IMPACT OF ORGANIC AND CHEMICALFARMING ON SOIL HEALTH AND PRODUCTION IN FINGER MILLET

ABSTRACT

Deterioration of soil health, expensive and unnecessary inputs, water-intensive/water-pollutive, lethal and ecologically harmful farming practices in chemical farming do no good to agricultural advancement, and to public health. To reduce ill effects of chemical farming, along term experiment is conducting to study the effect of organic manures and chemical fertilizers on yield, quality and soil healthin finger millet since*kharif* 2013 at Agricultural Research Station, Perumallapalle, ANGRAU, Andhra Pradesh, India with a test variety Vakula. The experiment consists of two treatments *viz*., organic farming and chemical farming. Recommended dose of manures and fertilizers were applied to organic and inorganic plots, respectively in each season. The data on yield parameters, yield, quality and soil properties was collected and statistically analyzed with paired t test by using SPSS2.0. The results revealed that during *kharif* 2022,significantly the highest grain yield (31.62q ha^{-1}),straw yield (84.06 q ha^{-1}), number of tillers/plant (1.9), were recorded with chemical farming. The highest N, P and K uptake by plant at flowering was also recorded with chemical farming during both *Kharif* and *Rabi*seasons. Regarding quality, high protein, total phenol and tannin content had been recorded with organic farming. Build up of organic carbon, available nitrogen and phosphorus were noticed in post harvest soil when compared initial values (*kharif* 2013.). Soil enzymatic activity and microbial population was also higher with application of organic manures and biofertilizers than chemical fertilizers. The grain yield of organic farming plot was comparable with chemical farming after nine years of experimentation.

Key words: Finger millet, chemical fertilizers, organic manures, bio fertilizers, soil health, yield, quality.

INTRODUCTION

"Organic farming practices are gaining importance as farmers realized benefits in terms of soil fertility, soil health and sustainable productivity. Intensive cultivation, unbalanced and inadequate fertilizers with restricted use of organic manures have made soil deficient in nutrients and health. Therefore, organic farming is important which mainly involves the use of on-farm resources largely avoiding the utilization of chemical fertilizers. Solid and liquid manures having higher amount of beneficial microbes, macro and micro nutrients, essential amino acids, growth promoting substance like IAA, GA may greatly help in increasing soil microbial population and soil fertility further increasing the crop growth, yield and quality" (Ashokh *et al*., 2022). "Heavy use of chemical fertilizers in agriculture has weakened the ecological base in addition to degradation the soil, water resources and quality of the food. At this junction, a keen awareness has sprung on the adoption of organic farming as a remedy to overcome the ill effects of modern chemical agriculture. Addition of organic manures to soil creates a favorable environment, improve soil health and the crop shows a good response to all management practices" (Aravind *et al*., 2020). "Boosting yield, reducing production cost and improving soil health are three interlinked components of sustainable triangle" (Kumar and Yadav, 1995). "Level of organic matter content in soil is the characteristic property of the soil health" (Pawar *et al.*, 2013). "It is difficult to build up the organic matter content in soil permanently in a small span of time. However, short term benefits of addition of organic manure on soil fertility and productivity can be achieved by increasing its content in soil by external application of organic manures" (Gurudeep *et al*., 2021). "Exclusive use of chemical fertilizers leads to depletion of soil health and create imbalance in the composition as well as availability of micro nutrients. Finger millet is an important millet food crop grown in India and has the pride of place. in having the highest productivity among millers. It has the capacity to produce rational yields even with minimum care. Finger millet cultivated area is gradually increasing every year in Southern states of India due to its rich nutritional value. The grain yield and quality is improved by use of organic manures" (Kejiya *et al*., 2023). Hence, an attempt was initiated to study the effect of organic manures on soil health status yield and quality of finger millet

