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Influence of organic manure enrichment on growth and yield of crops and soil properties: A review

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Abstract
In intensive agriculture, uses of high analyze inorganic fertilizers, little or scarce use of FYM and considerable reduction in recycling of crop residues resulted in deficiencies of nutrients in soil. Consequently, the deficiencies of macro and micro-nutrients in soil have become major constraint for maintaining soil productivity. Wide spread of these micronutrients deficiencies particularly Fe and Zn has been observed in India soils. Use of enriched FYM is one of the methods to decrease the nutrient losses. For better growth crop requires more nutrients to improve the yield components. Enriching FYM with inorganic fertilizers and PGPR boost crop grain yield, and harvest index significantly through improving the physico-chemical properties of the soil and sustain its productivity over years. The nutrient enriched organic manures being cheaper and eco-friendly and could be used as an alternative of chemical fertilizers for improving crop productivity and sustainability of the system. However, profitability of this technology needs to be tested at different locations and in different seasons in the different part of India.

Keywords: enriched FYM, PGPR, Soil fertility and micronutrient.

Introduction
During the era of Green Revolution, introduction of high-yielding varieties, extension of irrigated areas, use of high analysis NPK fertilizers and increase in cropping intensity, boosted the production in most of cases, propelled India towards self-sufficiency in food production. In the process, relative contribution of organic manures as a source of plant nutrients *vis-a-vis* chemical fertilizers declined substantially (Gohil *et al.* 2016) [16]. One way of replenishing nutrients in the arable lands is to recycle nutrients through application of organic material such as litter, crop residues, and manures. Organic manures, especially farmyard manure, have a significant role for maintaining and improving the chemical, physical and biological properties of soils. Organic materials play a critical role in sustainability in the arid and semi-arid regions. Despite this importance, there is little predictive understanding for the management of organic inputs in arid and semi-arid agro ecosystems.

It is now widely recognized that soil organic matter plays an important role in soil chemical (pH, base saturation, salinity and CEC changes) physical (bulk density, stabilization of soil structure and aggregate formation) properties and biological properties. Farm yard manure prepared from cattle manure is the most important organic soil amendment utilized in India. Organic amendments, such as FYM are known to improve soil physical properties. Organic matter is an important soil constituent influencing a number of constraints linked with crop productivity. The loss of soil fertility, in many developing countries, due to continuous nutrient depletion by crops without adequate replenishment poses an immediate threat to food and environmental security. Intensive cropping and tillage system have led to substantial decreases in soil organic matter levels of much prime land in the world. This decrease in soil organic matter levels seems to be associated with the decline in soil productivity. Hence, the application of FYM is essential for maintaining soil fertility. Use of enriched FYM is one of the methods to decrease the nutrient losses (Aswini *et al.* 2015).

The aim of enrichment of organic manures is to minimize excess use of fertilizers for optimum yield and quality of crops without harming soil and environment health by the application of PGPR and plant nutrient enriched FYM.

Farm Yard Manure

The term FYM refers to the decomposed mixture of dung and urine of farm animals along with the litter and left over material from roughages or fodder fed to cattle. FYM collected from dairy / cattle shed consists mainly of dung and part of the urine soaked in the refuses.

Table: Nutritional status of FYM (%)

Nitrogen	0.5000
Phosphorus	0.2500
Potassium	0.4000
Calcium	0.0800
Sulfur	0.0200
Zinc	0.0040
Copper	0.0003
Manganese	0.0070
Iron	0.4500

Enriched FYM

FYM is enriched by the addition of chemical preservative, which helpful to reduce the nitrogen losses. The preservatives are applied in the cattle shed to permit direct contact with the liquid portion of excreta or urine, as loss of N from urine starts immediately. The commonly used preservatives are Gypsum and Superphosphate. Ammonium carbonate is the immediate product of decomposition of urea in urine, which reacts with Gypsum. The resultant outcome of the reaction is ammonium carbonate is changed in to Ammonium sulphate which is a stable salt. The reaction is as under:

$(NH_4)_2\ CO_3 + CaSO_4 \rightarrow CaCO_3 + (NH_4)_2\ SO_4$

Ammonium Carbonate Gypsum Calcium Carbonate Ammonium Sulphate

Super phosphate has been extensively used as a manure preservative, since superphosphate contain 50 – 60 % Gypsum (Calcium Sulphate) besides monocalcium phosphate. The action of SSP is similar to that of Gypsum. In Indian conditions due to high temperature FYM becomes dry, the use of SSP could be safely recommended.

