Environment and Ecology 41 (2) : 852—856, April—June 2023
ISSN 0970-0420

Effect of Enriched FYM Levels and Fertilizer Levels on Yield, Soil Properties and Nutrient Availability in Soil after Harvest of *Hirsutum* Cotton Variety (*Gossypium hirsutum* L.)

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Received 25 November 2022, Accepted 9 February 2023, Published on 24 April 2023

ABSTRACT

A field experiment was conducted during *kharif*-2021 at Main Agricultural Research Station, Raichur, Karnataka to study the "Effect of enriched FYM levels and fertilizer levels on yield, soil properties and nutrient availability in soil after harvest of *Hirsutum* cotton variety (*Gossypium hirsutum* L.)". Among enriched FYM levels, application of 7.5 t ha^{-1} enriched FYM through spot application (M_3) recorded significantly higher seed cotton yield (2629 kg ha^{-1}), available N (203.63 kg ha^{-1}), P_2O_5 (34.81 kg ha^{-1}), K_2O (225.19 kg ha^{-1}), Zn (0.57 ppm) and Fe (4.12 ppm) in soil over rest other treatments. Among sub plot treatments, significantly higher seed cotton yield (2676 kg ha^{-1}), N (205.95 kg ha^{-1}), P_2O_5 (35.09 kg ha^{-1}), K_2O (226.55 kg ha^{-1}), Zn (0.58 ppm) and Fe availability (4.23 ppm) in soil were noticed at application of 150 % RDF (F_3) over remaining two other treatments i.e., 25% RDF and 100 % RDF.

Keywords Enriched FYM, *Hirsutum* variety, Nutrients availability, Soil properties, Yield.

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INTRODUCTION

Cotton (*Gossypium hirsutum* L.) the "white gold or the king of fibers" is one of the most important cash and commercial crop in India and world. Cotton plays an important role in Indian economy as the country's textile industry is predominantly cotton based. The Indian textile industry contributes to around 5% to country's gross domestic product (GDP), 14% to industrial production and 11% to total export earnings (Anon 2021). Globally, cotton was cultivated in about 31.97 million hectares area with annual production of 24.22 million MT with productivity of 759 kg lint ha^{-1} during 2020-21 (Anon 2021a). India is the largest producer of the cotton accounting for about 24.97% of the world's cotton production. It has the distinction of having the largest area of 13.48 million hectares under cotton and ranks first in production with 6.05 million MT. The productivity is about 462 kg lint ha^{-1}; which is however much below the world's average productivity of 759 kg lint ha^{-1} (Anon 2021a). It is mainly due to the fact that more than 65% of the cotton area is under rainfed condition, low fertilizer consumption and low fertilizer use efficiency. Among various production constraints, imbalanced and inadequate nutrition to cotton crop is considered to be one of the important factor.

No doubt, chemical fertilizers increased the productivity but due to high fertilizer cost, the profit margin per unit of input applied was low. Soil fertility is the primary limiting factor which influences production under intensive crop cultivation. After introduction of exhaustive high yielding varieties and hybrids in many crops including cotton, increased use of chemical fertilizers devoid of micro nutrients and inadequate application of organic manures due to its scarcity resulted in wide spread nutrient deficiency and nutrient imbalance which adversely affected cotton yields. Higher productivity of crops in sustainable manner without deteriorating the soil and other natural resources could be achieved only by applying appropriate combination of different organic manures and inorganic fertilizers.

The organic manures viz., farm yard manure (FYM), poultry manure (PM), vermicompost (VC) and compost besides improving soil physical and chemical properties but also serve as a source of N, P, K and micronutrients and also makes unavailable sources of nitrogen, bound phosphates and micronutrients as available due to their chelating nature. Numerous compounds including humic acid and fulvic acid and a variety of biological substances including organic acids, polyphenols, amino acids and polysaccharides of different organic materials form stable complexes with native soil nutrients and prevent them from precipitation, fixation and leaching. It also improves the efficiency of applied nutrients. Farm yard manure improves soil aeration and organic matter, thereby increasing the soil microbial population. Incorporation of farm yard manure was found to increase water holding capacity and decreases the bulk density, electrical conductivity and pH of the soil. It also decreases the penetration force and increased the hydraulic conductivity and the infiltration rate resulting in favorable soil condition for getting higher crop yields.

