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Long-term Effect of Organic and Chemical Sources of Nutrients on Yield and Economics of Pearl Millet in Inceptisols of Gird Region of Madhya Pradesh

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ABSTRACT: The studies on the long-term effect of the application of organic and chemical sources of nutrients in pearl millet were conducted at a research farm, Department of Soil Science and Agricultural Chemistry, College of Agriculture, Gwalior, (M.P.) during *Kharif* 2020 and 2021 with nine treatments replicated thrice in RBD. An essential component of crop production is the balanced use of fertilizers. Farmers are using straight chemical fertilizers in an imbalanced manner This imbalanced, excessive use of fertilizers, or the use of purely inorganic fertilizers, has resulted in a negative impact on soil health, fertility and productivity. In order to improve soil health and ecosystem services, the study was conducted to implement strategies that integrate the use of inorganic substances and organic manures, as well as a combination of both. The results indicated that integration of vermicompost @5t ha^{-1} + 50% RDF resulted in achieving significantly higher grain yield (2779 kg ha^{-1}), straw yield (6921 kg ha^{-1}), harvest index (28.7%) gross return (₹92114 ha^{-1}) and net return (₹66929 ha^{-1}) of pearl millet on the pooled mean basis in comparison to absolute FYM @20 t ha^{-1} or vermicompost @10 t ha^{-1} or 100% RDF alone or their graded combinations. The benefit: cost ratio of pearl millet was recorded at par with the integration of FYM @ 10t ha^{-1} with 50% RDF, FYM @ 5t ha^{-1} with 75% RDF, vermicompost @ 5t ha^{-1} with 50% RDF, vermicompost @ 2.5 t ha^{-1} with 75% RDF and absolute chemical but they were found significantly higher than the treatments with absolute FYM or Vermicompost or their integration with 25% RDF. This study contributed to the fact that the integration of sources of nutrients gives better results in terms of improving the soil health, soil fertility, biological ecosystem of the soil, which ultimately will increase the production and economics of the crop.

Keywords: Vermicompost, FYM, organic nutrients, chemical nutrients, NPK, productivity, pearl millet.

INTRODUCTION

Pearl millet (*Pennisetum glaucum*), the fourth most important cereal crop, is a popular crop in India as it is tolerant to heat and drought and can grow well on soil with low fertility. In many regions of India and among the inhabitants of other nations with arid soil and little rainfall, pearl millet is a staple food. It is an excellent source of energy and vitamins & minerals are important for nutritional security. Pearl millet is the world's hardiest warm-season cereal crop (Reddy *et al.,* 2012). Globally, it ranks sixth after rice, wheat, maize, barley and sorghum in terms of area (Khairwal *et al.,* 2007) and shares 42 per cent of total world production (Ramesh *et al.,* 2006). It is generally cultivated in areas with annual rainfall between 150 and 700 mm (Knairwal and Yadav 2005). In India, pearl millet is grown over an area of 7.57 Mha with an annual production of 10.86 Mt and productivity of 1436 kg ha^{-1}. In Madhya Pradesh, it is cultivated on 3.3 lakh hectares with an annual production of 7.4 lakh metric tonnes leading to an average productivity of 2256 kg ha^{-1} (Economic Survey, 2021-2022). India is the largest producer of pearl millet (10.05 mt) with average productivity of 1156 kg/ha (Bhardwaj *et al.,* 2014).

Farmers are, now a day, using straight chemical fertilizers in an imbalanced manner resulting in the deterioration of soil health and fertility and a reduction in yields. An essential component of crop production is the balanced use of fertilizers. But an imbalance, excessive use of fertilizers, or the use of purely inorganic fertilizers, has resulted in a negative impact on soil fertility and productivity. In order to improve soil health and ecosystem services, farmers have long been encouraged to implement strategies that integrate the use of inorganic substances and organic manures, as well as a combination of both. To sustain and enhance SOC, the approach of long-term practice must be used (Satyajeet and Nanwal 2007). Organic manures, particularly FYM and vermicompost not only supply macronutrients (in smaller proportion) but also meet the requirements of micronutrients, besides improving soil health and beneficial microbial activities (Kumar *et al.*, 2014). Utilizing farmyard manure in a balanced and integrated manner may dramatically increase soil organic carbon (SOC) concentrations as well as overall soil quality, which are created by combining various physical, chemical, and biological characteristics of the soil. Integrated plant nutrient supply system has assumed great importance and is of vital significance for the maintenance of soil productivity and is the need of the hour. The conjunctive application of organic with

