REVIEW ARTICLE

Enrichment of organic manures using bio-fertilizers to improve the soil wealth and pulses crop improvement

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ABSTRACT

The widespread use of chemical fertilizers causes severe side effects such as environmental contamination, pest resistance development, and a decline in food safety. So, Organic manure applications have environmental benefits that reduce pollution. The environmental benefits attributable to reduced chemical inputs, less soil erosion, water conservation, and improved soil organic matter and biodiversity were consistently greater in the organic systems. Now a day, the researches focused on applying bio fertilizer enriched organic manures to revitalize and restore soil fertility and reviving the microbial activity of the soil and to partially replace chemical fertilizer use is increasing due to the requirement of sustainable agriculture development. Traditionally farmyard manure, animal wastes, compost, vermicompost, coir pith are used as source of organic fertilizers for improving soil fertility and crop productivity. Although in comparison to inorganic fertilizers, organic manures contain smaller quantities of plant nutrients. Progressively, there is a decline in microbial activity of organic manures which in turn to exhaustion of nutrient composition and enzymatic activity. So, manure enrichment improves the plant and soil nutritional content, microbial population, enzyme activity, soil fertility, microbial diversity, nutrient solubilization, plant growth promotion, regulate the plant metabolic pathway and increase the crop yield. Manures enrichment is done by bio fertilizers namely, Rhizobium, Bacillus, Pseudomonas, Azotobacter, Azospirillum, Fraturia, Trichoderma, and Glomus have more benefits on pulse crops and other traditional agriculture crops. Application of bio fertilizer enriched organic manures will promoted to all traditional agriculture crops and it's have lot of benefits in terms of availability of nutrients, increased pest and disease resistance, soil microbial population and crop yield. The present review work was aimed to explore the possibility of utilization of enriched organic manures on pulse crop growth, yield and soil health and reduce the environmental pollution from the usage of chemical fertilizers. Keywords: organic manures, Biofertilizers, Soil Wealth, Crop yield

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INTRODUCTION

In the current agrarian scenario, pulses are an important source for some of the essential amino acids and have been reported to reduce the levels of cholesterol and blood glucose. Some legumes are known to have medicinal and therapeutic properties as well. Hence, they are rightly termed as "Unique Jewels" of Indian crop husbandry. Pulses historically have been one of the most important constituents of the Indian cropping and consumption patterns. Pulse crops form a unique feature of our farming system, particularly in dry land. agriculture They provide food for human consumption, green and nutritious fodder for animals and in addition enriching soil through biological nitrogen fixation (Annual group meet of AICRP on MULLARP & ARID Legumes, 2019). Canada is the leading producer and exporter of pulses [9

& 12]. However, we failed to achieve self-sufficiency in pulse production whose productivity is 500 kg ha⁻¹ which is insufficient to meet the emerging demands [32].

In India, total pulse area and production during 2017-18 have been >293 lakh hectares and 245 lakh tonnes respectively. Out of the total area, >73 Lha is in Madhya Pradesh alone, earning a prime status in pulse production, registering at remarkable 25% of the country's pulse area with 33% production, thereby ranking first both in area and production. This is followed by Rajasthan in respect of an area (16 per cent) and Maharashtra in case of total production (13%). More than 90% of total pulse production contributing from 10 states namely, Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh, Karnataka, Andhra Pradesh, Gujarat, Jharkhand, Tamil Nadu (8.16%) and Telangana (Pub: Pulse Revolution from food to Nutritional Security) [16].

There are several reasons why pulse productivity is low, such as cultivation on marginal and less fertile soils with low inputs, imbalanced nutrient use. But imbalanced use of chemical fertilizers as well as reduction in use of organic manures resulted in deterioration of soil physical and chemical properties and crop productivity. Also, at present ever increasing cost of fertilizers and low purchasing efficacy of resource, poor farmers created considerable interest for search of alternative cheap sources of plant nutrients like bio fertilizers, farmyard manure, green manures, compost *etc.* are prerequisites to sustain soil fertility, to produce maximum crop yield with optimum input level [8]. Awareness about crop quality and soil health increased attention of people towards organic farming [29].

