^0 57'N Latitude and 74^0 32'E and 74^0 19'E longitude. The altitude varies from 495 to 569 meters above mean sea level. This tract is lying on the Eastern side of Western Ghat and falls under rain shadow area. Climatologically, it falls in semi arid tropics with an annual rainfall varying from 307 to 619 mm. The average annual precipitation is 520 mm. Out of the total annual rainfall, about 80 per cent rains are received from South – West monsoon (June to September), while rest receives from North – East monsoon. The number of rainy days varies from 15-45 in a year. The mean annual maximum and minimum temperature ranges from 33 ^{0}C to 43 ^{0}C and 3 ^{0}C to 18 ^{0}C, respectively. The mean relative humidity during morning and evening hours is 59 and 35 per cent, respectively. The mean pan evaporation ranges from 5.3 to 12.1 mm and the sunshine hours ranges from 7 to 9 day^{-1}. The soil of experimental site was sandy loam with bulk density of 1.39 Mg m^{-3}. In soil organic carbon was 0.51 with 241.35 kg ha^{-1} available N, 22.85 kg ha^{-1} available P, 365.75 kg ha^{-1} available K in first year, respectively. The pH was 8.20 with EC of 0.33 dSm^{-1} respectively.

Experimental design and treatments

The experiment included two crops per year, namely, *kharif*-sweet corn (July-November), winter potato (November-March).The field trial was conducted on the same field and on same layout without changing randomization during both the years. The experiment was laid out in Randomized Block Design, during *kharif* season the main plot treatments comprised of the gross recommended dose of fertilizers and three levels of FYM and vermicompost to sweet corn, replicated thrice and during *rabi* season each sub plot treatment was divided into two sub plot treatments with two levels of the gross recommended dose of fertilizers to potato. Thus, during *rabi* season there were fourteen treatments comprised of seven main plot treatment of FYM and vermicompost and two sub plot treatments comprised of two levels of fertilizer to potato replicated thrice in split plot design. The recommended dose of NPK in sweet corn was applied through urea, single super phosphate and muriate of potash, respectively. The nitrogen was applied into three split (1/3 each as basal, tasseling and grain formation stage). The full dose of P and K was applied as basal. The treatment details along with symbols used are presented in following Table 1. The treatment consisted T_1 – 100% GRDF, T_2 - 75% RDN + 25% N through FYM, T_3 - 75% RDN + 25% N through VC, T_4 – 100% RDN + 25% N through FYM T_5 - 100% RDN + 25% N through VC, T_6 – 125% RDN + 25% N through FYM and T_7 – 125% RDN + 25% N through VC for *kharif* sweet corn as a main plot treatment, whereas for *rabi* potato two sub plot treatment levels of GRDF viz., F_1 - 75% GRDF and F_2 - 100% GRDF replicated two times in split plot design resulting in seven treatment combinations replicated thrice during *kharif* season and fourteen treatment combinations during *rabi* season in RBD-split plot design replicated thrice. The experiment was conducted on same site without changing the randomization of the treatments for successive years. The required quantity of different manures *viz*. vermicompost and FYM as per the treatments was applied in field ten days before sowing of both the crops. The available N, P and K content were 1.02, 0.50 and 0.80% in vermicompost, 0.50, 0.20, and 0.44% in FYM. In doing so the respective contribution of P and K from vermicompost and FYM was also considered. The fertilizers used were urea for N, single superphosphate for P, and muriate of potash for K. The seed of of sweet corn var. Suger-75) was dibbled on the ridge sides at a spacing of 20 cm at 4 cm depth and required plant population (83,000 plant ha^{-1}) was maintained by thinning of plants after one week of germination. Similarly, potato var. K. Jyoti seed tubers of 25–30 cm size were sown 5 cm deep on the south side of the ridges at a spacing of 20 cm between tubers in rainy and winter seasons respectively.