inorganic sources of nutrients reduces the dependence on chemical inputs (Munda *et al.,* 2011). The scientific literature on the long-term effect of different sources of nutrients alone or in combination on the productivity and economics of pearl millet in this region is meagre. Therefore, in view of the facts discussed above, the present study was conducted on the long-term effect of organic and chemical sources of nutrients on the yield and economics of pearl millet in Inceptisols of the Gird region of Madhya Pradesh.

MATERIAL AND METHODS

A field investigation was carried out during the *Kharif* 2020 to *Kharif* 2021 in continuation of a 14 years old long-term experiment on pearl millet (from *Kharif* 2006) at the Research Farm, College of Agriculture, Gwalior situated in Grid zone (26° 13'N and 76°10'E with an altitude 197 meters) of Madhya Pradesh. The climate of the experimental site is semi-arid and sub-tropical with extreme weather conditions having hot and dry summer and cold winter, where the maximum temperature goes up to 44.7°C during summer and minimum as low as 2.9°C. The mean annual rainfall of the area is 700-800 mm. The experiment treatments consisted of nine fertility management practices *viz.,* FYM @20 t/ha (Absolute Organic with FYM), FYM @10 t/ha + 50 % NPK, FYM @15 t/ha + 25 % NPK, FYM @5 t/ha + 75 % NPK, VC @10 t/ha (Absolute Organic with VC), VC @5t/ha + 50 % NPK, VC @7.5 t/ha + 25 % NPK, VC @2.5 t/ha + 75 % NPK and 100 % NPK (Absolute Chemical). The recommended dose for pearl millet through chemical fertilizer was 80 kg N, 40kg P_2O_5 and 20 kg K_2O ha^{-1}. Half of the nitrogen was applied in the form of urea as a basal dose and the remaining was top-dressed after 1st irrigation at 30 DAS. The full dose of phosphorus and potash was applied as single super phosphate and muriate of potash at the time of sowing; while, 100%N was applied through FYM @10t ha^{-1} (0.8%N, 0.30% P and 0.45% K) and 100% vermicompost @5t ha^{-1} (1.56% N, 1.0% P and 0.8%K) as per treatments. The soil of the experimental site was alluvial, sandy clay loam in texture and classified as Typic Ustochrepts at great group level. Observations on the grain yield and straw yield were recorded per plot and further converted into a per-hectare basis. Harvest Index (%) was calculated by using the formula:

$$\text{Harvest Index (\%)} = \frac{\text{Grain Yield (Kg ha}^{-1})}{\text{Biological Yield (Kg ha}^{-1})} \times 100$$

RESULTS AND DISCUSSION

Yield and Harvest index of pearl millet. The data illustrated in Table 1 and Fig. 1 and 2 showed the effect of graded doses of organic and chemical sources of nutrients and their combinations on the yield and harvest index of pearl millet in *Kharif* in 2020 and 2021. The grain and straw yield of pearl millet was found significantly higher under the treatment T_6, where vermicompost @ 5t ha^{-1} + 50% recommended dose of NPK was used, as compared to all the other treatments under study in both the years except the grain yield in treatment T_2 (FYM @10 t/ha + 50 % NPK) which was found at par with T_6 in *Kharif* 2020. Whereas, the harvest index of pearl millet was recorded at par under T_2, T_6 and T_8 but these treatments were found significantly higher as compared to all the other treatments.

Economics of pearl millet. The data illustrated in Table 2 showed the effect of graded doses of organic and chemical sources of nutrients and their combinations on the cost of cultivation, gross return, net return and benefit: cost ratio of pearl millet in *Kharif* 2020 and 2021. The cost of cultivation of pearl millet varies with the treatments. It was recorded as highest under treatment T_5 and lowest in T_9. The gross and net return of pearl millet was found significantly higher under treatment T_6, where vermicompost @ 5t ha^{-1} + 50% recommended dose of NPK was used, as compared to all the other treatments under study in both the years. Whereas, the benefit: cost ratio of pearl millet was recorded at par under T_2 (integration of FYM @ 10t ha^{-1} with 50 RDF), T_4 (integration of FYM @ 5t ha^{-1} with 75% RDF), T_6 (integration of vermicompost @ 5t ha^{-1} with 50 RDF), T_8 (integration of vermicompost @ 2.5t ha^{-1} with 75% RDF) and T_9 (absolute chemical) but these treatments were found significantly higher as compared to treatments with absolute FYM or Vermicompost or their integration with 25% RDF.

