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Soil properties, yield and quality of pearl millet influenced by integrated nutrient management on vertisol

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Abstract
The present investigation was conducted at Bajra Research Scheme, College of Agriculture, Dhule. The objective was to estimate the soil properties, yield and quality of pearl millet influenced by integrated nutrient management. The experiment was laid out in Randomized Block Design with eight treatments consists of inorganic fertilizers in combination with organics *viz*., FYM, vermicompost and poultry manure. Soil chemical properties were estimated at harvest stage. Nutrient uptake and quality parameters were estimated at harvest. Significantly maximum available N, P and K were noted under 50% RDN through fertilizers + 50% N through FYM i.e. 201.79 kg ha^{-1}, 24.64 kg ha^{-1} and 282.16 kg ha^{-1}, respectively. However, organic C was found higher with the application of 100% RDN through FYM (4.61 g kg^{-1}). Treatments comprised of vermicompost and poultry manure significantly increases organic C and available N, P and K contents in soil over control. The highest availability of micronutrients *viz*., Fe, Zn, Mn and Cu (5.97, 0.76, 14.12 and 3.82 mg kg^{-1}, respectively) were recorded in 50% RDN through fertilizers + 50% N through vermicompost. The maximum N, P and K uptake by grain (53.22, 22.59 and 14.09 kg ha^{-1}, respectively) and stover (45.17, 28.82 and 156.12 kg ha^{-1}, respectively) were noticed with application of 50% RDN through fertilizers + 50% N through FYM followed by 100% RDF through inorganic fertilizers. Among the all manure treatments, significantly maximum grain and stover yield (26.51 and 38.05 q ha^{-1}, respectively) was obtained with the application of 50% RDN through fertilizers + 50% N through FYM. Maximum protein percentage in grain (9.98%) was recorded in 50% RDN through fertilizers + 50% N through FYM, the maximum Fe (48.82 mg kg^{-1}) and Zn (33.92 mg kg^{-1}) contents in grain were noticed under the treatment 100% RDN through vermicompost.

Keywords: Soil properties, yield, nutrient uptake, quality, integrated nutrient management

Introduction
Today, global agriculture is at crossroad as a consequence of climate change, increased population pressure and detrimental environmental impacts. Increased population needs more food to live on earth. Indian agriculturists are in a position to increase our food production within the available cultivated land. Application of commercial fertilizers to soil is more expensive and also resulted in soil degradation. New mechanism must be found to ensure food security through sustainable crop production systems that supply adequate nutrition, without harming the agro ecosystem (Panwar and Vijayaluxmi, 2005) [11]. To stop nutrient mining and use of imbalance of fertilizers, it is not justified to just increase the use of inorganic fertilizers, the organic sources of plant nutrients *viz*; cow dung, poultry manure, compost, green manure etc. need to be also considered. Organic manure such as FYM and vermicompost can be prepared at own fields of farmers and thus reducing the cost of cultivation. Therefore, to achieve improved and sustainable soil fertility and crop yield, balanced and integrated application of chemical and organic fertilizers is the key factor.

Pearl millet or *Bajra* (*Pennisetum glaucum*) is the most widely grown type of millet. India is largest producer of pearl millet of 6.93 million ha with production of 8.61 million tones and with productivity of 1243 kg ha^{-1} during 2020 (Directorate of Millets Development, 2020). In Maharashtra, this crop is grown on 8.76 *lakh* ha of land with 4.01 *lakh* tonnes of grain production having productivity of 467 kg ha^{-1} in 2016-2017. However, in Dhule district, pearl millet is grown on 1.20 lakh ha of land with 0.71 lakh of tonnes of grain production having productivity of 592 kg ha^{-1} in 2016-17 (Anonymous, 2017-18). Fertilization may be the most important way to maintain high crop quality. To produce more and more from unit land in recent years due to only applications of chemical fertilizers on the soil, using area, the conservation and maintenance of soil fertility should be of the most important tactical targets