In order to analyze the influence of soil properties on agronomic performance and to assess the impact of integrated nutrient management on soil fertility, representative soil samples were taken from experimental plot and initial soil status was assessed. Rest all the soil samples were taken at the end of second year cropping sequence. Samples were taken from the cultivated soil layer (upper 15 cm), using a single auger. The samples were air-dried, crushed, and gravel and other particles of size more size than 2 mm were removed with a sieve. Thereafter, the samples were analyzed for the soil parameters are presented in following Table 2. Field moist soil was used for analyzing all the biological parameters. The fungal, bacterial and actinomycetes population were estimated by standard plate count method using Marten's for fungi (Martin, 1950) [33], and nutrient agar medium for bacteria and actinomycetes (Allen, 1959) [3]. Microbial population was calculated and expressed as number of cells, x10n/g soil. The experimental data pertaining to each character was analyzed statistically by using the technique of 'Analysis of variance' for split plot design (Panse and Sukhatme, 1987) [39] and significance was tested by 'F' test. Standard error of mean [SE(m)] and critical difference (CD) were worked out for each character studied to evaluate difference between the treatments and interaction effects at 5% levels of significance.

Results and Discussion

Effect of INM on yield sweet corn:

The treatment T_7-125% RDN + 25% N through VC proved to be significantly superior green cob yield than rest of the treatments tried and at par with treatment T_6 -125% RDN + 25% N through FYM during both the years and in pooled result also (Table 3). The higher yield observed with the application of vermicompost in comparison to FYM may be explained on the basis of higher nutrient content, faster decomposition and released nutrients in vermicompost besides enhancing the microbial population and higher root biomass (Kannan *et al.,* 2005) [22]. These might be due to vermicompost which improved the soil fertility where all the appropriate nutrients are in readily available forms to the plants and have narrow C:N ratio (below 20:1) than FYM (Vasanthi and Kumarswany, 2000) [56]. These results are in accordance with the findings by Shambhavi and Sharma, (2008) [49]. These findings are alike with those reported by Meena *et al.*(2007), Sujatha *et al.* (2008) [53], Keerati *et al.* (2013) on INM in sweet corn, Zeinab *et al.* (2014) and Syahmi *et al.* (2O15) in sweet corn.

Effect of INM on yield potato

The highest tuber were recorded on the residual fertility of FYM application treatment T_1-100% GRDF recorded significantly superior total tuber yield than rest of the treatments and was at par with treatment T_6-125% RDN + 25% N through FYM (Table 3). This result indicated that FYM applied during preceding sweet corn would have not been fully utilized by the crop during that season. However, during second season FYM applied may have also been supplemented by the remaining effect of FYM already applied during first season which would have resulted in higher tuber yield in the treatment comprising of organic manure (FYM @ 30 t ha^{-1}) during second season. Application of FYM to the preceding sweet corn crop recorded higher tuber yield and the magnitude of yield increase was over the application of NPK through VC. The increase in tuber yields under these treatments was the reflection of improved growth, yield parameters and nutrient uptake of the crop. The superiority of FYM was attributed to its slow decomposition (Singh *et al.*, 1996), which caused immobilization of nitrogen and low availability of nitrogen for the sweet corn crop found to be reversed during the succeeding potato crop. Kapur and Rana, (1980) also reported that only 30% of N, 66% of P and 70% K from FYM is likely to be used by the first crop, the remaining maybe available to the second crop and to a little extent to the subsequent crops raised on the same land. With nutrition point of view, it was observed that increase in tuber yield due to integration of synthetic fertilizers and farmyard manure might regulated supply of nutrients to potato crop through readily available nutrients from synthetic fertilizers at initial stage and later stages through mineralization of organic manure into available form of nutrients for crop (Sarkar *et al.*, 2011, Kumar *et al.*, 2012). Similarly, integrated use of inorganic and organic sources of nutrients significantly improved the yield of potato. Such a production of higher yield of tuber in integrated nutrient application was also reported by Parmar *et al.*, (2007) [40]; Chettri *et al.*, (2004); Congera *et al.* (2013) [12]; Najm *et al.* (2013) [36]; Narayan *et al.* (2013) [37]; Balemi (2014) [5] and Biruk *et al.* (2014) [7].

Effect of INM on physical properties of soil

Bulk density: Bulk density of soil was not affected significantly both in main and sub plot (Table 4). In general, the effect of integrated application of FYM on bulk density was more pronounced than the VC. Maximum reduction (1.33 Mg m^{-3}) in bulk density was recorded in three treatments namely T_1-100% GRDF higher over than rest of treatments. This can be attributed to greater organic carbon content maintained as a result of continuous applications of FYM and VC. Santhey *et al.* (1999) [47] also reported reduced bulk density of soil resulting from application of organic manure in an INM experiment. The highest bulk density was observed by application of VC according to FYM. Application of FYM led to the lower bulk density than the vermicompost treatments. Zhao *et al*. (2009) [61] also reported the similar findings. It might be due to more availability of higher amount of organic matter, which is capable of imparting binding effect on soil particles might have been responsible to improve aggregation, porosity and humus which in turn, might have induced favorable effect on physical properties of soil. The reduced bulk density was noticed by application of FYM over vermicompost and leaf compost (Sujatha *et al*., 2008) [53]. Similar beneficial effects of reduced bulk density by addition of organic sources have been reported by Kumpawat (2004) [30]. No specific trend was recorded in sub plot treatments where different fertilizer levels were applied.

