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EFFECT OF INTEGRATED APPLICATION OF INORGANIC AND ORGANIC SOURCES ON SOIL PROPERTIES, YIELD AND NUTRIENT UPTAKE BY PEARLMILLET

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ABSTRACT

A field experiment was carried out during *Kharif* 2014 to study the effect of organic and inorganic source of nutrient on soil properties, yield, and nutrient uptake of pearlmillet cv. JBV-3. Application of organic and inorganic sources of nutrient in combination remarkably increased yield. Higher yield (4192.46 kg ha^{-1}) in comparison to 100% FYM and 100% vermicompost were recorded with 50% vermicompost + 50% NPK and this was followed by 100% NPK (3891.6 kg/ha^{-1}).The highest build-up of organic carbon in the soil was recorded in 100% NPK (4.61gkg^{-1}), which was at par with 25% vermicompost + 75% NPK and 75% vermicompost + 25% NPK. The highest total uptake (grain +straw) of NPK (180, 38.81, 303.05 kg ha^{-1} respectively) and sulphur(23.06 g ha^{-1}) was recorded with the incorporation of 100% NPK.The status of available NPKS declined in almost all treatments as compared to its initial status.

INTRODUCTION

Pearl millet [*Pennisetum glaucum* (L.) R. Br.], 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 share 42 per cent of total world production (*Ramesh et al.,* 2006). India is the largest producer of pearl millet in terms of production (10.05 m t) with an average productivity of 1156 kg/ha (Bhardwaj et al., 2014). It is generally cultivated in areas with annual rainfall between 150 and 700 mm (Knairwal and Yadav, 2005). Pearlmillet traditionally is an indispensable component of dry-farming system and it is considering more efficient in utilization of soil moisture, and has a higher level of heat tolerance than even sorghum and maize. Adoption of pearlmillet-wheat or pearlmillet-mustard sequence over a long period without a provision for adequate replenishment of nutrients results in declining of soil fertility. Withdrawal of nutrients from the soils of rainfed areas has remained much higher than their application (Gupta, 2001). Use of organic sources along with chemical fertilizers not only conserves moisture and reduces erosion but also increases the nutrients use efficiency, thereby improving the overall productivity of soil (Sinha et al., 2011). Further, Long-term studies being carried out at several locations in India indicated that application of all the needy nutrients through chemical fertilizers have deleterious effect on soil health leading to unsustainable yields (Anand Swarup 2002). Therefore, there is a need to improve nutrient supply system in terms of integrated nutrient management involving the use of chemical fertilizers in conjunction with organic manures. Application of organic manures in general improves the availability of micro nutrients like zinc, iron, manganese and copper (Ashok Kumar et al., 2008). Nitrogen is an essential major nutrient for plant growth, which is closely associated with vegetative growth and development of plants; it plays an important role in plant metabolism by virtue of being an essential constituent of structural component of the cell wall and many metabolically active compounds. It is also a constituent of chlorophyll, which is important for harvest of solar energy (Bray, 1983). Phosphorus has a key role in the energy metabolism of all plant cells (Erman *et al.*, 2009). Potassium, unlike other vital nutrients does not become a part of chemical structure of plants but provide strength through thickness of cell wall. The present investigation was, therefore, planned to study the effect of integration of FYM, vermicompost and chemical fertilizers on yield, soil fertility status and nutrient uptake of pearl millet.