In this regard, FYM supply variety of macro & micro nutrients to the soil, but also improves the physicochemical and biological properties of the soil which help to maintain the soil health [37]. Use of FYM alone cannot satisfy the crop requirements. This is mainly due to the slow decomposition rate of manure. Thus proper ratio between, FYM and bio fertilizer sources should be worked out to derive the best possible advantages of the inputs. And also vermicompost is a potential source as it contains readily available plant nutrients, growth enhancing substances and a number of beneficial microorganisms. Moreover, application of organics in soil serve as a source of food for microbes which results in themenhance organic content in soil and helping to improve the soil texture. Bio fertilizers keep the soil environment rich in all kinds of macro and micro nutrients via nitrogen fixation, phosphate and potassium solubilisation, release of plant growth regulating substances, production of antibiotics and biodegradation of organic matter in the soil. *Rhizobium* inoculation enhances biological nitrogen fixation and thus more nitrogen availability to the plant and build up nitrogen status of soil besides reducing cost of nitrogenous fertilizers. Phosphorus solubilizing bacteria application to legumes plays a key role in the formation of energy rich phosphate bonds, and mobilizes the bound phosphorus in the soil thereby increasing its availability to the crop. The process of organic sources decomposition results in the increase of microbial diversity and activity dramatically and the its produced could be a source of plant growth regulators produced by interactions between microorganisms and organic manures, which could contribute significantly to increased plant growth, flowering, and yields. So, the addition or enrichment of microbial inoculants such as biofertilizer would provide an increased plant growth and yield. Now a day. the organic manures production is very low. So, directly applicable is not possible.

Hence, thus information on quality of the organic wastes due to microbial inoculation into finished organic product possible avenue of using biofertilizer in a big yet simple way for the farming community. So, considering the benefits of pulses and its potential, it is time to give attention to increase the production potential of the crop.

EFFECT OF CHEMICAL FERTILIZERS ON AGRICULTURE

Fertilization improves productivity and improves the consistency of commodity recovery in agricultural operations. This is one of the most effective ways to do so. Non-organic fertilizers include primarily phosphate, nitrate, ammonium and potassium salts. However, in recent years, the use of fertilizers has risen exponentially in the world, causing major environmental concerns. Fertilization can cause the accumulation of heavy metals in soil and plant systems. Plants ingest fertilizers from the soil, and they can join the food chain. As a result, fertilization leads to water, soil and air contamination [34]. Excessive usage of chemical fertilizers in agriculture, resulting in a vast amount of environmental issues, since certain fertilizers include heavy metals. Subsequently, agro-ecosystem fertilizers are the primary cause of heavy metals in plants and others result in the accumulation of inorganic contaminants. Greenhouses, aquaculture, particularly large quantities of chemical fertilizers used during peak season, thus dangerously contaminated well water, in particular water resources, crop production quantity and product quality is deteriorating. Nitrate levels can rise in drinking water and rivers due to high levels of nitrogen fertilizer usage. The amount of phosphate in drinking water and rivers can increase as a result of

the transport of phosphorous fertilizer with surface flow. It consists of carcinogenic substances such as nitrosamines, especially plants are eaten. There are harmful accumulation of NO_3 and NO_2 .

WHAT IS ORGANIC MANURE?

Organic manures are natural products used by farmers to provide food (plant nutrients) for the crop plants. There are a number of organic manures like farmyard manure, green manures, compost prepared from crop residues and other farm wastes, vermicompost, oil cakes, and biological wastes - animal bones, slaughter house refuse. Organic manures increase the organic matter in the soil. Organic matter in turn releases the plant food in available from for the use of crops. However, organic manures should not be seen only as carriers of plant food. These manures also enable a soil to hold more water and also help to improve the drainage in clay soils. They provide organic acids that help to dissolve soil nutrients and make them available for the plants.

Organic manure can be grouped as farmyard manure, green manure and compost manure. Following are the different types of manure used by the farmers: Green manure increases the percentage of organic matter in the soil. The roots of such manures go deep into the soil. These help in the suppression of weeds and the prevention of soil erosion. Farmyard manure improves the soil structure and is used as a natural fertilizer in farming. It increases the soil capacity to hold more water and nutrients. It also increases the microbial activity of the soil to improve its mineral supply and also the plant nutrients. Compost manure improves the soil structure and water and nutrient holding capacity of the soil. Thus, it increases the nutrient value and thereby improves the health of the plants.

HOW IS ORGANIC MANURE BENEFICIAL TO US?

Carbon present in soil is in the form of organic matter. The organic materials most commonly used to improve soil conditions and fertility include farm yard manure (FYM), animal wastes, crop residues, urban organic wastes (either as such or composted), green manures, bio-gas spent slurry, microbial preparations, vermicompost and biodynamic preparations. Sewage sludge and some of the industrial wastes also find application in agriculture.