Field capacity: Field capacity of soils varied from 40.87 to 39.45% under various treatments but did not vary significantly where FYM were applied or where the quantity of VC (Table 4). The highest field capacity was observed by application of T_1-100% GRDF (40.87%). Change in structural condition of soil due to application of FYM and VC with inorganic fertilizer could be the possible reason, as reported by Gawai (2003) [18]. Soil field capacity is controlled primarily by the number of pores, their distribution, and specific surface area of soils (Saha *et al*. 2010). However field capacity did not vary significantly for various fertilizer levels to sweet corn and it increased with increase in fertilizer levels. The highest field capacity was recorded by application of T_1-100% GRDF.

Permanent wilting point: Permanent wilting point of soil varied significantly from (Table 4) 24.15 to 26.23% under various treatments. The highest permanent wilting point was recorded by T_3: 75% RDN + 25% N through VC (26.23%) and was at par with application of 75% RDF + 25% RDN through FYM. The lowest permanent wilting point was observed by application of T_1-100% GRDF (40.87%). The general observation from the data of permanent wilting point shows that, where ever application of organic manure (FYM) combination with inorganic fertilizer was done there was reduction in permanent wilting point than vermicompost. This might be due to increase in the porosity of soil due to application of organic manures viz., FYM and VC to the INM treatments, as reported by Gawai (2003) [18]. Application of GRDF levels to sub plots of potato varied not significantly and did not shown any trend. Permanent wilting point shows its relation with field capacity. This higher difference is useful for holding more capillary water Gawai (2003) [18].

Hydraulic conductivity: FYM treatments had a significant effect on hydraulic conductivity of soil. Application of FYM with chemical fertilizers recorded maximum hydraulic conductivity (Table 4). Better aggregation and increased porosity is due to addition of FYM which directly influenced hydraulic conductivity and ultimately soil water dynamics. The hydraulic conductivity under treatment T_1-100% GRDF was (1.67 cm hr^{-1}) more than rest of treatments. Similarly, results also observed by Gopinath *et al*. 2008. Organic manures decreased the bulk density and improve the soil physical properties due to reduced mass per unit of soil (Das *et al*., 2002 and Yaduvanshi, 2003) [13, 57, 85].

Infiltration rate (cm hr^{-1})

The infiltration rate under different treatments was not significant after potato harvest but which showed that cumulative infiltration varied from 0.90 to 1.03 cm hr^{-1}. The highest cumulative infiltration (1.03 cm hr^{-1}) was observed by application treatment T_1-100% GRDF, which was significantly higher over other treatments except treatment T_6-125% RDN + 25% N through FYM(1.02 cm hr^{-1}). The organic residues that are added to the soil undergo microbial decomposition and in this process, various organic products of decay like polysaccharides are released which act as strong binding agents in the formation of large and stable aggregates which helps to improve the physical properties of the soil.

Chemical properties of soil

Soil pH: The soil pH at the end of second sequence of potato crop, the pH of soil was not significant (Table 5), but decreased in comparision to its initial status (pH 8.20). After potato harvest the pH of the soil varied from 8.15 to 8.18. Soil pH tended to be the lowest (8.15) in treatment (T_1-100% GRDF) where 10 t FYM was added in combination of RDF. So application of FYM with chemical fertilizer for N substitution decreased soil pH as compared with partial substitution of N through VC which may be attributed to production of organic acids during decomposition of organic manures.

Electrical conductivity: The electrical conductivity of the soil was significant and decreased under sweet corn-potato cropping sequence as compared to initial value of 0.33 dS m^{-1} (Table 5). After the harvest of potato, it varied from 0.28 to 0.32 dS m^{-1}. The lower values were observed in treatments where FYM were applied in combination. The lowest electrical conductivity was observed in treatment T_1-100% GRDF (0.28 dS m^{-1}).