However, the insufficient availability of organics and most of the organics are bulky in nature, they have low nutrient content, labor intensive in terms of application and transport and difficulty in handling hinder their usage. It also takes long time to decompose, hence slowly releasing of nutrients. Therefore, it is necessary to make eco-friendly organic manure source marked with high nutrient content to be able to compete with mineral sources, with a low volume to minimize the extra cost of manpower and transportation. So, there is need to enrich organics with inorganics especially with micronutrients. The process of enrichment of organics with micronutrients has drawn attention as the enrichment not only improves the nutrient use efficiency but also helps in reducing the load of inorganic chemicals as well as quantity of organics to considerable extents. The enrichment technique improves the quality of organics in terms of nutrients and therefore the addition of enriched organics in lower quantities is expected to yield the similar results to that of use of organics in higher quantities (without enrichment). The enriched organics are expected to provide beneficial effect on plant growth for longer time.

MATERIALS AND METHODS

The experiment was laid out in split plot design and replicated thrice. There are twelve treatment combinations comprising of four levels of enriched FYM application (M_1-2.5 t ha^{-1} enriched FYM through spot application, M_2-5.0 t ha^{-1} enriched FYM through spot application, M_3-7.5 t ha^{-1} enriched FYM through spot application and M_4-10 t ha-^{1} normal FYM through broadcasting) and three levels of fertilizers (F_1-100 % RDF, F_2-125% RDF and F_3-150 % RDF). The enriched FYM levels were allotted to main plot and fertilizer levels were allotted to sub plot. The soil of experimental plot was *Vertisols* i.e., clayey in texture. The recommended dose of fertilizers was 80:40:40 kg NPK ha^{-1}. Half of nitrogen, entire dose of phosphorous and potassium in the form of urea, di ammonium phosphate (DAP) and muriate of potash (MOP), respectively were band placed as per treatments. Remaining half dose of nitrogen in the form of urea was top dressed in three equal splits at 50, 75 and 100 days after sowing. Variety BGDS-1063 was selected for study.

Note

Preparation of enriched FYM: Known quantity of FYM as per treatments requirement are enriched with micronutrients like Zn and Fe at the recommended dose of 15 kg $ZnSO_4$ and $FeSO_4$ each per 10 tonnes of FYM and the FYM were allowed to ferment for a month by frequently sprinkling of water and mixing the contents 2 to 3 times a day. The enriched FYM were applied at the time of sowing as per the treatments.

RESULTS AND DISCUSSION

Yield

Among various levels of enriched FYM application, application of 7.5 t ha^{-1} enriched FYM as spot method (M_3) resulted in significantly higher seed cotton yield (2629 kg ha^{-1}) over 5.0 t ha^{-1} enriched FYM as spot application (M_2) (2390 kg ha^{-1}) and 10 t ha^{-1} normal FYM application as broadcasting (M_4) (2208 kg ha^{-1}). Application of 2.5 t ha^{-1} enriched FYM as spot method (M_1) recorded lower seed cotton yield (2072 kg ha^{-1}). Significantly higher seed cotton yield was recorded at application of higher quantities of enriched FYM over lower levels was mainly due to increase in yield attributing characters viz., total number of bolls, good opened bolls, boll weight and seed cotton yield per plant which could be due to continuous supply of organically chelated iron and zinc, apart from available NPK nutrients to the crop.

Among various levels of NPK, 150 % RDF (F_3) recorded higher seed cotton yield (2676 kg ha^{-1}) over 125% (F_2) (2312 kg ha^{-1}) and 100 % RDF (F_1) (1987 kg ha^{-1}). These results are in orthodoxy with those of Hosamani *et al.* (2013) Solanke *et al*. (2000) and Ram and Giri (2006) due to higher levels of RDF.