When organic fertilizer is coupled with organic manures, its effectiveness is greatly increased (FYM and vermicompost). It's possible that the balanced C:N ratio and the enhanced vegetative development improved the production of carbohydrates, which eventually increased yield. The findings of Satyajeet and Nanwal (2007); Parihar *et al.* (2010) are closely in line with the current trend of rising yield. In the early growth stages of the crop, the need for nitrogen is met by the application of urea, an inorganic form of nitrogen, and in the later growth stages of the crop, all of the plant nutrients are released from FYM, which has had a significant positive impact on yield and supplied plant nutrients throughout the period of crop growth. Agarwal and Praveen (1995); Singh *et al.* (1981) both indicated that FYM had a favourable impact on pearl millet yield. The addition of FYM may have increased seed and stover yields by stimulating enzyme activity, which encourages the recycling of nutrients in the soil ecosystem (Singaram and Kamalakumari 1995; Ram *et al.,* 2015). As a result, VC recorded higher yield improvement than FYM, even if the rate of application of the latter was four times higher (Rani *et al.,* 2020). When P and N were applied together, the yield of pearl millet was much higher than when FYM was used alone. Greater root growth and improved water and nutrient absorption have been linked to higher phosphorus availability. In comparison to FYM and vermicompost alone, the application of K together with NP considerably boosted the grain and straw yield of pearl millet, highlighting the necessity of balanced fertilization to increase pearl millet productivity. K, perform several crucial responsibilities in a variety of functions. In various combinations of NPK + vermicompost, pearl millet production increased as

fertility levels dose. The findings of the current study are consistent with those of Kavimani *et al.* (2000). The controllable release of nutrients in the soil was caused by the mineralization of organic manure may have promoted improved crop development and increased yield when inorganic fertilizer and organic manure were applied together (Archarya *et al.,* 2012; Shahid *et al.,* 2013; Prasad *et al.,* 2014).

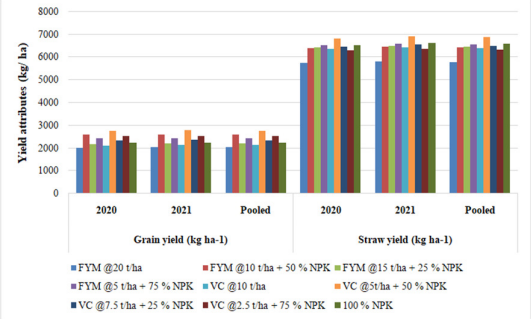

Fig. 1. Effect of organic and chemical sources of nutrients and their combinations on grain and straw yield of pearl millet.

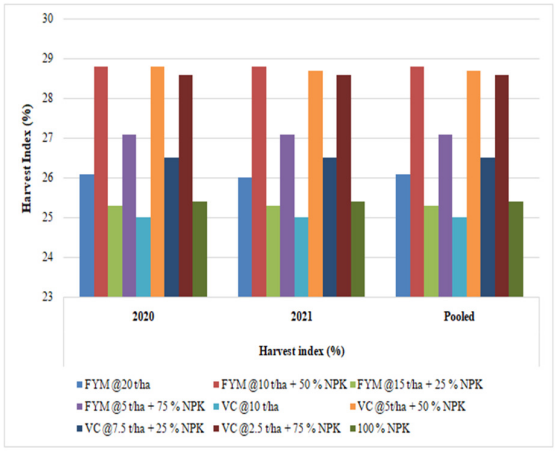

Fig. 2. Effect of organic and chemical sources of nutrients and their combinations on harvest index of pearl millet.

Table 1: Effect of organic and chemical sources of nutrients and their combinations on yield and harvest index of pearl millet.