for sustaining productivity (Swarup and Shrinivasarao, 1999) [16]. Integrated use of chemical fertilizers with organic manures has been found to be quite promising in maintaining high productivity and providing greater stability to crop production. In addition to supply nutrients, organic manures may improve the soil health, physico- chemical properties and biological condition of the soil. The use of organic matter along with inorganic fertilizers may help to improve nutrient availability and crop quality. Both organic manures and chemical fertilizers in appropriate proportions assume special significance as complementary and supplementary to each other in crop production. Dependent on chemical fertilizers for future agriculture growth would mean further loss in soil quality, possibilities of water contamination and unsustainable burden on the fiscal system. The Government of India has been trying to promote an improved practices involving use of manures and crop residues along with mineral fertilizers. The present investigation was planned and conducted with objectives to determine the soil nutrient availability and evaluate the quality of crop as influenced by inorganic and organic inputs.

Materials and Methods

The field experiment on soil properties, yield and quality of pearl millet influenced by integrated nutrient management was carried out at Bajra Research Scheme, College of Agriculture, Dhule (Maharashtra) during *kharif* season. The experimental soil was clayey in texture, low in available nitrogen (172.06 kg ha^{-1}) and phosphorus (13.76 kg ha^{-1}), high in available potassium (252.40 kg ha^{-1}) content and moderately alkaline in reaction (pH 8.0) with EC 0.39 dSm^{-1}. The pearl millet variety aadishakti was used for this study. The sowing was done by dibbling method. The required cultural practices (thinning and weeding) were done at proper time. The organic manures were applied in field as per the treatments before ten days of sowing of crop. The experiment was laid out in Randomized Block Design with eight treatments replicated three times. Treatment composed of T_1: control, T_2: 100% RDF (50:25:25 NPK kg ha^{-1}), T_3: 100% RDN through FYM, T_4: 100% RDN through vermicompost, T_5: 100% RDN through poultry manure, T_6: 50% RDN through fertilizers + 50% N through FYM, T_7: 50% RDN through fertilizers + 50% N through vermicompost and T_8: 50% RDN through fertilizers + 50% N through poultry manure. Recommended dose of P and K were common for T_3 to T_8 treatments.

The proximate analysis of FYM, vermicompost and poultry manure were done initially for chemical properties (Table 1). Soil properties *viz*., organic C, available N, P and K, micronutrients (Fe, Mn, Zn and Cu) and nutrient uptake, yield and quality were estimated at harvest.

From organic manures the organic carbon was estimated by combustion method (Black 1982) [2], total N by Micro Kjeldahl (Digestion distillation) method (Parkinson and Allen 1975) [12] and total P estimated by Vanadomolybdophosphoric yellow color method (Piper 1966) [13], total K by Flame photometry (Chapman and Pratt 1961) [4] and micronutrients (Zn, Mn, Cu and Fe) by AAS (Zoroski and Burau 1977) [22]. At harvest of pearl millet the soil properties were estimated by using standard methods, organic C by wet oxidation (Nelson and Sommer 1982) [10], available N by alkaline permanganate (Subbiah and Asija 1956) [15], P by colorimetric method (Watanabe and Olsen 1965), K by flame photometry (Jackson 1973) [6] and micronutrients by Atomic Absorption Spectrophotometer (Lindsay and Norvell 1978) [7].

Table 1: Proximate analysis of FYM, vermicompost and poultry manure

Sr. No.	Parameters	FYM	Vermicompost	Poultry manure
1	pH	7.12	6.82	5.58
2	EC (dSm^{-1})	0.53	0.66	0.50
3	Organic C (%)	14.7	21.60	30.0
4	Total N (%)	0.63	1.19	2.09
5	Total P (%)	0.42	0.90	2.41
6	Total K (%)	0.67	1.12	1.57
7	C:N ratio	23.33	18.18	14.35
8	Total Fe (mg kg^{-1})	8.17	13.60	7.45
9	Total Zn (mg kg^{-1})	12.39	15.42	10.24
10	Total Mn (mg kg^{-1})	16.57	20.17	14.36
11	Total Cu (mg kg^{-1})	4.28	5.12	3.82