For all organic matter, atmospheric carbon dioxide serves as the main source of carbon. Carbon dioxide is converted to organic carbon largely by the action of photoautotrophic organisms; the higher green plants on land and algae in aquatic habitats. Carbon is being contentiously fixed into organic form through the process of photosynthesis and once bound; the carbon becomes unavailable for use in the generation of new plant life. Carbon fixation involves a reduction of carbon dioxide by hydrogen donor NADPH (reduced form of the co-enzyme nicotinamide adenine dinucleotide phosphate, NADP) and the synthesis of carbohydrate from reduced carbon through complex cyclic mechanism called the Calvin cycle [6].

Carbon dioxide constitutes only 0.03 percent by volume of the earth's atmosphere. It has been estimated that the vegetation of the earth's surface consumes some 90 billion kg carbon dioxide per annum, about one twenty - fifth of the total supply of the atmosphere and that the total supply of carbon dioxide would be completely exhausted in twenty years at the present rate of photosynthesis, if not replenished by decomposition of organic materials. As the availability of carbon dioxide on the earth's surface is very limited, it must be recycled. Upon the death of the plants and animals, microbiological metabolism assumes the dominant role in cyclic sequence. The dead tissues added to soil undergo decay and are transformed into microbial cells and a vast heterogeneous body of carbonaceous compounds. According to the different stages of decomposition, the soil organic matter becomes available in distinct fractions. Farm yard manure made from cattle dung, excreta of other animals, animal tissues and excretory products, and compost from rural and urban wastes, crop residues and green-manure are collectively designated as bulky organic manures because of their low contents of major nutrients, while materials like oil cakes, fish meal, animal meal, poultry manures, slaughter house wastes containing comparatively higher contents of plant nutrients are grouped under concentrated organic manures. In general organic manures containing up to two percent nitrogen are included in bulky category and those with more than two percent nitrogen are treated as concentrated. Irrespective of source and composition, organic matter when added into the soil undergoes microbial decay and becomes the food for micro flora and fauna. Even the microbial cells serve as a source of carbon for succeeding generations of microscopic populations. A great variety of microorganisms live in soil which include bacteria, actinomycetes, fungi, algae and protozoa. In general, the number per gram of soil is bacteria > actinomycetes > fungi > algae > protozoa.

Organic manure provides all the nutrients that are required by plants but in limited quantities. It helps in maintaining C: N ratio in the soil and also increases the fertility and productivity of the soil. It improves the physical, chemical and biological properties of the soil. It improves both the structure and texture of

the soils. It increases the water holding capacity of the soil. Due to increase in the biological activity, the nutrients that are in the lower depths are made available to the plants. It acts as much, thereby minimizing the evaporation losses of moisture from the soil [31].

NUTRITIONAL QUALITY OF TRADITIONAL ORGANIC MANURES

Organic farming is the background of sustainable agriculture, which improves the crops and soil health, resist pest and disease attack. It is an ecologically sound and sustainable way of growing more food. Pichler and Knabner [26] reported that the compost stability is strongly related to the rate of microbial activity in compost. Increased dry matter production in black pepper (*Piper nigrum*) due to the application of composted coirpith, sand and farmyard manure was reported and the effects of coirpith compost on mulberry plant (*Morus alba* L.) and found that coirpith compost provides all the essential nutrients required for the growth, yield and protects the physico-chemical and biological characteristics of the soils reported by Srinivasan and his co-workers [36].

According to Tolessa and Friesan [37] the effect of growth and yield of maize were significantly increased with the application of enriched farmyard manure at 25 percent and 50 percent of recommended nitrogen (N) and phosphorus (P) fertilizers. Enriched farmyard manure increases the grain yield by 40 per cent when compared to conventional farmyard manure. According to Gopal and Gupta [10], coirpith stored causes contamination of ground water due to the percolation of leachates containing residual phenol. Mahalakshmipriya and Vijayalakshmi [20] concluded that sago waste and pressmud individually and in combination with bio-fertilizer increased the growth parameters of green gram. And also, observed that the most effective treatment for *Oryzasativa* was the combination of gypsum, pressmud and farmyard manure (94 percent increase yield over control) followed by pressmud alone (60%) and farmyard manure (75%).