MATERIALS AND METHODS

A field experiment was initiated during *kharif*, 2013 on a sandy loam soils at Agricultural Research Station, Perumallapalle, Andhra Pradesh with the variety Vakula and continued as a long term experiment to study the effect of organic farming and chemicalfarming on soil health, nutrient uptake, yield and quality of finger millet. The experiment consists of two treatments viz., organic farming and chemical farming. FYM @ 4t ha^{-1}, vermi compost @ 1t $ha^{-1}$and biofertilizers (*Azospirillum,* PSB and KSB @ 5 kg ha^{-1} each)were applied to organic plot. FYM applied as basal at the time of transplanting. Half quantity of vermi compost applied as basal and rest half quantity of vermi compost was applied at 30 days after planting. Bio fertilizers *viz.,Azospirillum,* PSB and KSB were mixed with 100 kg of well decomposed FYM and applied as basal. The recommendeddose of fertilizer (60-30-20 kg N-P_2O_5-K_2O ha^{-1}) was applied to inorganic plot. Entire P and K were applied as basal in the form of single super phosphate and muriats of potash, respectively. N was applied in two equal splits half as basal and half at 30 days after planting. Plant samples collected at flowering and at harvest and soil samples were collected afterharvest.Soil properties *viz.*, bulk density, water holding capacity, porosity, pH, EC, OC, available N, P, K, Fe, Mn, Zn, Cu, urease activity, dehydrogenase activity, acid and alkaline phosphorus activity, soil microbial population and plant nutrient content were estimated by using standard procedures (Tandon, 1973). The nutrient uptake was obtained from nutrient content and dry matter production. The quality parameters viz., protein content, total phenol and tannin content in grain were also estimated. The data collected on various growth characters, yield parameters and yield were subjected to statistical scrutiny by following paired t test with the method as outlined by Panse and Sukhatme (1985). Statistical significance was tested with 'p" value at 5 percent and 1 per cent level of probability by using SPSS-2.0.

RESULTS & DISCUSSION

Grain and straw yield

The data pertaining to yield (grain and straw) and yield attributing characters is presented in Table 1.It indicated that, during *Kharif* 2022, grain yield, straw yield and number of tillers have been significantly influenced by organic farming and chemical farming. Significantly the highest grain yield (31.62 q ha^{-1}a), straw yield (84.06 q ha^{-1}) and number of tillers/ plant (1.9) were recorded with chemical farming than organic farming. However during *rabi* 2022-23, no significant effect on grain yield, straw yield and other yield attributing characters was observed with organic and chemical farming. Numerically higher values had been noticed with chemical farming. In both *kharif* and *rabi* seasons, the benefit cost ratio was higher with chemical farming (2.53 and 1.77, respectively) than organic farming (1.41 and 1.18 respectively).Maximum number of tillers with chemical farming (100 % RDF) might be due to increase the availability of nutrients in soil as well as promoted the root growth and yield attributing characters. The present findings are in accordance with findings of Divya *et al.* (2017) and Gowthami *et al.,* (2022)

The highest grain yield was recorded with application of 100 % RDF might be attributed to better and instant supply of nutrients leading to better root activity and higher nutrient absorption, which resulted in more plant growth and superior yield attributes responsible for higher yield. The present findings are in accordance with findings of Abbasi and Yousra (2012) and Vajantha*et al*. (2017). The Increase in straw yield due to application of 100 % RDF might be due to addition of inorganic fertilizers which might have increased the uptake of plant nutrients to manufacture more quality of photosynthates resulting higher straw yield. The present findings were in accordance with findings of Patil *et al*. (2014).

Nutrient uptake by plant and grain

Nutrient uptake by plant at flowering and harvest was depicted in Table 2. The N, P and K uptake by plant at flowering was significantly influenced by organic and chemical farming. Significantly the highest N, P and K uptake (40.22, 10.37 and 28.60 kg ha^{-1} during *kharif*, 22, 36.40, 9.14 and 26.55 kg ha^{-1} during *rabi* 2022-23, respectively) has been recorded with chemical farming over organic farming.Significantly the highest nutrient uptake by plant was noticed in chemical farming due to increased N,P and K availability in the soil ascribed to synergistic effect between nitrogen and phosphorus might have supplied more of nitrogen to plant from soil resulting in higher production of dry matter leading to higher uptake of nutrients. These findings are in agreement with findings of Kejiya*et al*. (2019).