Results and Discussion

Soil organic C and available nutrients

Results (Table 2) indicated that the organic C content in soil varied from 4.23 to 4.61 g kg^{-1}. Among the various treatments, the maximum organic carbon content (4.61 g kg^{-1}) was noted with 100% RDN through FYM (T_3) followed by 50% RDN through fertilizers + 50% N through FYM (T_6) treatment (4.47 g kg^{-1}). Next to FYM, vermicompost application recorded higher soil organic carbon content. It is evident from the data that treatments comprises of FYM, vermicompost and poultry manure application increased organic C content by 4.68 to 7.96, 2.81 to 3.51 and 0.70 to 1.41 per cent, respectively over inorganic fertilizer alone (T_2) treatment. The present findings are in agreement with those of Manna *et al*. (2001) [8]. They stated that soil and crop management practices such as cultivation, crop rotation and residue management can enhance the amount of organic C in the soil.

The available N, P and K content was significantly higher in 50% RDN through fertilizers + 50% N through FYM (201.79, 24.64 and 282.16 kg ha^{-1}, respectively) followed by 100% RDN through FYM (198.30, 23.62 and 277.79 kg ha^{-1}, respectively). It is seen that FYM application along with chemical fertilizer increases the available nitrogen, phosphorus and potassium contents when compared with only chemical fertilizer. Close examination of the results indicated that the FYM along with inorganic fertilizers and FYM alone treatments increases available N in soil by 3.37 and 1.58 per cent, available P by 12.87 and 8.19 per cent and available K by 2.12 and 0.54 per cent over RDF alone. Vermicompost and poultry manure application significantly increases available nutrients over control. The effect of organics are in order FYM > vermicompost > poultry manure. The soil fertility in terms of nutrient availability was significantly improved with the addition of organic manure over control was noticed by Thakare and Wake (2014) [17]. The effect of manures in enhancing available nutrients was more pronounced with FYM was previously noticed by Brar *et al*. (2015) [3].

Soil available micronutrient content at harvest of pearl millet was presented in Table 2. The availability of micronutrient *viz*., Fe, Zn, Mn and Cu with different organic and inorganic treatment were ranged from 3.92 to 5.97, 0.48 to 0.76, 5.98 to 14.12 and 0.87 to 3.82 mg kg^{-1}, respectively and significantly highest contents were recorded in 50% RDN through fertilizers + 50% N through vermicompost (T_7) followed by 100% RDN through vermicompost (T_4) i.e. 5.77, 0.72, 13.91 and 3.27mg kg^{-1}, respectively. Among the FYM treatments, the available Fe, Zn, Mn and Cu were significantly increased

with the application of 50% RDN through fertilizers + 50% N through FYM (5.54, 0.68, 12.84 and 2.90 mg kg^{-1}, respectively) as compared to 100% RDN through FYM. As compared to vermicompost and FYM, poultry manure treatments recorded lower micronutrient contents. Overall results brings out the fact that, when we compared the vermicompost and FYM, the vermicompost application with chemical fertilizer increased the Fe, Zn, Mn and Cu by 40.05 to 44.90, 38.46 to 46.15, 106.99 to 110.12 and 214.42 to 267.31 per cent, respectively over RDF alone. However, these increased with FYM treatments were 14.32 to 34.47, 23.08 to 30.77, 71.73 to 91.07 and 109.61 to 178.85per cent, respectively for Fe, Zn, Mn and Cu over RDF alone. DTPA extractable Zn, Fe, Mn and Cu increased by 18.5, 30.6, 36.5 and 30.0 per cent, respectively due to INM over their initial values were reported by Vidyavathi *et al*. (2012) [20].