Enrichment with micronutrients and PGPR

The known quantity of FYM was filled in four pits. The solution of $ZnSO_4.7H_2O$ was prepared on the basis of 2.5 and 5.0 kg Zn ha^{-1} (according to soil test) and thoroughly mixed in respective pits of known quantity of FYM as required of one hectare of soil. After 21 days, a composite microbial culture consisting of PGPR consortium (*Azospirillum brasiliense, Pseudomonas fluorescens, Pseudomonas aeruginosa, Bacillus subtilis, Paenibacillus polymyxa, Trichoderma harzianum*) was added and thoroughly mixed to ensure complete contact with the decomposing materials (FYM). PGPR consortium was added after 21 days of initial composting to protect the microbes from direct exposure to excess heat generated from the materials. The moisture percentage of organic manures after mixing with $ZnSO_4.7H_2O$ and PGPR was maintained around 60% throughout enrichment process. The cattle dung slurry @ 1% was applied as starter inoculums of microorganism to boost up the microbiological activities for enhancement of natural process of composting to fix the externally added Zn through zinc sulphate. The pits were covered by polythene sheet and allowed to decompose. The mixture was turned over weekly and also maintained moisture (Regar and Yadav, 2017) [11].

Effect of Enriched Organic Manure on Crop Growth and Yield

Debele *et al.*, (2000) [5] found that application of enriched FYM either 4 or 8 t ha^{-1} significantly improved the grain yield of maize by 32.6 and 22.4 per cent over the respective levels of conventional FYM.

Basavaraj and Manjunthaiah (2003) [3] found that the combined application of P-enriched organic manure at 100 percent RDF-P had significant effect on grain yield of maize, which accounted 27.50 per cent increase in yield over control.

Field experiment was conducted during r*abi* season of 2009-10 on an established plantation from 2006 at Agroforestry Research Centre, Haldi, G. B. Pant University of Agriculture and Technology, Pantnagar to evaluate the suitable sources of phosphorus nutrition on the yield of understorey wheat crop by Chaturvedi *et al.*, (2011) [4]. Rock phosphate (RP) enriched with FYM + PSB had significantly highest wheat yield among all the treatments however, it was statistically at par with RP + PM + PSB. Rock phosphate (RP) enriched with FYM + PSB had recorded 16.49 % higher yield over SSP alone. Yield attributes like number of spikes, number grains per spike, 100 grain weight were found maximum with RP + FYM + PSB being statistically at par with all enriched treatments except RP alone and RP+ FYM.

Application of compost enriched with N and LTRP in the presence of 50% supplementary dose of N fertilizer significantly increased the fresh biomass (11.8%), cob weight (12.6%) and grain yield (13.6%) compared to full dose of N fertilizer. Similarly, application of enriched compost plus 50% N had significant increasing effect on root weight (15.7% more than the full dose of N fertilizer) of maize plants. In general, N plus L-TRP enriched compost gave better performance than the application of N enriched compost **(**Ahmad *et al.* 2007) [1].

At Anand (Gujarat) application of Zn and Fe enriched FYM improved average mustard seed yield by 20 per cent over control whereas it was 11 per cent over straight Zn and Fe application. The Zn and Fe enriched FYM enhanced uptake of N, S and micronutrients by mustard, and improved oil and protein content of mustard seed. The yield of subsequent sorghum (fodder) increased by 11 per cent due to residual effect of FYM over control (Meena *et al.* 2008) [9].

A significant increase in grain and straw yield was noticed in the treatments which received Zn-E compost at 15 kg ha^{-1} (54.06 and 78.01 q ha^{-1}) and 10 kg ha^{-1} (53.96 and 78.90 q ha^{-1}) it was on par with package of practice (55.80 and 79.17 q ha^{-1} by Veeranagappa *et al.*, (2010) [15].