MATERIALS AND METHODS

Field study was conducted at the Crop Research Farm of RajmataVijayarajeScindia Agriculture University, Gwalior (M.P.) in Kharif season 2014 with Pear millet as a test crop. The experimental soil having p H (1:2) 7.5, electrical conductivity (E.C.) 0.43$dSm^{-1,}$ organic carbon (O.C.) 4.53 g kg^{-1}, available N(172.96) kg ha^{-1}, Olsen-P(11.79) kg ha^{-1}, available K (198.24) kg ha^{-1} and available S(6.88) $mgkg^{-1}$. The 100% NPK recommended dose of fertilizer for Pearl millet

was 80 kg N, 40 kg P_2O_5 and 20 kg K_2O ha^{-1} respectively. The experiment consisted of nine treatments replicated three times in a randomized block design viz., FYM @ 160 q ha^{-1} (T_1), N_{40} P_{20} K_{10} + FYM @ 80 q ha^{-1}: T_2, N_{20} P_{10} K_5 + FYM@120q ha^{-1}: T_3, N_{60} $P_{30}K_{15}$ + FYM@ 40 q ha^{-1}: T_4, Vermicompost 5334 kg ha^{-1}: T_5, $N_{40}P_{20}K_{10}$ +Vermocompost @ 2667 kg ha^{-1}: T_6, $N_{20}P_{10}K_5$ + Vermicompost @ 4000 kg ha^{-1}: T_7, $N_{60}P_{30}K_{15}$ +Vermicompost @ 1334 kg ha^{-1}: T_8, $N_{80}P_{40}K_{20}$: T_9. The farmyard manure (FYM) was obtained from small dairy holders. The FYM @ 160 q ha^{-1} was incorporated one month before sowing as per treatments. Total N, P, and K contents of the FYM were 0.50, 0.25 and 0.50 % respectively. Half of the N and entire dose of P, K were applied at the basal dose and remaining quantity of N was top dressed after 35 days, in the form of urea, di-ammonium phosphate, murate of potash. Grain and straw yields were recorded after harvest of crop. The grain and straw samples were digested in H_2SO_4 for determination of N and di-acid mixture of HNO_3 and $HClO_4$ (2:5) for P, K and S estimation. Plant uptake of N, P, K and S were computed by multiplying the yield with the respective nutrient content. After harvest of the crop, the composite surface (0-15 cm) soil samples from each plot of the experimental field were analyzed for pH , EC, OC, available N, P, K by following standard procedures (Dhyan Singh *et al.,* 2005).

RESULTS AND DISCUSSION

Soil Properties

A perusal of data in Table 1 showed that continuous use of chemical fertilizers and their combination with organics resulted in no changes in pH and EC of the soil.

Organic Carbon

The organic carbon of soil increased significantly with the application of FYM and vermicompost along with graded dose of fertilizers (table-1). The highest build-up 4.61g kg^{-1} in the soil was recorded in 100% NPK, which was at par with 25% vermicompost + 75% NPK 4.59 g kg^{-1} and 75% vermicompost + 25% NPK 4.5g kg^{-1}.Thus, integrated application of organics with chemical fertilizers (vermicompost + NPK) resulted in significantly higher organic carbon content in soil. The increase in OC content in the manorial treatment combinations is attributed to direct addition of organic manure in the soil which stimulated the growth and activity of microorganisms and also due to better root growth, resulting in the higher production of biomass, crop stubbles and residues (Moharana *et al.*2012). The subsequent decomposition of these materials might have resulted in the enhanced carbon content of soil. These results are in agreement with the findings of Nayak *et al.* (2012). Addition of organic nutrient source might have created environment conducive for formation of humic acid and stimulated the activity of siol micro-organism, resulting in an increase in the organic carbon content of the soil (Srilatha *et al.* 2013).

Available Nitrogen

A perusal of data in table 1 indicated a declining trend in available N status (150 to 171 kg ha^{-1}) from its initial level (209 kg ha^{-1}). It is of interest to note that there was a decline in every treatment in comparison to its initial value irrespective of the treatments. Decline values in status were higher in T_4 and T_8 in these treatments increased yield were also recorded. The results clearly suggest that added N was not able to meet out the demand of crop hence crop utilized the native nitrogen. However, there was a significant build-up of available N in soil receiving 100% NPK over other treatments. The higher available N content in the 100% NPK treatment may be due to optimal fertilizer input. These results are in line with the findings of Antil *et al.* (2011).