Table 2: Soil organic C and available nutrients as influenced by organic and inorganic fertilizer application

Treatment	Organic carbon (g kg^{-1})	Available nutrients (kg ha^{-1})			Micronutrient (mg kg^{-1})			
		N	P	K	Fe	Zn	Mn	Cu
T_1 Control	4.23	159.12	12.91	246.22	3.92	0.48	5.98	0.87
T_2 100% RDF (50:25:25 NPK kg ha^{-1})	4.27	195.21	21.83	276.30	4.12	0.52	6.72	1.04
T_3 100% RDN through FYM	4.61	198.30	23.62	277.79	4.71	0.64	11.54	2.18
T_4 100% RDN through vermicompost	4.39	182.42	16.42	260.17	5.77	0.72	13.91	3.27
T_5 100% RDN through poultry manure	4.30	177.39	14.35	258.61	4.27	0.57	9.40	1.62
T_6 50% RDN through fertilizers + 50% N through FYM	4.47	201.79	24.64	282.16	5.54	0.68	12.84	2.90
$T_7$50% RDN through fertilizers + 50% N through vermicompost	4.42	191.72	19.20	271.80	5.97	0.76	14.12	3.82
T_8 50% RDN through fertilizers + 50% N through poultry manure	4.33	186.60	18.52	266.35	4.48	0.60	10.62	1.92
SE ±	0.01	0.69	0.50	0.74	0.11	0.01	0.29	0.03
CD at 5%	0.05	2.10	1.51	2.25	0.34	0.03	0.88	0.13

NPK uptake

Perusal of the data presented in Table 3 indicated that the N, P and K uptake by grain were ranged between 28.73 to 53.22 kg ha^{-1}, 13.25 to 22.59 kg ha^{-1} and 8.27 to 14.09 kg ha^{-1}, respectively. The significantly maximum N, P and K uptake (53.22, 22.59 and 14.09 kg ha^{-1}, respectively) was recorded in50% RDN through fertilizers + 50% N through FYM (T_6) followed by (T_2) application of RDF alone (51.87, 21.28 and 13.53 kg ha^{-1}, respectively) and (T_3) 100% RDN through FYM i.e. 50.10, 20.03 and 13.48 kg ha^{-1}, respectively. However, treatment T_6 was found at par with T_2. The nutrient uptake by pearl millet stover did vary significantly due to different manures application. Appraisal of the results pointed out that, among INM treatments, the maximum N, P and K uptake by stover i.e. 45.17, 28.82 and 156.12 kg ha^{-1}, respectively was noticed under treatment T_6 (50% RDN through fertilizers + 50% N through FYM) followed by 100% RDF(T_2) i.e. 44.50, 28.37 and 155.36 kg ha^{-1}, respectively. Application of RDN through vermicompost and poultry manure also significantly increased the nutrient uptake by pearl millet over control. The effect of organics are in order FYM > vermicompost > poultry manure. The findings are in consonance with those of Togas *et al.* (2017). They noticed the maximum total uptake of N, P and K by pearl millet crop with the application of FYM followed by vermicompost.

Table 3: Nutrient uptake, yield and quality of pearl millet as influenced by organic and inorganic fertilizer application

Treatment	Grain uptake (kg ha^{-1})			Stover uptake (kg ha^{-1})			Yield (q ha^{-1})		Protein (%)	Fe (mg kg^{-1})	Zn (mg kg^{-1})
	N	P	K	N	P	N	Grain	Stover			
T_1 Control	28.73	13.25	8.27	19.75	17.53	82.21	11.80	21.80	8.12	47.00	32.15
T_2 100% RDF (50:25:25 NPK kg ha^{-1})	51.87	21.28	13.53	44.50	28.37	155.36	23.10	36.13	9.79	47.12	32.31
T_3 100% RDN through FYM	50.10	20.03	13.48	43.31	26.31	153.14	21.30	35.63	9.45	47.76	33.12
T_4 100% RDN through vermicompost	44.85	18.79	12.62	38.57	23.90	148.87	20.27	33.60	8.78	48.82	33.92
T_5 100% RDN through poultry manure	42.08	17.15	12.03	36.01	23.17	146.68	19.70	32.14	8.42	47.35	32.58
T_6 50% RDN through fertilizers + 50% N through FYM	53.22	22.59	14.09	45.17	28.82	156.12	26.51	38.05	9.98	48.02	33.45
$T_7$50% RDN through fertilizers + 50% N through vermicompost	47.51	19.35	12.99	40.85	25.28	151.42	21.40	34.83	9.16	48.63	33.75
T_8 50% RDN through fertilizers + 50% N through poultry manure	46.62	18.59	13.42	40.15	24.92	148.17	20.48	35.73	8.96	47.50	32.84
SE ±	0.79	0.51	0.36	0.94	0.64	0.38	0.94	2.55	0.19	0.38	0.31
CD at 5%	2.40	1.55	1.08	2.85	1.94	1.14	2.84	7.72	0.57	1.16	0.95