A field study conducted to find out the effect of zinc-enriched organic manures. The treatments were NPK alone, NPK +200 kg FYM without enrichment, NPK + 200 kg FYM enriched with different levels of Zn (1.25 kg, 2.50 kg and 5.0 kg Zn ha^{-1}), NPK + cow dung without enrichment, NPK + 200 kg cow dung enriched with different levels of Zn. The result of the field experiment revealed that recommended dose of NPK +200 kg FYM enriched with 5.0 kg zinc increased the grain (5430 kg ha^{-1}) and straw (7075 kg ha^{-1}) yields which was due to increased availability of zinc in soil (Sridevi *et al.* 2010) [13].

A pot study was conducted in Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad, Pakistan during 2010 to compare Zn enriched farm yard manure (FYM) with chelated (Zn-EDTA) and non chelated (zinc sulphate, $ZnSO_4$) Zn sources for optimum grain yield and higher Zn concentration in grains of rice (cv. Shaheen Basmati) grown in a salt-affected soil. Treatments

comprised of 1.5, 3 or 6 mg Zn kg^{-1} soil in the form of both $ZnSO_4$ and Zn-EDTA, and Zn-enriched farm yard manure 5% of soil (w/w). Zn enrichment was done with same three levels of Zn using $ZnSO_4$. Application of Zn increased plant growth, grain yield and Zn concentration in various tissues, irrespective of the Zn source. The increase in plant growth and Zn concentration was higher when plants were grown with Zn enriched FYM compared to $ZnSO_4$ or Zn-EDTA application alone. The maximum Zn concentration in rice grains (13.9 mg kg^{-1}) and straw (19.1 mg kg^{-1}) were obtained with the same treatment. It was concluded that application of $ZnSO_4$ enriched FYM proved better over application of alone $ZnSO_4$ or Zn-EDTA indicating the positive role of organic matter in increasing grain yield and grain Zn concentration on soils affected with salts and depleted in organic matter (Ahmad *et al.* 2012).

Mali *et al.*, (2015) observed that the maximum plant height (206.73 cm), dry matter (164.67 g plant), average cob length (16.87 cm), no. of grains cob (391.00 grain cob), cob weight (134.67 g) and test weight (197.0 g) were recorded under application of 25% RDP through PRC + vermiculture + PSB + 75% RDP through DAP. The maximum grain yield (3.93 t ha), stover yield (5.74 t ha), net return (38337 Rs ha) and B:C ratio (2.19) were recorded under application of 25% RDP through PRC + vermiculture + PSB + 75% RDP through DAP and lowest grain yield (1.89 t ha), stover yield (3.14 t ha), net return (14611 Rs ha) and B:C ratio (1.14) were noted in control where phosphorus rich compost was not applied. Maximum yield response (107.5%) was recorded with 25% RDP through PRC + vermiculture + PSB + 75% RDP through DAP followed by 25% RDP through PRC + PSB + 75% RDP through DAP (95.7%).

A Field experiment to assess the effect of enriched farm yard manure (FYM) and fertilizer levels on growth and yield components of aerobic rice was carried out at university of Agricultural and Horticultural Sciences, Shivamogga during kharif, 2013 by Ashwani *et al.*, (2016). Among the methods of application, spot application of enriched manure recorded significantly higher 1000 grain weight (24.24 g) and grain yield (54.03 q ha^{-1}) due to timely available of nutrients. Interaction of spot application of enriched manure with 125:62.5:62.5 kg NPK ha^{-1} has registered higher grain yield (60.58 q ha^{-1}) and filled grains $panicle^{-1}$ (128.75). While, higher 1000 grain weight (25.80 g) was recorded in spot application of enriched manure with 100:50:50 NPK kg ha^{-1}.

An experiment was conducted in three *rabi* seasons from 2010-11 to 2012-13 at Center for Research on Seed Spices, S. D. Agricultural University, Jagudan to find out the effect of Fe and Zn enriched with farm yard manure on growth and yield, quality and uptake of nutrients for cumin. Enrichment of Fe or Zn or both with FYM (T_8, T_7 and T_6) increased not only seed yield but net income and BCR also. Combine application of Fe and Zn found better than alone application of Fe or Zn. Moreover, enrichment of Fe and Zn with FYM not only reduced the 50 per cent requirement of micronutrient but increased the yield (577 kg ha^{-1}) considerably also. An application of RDF along with 1.0 t FYM enriched with 1.5 kg Fe and 0.75 kg Zn ha^{-1} (T_8) registered significantly higher uptake of Fe (64.70 g ha^{-1}) and Zn (24.60 g ha^{-1}) by seed (Patel *et al.* 2016).

