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Organic Fertilizer: A Key Component of Organic Agriculture-A Review

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ABSTRACT

Gradually the area under organic farming is increasing and farmers are more attracted to organic farming due to various negative impacts associated with chemical fertilizers on soil as well as human health. But, while promoting the area under organic farming the main constraints that the farmers use-to face is lack of proper source, availability of adequate quantity of organic fertilizers for better crop production. For ages, although FYM and compost is the predominant source of organic agriculture, but the bulk requirement of the same discourages the farmers many a times. Now lot of organic fertilizers including liquid organic fertilizers is in use which is very cost effective and easy to apply. Therefore, an attempt has been made to review the different organic source, their nutrient content and their effect of different crops as well as on soil health.

Key words: Compost, Nutrient, Organic, Quality, Soil health.

Globally, organic agriculture has been adopted by around 2.4 million farmers in area of 50.9 Mha which shares only 1.1% of total agricultural land (Willer and Lernoud, 2017). Moreover, with the crop intensification the nutrient demand could not be fulfilled by inorganic fertilizers alone, so 25-30 per cent of Indian agriculture's nutrient requirement must be meeting by different organic nutrient sources (Lalrintluangi *et al*., 2020). By considering the negative impact of chemical fertilizers on soil health, scientists are trying to curtail the use of chemical fertilizers by partly replacing them with bio-organic sources. Organic fertilizers also improved the quality of certain crops, for *e.g*. increased the dry matter content in potato (Haase *et al*. 2007), pungency in chilli (Maheswari *et al*., 2004) and improved the milling quality of rice grain and cooking quality (Yadav and Lourduraj, 2006).

Organic fertilizer

Organic fertilizers are mainly derived from animal or plant material which can change soil properties due to the abundance of organic matter, presence of both micro and macro nutrients.

Different Organic Sources

Animal manure

The faeces, urine and animal bedding of animal manure turned up to finely decomposed end product. It acts as manure as they are rich source of many essential plants nutrients (Table1). Generally, the excreta of most of animals such as cattle, pig, sheep etc is used as manure, but out of these, cow dung is an excellent source of nitrogen and phosphorus (Goss *et al*., 2013).

Since long back it was well documented that cattle manure either in solid or liquid form upon application improved the soil properties (Eghball, 2002) and eventually increase the crop yield (Butler and Muir, 2006). But because of presence of more quantity of immediately available N in liquid fertilizers it can work better than solid form. Cattle urine contains almost 95% water, 2.5% urea and others minerlas, hormones and enzymes that makes it suitable for applying as bio fertilizer (Khanal *et al*., 2011).Several researchers reported about the beneficial effect of cattle manure on crop as well as soil properties (Eghball, 2002; Butler and Muir, 2006). While applying dairy cattle manure at a rate equivalent to the RDF greatly increased the cob of maize (Anastasios *et al*., 2007). The effect of cattle manure is more or less equivalent to inorganic fertilizers, although availability of N to crop through cattle manure is lower than inorganic fertilizers due to slow-release pattern from organically bound N (Griffin *et al*., 2002; Matsi *et al*., 2003).

Cow based liquid organic manure

Now a days instead of sole application of cow urine or cow dung some cow based organic nutrient formulations such as panchagavya, sanjibani, kunapajala, amrit pani, Beejamruth, Jeevamruth, Amritmitti and Amritjal etc. are used in Agriculture (Gore and Shreenivasa, 2011). These liquid manures are nutritionally superior to cow dung/cow

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urine and rich in all essential macro and micro nutrient, plant growth hormone and vitamins *etc*. (Table 2). These liquid formulations are known for increasing crop yield, quality as well as enriching the soil fertility (Sornalatha and Esakkiammal, 2018). These organic nutrient formulations along with chemical fertilizers showed synergetic effect on crop growth and development (Patil and Udmale, 2016). The organic foliar spray ensures the adequate nutrients supply because of more persistence of organic droplets on leaf surface and better nutrient uptake (Mangle, 2002). The spraying of bio formulation like panchagavya, beejamrut, jivamrut increased the yield of soybean (Shwetha, 2008), black gram (Kumar and Singh, 2011) and many other crops. In addition to that, these liquid formulations helped in 25% reduction of pest problem in sweet corn particularly at tasseling and cob formation stages (Devakumar *et al*., 2008).

Panchagavya

Panchagavya is broadly applied as organic product plays a significant part in organic Agriculture. "Panchgavya "is a sanskrit word which means blending of five products obtained from cow namely dung, urine, milk, curd and ghee (Patel *et al*., 2018). Besides having nutrients as well as plant growth hormone like IAA and GA essential for plant growth and development (Selvaraj *et al*., 2007), it is also rich in beneficial microbes such as bacteria, yeast, actinomycetes, photosynthetic bacteria, *Acetobacter, Azospirillum*, phosphobacteria and *Lactobacillus* (Selvaraj, 2003). Thus, spraying of these organic formulations helps in increasing the soil beneficial microbe's *i.e Rhizobium, Azospirillum* and *Azotobacter*etc. (Tharmaraj *et al*., 2011; Kumar and Singaram, 2011). Moreover, it also acted as a growth promoter (75%) and immunity booster (25%) in increasing crop yield (Vedivel, 2007).