Organic carbon: The organic carbon of the soil was not significant (Table 5), but, the maximum organic carbon was recorded by application of treatment T_1- 100% GRDF and at par with treatment T_6-125% RDN + 25% N through FYM. This might be due to build up of higher amount of organic carbon in the soil after harvest of the crop which is due to addition of higher biomass to soil. The higher values organic carbon content and lower soil pH content and electrical conductivity in soil with T_1-100% GRDF might be due to biological immobilization and continuous mineralization of FYM on surface soil layer. In similar increasing the soil organic carbon content status in soil due to addition of organic matter through organic manures for supply of major and micro nutrient content in soil can be assigned as possible cause for variation of initially soil fertility status to post harvest the crops (Choudhary and Sinha, 2001) [11]. The increase in organic carbon with the application of FYM was attributed to greater input of root biomass due to better crop productivity. Similar results also observed by Edmeades (2003) [17].

Effect of INM on available N, P and K contents in soil

Direct and residual fertility of varying sources and levels of nutrients on soil available N, P and K were found significant after sweet corn–potato cropping sequences (Table 6). Available N, P and K increased significantly with application of organic manures FYM. Higher N, P, K under organic treatments may be due to continuous application of FYM. These sources may enhance organic matter status in soil, which further improves soil physical as well as microbiological activities and increases the availability of plant nutrients confirmed the role of organic manures in releasing N and improving N availability in soil. During decomposition of organic manures, various phenolic and aliphatic acids are produced which solubilize phosphatase and other phosphate bearing minerals and thereby lowers the phosphate fixation and increase its availability. The residual fertility of T_1-100% GRDF plots had significantly higher contents of available N, P and K in soil compared than rest of the treatments although, it remain staticsally at par with the residual effect of T_6-125% RDN + 25% N through FYM, during both the years. These observations are in agreement with the findings of Sharma *et al*. (2009) and Patel *et al*. (2008) [41].

Soil biological properties

The microbial population viz., bacteria, fungi and actinomycetes showed significant differences in soil as influenced by different treatments in their microbial build of soil (Table 6). The highest bacterial fungi and actinomycetes population was associated with the application of treatment T_1-100% GRDF which was almost higher than other treatments, The increase in microbial population with the application of organic manure might be due to stimulated growth and activities of soil microorganism. The crop plant secreted various types of organic acids from roots, which is an easily available source of food for soil microorganism. The addition of organic inputs enhanced the microbial counts in soil, which might be due to carbon addition and changes in physico-chemical properties of soil. Microbial populations were more numerous in the application of either through FYM than vermicompost due to loss of beneficial microbial populations particularly fungi, bacteria and actinomycetes during sterilization and also the degradation of vermicomposts and microbial activity on exposure to sun and air. Microbial populations were more numerous in the application of through FYM probably due to the bioavailability of growth-promoting substances. Microbial population composition and density is an important attribute of soil organic matter quality, as it provides an indication of a soil's ability to store and recycle nutrients and energy. Among, all treatments bacteria, fungi and actinomycetes population lowest in treatment T_3 - 75% RDN + 25% N through VC.

Available micronutrients

The significant effect of the organics was recorded on DTPA extractable Fe, Mn, Zn and Cu (0.15, 3.23, 3.77 and 0.72 mg kg^{-1}) content in the soil after sweet corn –potato crop harvest (Table 7). The Fe, Mn, Zn and Cu content of soil was significantly higher in T_1– 100% GRDF. The increase of availability with the application of organic manures may be attributed to the increased solubility due to decrease the soil pH by the virtue of organic treatments. The available micronutrients Fe, Mn, Zn and Cu content in the soil was found to be higher in the treatments receiving fertilizers regularly. Long-term fertilization influenced changes in micronutrients contents only to some extent. The highest contents of available forms of Cu, Fe, Mn and Zn were observed in soil with the lowest pH of soil. While, FYM applications significantly increased the content of this element in soil in relation to vermicompost**.** More micronutrient build up was observed during both years in all the integrated nutrient treatments. The results are well supported by the findings of Ramesh *et al*. (2006) [44] and Banik and Sharma (2008) [6]. The higher availability of micronutrients in soil particularly with use of FYM may be ascribed to mineralization, reduction in fixation of nutrients by organic matter and complexing properties of humic substances released from vermicomposts with micronutrients (Prasad *et al*. 2010) [43]. Application of T_1- 100% GRDF and treatment T_6-125% RDN + 25% N through FYM helped for improvement soil physical parameters viz. bulk density, field capacity, permanent wilting point, hydraulic conductivity and infiltration rate by improvement in soil porosity, soil chemical properties viz. soil pH, EC, organic carbon, available nutrients and soil biological properties were also improved due to organic compounds added to the soil in the form of FYM and VC which are preventing fixation, oxidation, precipitation, and leaching of nutrients and making it available for crop plant by chelating action. The beneficial effect of FYM as was observed in the present study is in agreement with the findings of Loganathan, S. (1990) [31, 32] and Dubey. and Mandal. (1994) [16].