Available Phosphorus

The available P content was minimum in 100% FYM plots. The available-P ranged from 6.46-11.48kg ha-1 in surface soils, after harvest of the crop. The highest available P was observed under T9 (100% NPK) was significantly at par with T8 (25% vermicompost + 75% NPK) and T7 (75% vermicompost + 25% NPK) treatments. A significant reduction in available P content of soil observed under 100% FYM and 50 % NPK + 50% FYM due to removal of P by crops in the absence of external sources of P. Such a declined noticed was higher in organic matter treated plots. Thus it is obvious that organic matter sources could not meet the requirement of the crop. Similar, findings have also been reported by Kumar *et al.* (2012).

Available Potassium

The status of available K declined in almost all the treatments as compared to its initial status 245.65 kg ha-1 (table 1). The maximum decline was in 100% FYM. The exclusion of K in crop nutrition (100% FYM and 100% vermicompost) has led to the maximum mining of its native pools over the years. The

Table 1: Influence of integrated application of inorganic and organic sources on soil chemical properties of post-harvest soil

Treatments	pH (1:2)	EC (d Sm^{-1})	OC (g kg-1)	Available nutrients (kg ha^{-1}) N	P	K	(mg kg^{-1}) S
100% FYM	7.4	0.42	4.24	154.68	6.46	131.78	4.11
50% FYM + 50% NPK	7.7	0.42	4.36	163.02	6.9	150.01	6.26
75% FYM +25% NPK	7.7	0.43	4.49	154.69	7.5	175.46	6.88
25% FYM + 75% NPK	7.5	0.44	4.46	150.48	7.57	198.24	6.88
100% Vermicompost	7.7	0.42	4.34	171.38	8.63	153.44	4.63
50% Vermi +50% NPK	7.6	0.45	4.5	154.66	9.57	196.37	5.8
75% Vermi + 25% NPK	7.5	0.45	4.5	171.38	10.99	160.53	6.14
25% Vermi + 75% NPK	7.6	0.46	4.59	154.66	11.3	197.86	5.97
100% NPK	7.4	0.46	4.61	172.92	11.79	187.66	3.73
CD (P=0.05)	NS	NS	0.17	NS	1.87	31.83	1.03

increase in available K under integrated treatments might be due to addition of organic matter that reduced K fixation and released K due to interaction of organic matter with clay, besides the direct K addition to the pool of soil (Subehia and Sepehya 2012).

Available Sulphur

It is surprising to note that sulphur status declined in every treatments in soil after harvest of the crop and the differences in status were significant, lowest (3.73ppm ha^{-1}) and highest (6.88 $ppmha^{-1}$) respectively were in T_1 (100% NPK) and T_3 (75% FYM + 25% NPK) and T_4. In general vermicompost and its different combinations analyzed also higher sulphur in at harvest and its combinations with NPK.

Table 2: Influence of application of inorganic and organic sources on yield of Pearl millet

Treatments	Grain Yield (kg ha^{-1})	Straw Yield (kg ha^{-1})
100% FYM	3170.66	9723
50% FYM +50% NPK	3549.3	12038
75% FYM + 25% NPK	3468.23	12038
25%FYM + 75% NPK	3693.43	12346
100% Vermicompost	3044.73	11575
50% Vermicompost + 50% NPK	4192.46	11266
75% Vermicompost + 25% NPK	3450.16	10957
25% Vermicompost + 75% NPK	3774.46	12964
100% NPK	3891.6	14507
CD (P=0.05)	646.27	1814.04