The nutrient uptake by grain in both seasons was not significantly affected by organic and chemical farming (Table 3). However numerically higher values recorded in chemical farming. It indicated that the nutrient uptake by grain with addition of organic manures is comparable to inorganicfertilizers.Sstatistically non significant,however numerically higher P, K, Fe and Zn uptake was recorded with application of chemical fertilizers than organic manures during both seasons. The higher nutrient uptake with inorganic fertilizers may be due to high nutrient in grain coupled with higher grain yield (Somasundaram *et al*, 2007).

Grain quality

Application of organic manures and bio-fertilizers play an important role in improving quality of grain (Table 4).Thus higher quantity of protein (8.76 and 7.97 %), total phenol (295 and 274 mg GAE/100g) and tannin content (914 and 751 mg CE/100g) were recorded with organic farming during both seasons respectively than chemical farming.This may be due to adequate quantity of organic matter available to microbes as food lead to increased microbial load in soil which secretes many growth promoting substances which accelerates the physiological processes which causes production of phenol and tannin content. The similar results are obtained by Kumar *et al.* (2018) and Patil *et al.* (2018).

Soil properties

An impact of organic farming and chemical farming on soil physical, physico-chemical and chemical properties was presented in Table 5. Water holding capacity, pore space, available N and K_2O were significantly affected by application or organic manures and chemical fertilizers.Significantly the highest available N (238 kg ha^{-1}), available K_2O (264 kg/ha^{-1}), WHC (43.77%) and pore space (46.52%) were noticed in organic farming plot than chemical farming (220 kg $ha^{-1}$of N, 243 kgha^{-1} of K_2O, 39.18% of WHC and 42.50% of pore space). Similar trend was observed in *rabi* 2022-23 also. It indicated that congenial physical properties have been observed in organic plot due to high organic matter content which enhances aggregate stability led to more water holding capacity. This are in confirmation with Kavitha *et al.,* (2020). One important observation noticed in this study, after 9 years of experimentation (from *kharif* 2013 to *rabi* 2022-23), the organic carbon had increased from 0.41% to 0.51% in organic farming and 0.41 to 0.48% in chemical farming. Build up of available nitrogen and phosphorus was observed by application of both organic farming and chemical farming (9.52% and 2.24% of available N, 18.01% and 5.59% of available phosphorus, respectively) when compared initial available nitrogen and phosphorus (Fig 1). The most likely cause is the mineralization of organic phosphates and the production of organic acids from microbial decomposition of organic materials and also due to application of biofertilizers *viz.*, PSB which solubilize native soil phosphates and organic amines resulting in a halt in P fixation in soil and improves phosphorus availability in soil. Further the study revealed that depletion of available potassium was noticed in both organic and chemical farming (-9.0 and 14.09%, respectively). The less depletion of potassium in organic farming plot might be due to application of organic manures reduces potassium fixation and KSB helps to solubilize potassium from potassium bearing minerals, thus availability of potassium more in organic farming plot than chemical farming plot. Regarding micronutrients, significant difference was recorded between organic farming and chemical farming.Significantly the highest DTPA extractable Fe, Mn, Zn and Cu were observed in organic farming (3.92, 24.18, 1.92 and 0.94 mg kg^{-1}, respectively) over chemical farming, (2.94, 16.45, 1.70 and 0.71 mg kg^{-1}, respectively) (Fig. 2) (Vajantha *et al*., 2010).

Data in table 6 showed that the impact of organic and chemical farming on soil biochemical properties at flowering and harvest. Higher urease, dehydrogenase, acid and alkaline phosphatase activity had been recorded in organic farming only at both the stages. This could be attributed to an increased microorganism population due to available substrate, consequently leading to the release of these extracellular enzymes. These findings align with the research conducted by Ramakrishnaiah

Among the stages, the enzymatic activity is more at flowering stage and decreased to harvest stage on both farming (Rajiv *et al.,* 2018).