Regar and Yadav (2017) [11] found that application of PGPR and Zn @ 5.0 kg ha^{-1} enriched FYM along with 60 kg P_2O_5 ha^{-1} resulted in markedly higher plant height (109.07 cm), grain yield (59.62 q ha^{-1}), straw yield (79.94 q ha^{-1}) and biological yield (139.56 q ha^{-1}) but showed at par result with PGPR and Zn @ 2.5 kg ha^{-1} enriched FYM applied in conjunction with 40 kg P_2O_5 ha^{-1}. The aim of this experiment was to minimize excess use of fertilizers for optimum yield and quality of rice without harming soil and environment health by the application of PGPR and Zinc enriched FYM.

Effect of Enriched Organic Manure on Soil properties

Improvement in the nutrient uptake with the use of enriched FYM either alone or in conjunction with fertilizer was observed by Debele *et al.*, (2000) [5]. Soil organic carbon declined while there was marginal increase in available N due to enriched FYM.

Kumar *et al.*, (2004) found that incorporation of farmyard manure at 12.5 t ha^{-1} along with Zn solubilizing bacteria stood superior by registering highest values for available of N, P and K content in the soil. The DTPA - Zn content of the soil though evidenced significant variation for the application of FYM, FYM + ZSB, Zn + Fe on an overall basis the actual values did not exceed the deficiency level.

Ahmad *et al.*, (2007) [1] reported significant improvement in N, P and K contents of maize plant in response to application of N and L-TRP enriched compost supplemented with 50% N fertilizer. Maximum increases (10.1% N, 11.9% P and 7.5% K) were found in response to combined application of enriched compost and N fertilizer compared to sole application of full dose of N fertilizer. The effect of N enriched (without L-TRP) compost plus 50% N was statistically similar to that observed in case of full dose of N fertilizer alone.

Nitrogen, phosphorus, potassium and Zinc uptake significantly differed among the treatments. Recommended NPK + 200 kg FYM enriched either with 5.0 kg Zn ha-1 or 2.5 kg Zn ha-1 was superior in recording higher nitrogen uptake than control, but on par with each other treatments and showed statistical parlance among themselves (Sridevi *et al.* 2010) [13].

Different rock phosphate enriched treatments had non-significant effect on soil properties after cop harvesting, however, Organic carbon, Available N, P and K were found to be higher under tree as compared to control. The tree mean diameter (cm $tree^{-1}$) at standard (1.37m) breast height was maximum under RP + FYM followed by SSP alone. However, Height was highest in RP+FYM+PSB followed by RP + Pressmud (Chaturvedi *et al.* 2011) [4].

A slight improvement in soil pH, electrical conductivity and organic carbon content noticed higher values in NPK + zinc enriched levels followed by package of practice. The application of Zn-E compost increased the amount of zinc present in different fractions. Increase in amount of zinc present in different zinc fractions might be due to the higher solubility and mobility of the added zinc source. Water soluble plus exchangeable fractions significantly increased with the enrichment of compost (Veeranagappa *et al.* 2011) [15].

The availability of all the three major nutrients has conspicuously improved for the different treatments. Incorporation of farmyard manure@12.5 t ha^{-1} along with Zn solubilizing bacteria stood 84 Effect of Zn enriched organic manures and zinc solubilizer application on yield, curcumin content of turmeric superior to FYM alone and control treatment by registering the highest values for availability of N, P and K content in the soil. As compared to control, *per se* addition of FYM also exerted positive effect on the major nutrients availability, which was quite natural since it has been well established that bulky organic manures play a vital

role in improving the major nutrient availability by direct contribution as well as indirectly by influencing chemical transformation reactions and microbial activity. The Zn solubilizing organism (*Bacillus* sp.) proved to have a favourable effect on the availability of N, P and K, thereby indicating the vital role of these organisms in the transformation reaction of these three nutrients in the soil. The DTPA - Zn content of the soil though evidenced significant variation for the application of FYM, FYM + ZSB, Zn + Fe on an overall basis the actual values did not exceed the deficiency level. However at 90 DAS and 120 DAS the treatments receiving ZnSO4 as such and also as Zn fortified FYM / coirpith reached the level of sufficiency (Regar and Yadav, 2017) [11].

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