It can be applied both in soil as well as crop foliage. Seed or seedlings are also treated with panchagavya for better germination. Although 3% concentration is mostly followed by organic growers (Somasundaram *et al*., 2003) but it varies depending on crop (Natarajan, 2002). Spraying of panchagavya 3% at 10 days interval in addition to recommended dose of fertilizers also increased the green forage as well as dry matter yield as compared to control (Thirumeninathan *et al*., 2017). In most experiments, 3% foliar spray of panchagavya enhanced the growth and yield of many crops like rice (Ramanathan, 2006), fodder

Table 1: Nutrient content of differentanimal manure.

Manure type	Nitrogen (N %)	Phosphorus (P %)	Potassium (K %)
Cow	0.6	0.2	0.5
Horse	0.7	0.3	0.6
Pig	0.5	0.3	0.5
Sheep	0.7	0.3	0.9
Rabbit	2.4	1.4	0.6
Swine	3.0	0.4	0.3

Source FAI (2012).

Table 2: Properties of different liquid organic nutrient sources.

Parameters	Panchagavya	Sanjibani	Neem leaf extract	Wood extract	Vermiwash	Vermicompost	EM compost
pH	5.6	7.8			7.11	6.12	7.8
Total soluble salts(ppm)					9841.67	3148.67	
OC (%)	14	10.3			0.18	9.77	
N (%)	1.4	1.03	3.56	0.15	0.02	1.11	1.66
P (%)	0.08	0.04	0.83	0.53			0.31
K (%)	0.05	0.05	1.67	2.60	0.002	0.024	
Ca			0.77	15.00			
Mg			0.75	1.00			
Ca (ppm)					192.4	322.33	
Mg (ppm					142.53	137.33	
Mn (ppm)					0.04	0.69	
Fe (ppm)					2.21	0.11	
Cu (ppm)					0.35	0.01	
Zn (ppm)					0.03	2.13	
EC (S·m"1)	4.6	3.5					0.38
C/N ratio							15.66

Source: Ali *et al.* (2011); (Emmanuel, 2012); Ansari and Kumar (2010); Sharma *et al*., 2017.

(Kumaravelu and Kadamban, 2009), black gram (Swaminathan *et al*., 2007), foxtail millet (Atish *et al*., 2020). However, in few crops like groundnut foliar spray of 4% panchagavya along with soil application of jeevamrutha @500 L ha^{-1} performed better than recommended dose of fertilizer (Patel *et al*., 2018). Similarly in black gram foliar spray of 4% panchagavya at branching and flowering stage recorded higher yield than the control (Choudhury *et al*., 2017). Panchagavya also showed synergistic effect on crop growth and development when it was applied with other manures like poultry manure (Lourduraj *et al*., 2005).

Besides foliar spray, soaking of seeds with 3% panchagavya followed by spraying of same concentration at tillering and jointing stage integrated with recommended dose of fertilizers significantly helped in boosting crop growth and yield of wheat (Pagar *et al*., 2016). Apart from field crops, panchagavya performed well in increasing crop yield and quality of many horticultural crops like ladies finger (Suchitra *et al*., 2017) and capsicum (Boraiah *et al*., 2017).

Beejamruth

It is also prepared from cow urine, cow dung, cow milk, lime and water mainly used as seed treatment for better germination, crop establishment, for more crop growth and yield.Because of presence of abundant beneficial microorganisms, it saved the crop from other soil and seed borne pathogens (Sreenivasa *et al*., 2009). It also showed harmonizing effect to tomato growth and yield when applied with other liquid formulations such as panchagavya and jeevamruth (Gore and Sreenivasa, 2011). It performed better panchagavya in terms of seed germination and seedling vigour index (Shakuntala *et al*., 2012). It also helped in increasing the root length, epicotyl and hypocotyl length, crop growth and yield of many agricultural crops.

Jeevamruth

It is a mixture of cow dung, urine, Jaggery, flour, active soil and water and considered as an organic solution rich in beneficial microorganisms for crop growth and development.