Grain and Straw Yields

Higher yield in comparison to 100% FYM and 100% vermicompost were recorded with 50% vermicompost + 50% NPK (table 2). There was a significant response of different treatments as compared to organic sources. Grain yield varied from 3044.73 to 4192.46 kg ha^{-1} under different treatments which were in T_5 (100% vermicompost) and T_6 (50% vermicompost +50% NPK) The efficacy of organic fertilizer is much pronounced when it is combined with organic manures (FYM and vermicompost). The increased vegetative growth and the balanced C:N ratio might have increased the synthesis of carbohydrates, which ultimately promoted yield. The present

trend of increase in yield is in close conformity with the findings of Satyajeet and Nanwal (2007) and Parihar *et al*. (2010).During initial growth stages of crop, requirement of N is fulfilled by inorganic form of N applied through urea and in the later stages of crop growth, all the plant nutrients are released from FYM which have significantly influenced positively on yield and supplied plant nutrients throughout the period of crop growth. A positive effect of FYM on pearl

millet yield had also been reported by Singh et al., (1981) and Agarwal and Kumar (1995). Increase in seed and stover yield might be due to addition of FYM resulted in stimulation of the

enzyme activity which promotes the recycling of nutrients in the soil ecosystem (Singaram and Kamalakumari, 1995).. Application of P along with N considerably increased yield of pearl millet compared to the application of FYM alone. A better

Table 3: Nitrogen uptake (kg/ha) in Grain, Stover and Total as influence by various treatments

Tr. No.	Treatments	N-Uptake (kg/ha) Grain	Stover	Total
T_1	100% F Y M	33.86	46.60	64.79
T_2	50% FYM + 50% NPK	47.30	78.24	114.89
T_3	75% FYM + 25% NPK	42.17	62.17	97.35
T_4	25% FYM +75% NPK	52.37	57.71	85.62
T_5	100% Vermicompost	34.43	64.58	84.07
T_6	50%Vermicompost+50% NPK	60.02	71.37	116.11
T_7	75%Vermicompost+25% NPK	45.50	70.91	96.10
T_8	25 %Vermicopost+75% NPK	54.90	85.80	137.39
T_9	100% NPK	73.83	106.95	180.78
SEm (±)		4.56	7.65	9.16
C. D. (5%)		13.69	27.73	27.48

Table 4: Phosphorus uptake (kg/ha) in Grain, Stover and Total influenced by various treatments

Tr. No.	Treatments	P-Uptake (kg/ha) Grain	Stover	Total
T_1	100% F Y M	7.94	2.11	10.05
T_2	50% FYM + 50% NPK	9.20	13.80	23.00
T_3	75% FYM + 25% NPK	9.91	13.56	23.47
T_4	25% FYM +75% NPK	12.71	14.55	27.26
T_5	100% Vermicompost	11.55	16.06	26.09
T_6	50%Vermicompost+50% NPK	17.84	19.85	37.83
T_7	75%Vermicompost+25% NPK	15.25	10.32	25.24
T_8	25 %Vermicopost+75% NPK	17.94	15.44	33.29
T_9	100% NPK	18.95	19.81	38.81
SEm (±)		1.35	1.56	2.26
C. D. (5%)		4.06	4.70	6.79

Table 5: Potassium uptake (kg/ha) in Grain, Stover and Total as by affected various treatments

Tr. No.	Treatments	K -Uptake (kg/ha)		
		Grain	Stover	Total
T_1	100% F Y M	15.61	126.66	142.27
T_2	50% FYM + 50% NPK	17.28	182.17	199.45
T_3	75% FYM + 25% NPK	18.02	188.99	207.02
T_4	25% FYM +75% NPK	19.10	202.92	221.03
T_5	100% Vermicompost	21.61	185.70	207.32
T_6	50%Vermicompost+50% NPK	32.01	193.91	225.92
T_7	75%Vermicompost+25% NPK	22.35	191.32	213.67
T_8	25 %Vermicopost+75% NPK	20.08	234.46	245.54
T_9	100% NPK	29.27	273.78	303.05
SEm (±)		1.30	10.93	11.79
C. D. (5%)		3.90	32.77	35.36

Table 6: Sulphur uptake (g/ha) in Grain, Sover and Total as influenced by various treatments