Pearl millet yield

Revealed from data (Table 3) that the maximum grain yield (26.51 q ha^{-1}) was obtained with the application of 50% RDN through fertilizers + 50% N through FYM (T_6) which was significantly higher over (T_2) chemical fertilizer treatment (23.10 q ha^{-1}) and the magnitude of increase over is 14.76 per cent. Next to these treatments, the application of 50% RDN through fertilizers + 50% N through vermicompost (T_7) recorded higher yield of 21.40 q ha^{-1} followed by (T_3) 100% RDN through FYM (21.30 q ha^{-1}). Poultry manure application along with inorganic fertilizers also significantly increased the grain yield over control. Significantly maximum stover yield (38.05 q ha^{-1}) was found under treatment receiving 50% RDN through fertilizers + 50% N through FYM (T_6) followed by the treatment (T_2) 100% RDF through fertilizers (36.13 q ha^{-1}) and the yield under T_6 increased by 5.31 per cent over T_2. The treatment 50% RDN through fertilizers + 50% N through poultry manure (T_8) recorded higher stover yield of 35.73 q ha^{-1} as compared to T_3 treatment i.e. 100% RDN through FYM (35.63 q ha^{-1}) and both treatments found at par. The results of the present investigation are in congruence with those of Mondal *et al*. (2015) [9], they concluded that

replacement of 50% N by organic were most conducive for obtaining higher grain and straw yield of rice. Thakare and Bhoyar (2012) [18] investigated that combine application of organic and inorganic input significantly increased soybean yield.

Protein, Fe and Zn contents in pearl millet

The protein per cent in pearl millet grain ranged from 8.12 to 9.98 per cent (Table 3). Among the treatments, maximum protein percentage (9.98%) was recorded in T_6 treatment (50% RDN through fertilizers + 50% N through FYM) followed by T_2 i.e. 100% RDF (9.79%) and (T_3) 100% RDN through FYM (9.45%), however, T_6 treatment found at par with T_2 and T_3. Results further, indicated that incorporation of vermicompost and poultry manure significantly improved the protein per cent over control. Shobha *et al*. (2017) [14] observed maximum protein per cent in pearl millet grain with the application of 25% RDN through vermicompost + 75% RDN through urea.

The Fe and Zn contents in pearl millet grain ranged between 47.00 to 48.82 and 32.15 to 33.92 mg kg^{-1}, respectively. The maximum contents of Fe (48.82 mg kg^{-1}) and Zn (33.92 mg kg^{-1}) were noticed under the treatment (T_4) 100% RDN through vermicompost followed by (T_7) 50% RDN through fertilizers + 50% N through vermicompost (48.63 and 33.75 mg kg^{-1}, respectively) and (T_6) 50% RDN through fertilizers + 50% N through FYM (48.02 and 33.45 mg kg^{-1}, respectively). The treatment T_4 found at par with T_7 and T_6 treatments. Application of 100% and 50% RDN through poultry manure significantly increased the Fe and Zn contents in grain. From the above result, it may aptly be inferred that combine use of organic and inorganic fertilizers increased the nutrient contents in grain and lead to improve the quality of grain.

Conclusion

Soil nutrients availability and yield is more for pearl millet under integrated nutrient management and the effect of organics are in order FYM > vermicompost > poultry manure. For micronutrients, vermicompost found better over FYM and poultry manure. Quality of pearl millet in terms of protein, Fe and Zn contents is improved with conjunctive use of organic and inorganic fertilizers. From the conspectus of earlier results, it is concluded that the soil chemical indicators with crop yield were significantly affected by the fertilizer along with manure application. Organic fertilization is important mean for improving soil fertility. Therefore, there is need for extensive and consistent research efforts on the addition of this type organic waste, may be considered as a good strategy for recovering semi arid areas.

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