These organic nutrient formulations are synergistic in effect and showed positive response in terms of boosting crop production. Patel *et al*. (2018) stated that spraying of both panchgavya and jivamrut at branching and flowering stages performed better than the single application either at branching or flowering stage. Moreover, the application of both panchgavya @ 2% + jivamrut @ 500 l/ha produced equivalent pod yield (1563 kg/ha) with 100% RDN through FYM which was at par with foliar spray of panchgavya @ 4% along with soil application of jeevamrutha@ 500 lit./ ha.Besides beneficial microbes, the presence of other growth hormone like IAA, GA, cytokinin, kinetin and essential plant nutrients are responsible for enhancing growth of crop (Ramesh *et al*., 2015). It is also reported that 5% foliar spray of jeevamrutha performed better in terms of crop growth and yield. Jeevamrutha can also be applied with irrigation water; the application of jeevamrutha @ 600 l ha^{-1} three times through irrigation water greatly enhanced the growth and yield of sweet corn (Safiullah *et al*., 2018).

Sanjibani

Sanjibani is organic nutrient formulation prepared mainly from cow dung and cow urine. Apart from improving soil quality and crop productivity it is also having pest repellence properties (Swaminathan *et al*., 2007). Sanjeevani is prepared by mixing 1:1:10 proportions of cow dung: cow urine: water with handful of garden soil and 50 g of jaggery, In most of the experiment, 5% Sanjeevani performed better than its lower as well as higher dose.

Fish based formulation

The fish wastes like head, gut, fins, bones, scales *etc*. are rich in many essential nutrients. These waste materials could be converted to resource by simple fermentation process by using some carbohydrate source such as jaggery or molasses (Thendral *et al*., 2014). Besides this, trash fish is another material that has the potentiality to promote plant growth. Trash fish means the discarded fish which are not consumed by human being because of various reasons like poor quality, very small size *etc* (Immaculate *et al*., 2013). In this context, Ramalingam *et al.* (2014) reported 50, 45 and 66% higher shoot length in *Lycopersicon esculentum*, *Hibiscus esculentus* and *Solanum melongena*, respectivelydue to application of trash fish manure as compared to control. Thendral *et al*. (2014) also reported the spraying of liquid fermented fish waste helped in increasing plant growth and development because of increasing the thickness of the plant conducting systems. Table 3 presented the nutritional quality of fish manure (Ramalingam *et al*., 2014).

Compost

Compost is prepared from any biodegradable waste materials like straws, crop stubbles, crop residues, weeds, waste fodder, waste vegetables and other organic material such as rice straw, wood, saw dust, sugarcane trash and corn cobs *etc*. These organic materials are rich in organic carbon and the addition of these organic materials improves the soil physicochemical characteristics. As shown in Table 4 some common weed species having high nutrient content

Table 3: Concentration of minerals and metals in trash fish manure.

Minerals	Content (mg/100 mg)
Phosphorous	5.2187
Calcium	0.4039
Sodium	0.1128
Potassium	4.3541
Magnesium	0.3321
Nitrogen	6.0193
Nickel	Traces
Copper	Traces
Zinc	Traces

Source: Ramalingam *et al*. (2014).

and can be used as a substrate for compost (Bordoloi *et al*., 2015).

To enrich the compost sometimes rock phosphate, *Azotobocter*, *Acetobacter,* PSB is also added. The N, P, K content of general compost was found to be enhanced by 2.76, 3.70 and 2.20 fold higher after incubation with microbes like *Aulosira*, *Azosprillum* and *Azotobacter* for 6 weeks (Jacob *et al*., 2017).Thus, enrichment of compost with beneficial organisms like plant growth-promoting microorganisms further helps in increasing benefits of compost towards both agriculture as well as environment (Sousa *et al*., 2018).

Considering the importance of beneficial microbes, efficient microorganism (EM) compost is prepared by mixing the EM consortium like *Candida tropicalis*, *Phanerochaete chrysosporium*, *Streptomyces globisporous*, *Lactobacillus sp*. and photosynthetic bacteria etc. with the other compost material like paddy straw (Sharma *et al*., 2014). Apart from increasing the crop yield, the addition of EM compost also increased the microbial biomass C of soil (Sharma *et al*. 2017). When rock phosphate is added with compost materials like animal faeces, plant residues and microbes, it increased the P solubility from rock phosphate because of release of more soluble P due to the action of organic acids produced by the microbes (Puente *et al*., 2004). Apart from increasing the yield of wheat crop, the addition of rock phosphate enriched compost (rock phosphate + poultry litter + *Pseudomonas* sp.) enhanced soil chemical and biological properties as compared to control (Billah *et al*., 2020).