Tr. No.	Treatments	S -Uptake (g/ha)		
		Grain	Stover	Total
T_1	100% F Y M	5.81	2.37	8.18
T_2	50% FYM + 50% NPK	8.60	3.03	11.63
T_3	75% FYM + 25% NPK	6.82	4.29	11.11
T_4	25% FYM +75% NPK	8.08	4.78	12.86
T_5	100% Vermicompost	5.68	4.66	10.34
T_6	50%Vermicompost+50% NPK	10.02	5.06	15.08
T_7	75%Vermicompost+25% NPK	9.49	5.36	14.85
T_8	25 %Vermicopost+75% NPK	13.19	6.75	19.95
T_9	100% NPK	14.78	8.27	23.06
SEm (±)		0.83	1.19	0.98
C. D. (5%)		2.51	0.39	2.95

supply of phosphorus has been associated with prolific root growth resulting in enhanced water and nutrient absorption. The application of K along with NP significantly increased the grain and straw yield of pearl millet over FYM and vermicompost alone, emphasizing on the essentiality of balanced fertilization to obtain higher pearl millet productivity. As K play a number of indispensable roles in a wide range of function. Increasing fertility levels increased the yield of pearl millet in different combination of NPK + vermicompost. The result obtained in present study are in conformity with those of Kavimani *et al*. (2000) and Sharma *et al* (2012). Improvement in yield due to combined application of inorganic fertilizer and organic manure might be attributed to control release of nutrients in the soil through mineralization of organic manure which might have facilitated better crop growth (Archarya *et al*. 2012 ; Shahid *et al*. 2013), (Prasad *et al*. 2014).

Nutrient Uptake

Application of balanced fertilization of N, P and K led to significantly higher NPK uptake in comparison to FYM and vermicompost alone (table 3,4,5 and 6). Nutrient uptake was influenced significantly by the application of chemical fertilizers alone or in combination with FYM and vermicompost. The highest total uptake (grain +straw) of NPKS (180, 38.81, 303.05 and 23.06 kg ha^{-1} respectively) was recorded with the incorporation of 100% NPK. It is obvious as from inorganic fertilizer release of NPK is faster in the solute form, whereas NPK availability from organics is after its mineralization which depends on soil conditions. Similar results were reported by Rathore *et al*. (2004). Application of FYM also increases cation exchange capacity and microbial activity in soil besides supplying macro and micro plant nutrients. It helps in minimizing leaching losses, improving buffering capacity and influencing the redox conditions in the soil (Gaur et al., 1971). Integration of nutrients (organic and inorganic) influenced the NPKS content significantly which could be due to additional supply of these nutrients through FYM and improvement in the soil physical condition for better plant growth which ultimately led to higher NPKS content. Use of 25% vermicompost in combination with 75% NPK significantly enhanced the total uptake of N, P, K and S. The increase in NPKS uptake by pearl millet with integrated application of nutrients may be due to improvement of the soil environment which encouraged proliferation of roots resulting in more absorption of water and nutrient from larger area and depth. This might be due to improved nutritional environment in the rhizosphere as well as its utilization in the plant system leading to enhanced translocation of nutrients towards reproductive structures *viz*., ear heads, seeds and other plant parts. These results gain support from Meena and Gautam (2005).Moreover organic manures after decomposition released nutrient which became available to the plants and thus increased NPKS concentration. The higher nutrient uptake with organic manure might be attributed to solubilization of native nutrients, chelation of complex intermediate organic molecules produced during decomposition of added organic manure their mobilization and accumulation of different nutrients in different plant part. (Varma *et al*. 1999 and Vora *et al*. 2010).

It may be concluded from the present study that application of 100% NPK and its combination of 25% vermicompost +

75% NPK not only produced the higher yield of pearl millet but also improved the soil fertility as compared to application of chemical fertilizer alone. Thus optimum mineral nutrients in conjunction with organic manures can play a vital role in exploiting high yield potential of pearl millet its favorable effect on nutrient supply and soil properties in the study zone.

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