Table 1: Details of the treatment and symbol used

Sr. No.	Treatment details	Symbol
A	**Main plot treatments (*Kharif* season sweet corn)**	
1	100% GRDF	T_1
2	75% RDN + 25% N through FYM	T_2
3	75% RDN + 25% N through vermicompost	T_3
4	100% RDN + 25% N through FYM	T_4
5	100% RDN + 25% N through vermicompost	T_5
6	125% RDN + 25% N through FYM	T_6
7	125% RDN + 25% N through vermicompost	T_7
GRDF (120:60:40 N, P_2O_5, K_2O kg ha^{-1} + 10 t FYM ha^{-1})		
B	**Sub Plot Treatments (*Rabi* season potato)**	
1	75% GRDF (112:60:90 kg N, P_2O_5, K_2O ha^{-1}+ 22.5 t FYM ha^{-1})	F_1
2	100% GRDF (150:80:120 kg N, P_2O_5, K_2O ha^{-1} + 30 t FYM ha^{-1})	F_2

(A common seed treatment with *Azotobacter*+ PSB also given to all treatments at the time of sowing)

Table 2: Physical and chemical properties experimental site

Sr. No.	Particular	composition	Method adopted	References
(A)	**Chemical Composition**			
1	Organic carbon (g kg^{-1})	0.51	Walkley and Black's rapid titration method	Piper (1966)
2	Available N (kg ha^{-1})	241.35	Alkaline $KMNO_4$ method	Subbiah and Asija (1956)
3	Available P_2O_5 (kgha^{-1})	22.85	0.5 N $NaHCO_3$ Ascorbic acid	Olsen and Dean 1965)
4	Available K_2O (kg ha^{-1})	365.75	Flame photometer	Jackson (1973
5	Soil pH (1:2.5 soil water suspension)	8.20	Potentiometric	Jackson (1973)
6	Electrical conductivity (dS m^{-1})	0.33	Conductometric	Jackson (1973)
(B)	**Soil moisture constants**			
1	Field capacity (%)	39.42	Pressure plate apparatus	Richard (1968)
2	Permanent wilting point (%)	21.28	Pressure plate apparatus	Richard (1968)
3	Bulk density (Mg m^{-3})	1.39	Core sampler	Dastane (1967) [14]
(C)	**Chemical properties of FYM**			
1	Total N (%)	0.50	Macro-kjeldhals method	A.O.A.C. (1992)
2	Total P_2O_5 (%)	0.20	Vanadomolybdate yellow colour method in nitric acid	Jackson (1973)
3	Total K_20 (%)	0.44	Flame photometer method	Knudsen *et al.* (1982)
(E)	**Chemical properties of vermicompost**			
1	Total N (%)	1.02	Macro-kjeldhals method	A.O.A.C. (2005)
2	Total P_2O_5 (%)	0.50	Vanadomolybdate yellow colour method in nitric acid	Jackson (1973)
3	Total K_20 (%)	0.80	Flame photometer method	Knudsen *et al.* (1982)

Table 3: Green cob of sweet corn and total tuber yield of potato during both years on pooled mean as influenced by different treatments

