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Review on vermicompost, poultry manure, farmyard manure, biogas digest, biochar, urban compost and biofertilizers as potential alternate nutrient sourcesf for sustainable agriculture

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Abstract
Organic sources of nutrients like vermicompost, poultry manure, farmyard manure, biogas digest, biochar, urban compost are rich sources of macro & micro nutrients, vitamins and other growth promoting substances. The activity of soil microflora increases tremendously with the application of organic manures to soil. Several investigations reveal that organic manures can substitute 25-30 per cent of the recommended doses of inorganic fertilizers in crop production. The integrated use of all available sources of nutrients increases the soil health, yield and quality of crop produce. Use of organic manures as nutrient sources with possible substitutions through INM decreases the cost of inorganic fertilizers. These organic manures are also playing greater role in organic farming. Organic manures improve soil quality by increasing the soil carbon content. Integrated use of these organic source of nutrients along with inorganic sources increases the crop yields 15-30 per cent.

Keywords: Organic manures, composts and crop production

Introduction

Sustainable agriculture is dependent on good nutrient management practices. Intensive cultivation and imbalanced fertilizer use have lead to multiple nutrient deficiencies in Indian soils. As a result, yields of various crops have reached a plateau or are on the decline. Presently in India farmers are practicing several nutrient management practices, however, the best nutrient management practice is integration of all available nutrient sources. In India it has been estimated that all animal excreta can potentially supply 17.77 million tonnes of plant nutrients. Annually most of the metropolitan cities of India are generating about 150 million tonnes of city refuse that have nutrient potential of about 1.72 million tonnes of N,P and K (Singh and Subba Rao 2009) [32]. It is widely recognized that neither use of organic manures alone nor chemical fertilizers can achieve the yield sustainability under the modern intensive farming. Therefore, it is necessary to use organic manures in conjunction with fertilizers to meet nutrient requirement and obtain optimum yields. Recycling of organic wastes is not only ecological necessity but in a country like India, it is a compulsion since India produces about 7000 metric tons of organic waste annually (Sharma *et al.*, 2004) [27].

Vermicompost

Organic manures produced due to activity of earthworms is commonly referred to as vermicompost. It is a rich source of macro and micronutrients, vitamins, growth hormones and microflora (Bhavalkar, 1991) [6]. Vermicompost produced from different organic residues can supply 30 per cent of the total crop requirement as it is a potential source of readily available nutrients for plant growth (Curry and Byrne, 1992) [8]. According to Shinde *et al*. (1992) [29], the contents of DTPA extractable micronutrients in vermicompost were 17.8 mg Fe, 24.6 mg Mn, 19.2 mg Zn and 7.6 mg kg^{-1} Cu. Jambhelkar (1994) [14] reported that vermicompost contained 2.0 to 2.5 per cent nitrogen, 1.0 to 1.5 per cent phosphorus and 1.0 to1.5 per cent potassium and also secondary and micronutrients *viz*., Ca, Mg, Fe, Cu, Zn and Mo in ample quantities. It also contained enzymes like phosphatases, Invertase, chitinase etc., and also growth hormones like indole acetic acid and gibberellic acid. Microbial analysis confirm that vermicompost is rich in beneficial Microbes *viz*., bacteria like *Azatobactor*, *Azospirillum* and *Actinomycetes* etc.

According to Ghosh and Sarkar (2000) [11], the vermicompost developed from animal and agricultural waste had higher nutrient and microbial population. In general one tonne of compost could supply 15 kg nitrogen, 8 kg phosphorus and 10 kg potash which can substitute chemical fertilizer to some extent. They did not report micronutrient deficiencies in vermicompost treated soil. Also there was an increase in yield by 11.1 per cent with mature compost and 11.7 per cent with fresh compost when compared to fertilizer applied plots. Reddy and Reddy (1998) [24] from their studies on vermicompost reported that there was 1.98 per cent N, 1.23 per cent P, 1.59 per cent K, along with micro nutrients *viz*., 132.0 mg Zn, 70.5 mg Cu, 1440.2 mg Fe and 317.5 mg Mn. The total N, P and K content of different vermicompost generated in Hyderabad city had 1.02, 0.58 and 0.45 per cent NPK respectively (Gayathri, 1997) [10]. The micronutrients content was 3500 ppm Fe, 125 ppm Zn, 181 ppm Mn and 16 ppm Cu.

Vasanthi *et al.* (1995) [36] reported that the application of vermicompost along with inorganic fertilizers increased the organic carbon content and available nitrogen of soil by 87.7 and 42.9 per cent, respectively. According to Bangar and Jatgar (1995) [2], there was significant increase in organic carbon by 17.8 per cent, available nitrogen by 20.9 per cent, available phosphorus by 6.82 per cent and available potassium by 15.93 per cent through vermicomposting. Basker *et al*. (1994) [3] reported that the casts of earthworm contained two to three times more available P and K than surrounding soil. The availability of K enhanced significantly following soil ingestion by earthworm casts and this could be due to the changes in distribution of K between non exchangeable to exchangeable form.