Soil physico-chemical properties viz., soil reaction, electrical conductivity and organic carbon differ significantly with various levels of enriched FYM application and the data was presented in Table 1.

pH

Among various main plot treatments, application of higher quantities of FYM i.e., 10 t ha^{-1} normal FYM as broadcasting (M_4) resulted in lower pH (8.01) than lower levels of FYM application after harvest of cotton crop. This is due to the fact that application of higher quantities of organic manures and their decomposition might have resulted in higher production of carbon dioxide and release of organic acids which might reflected in reduced the soil pH (Meena and Rathode 2006). This may be explained partially by circumstantial evidence that FYM may contain humic acid, growth hormones and high microbial population resulted into increased CO_2 concentration in soil arising from microbial activity and decomposition of native organic matter. The CO_2 in contact with water forms carbonic acid, which reacts with native $CaCO_3$ of soil to bring Ca in soil solution and Ca promotes the release of Na held on exchange complex which reduces pH. Earlier workers Santhosh *et al*. (2017) also reported similar results. Higher soil pH was resulted at application of 2.5 t ha^{-1} enriched FYM as spot method (M_1) (8.23) i.e., higher soil pH was recorded at lower levels of FYM application. None of sub-plot treatments were found significant with respect to soil pH.

EC

Electrical conductivity of soil is lower at application of 10 t ha^{-1} normal FYM as broadcasting (M_4) (0.26 dS m^{-1}) and found on par with 7.5 t ha^{-1} enriched FYM application as spot method (M_3) (0.26 dS m^{-1}). This is due to organic acids released while decomposition of FYM decreased soluble salt concentration in soil and there by lowering the EC of soil. None of sub-plot treatments were found significant with respect to soil EC.

Organic carbon (OC)

Higher organic carbon content was noticed at appli-

Table 1. Effect of FYM levels and fertilizer levels on soil reaction (pH), electrical conductivity (EC) and organic carbon (OC) in soil of *Hirsutum* cotton variety.

Treatment	Seed cotton yield (kg ha^{-1})	pH (1:2.5)	EC (dS m^{-1})	OC (%)
Initial values		**8.30**	**0.38**	**0.63**
Main plot (M): Manure levels				
M_1-2.5 t ha^{-1} enriched FYM through spot application	2072	8.23	0.34	0.66
M_2-5.0 t ha^{-1} enriched FYM through spot application	2390	8.13	0.31	0.70
M_3-7.5 t ha^{-1} enriched FYM through spot application	2629	8.05	0.26	0.73
M_4-10.0 t ha^{-1} FYM through broadcasting	2208	8.01	0.26	0.73
SEm±	**44**	**0.03**	**0.01**	**0.01**
CD at 5%	**153**	**0.09**	**0.04**	**0.04**
Sub plot (F): Fertilizer levels				
F_1-80:40:40 kg NPK ha^{-1}	1987	8.05	0.29	0.70
F_2-100:50:50 kg NPK ha^{-1}	2312	8.12	0.29	0.71
F_3-120:60:60 kg NPK ha^{-1}	2676	8.15	0.31	0.72
SEm±	**48**	**0.04**	**0.01**	**0.01**
CD at 5%	**143**	**NS**	**NS**	**NS**

cation of 10 t ha^{-1} normal FYM as broadcasting (M_4) (0.73 %) and found on par with application of 7.5 t ha^{-1} enriched FYM as spot method (M_3) (0.73 %). Lower amount of organic carbon content was found at application of 2.5 t ha^{-1} enriched FYM application as spot method (M_1) (0.66 %). Organic carbon content in the soil increased after harvest of the cotton due to the direct addition of organic matter through FYM. The reason for increase of carbon might be due to the application of large quantity of manures which provided sufficient quantity of carbonaceous materials for decomposition by microorganisms and converting them to mineralized organic colloids, besides adding them to soil reserves (Veeranagappa *et al.* 2011). None of sub-plot treatments were found significant with respect to soil organic carbon.

Availability of nutrients in soil

The availability of various nutrients differed significantly with various levels of enriched FYM and fertilizer levels and the data was presented in Table 2.