Shankaraiah and Murthy [28] stated that the combined application of enriched pressmud cake at 15 t ha⁻¹ and recommended NPK (250: 100: 125 kg ha⁻¹) resulted in increased cane and cane yields by 21% over chemical fertilizers alone. Srinivasan and his co-workers [35], reported that the mixed effect of composted coirpith and *Azospirillum* sp. increased the yield and quality of *Piper nigrum*. Mirza and his co-workers [23], revealed that both grain and straw yield of paddy were significantly improved by the application of *Sesbania* and farmyard manure. The results of Shah and Ahmad [27] suggested that the integrated use of urea and FYM performed better in improving crop and N yields of wheat. Ayoola and Adeniyan [3] reported that nutrient from inorganic fertilizers enhances the crops, but the yield is promoted when both organic and inorganic fertilizers are used in combined form.

The results of experiments of Balakrishnan and his co-workers [4], showed that the application of *Suaeda* compostin combination with farmyard manure and phosphate solubilising bacteria, significantly increased the soil micro flora such as bacteria, fungi and actinomycetes and soil enzyme activities such as dehydrogenase, alkaline phosphatase, cellulose and urease in soil cultivated with *Arachishypogaea*.

LIMITATIONS OF TRADITIONAL ORGANIC MANURES AND NEED FOR ENRICHMENT

Traditionally, various organic manures are mixed into the soil rhizosphere. However, this conventional approach involves an enormous amount of organic manure to have a meaningful impact, as most organic manures are dense in nature, have a poor nutrient content, are labour-intensive in terms of application and shipping, have trouble handling, besides the extra expense of manure.

Bio fertilizers for organic manure enrichment

Mixing of traditional organic manure with bio-fertilizers/ bio-inoculants to increase the nutrient content, decomposition, mineralisation and better microbial load is referred as organic manure enrichment. With the passage of time, there is a gradual decline in microbial activity of the traditional organic manure, which in turn leads to depletion of enzymatic activity and macronutrient composition. Enrichment increases the microbial population, available nitrogen, phosphorous and potassium content, enzyme activity and increase the fertility status of soil [14&21]. The availability of nutrients in enriched organic manures become much higher as microbial decomposition slowly increase the availability of nutrients to the plant throughout the growth period. Bio-fertilizers are the substances which contains living microorganisms that accelerate the different microbial processes in soil and enhance the availability of nutrients to growing plants. When they are applied as seed or soil inoculants, they colonize the interior of the plant and enhance nutrient cycling and growth of the plant. Biological fertilizers have the capacity to mobilize the nutritionally important elements from non-usable form to usable form through some biological processes and are known to enhance yield in different crops [17].

The commonly availablebeneficial soil microbes includes *Rhizobium, Azospirillum, Azotobacter; Pseudomonas, Bacillus, Enterobacter; Burkholderia, Acidothiobacillus, Bacillus;* soilbeneficial mycorrhiza

includes *Acaulospora, Entrophospora, Gigaspora, Glomus, Sclerocystis, Scutellospora*etc. Most of the microbes playsignificant role in balancing the dynamics ofdecomposition of organic matter and theavailability of essential plant nutrients in the soil. It provides nutrients through the action of nitrogen fixation, solubilising phosphorus and trigger growth of plant through synthesis of growth promoting essence [5].Bio-fertilizer plays an important role in maintaining long term fertility and sustainability of soil, which may enhance crop yield by 10-30% [15].

NUTRIENT PROPERTIES OF ENRICHED ORGANIC MANURES

Organic manures act as a store house of plant nutrients (Table 1). They played a direct role in supplying macro and micronutrients and indirectly in improving the physical, chemical and biological properties of soil [25]. The use of organic manures is not only important in the immediate contest of economy in use of fertilizer, but also for the maintenance of soil fertility and crop productivity for a longer period [38]. Farmers gradually realizing the harmful effects of chemical fertilizers on crop growth, soil health and environmental degradation, and now they are searching for good quality organic manures to substitute the chemical fertilizers for better crop growth, soil and human health.