Treatment		Green cob yield (q ha^{-1})		Pooled Mean (q ha^{-1})	Tuber yield (q ha^{-1})		Pooled Mean (q ha^{-1})
		2014	**2015**		**2014-15**	**2015-16**	
Fertilizer levels to sweet corn							
T_1 :	100% GRDF	265.25	271.99	268.62	280.21	286.96	283.58
T_2 :	75% RDN + 25% N through FYM	249.75	256.25	253.00	260.35	272.35	266.35
T_3 :	75% RDN + 25% N through VC	255.35	262.09	258.72	255.71	266.72	261.21
T_4 :	100% RDN + 25% N through FYM	258.45	264.84	261.65	265.53	276.51	271.02
T_5 :	100% RDN + 25% N through VC	260.74	267.04	263.89	261.65	274.71	268.18
T_6 :	125% RDN + 25% N through FYM	271.94	277.49	274.72	275.36	282.11	278.74
T_7 :	125% RDN + 25% N through VC	275.55	281.55	278.55	271.55	278.95	275.25
	S. Em. ±	2.69	2.75	2.73	2.47	2.53	2.51
	C. D. at 5%	7.98	8.25	8.20	7.41	7.59	7.51
Fertilizer levels to potato							
F_1 :	75% GRDF				264.66	274.75	269.71
F_2 :	100% GRDF				270.21	279.60	274.91
	S. Em. ±				2.44	1.04	1.28
	C. D. at 5%				NS	NS	NS
	Interaction				NS	NS	NS
	General mean	262.43	268.75	265.59	267.44	277.18	272.31

Table 4: Physical properties of soil as influenced by different treatments in sweet corn-potato crop sequence (After two years)

Treatment		Bulk density (mg cm $^{-3}$)	Field capacity (%)	Permanent wilting Point (%)	Hydraulic conductivity rate (cm hr^{-1})	Infiltration rate (cm hr^{-1})
Fertilizer levels to sweet corn						
T_1 :	100% GRDF	1.33	40.87	24.15	1.67	1.03
T_2 :	75% RDN + 25% N through FYM	1.36	39.75	26.07	1.43	0.93
T_3 :	75% RDN + 25% N through VC	1.37	39.45	26.23	1.40	0.91
T_4 :	100% RDN + 25% N through FYM	1.35	40.52	26.05	1.57	0.99
T_5 :	100% RDN + 25% N through VC	1.36	39.49	25.10	1.49	0.90
T_6 :	125% RDN + 25% N through FYM	1.34	40.82	24.87	1.64	1.02
T_7 :	125% RDN + 25% N through VC	1.36	39.82	25.29	1.54	0.95
	S. Em. ±	0.03	0.30	0.20	0.02	0.01
	C. D. at 5%	NS	NS	NS	NS	NS
Fertilizer levels to potato						
F_1 :	75% GRDF	1.37	39.84	25.11	1.37	1.01
F_2 :	100% GRDF	1.35	39.90	24.97	1.46	0.99
	S. Em. ±	0.02	0.20	0.12	0.01	0.80
	C. D. at 5%	NS	NS	NS	NS	NS
	Interaction	NS	NS	NS	NS	NS
	General mean	1.36	39.87	25.04	1.41	1.00
	Initial	1.39	39.42	21.28	1.30	0.88

Table 5: Chemical properties and biological properties of soil as influenced by different treatments in sweet corn-potato crop sequence (After two years)

		Chemical properties			Biological properties		
Treatment		pH	EC (dSm^{-1})	Organic carbon (%)	Bacteria (CFU x 10^4 g^{-1} soil)	Fungi (CFU x10^3 g^{-1} soil)	Actinomycetes (CFU x 10^3 g^{-1} soil)
Fertilizer levels to sweet corn							
T_1 :	100% GRDF	8.15	0.28	0.59	33.31	35.64	55.23
T_2 :	75% RDN + 25% N through FYM	8.17	0.30	0.55	22.56	25.83	49.63
T_3 :	75% RDN + 25% N through VC	8.18	0.32	0.53	21.15	22.63	45.56
T_4 :	100% RDN + 25% N through FYM	8.17	0.30	0.56	25.92	28.89	49.87
T_5 :	100% RDN + 25% N through VC	8.18	0.32	0.54	25.08	28.35	50.35
T_6 :	125% RDN + 25% N through FYM	8.16	0.29	0.57	31.81	33.69	52.18
T_7 :	125% RDN + 25% N through VC	8.17	0.31	0.55	28.56	29.79	51.76
	S. Em. ±	0.003	0.005	0.006	0.61	0.71	1.03
	C. D. at 5%	NS	0.016	NS	1.85	2.11	3.09
Fertilizer levels to potato							
F_1 :	75% GRDF	8.16	0.32	0.53	26.63	24.40	50.72
F_2 :	100% GRDF	8.18	0.30	0.55	26.72	25.80	50.82
	S. Em. ±	0.002	0.004	0.005	0.33	0.35	0.78
	C. D. at 5%	NS	NS	NS	NS	NS	NS
	Interaction	NS	NS	NS	NS	NS	NS
	General mean	8.17	0.31	0.54	26.67	25.10	50.76
	Initial	8.20	0.33	0.51	16.80	20.69	39.85