Among main plot treatments, application of 7.5 t ha^{-1} enriched FYM through spot application recorded significantly higher N (203.63 kg ha^{-1}), P_2O_5 (34.81 kg ha^{-1}), K_2O (225.19 kg ha^{-1}), Zn (0.57 ppm) and Fe availability (4.12 ppm) over rest other treatments. Higher available N, P, K, Zn and Fe content in soil after harvest of the crop was recorded with the application of zinc and iron enriched FYM. It may be attributed due to the application of enriched organics which resulted in the faster multiplication of soil microbes which could convert organically bound N to inorganic form of nitrogen, reduction of ferric phosphate present in the soil, release of occluded phosphate and phosphate adsorbed on amorphous iron and manganese oxides. The increase in phosphorus status of soil in enriched plots probably due to the formation of organic-Zn complexes preventing Zn from reacting with soil available P. Increase in the available potassium status of soil was due to application of enriched organic materials which might have ascribed to greater capacity of organic colloids to hold the nutrients at the exchange site and also reduction of potassium fixation and release of potassium to the available pool of soil. The zinc enriched organic manurial treatments were found to be better than the soil application of organic manures alone treatments in increasing the Zn content of soil. This was due to enrichment of organic manure with zinc which might have supplied additional Zn to crop growth. The DTPA extractable iron status of soil increased significantly due to application of iron enriched FYM. This may be due to the stable water soluble complexes formed by the organic manures prevent the reaction of

Table 2. Effect of FYM levels and fertilizer levels on available N (kg ha-¹), available P_2O_5 (kg ha-¹), available K_2O (kg ha-¹), available Fe (ppm) and available Zn (ppm) after harvest of *Hirsutum* cotton variety.

Treatment	Available N (kg ha^{-1})	Available P_2O_5 (kg ha^{-1})	Available K_2O (kg ha^{-1})	Available Fe (ppm)	Available Zn (ppm)
Initial values	**240.6**	**26.9**	**258.90**	**3.60**	**0.52**
Main plot (M): Manure levels					
M_1-2.5 t ha^{-1} enriched FYM through spot application	191.33	31.24	211.07	3.42	0.50
M_2-5.0 t ha^{-1} enriched FYM through spot application	197.70	32.88	219.00	3.74	0.54
M_3-7.5 t ha^{-1} enriched FYM through spot application	203.63	34.81	225.19	4.12	0.57
M_4-10.0 t ha^{-1} FYM through broadcasting	193.82	31.83	214.89	3.61	0.51
SEm±	**1.88**	**0.33**	**1.99**	**0.04**	**0.01**
CD at 5%	**6.49**	**1.13**	**6.90**	**0.13**	**0.02**
Sub plot (F): Fertilizer levels					
F_1-80:40:40 kg NPK ha^{-1}	186.36	30.02	208.10	3.13	0.49
F_2-100:50:50 kg NPK ha^{-1}	197.56	32.96	217.97	3.81	0.53
F_3-120:60:60 kg NPK ha^{-1}	205.95	35.09	226.55	4.23	0.58
SEm±	**2.76**	**0.50**	**2.00**	**0.06**	**0.01**
CD at 5%	**8.27**	**1.51**	**6.01**	**0.17**	**0.02**

Fe with soil constitution. The enriched organics has beneficial effects in mobilizing the native nutrients to increase their availability. Similar findings were also reported by Meena *et al*. (2008), Shilpa (2011), Veeranagappa *et al*. (2011) and Meena *et al.* (2017).

Among sub plot treatments, application of 150 % recorded significantly higher N (205.95 kg ha^{-1}), P_2O_5 (35.09 kg ha^{-1}), K_2O (226.55 kg ha^{-1}), Zn (0.58 ppm) and Fe availability (4.23 ppm) over rest other treatments. Availability of nutrients increases with increasing the level of fertilization i.e., from 100% to 150% . Similar results were obtained by Thimmareddy *et al.* (2013) and they stated that increase in availability of NPK at harvest (kg ha^{-1}) with increasing levels of NPK.

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