Application of organic manures and chemical fertilizers significantly influenced the microbial population of bacteria and fungi (Table.6).Significantly maximum bacterial population (41 x 10^7 and 28 x 10^7CFU g^{-1} soil at flowering and harvest, respectively) and fungi population (26 x 10^4 and 20 x 10^4CFU g^{-1} soil at flowering and harvest, respectively) were noticed in organic farming than chemical farming (34 x 10^7 and 20 x 10^7 CFU g^{-1} soil bacteria at flowering and harvest, respectively and 20 x 10^4 and 14 x 10^4 CFU g^{-1} soil of fungi at flowering and harvesting respectively). Highest microbial population with organic farming proliferation and functioning of micro organisms organic manures has a significant impact on microbial activity when has a direct impact on the breakdown and mineralization organic manures resulting in higher humus content. The inclusion of organic manures in soil enhanced the production of root exudates in the rhizosphere region which contain organic acids sugars and amino acids etc. These root exudates have aided to proliferate microbes in the rhizosphere. These findings are in confirmation with Sedvi *et al.,* (2005) and Kuntoji *et al.*, (2022).

CONCLUSION

From this study it was concluded that after nine years of application of FYM @ 4 t ha^{-1} + vermicompost @ 1 t ha^{-1} + biofertilizers (Azospirillum, PSB and KSB @ 5 kg/ha^{-1} each mixed with 100 kg FYM and applied to soil as basal) gave comparable yield with 100% NPK (60-30-20 kg N-P_2O_5-K_2O/ha).More buildup of soil OC, available nitrogen and potassium was noticed with organic manures application.

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Table 1: Effect of organic and chemical farming on yield and yield characters in fingermillet.

Particulars	Organic farming	Chemical farming	t value	p value

***Kharif* 2022**				
Grain yield (q / ha)	30.15	31.62	6.67	0.000**
Straw yield (q / ha)	72.85	84.06	1.08	0.037*
Protein (%) in grain	8.76	7.97	1.34	0.174
Plant height (cm)	88	82	4.44	0.000**
No. of tillers / Plant	1.6	1.9	2.78	0.009**
Ear head length (cm)	10.98	10.52	3.72	0.095
No. of fingers/Earhead	10	11	2.11	0.056
B:C ratio	1.41:1	2.53:1		
***Rabi*2022-23**				
Grain yield (q / ha)	28.02	29.48	4.027	0.097
Straw yield (q / ha)	64.59	69.02	2.520	0.154*
Protein (%) in grain	7.42	7.38	0.984	0.091
Plant height (cm)	69	63	1.685	0.154
No. of tillers / Plant	1.4	1.4	3.147	0.762
Ear head length (cm)	8.24	8.81	5.12	0.324
No. of fingers/Earhead	7	9	4.85	0.552
B;C ratio	1.18	1.77		

** Significant at P = 0.01 level * Significantt at P = 0.05 level

Table 2: Effect of organic and chemical farming on nutrient uptake by fingermillet.

Particulars	Organic farming	Chemical farming	p value	t value	Organic farming	Chemical farming	p value	t value
	***Kharif* 2022**				*Rabi*, 2022-23			
At flowering								
N uptake (kg/ha)	34.86	40.22	0.03	3.56	31.78	36.40	0.04	5.021
P uptake (kg/ha)	8.53	10.37	0.02	1.96	7.95	9.14	0.03	0.975
K uptake (kg/ha)	24.82	28.60	0.04	2.21	21.85	26.55	0.45	0.997
Fe uptake (g/ha)	62	55	0.15	2.65	78	72	0.05	2.440
Zn uptake (g/ha)	40	36	0.52	1.62	51	47	0.24	2.314
At harvest								
N uptake (kg/ha)	81.84	78.12	0.345	1.466	79.52	80.47	0.087	4.067
P uptake (kg/ha)	25.60	22.88	0.10	2.98	23.85	20.65	0.26	3.805
K uptake (kg/ha)	60.78	64.32	0.08	2.99	51.26	55.84	0.10	0.758
Fe uptake (g/ha)	142	152	3.85	149	171	182	0.552	1.925
Zn uptake (g/ha)	91	96	5.81	85	86	94	0.14	3.012

* Significantt at P = 0.05 level

Table 3: Effect of organic and chemical farming on nutrient uptake by grain of fingermillet.