Organic manures	Nitrogen (%)	Phosphorus (%)	Potassium (%)
Farmyard Manure	0.4	0.2	0.2
Sheep and goat manure	3.0	1.0	2.0
Vermicompost	3.0	1.0	1.5
Poultry manure	3.0	2.6	1.4
Paddy straw	1.5-3.5	0.7-4.0	0.3-0.6
Cattle urine	1.0	-	1.3
Neem cake	5.2-5.6	1.1	1.5
Groundnut cake	6.5-7.5	1.3	1.5
Sesame cake	4.7-6.2	2.1	1.3
Castor cake	4.0-4.4	1.9	1.4
Sugarcane trash	2.7	1.8	1.3

 Table 1. Nutrient composition of different organic manures[31]

EFFECT OF ENRICHED ORGANIC MANURES APPLICATION ON SOIL WEALTH AND CROP PRODUCTIVITY

Three organic manures Vermicompost, FYM, coir pith compost and green manuring has influenced the nutrient uptake and nutrient use efficiency. activity is closely associated with microbial activity. There exists a mutualistic association between earthworms and microorganisms in deriving nutrients from harder materials like cellulose and hemicellulose [19]. The enrichment of vermicompost with nutrients and microorganisms using different organic and inorganic materials and microbial inoculants is now becoming popular [1&11]. Vermicompost enriched with bio-fertilizer organisms *Serratiamarcesce*(P-solubilizer), *Aspergillus awamori* (P-solubilizer) and *Aspergillus niger*(Zn-solubilizer). The results showed that the enriched vermicompost significantly enhanced the growth characteristics like stem girth and bio-volume index of the plant except plant height. Plant fresh weight and dry weight was also more in enriched vermicompost treatment. It was also noticed that there was an increase in number of flowers per plant and also in flower diameter in enriched vermicompost treated plants compared to FYM and vermicompost treatments. The data shows that there is a positive response in bio-fertilizer enriched vermicompost. Vermicompost apart from supporting as carrier material for bio-fertilizers helps in stimulation of growth of plants and finally the yield [2].

Jacob and Banerjee [13] prepared an enriched bio-manure by mixing cow dung slurry with the mixture of cyanobacteria and free living nitrogen fixing bacteria and applied in the okra field at 10 t ha⁻¹. The result showed that the soil supplemented with enriched manure was found superior for fruit quality than the control and almost comparable to that chemical (urea) amended soil.Chaterjeeand his workers [7], showed that application of *Azotobacter*, phosphate solubilizer and potash mobilizer microbes enriched poultry manure produced cauliflower curds with highest chlorophyll, ascorbic acid and reducing sugar. Zinc enriched farmyard manure showed higher turmeric rhizome yield increase of 21.6% [18]. Increased yield by the Nitrogen and phosphorous solubilizing bacteria could be due to the increased availability of nutrients in the soil and better nodulation resulting in improved growth and development which might be attributed to better phosphorus mobilization and also hormonal balance on the plant system [22].

Singh and his co-workers [32], found that integrated application of farmyard manure (25 t ha⁻¹) and biofertilizer (PSB + *Azotobacter / Rhizobium*) increased the yield of okra, cowpea and bottle gourd during summer by 27.5, 40.1 and 8.33% while in rabi season integrated application of NADEP compost at 25 t ha⁻¹ and bio-fertilizer (PSB + *Azatobacter / Rhizobium*) increased the yield of cabbage (*Brassica oleraceavar. capitata*) and pea (*Pisumsativum*) by 12.8 and 23.5% respectively over conventional inorganic system.Shruthi[30] mstudied different organic manure based carrier to support the maximum microbial population for longer storage life. The result reported that press mud was the best carrier material for the beneficial microbes namely *Rhizobium phaseoli, Bacillus megaterium* and *Glomus fasciculatum*(AM fungi) for their prolonged storage followed by vermicompost. The consortium of *Rhizobium phaseoli, Bacillus megaterium* and *Glomus fasciculatum*(AM fungi) in press mud as carrier has resulted in higher yield than their individual application in French bean [31]., And also, recorded enhancement of yield parameters due to soil application of organic manures enriched bio-digested slurry and biofertilizer (phosphobacteria).



Fig.1. Flow diagram of enriched organic manure on Agriculture

CONCLUSION

The present review suggested that traditional organic manures like farmyard manure, vermicompost, coirpith and all other manures can be enriched by inoculating the manure with plant growth promoting bifertilizers. Application of enriched organic manures will benefit of agriculture crops in terms of more yield, better quality, disease and pest resistance, availability of essential nutrients and overall microbial population of the agriculture field, which will not only reduce the amount of organic manure requirement but also increase the use efficiency of the applied manure. The practice will gradually reduce the excessive usage of chemical fertilizers in crop production. Recent research outcome pointed that bio-inoculants enriched organic manures can be emerged as a possible tool for organic farming based crop production and crop protection. The different enriched organic manures and their utilization will motivate the farming community and more efforts will be required for scaling up preparation and

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application of enriched organic manures in crop production to achieve sustainability in crop production system.

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