Aldag and Greffi (1975) [1] reported that increased NH_4^+ concentration in the casts resulted from passage of the ingested soil and organic material through the gut and ejection as casts. This NH_4^+ whose geometry is similar to that of K^+ easily fits in the wedge zones of the clay lattice, thus releasing K^+ ions from the clay structure. The average quantity of urease (528.9 μg urea g^{-1} dry compost h^{-1}), cellulase (1249.7 μg glucose g^{-1} dry compost h^{-1}), acid (1705.0 μg PNP g^{-1} dry compost h^{-1}) and alkaline phosphatase (3231.8 μg PNP g^{-1} dry compost h^{-1}) were significantly higher compared to compost prepared by conventional method. The increase in urease activity due to earthworm inoculation was due to the increased biomass of earthworm and microbes (Zachariah and Chhonkar, 2004) [37]. Mulongoy and Bedoret (1988) [16] reported that the worm cast possessed high enzyme activities due to the presence of higher amount of humic acid and fulvic acid and higher HA: FA ratios. The earthworm activity accelerated the humification process.

Singh and Ganguly (2005) [30] reported that the nutrient content in vermicompost is highly variable from sample to sample detected in several studies. This could probably be due to the variations in raw material used and the climatic conditions, the type, time of composting and moisture content at the time of application.

Singh *et al*. (2018) [31] reported that vermicompost materials having 1.45% nitrogen, 0.46 % phosphorus, 0.55 % potassium, 0.39 % Sulphur and 1.32 ppm Boron.

Poultry manure

Poultry manure is one of the potential organic source of nutrients. Poultry production is one of the fastest growing enterprise @ 5-20% among the animal husbandry activities world wide. It is estimated that about 500 million chicken population is reared in India and poultry manure of 3.8 Mt is obtained annually. Andhra Pradesh is also a prominent state in poultry industry having 3.18 million fowl, 0.51 million ducks (IPI year book, 1990) [13]. Garg *et al.* (1971) [9] estimated that about one tonne of poultry manure is generated through the excreta of 40-50 birds per year, this manure provide 0.30 Mt N, 0.26 Mt P_2O_5 and 0.14 Mt K_2O through their nutrient composition of 7.5% N, 6.5% P_2O_5 and 3.5% K_2O. They are also a rich source of micronutrients supplying 60-100 ppm Zn, 7-15 ppm Cu, 380-1450 ppm Fe and 120-200 ppm Mn. Narahari (1999) [19] reported that the poultry manure is a rich source of nutrients for the crops. It contains 4.5-5.0% N, 2.5-2.98% P_2O_5, 2.04-2.33% K_2O, 2.4-8.8% Ca, 0.44- 0.67% Mg, 0.13-0.15%S, 235-450 ppm Zn, 98-150 ppm Cu and 150-450 ppm Fe. Relatively low nutrient composition was reported by several research workers than this estimate. Srivastava and Khanna, (1974) [34] and Prasad *et al.* (1996) [21] estimated that the nutrient range was 1.5-3.0% N, 1.0-2.63% P_2O_5 and 1.4-2.0% K in this manure. Such differences in estimates of nutrient composition in literature may probably be attributed to the method of composting, the extent of decomposition, feeding materials of the birds, age of the birds and prevailing environmental conditions.

The organic carbon content and C:N ratio in the organic manure is an important consideration that determines the release and availability of nutrients to the crops. Madhavi *et al*. (1995) [15] observed that the poultry manure had 7.6 pH, 24.9% organic carbon, 1.21% total N, 0.98% total P and 1.35% total K.

The organic manures are not only a good source of major, secondary and micronutrients but are also known to improve the physical properties of soil. Sharma and Rao (1996) [26] reported that a tonne of deep litter was estimated to contain 29.84 kg N, equivalent to 136.08-147.2 kg ammonium sulphate, 20.41 kg P_2O_5 equivalent to 113.40-136.08 kg single superphosphate, 20.41 kg potash equivalent to 113.40-136.08 kg muriate of potash, together with 6.80 kg Mg, 6.80 kg Na and 21.27 kg Ca in addition to a good amount of trace elements especially B and Zn. Sowjanya *et al*. (2017) [33] also reported that nitrogen content in FYM is 0.5 per cent.