Particulars	Organic farming	Chemical farming	p value	t value
***Kharif*, 2022**				
N uptake (kg/ha)	27.42	28.06	0.510	1.064
P uptake (kg/ha)	6.88	8.01	0.241	0.914
K uptake (kg/ha)	18.65	20.38	0.086	3.014
Fe uptake (g/ha)	140	152	0.621	0.985
Zn uptake (g/ha)	51	48	0.123	1.562
***Rabi*2022-23**				
N uptake (kg/ha)	24.32	26.85	0.075	2.054
P uptake (kg/ha)	7.02	8.25	0.	
K uptake (kg/ha)	21.52	20.64	0.102	3.620
Fe uptake (g/ha)	152	160	0.421	2.017
Zn uptake (g/ha)	42	46	0.901	1.052

Table 4: **Effect of organic and chemical farming on biochemical characters in finger millet grain**.

Particulars	***Kharif* 2022**		***Rabi*2022-23**	
	Organic farming	Chemical farming	Organic farming	Chemical farming
Protein (%)	8.76	7.97	7.42	7.38
Total phenol content (mg GAE / 100g)	295	241	274	262
Tanin content (mg CE / 100 g)	914	902	751	726
*GAE – Gallic Acid Equivalent		*CE – Catechin Equivalent		

Table 5: Effect of organic and chemical farming and inorganic fertilizers on soil properties after harvest.

Particulars	Organic farming	Chemical farming	p value	t value	Organic farming	Chemical farming	p value	t value
***Kharif*, 2022**					***Rabi*2022-23**			
Soil pH	7.38	7.42	0.102	1.920	7.40	7.43	0.324	0.887
Soil EC(dS m^{-1})	0.324	0.351	0.198	1.345	0.340	0.392	0.124	0.485
Organic carbon	0.50	0.47	0.254	1.026	0.51	0.48	0.357	0.918s
Available N (kg ha^{-1})	238	220	0.041*	0.420	242	228	0.018	0.187
Available PO_5	35	31	0.098	2.431	38	34	0.064	20.004
Available K_2O (kg	264	243	0.033*	1.832	271	256	0.037	1.125
Bulk density (mg	1.38	1.41	0.452	0.752	1.37	1.40	0.516	0.782
WHC (%)	43.77	39,18	0.307	1.005	44.82	40.16	0.026	0.992

Pore space (%)	46.52	42.50	0.182	1.962	49.91	47.05	0.041	1.365

Table 6: Effect of organic f and chemical farming on soil enzymatic activity in finger millet.

Particulars	Organic farming	Chemical farming	p value	t value	Organic farming	Chemical farming	p value	t value
	At flowering				**At harvest**			
Urease (ug of NH_4^+ -N released/ g soil/ h)	59.12	54.50	0.041*	1.69	42.33	40.16	0.524	1.41
Dehydrogenase (ug of TPF /g soil/ day)	72.36	67.88	0.032*	2.01	54.90	50.94	0.037	0.98
Acid phosphatase (ug of p-nitrophenol released /g soil/ h)	50.82	46.18	0.124	0.98	33.84	30.44	0.061	2.58
Alkaline Phosphatase (ug of p-nitrophenol released /g soil/ h)	68.64	65.25	0.040*	1.88	39.40	30.85	0.04*	1.12
Bacteria cfu g^{-1} soil)	$41x10^7$	$34x10^7$	0.017*	3.021	$28x10^7$	$20 x10^7$	0.027	0.856
Fungi (cfu g^{-1} soil)	$26x10^4$	$21x10^4$	0.047*	2.155	$20x10^4$	$14 x10^4$	0.042	0.754