Treatments		Grain yield (kg ha^{-1})			Straw yield (kg ha^{-1})			Harvest index (%)		
		2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
T_1	FYM @20 t/ha	2025	2046	2036	5746	5809	5777	26.1	26.0	26.1
T_2	FYM @10 t/ha + 50 % NPK	2586	2610	2598	6395	6466	6431	28.8	28.8	28.8
T_3	FYM @15 t/ha + 25 % NPK	2188	2210	2199	6448	6519	6484	25.3	25.3	25.3
T_4	FYM @5 t/ha + 75 % NPK	2427	2451	2439	6533	6605	6569	27.1	27.1	27.1
T_5	VC @10 t/ha	2124	2145	2135	6380	6450	6415	25.0	25.0	25.0
T_6	VC @5t/ha + 50 % NPK	2765	2793	2779	6845	6921	6883	28.8	28.7	28.7
T_7	VC @7.5 t/ha + 25 % NPK	2341	2364	2352	6482	6553	6518	26.5	26.5	26.5
T_8	VC @2.5 t/ha + 75 % NPK	2525	2550	2538	6297	6367	6332	28.6	28.6	28.6
T_9	100 % NPK	2234	2256	2245	6550	6623	6586	25.4	25.4	25.4
S.Em.		60.9	53.6	40.6	35.5	35.9	25.3	0.53	0.43	0.34
CD (0.5 %)		182	161	117	107	108	73	1.58	1.29	0.98

Table 2: Effect of organic and chemical sources of nutrients and their combinations on Cost of cultivation(₹ ha^{-1}), Gross return (₹ ha^{-1}), net return (₹ ha^{-1}) and B: C Ratio of pearl millet.

Treatments		Cost of cultivation			Gross return			Net return			B: C Ratio		
		2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
T_1	FYM @20 t/ha	28320	28600	28460	69402	72167	70785	41082	43567	42325	1.45	1.52	1.49
T_2	FYM @10 t/ha + 50 % NPK	24045	24325	24185	84379	87819	86099	60334	63494	61914	2.51	2.61	2.56
T_3	FYM @15 t/ha + 25 % NPK	26183	26463	26323	76064	79064	77564	49881	52601	51241	1.91	1.99	1.95
T_4	FYM @5 t/ha + 75 % NPK	21908	22188	22048	81582	84878	83230	59674	62690	61182	2.72	2.83	2.77
T_5	VC @10 t/ha	30320	30600	30460	74381	77299	75840	44061	46699	45380	1.45	1.53	1.49
T_6	VC @5t/ha + 50 % NPK	25045	25325	25185	90251	93977	92114	65206	68652	66929	2.60	2.71	2.66
T_7	VC @7.5 t/ha + 25 % NPK	27683	27963	27823	79492	82681	81086	51809	54718	53263	1.87	1.96	1.91
T_8	VC @2.5 t/ha + 75 % NPK	22408	22688	22548	82630	86036	84333	60222	63348	61785	2.69	2.79	2.74
T_9	100 % NPK	19770	20050	19910	77497	80557	79027	57727	60507	59117	2.92	3.02	2.97
S.Em.					**1296**	**1234**	**895**	**1296**	**1234**	**895**	**0.06**	**0.06**	**0.04**
CD (0.5 %)					**3885**	**3699**	**2577**	**3885**	**3699**	**2577**	**0.19**	**0.17**	**0.12**

CONCLUSIONS

Field experiments were carried out from *Kharif* 2020 to *Kharif* 2021 to assess the effect of organic and chemical sources of nutrients and their combinations on the yield and economics of pearl millet in Inceptisols of the Gird region of Madhya Pradesh. The principal findings revealed that the integrated application of

vermicompost @5t/ha with 50% NPK gave significantly higher grain yield, straw yield and harvest index of pearl millet followed by FYM @10 t/ha with 50% NPK. Also, the integrated application of vermicompost @5t/ha with 50% NPK gave a higher net return and B:C ratio of pearl millet followed by FYM @10 t/ha with 50 % NPK.

FUTURE SCOPE

To sustain and enhance soil organic carbon, the approach of long-term practice must be used. Organic manures, particularly farmyard manure and vermicompost not only supply macronutrients (in smaller proportion) but also meet the requirements of micronutrients, besides improving soil health and beneficial microbial activities. Utilizing farmyard manure in a balanced and integrated manner may dramatically increase soil organic carbon concentrations as well as overall soil quality, which are created by combining various physical, chemical, and biological characteristics of the soil.

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Conflict of Interest. None.

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