Farmyard manure

Farmyard manure (FYM) and compost are generally considered as best and reliable sources in organic systems. FYM/Compost as a primary source of nitrogen for crops, continuous use of these manures for the substitution of nitrogen leads to Phosphorus accumulation in the soil (Nagendra Rao, 2009) [17]. Sowjanya *et al*. (2017) [33] reported that FYM consists of 0.5% N

Bio gas digest

Anaerobic digestion of animal waste and crop residues produces two main outputs *viz*., biogas and biogas digest/slurry, this was widely used technology for waste management and production of renewal energy in rural areas of India. Biogas digest composition can exist of 93% water and 7% of dry matter, of which 4.5% is organic matter and 2.5% inorganic matter. Gurung (1998) [12] recorded that, Digested slurry contains 1.5-2.0% nitrogen, 1.0% phosphorus, 1.0% potassium.

Biochar

Biochar is a fine grained carbon rich, porous product obtained when biomass is subjected to thermo chemical conversion process (pyrolysis) at temperature of 350-600 ^{0}C in an environment with little or no oxygen. Chen *et al*. (2010) [7] characterized the sugarfactory baggase biochar, which consisted of 3.7g kg-1 total nitrogen, 632.2 g kg-1 total carbon, 0.8 mg kg-1 phosphorus and 19.9 mg kg-1 potassium with a pH value of 7.3. Purakayastha *et al*. (2013) [22] characterized chemical composition of biochar derived from various crop residue and reported that rice residue biochar showed highest cation exchange capacity, while highest pH was recorded in residue of maize (10.7) and pearl millet biochar (10.6); highest total carbon content (61%) was associated with pearl millet biocha, however, maize biochar was richer in plant nutrients (N,P, K, Ca, Mg, Fe, Mn, Zn and Cu) followed by wheat biochar.

Urban compost

Singh *et al*. (2018) [31] reported that sewage sludge having 1.33% nitrogen, 0.21% Phosphorus, 0.14% potassium, 0.44 % sulphur and 2.10 ppm boron. Parul sudha *et al*. (2018) reported that urban compost of Delhi contains 0.67% N, 6.89% total carbon, 80.15% ash, 10.98 g kg^{-1} total K, 65.10 g kg^{-1} total Mg and 21 g kg^{-1} of total Ca. The chemical analysis of municipal solid waste showed that the contents of N, P_2O_5 and K2O is about 2.85 lakh tonnes that could be reached 5.4 lakh tonnes by 2025 (Singh and Subba Rao, 2009) [32]

Biofertilizers

Biofertilizers are eco friendly, cheap and handy to reduce the dependence of fertilizers. They can successfully be used as supplementary source of nutrients. *Azotobacter* and *Phosphorus solubilising bacteria* are known to release hormones, vitamins and enzymes which enhance germination and improves the growth of crop. *Azotobacter* fixes atmospheric nitrogen and make it available to the plants and also produces thiamine, riboflavin, nicotine, indole acetic acid and gibberellins to enhance the plant growth.

Phosphorous solubilising bacteria helps in solubilization of P which otherwise would not be available to growing plants. Nambiar and Abrol (1989) [18] and Hegde (1992) [13] emphasized the importance of integrated nutrient supply in sustaining productivity in the long run which otherwise is likely to deteriorate due to continuous and intensive cultivation without adequate nutrient management. Bacterial inocula applied in combination with organic manure and smaller dose of inorganic N and P fertilizer has been found to enhance crop yield and soil physical, chemical and biological properties which contributed towards long-term sustainable production of rice-legume-rice system (Narayan Chandra Talukdar, 2017) [20]. Thakuria *et al*. (2009) [35] reported that zinc uptake of rice crop and DTPA-Zn content on soil increased significantly in bacterial bioinoculants treated INM plots compared to their nutrient management plots. Rhizobium inoculation of legumes helps in increasing yields by 15-30% with an absolute yield increments of 50-200 kg /ha and in some cases even upto 300 kg/ha. In legumes additional plant N uptake of 10-15 kg/ha have been shown from field experiments conducted for three years and also observed that co-inoculation of Rhizobium, Azospirillum, Vesicular arbuscular mycorrhiza (VAM) and phosphorus solubilizing (PSB) has been found significantly better than their single inoculation. Inoculation with PSB or VAM was shown to save upto 8-10 kg P2O5 per hectare in rice, wheat, groundnut, soybean and other crops (Rao, 2009) [17, 23, 32].

Arbuscular mycorrhizal fungi (AMF) in soil play very important role in sustainable soil nutrient cycling through their positive role on soil structure, seedling establishment and reducing nutrient leaching. Bender *et al*. (2014; 2015) [4-5] showed that AMF inoculated plot produced more plant biomass and reduced p leaching.

Conclusion

The presence of good content of plant nutrients like N, P, K, Ca, Mg, S, Fe, Mn, Cu, Zn and other micro nutrients in organic manures and their abundant availability in India increase their potential role as alternate nutrient sources and can be substituted to the extent of 25-30 per cent in supplying recommended dose of chemical fertilizers for improving soil health, plant health and productivity. Application of microbial consortia instead of single microbial inoculation proved better performance on crop growth and yield.

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