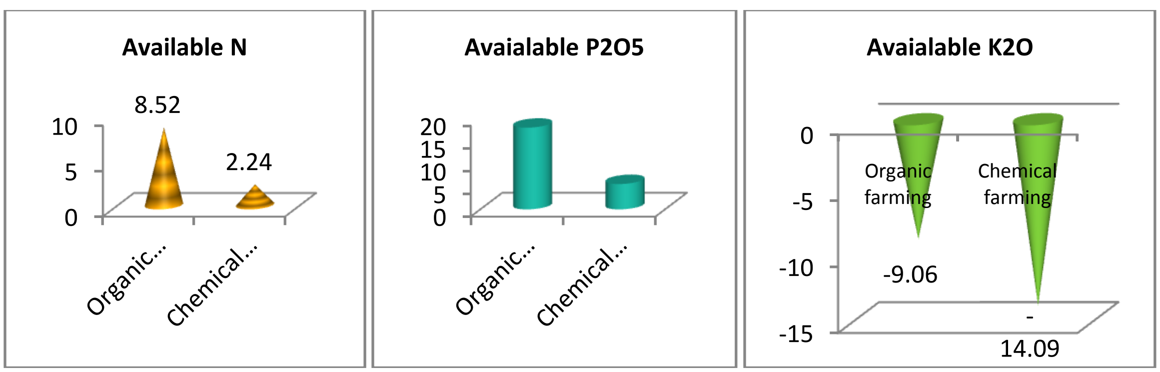

Fig 1: Percent buildup or depletion of available nutrients in soil during *Rabi* 2022-23.

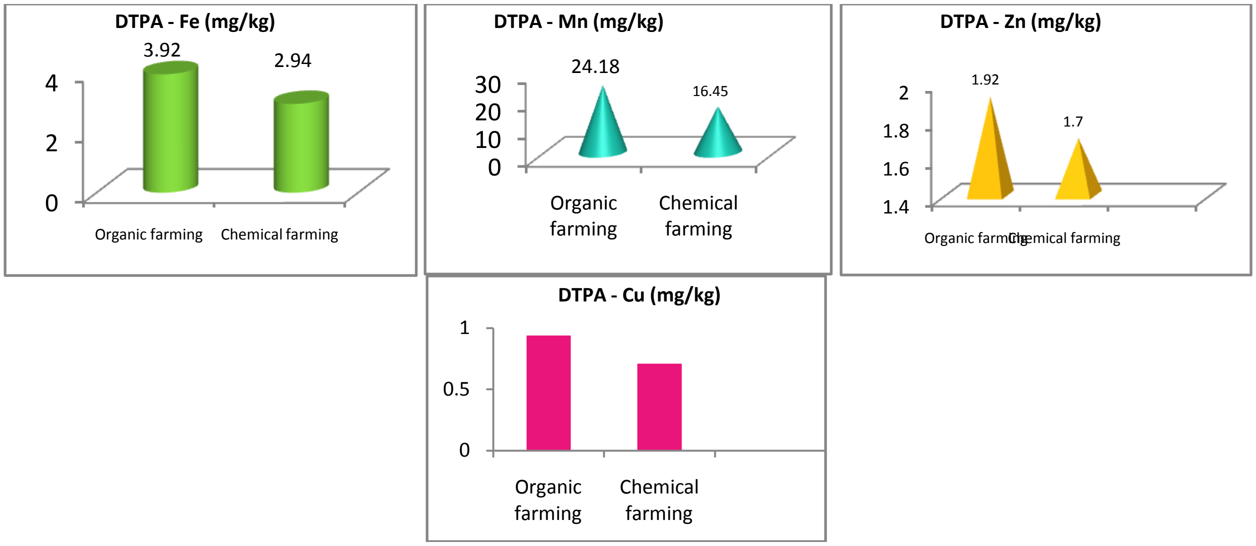

Fig 2: DTPA extractable micronutrients in soil after harvest during *Rabi* 2022-23.