Table 6: Effect of INM on nutrient availability N, P, K and Available micronutrients of soil influenced in sweet corn-potato crop sequence (After two years)

Treatment		Available nitrogen (kg ha^{-1})	Available phosphorus (kg ha^{-1})	Available potassium (kg ha^{-1})	Zn (mg kg^{-1})	Fe (mg kg^{-1})	Mn (mg kg^{-1})	Cu (mg kg^{-1})
Fertilizer levels to sweet corn								
T_1 :	100% GRDF	202.85	23.73	341.43	0.17	3.30	3.92	0.76
T_2 :	75% RDN + 25% N through FYM	193.08	21.01	328.09	0.13	3.18	3.80	0.72
T_3 :	75% RDN + 25% N through VC	191.72	20.58	326.06	0.13	3.16	3.78	0.73
T_4 :	100% RDN + 25% N through FYM	197.10	21.84	330.47	0.14	3.22	3.83	0.74
T_5 :	100% RDN + 25% N through VC	194.48	21.68	329.27	0.14	3.20	3.85	0.74
T_6 :	125% RDN + 25% N through FYM	201.35	23.45	332.92	0.16	3.26	3.88	0.75
T_7 :	125% RDN + 25% N through VC	198.03	22.69	331.69	0.16	3.27	3.86	0.73
	S. Em. ±	0.51	0.09	2.85	0.01	0.02	0.03	0.001
	C. D. at 5%	1.47	0.24	8.44	0.03	0.06	0.09	0.003
Fertilizer levels to potato								
F_1 :	75% GRDF	194.99	21.68	330.27	0.14	3.20	3.75	0.71
F_2 :	100% GRDF	196.94	21.96	332.57	0.16	3.26	3.80	0.73
	S. Em. ±	0.41	0.06	2.62	0.01	0.02	0.02	0.001
	C. D. at 5%	NS	NS	NS	NS	NS	NS	NS
	Interaction	NS	NS	NS	NS	NS	NS	NS
	General mean	195.97	21.82	331.42	0.15	3.23	3.77	0.72
	Initial	163.24	19.64	327.78	0.12	3.18	3.50	0.70

Table 7: DTPA Extractable micronutrients Cu, Zn, Mn and Fe of soil as influenced by different treatments in sweet corn-potato crop sequence (After two years)

	Treatment	Zn (mg kg^{-1})	Fe (mg kg^{-1})	Mn (mg kg^{-1})	Cu (mg kg^{-1})
Fertilizer levels to sweet corn					
T_1 :	100% GRDF	0.17	3.30	3.92	0.76
T_2 :	75% RDN + 25% N through FYM	0.13	3.18	3.80	0.72
T_3 :	75% RDN + 25% N through VC	0.13	3.16	3.78	0.73
T_4 :	100% RDN + 25% N through FYM	0.14	3.22	3.83	0.74
T_5 :	100% RDN + 25% N through VC	0.14	3.20	3.85	0.74
T_6 :	125% RDN + 25% N through FYM	0.16	3.26	3.88	0.75
T_7 :	125% RDN + 25% N through VC	0.16	3.27	3.86	0.73
	S. Em. ±	0.01	0.02	0.03	0.001
	C. D. at 5%	0.03	0.06	0.09	0.003
Fertilizer levels to potato					
F_1 :	75% GRDF	0.14	3.20	3.75	0.71
F_2 :	100% GRDF	0.16	3.26	3.80	0.73
	S. Em. ±	0.01	0.02	0.02	0.001
	C. D. at 5%	NS	NS	NS	NS
	Interaction	NS	NS	NS	NS
	General mean	0.15	3.23	3.77	0.72
	Initial	0.12	3.18	3.50	0.70

Conclusion

Based on two years experimentation, it can be illustrated that the performance of sweet corn–potato cropping sequence was assessed in terms of residual fertility status, physico-chemical and biological properties was registered maximum under treatment T_1- 100% GRDF to preceding crop sweet corn during *kharif* season at the end of two years experimentation closely followed T_6-125% RDN + 25% N through FYM. in respect of soil properties.

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