Vermicompost

It is product of quick semi-aerobic process where organic residues are converted into fine organic material by some specific earthworms. It contains higher level of nitrogen (1.6%), phosphorus (0.7%) and potassium (0.8%), calcium (0.5%) and magnesium (0.2%) (Buchanan *et al*., 1988) as well as presence of some hormones, enzymes and humic acids (Khan, 2018). Now a days for nutrient enrichment of vermicompost, azolla and cattle dung is also used as a substrate of earthworm in addition to rice straw (Arora and Kaur, 2019). Since the nutrient content of *azolla* is comparatively more than rice straw, (5.3% N, 8.3% K) (Sreenivasa, 2012), thus nutrient content of vermicompost prepared through rice straw blended with azolla is also higher. Because of the robust metabolic system of earthworm, it has the potentiality to valorize and detoxify heavy metals in industrial by-products. Thus,vermicompost prepared from Municipal solid wastes (MSW) can also be effectively applied for crop growth and development (Banashree *et al*., 2020).

Vermicompost greatly enhances the root formation, elongation of stem and biomass production in many crops. It also enhances the soil physical properties like porosity, aeration, bulk density, drainage, water-holding capacity as well as other microbial activity of soil (Lim *et al*., 2014).

Vermiwash

Vermiwash is a collection of excretory products and mucus secretion of earthworms along with micronutrients from the soil organic molecules. It contains enzyme, vitamins, micro and macro nutrients as well as other plant growth promoting hormones like cytokinins, gibberlines (Tripathi and Bhardwaj, 2004) due to which it is considered as very good plant tonic. It plays a vital role in plant growth and development by accelerating the process of root initiation, root growth, plant development. Foliar spray of vermiwash promotes the physiological processes that ultimately helps in obtaining more crop growth (Gamaley *et al*., 2006). Actually it acts as natural growth promoter for many plantation as well as horticultural crops (Weersinghe *et al*., 2006). Because of presence of higher quantity of Na, vermiwash it increased the disease resistance capacity of the crop (Yadav *et al*., 2005). It also hastens the flowering, increase the longevity of inflorescence, photosynthesis and soil microbial population *etc*. When seed treatment was done with vermiwash, it increased the germination rate and seedling vigor index of mung (Chattopadhyay, 2015), cowpea and paddy crops (Prabhu, 2006). Moreover, vermiwash showed significant yield improvement of many crops like paddy (*Oryza sativa*), maize (*Zea mays*), millet (*Penisetumtyphoides*), radish and many other crops.

Plant based organic manure/botanicals

These includes neem leaf extracts, wood ash extract.

Neem products

The neem products are well known for its insecticidal, antifeedant, hormonal, antifungal, antiviral and nematicidal properties. Because of numerous properties connected with

Table 4: Nutrient content of some common weed species.

Weed species	Nutrient content (%)		
	N	P	K
Eupatorium odoratum	3.42	0.16	0.97
Eichhornia crassipes	2.94	0.94	0.16
Ipomea Spp	2.12	0.45	0.46
Ambrossiaartimisifolia	3.14	0.17	0.82
Lantana camara	2.48	0.11	1.33
Mikania micrantha	2.98	0.22	1.79
Azolla caroliniana	2.32	0.59	2.82

Source: (Bordoloi *et al*., 2015).

neem based products, it has been used in various agricultural uses such as seed treatment, manurial application for increasing nutrient efficiency etc (Subbalakshmi *et al*., 2012). Almost every parts of this crop are utilized in Aagriculture starting from leaves, twigs, seeds, bark and root. For preparing the neem extract, 10 kg of fresh neem leaves were taken and chopped into pieces using a sharp knife then immersed them in a plastic container having 50 liters of water and kept in shade. The solution was stirred in every 3 days to allow proper leaching of the nutrients in the leaves into the water up to 14 days. Thereafter, the leaves were carefully re-moved using sieve of 2 mm to obtain clean neem leaf extract and diluted with water (1:1) (Emmanuel, 2012). After extraction of oil from seed the left-over material is known as seed cake that acts a source of nutrients to crop (Subbalakshmi *et al*., 2012).

Wood ash extract

Wood ash extract is prepared by weighing 10 kg of sieved wood ash into 50 litres of water in a plastic, thoroughly stirred with paddle every 3 days to enhance pro- per leaching of nutrients upto 14 days. Thereafter, suspension are properly sieved to obtain clear suspension of the wood ash extracts (Emmanuel, 2012).

Oil cakes

Oil cake solid residue obtained after extraction of oil from seeds can utilized as good organic fertilizers. For example, mustard, soybean, castor, Cotton seed oil cake *etc*. These oil cakes are rich N which helps in plant growth and development. Yasmin *et al*. (2021) found that effect of castor oil cake is better than mustard oil in terms of enhancing the yield of rice (Table 5).

Impact of organic fertilizers on soil properties

The status of soil micro-flora largely depends on soil type, soil temperature, availability of soil moisture and nutrients, pH *etc*. (OECD, 2007). The moderation in soil organic carbon (OC), nutrient availability, water holding capacity (WHC) due to application of organic inputs like farm yard manure, Beejamruth and Jeevamruth enhance mycoflora colony forming unit (CFU) and more species diversity (Gachande and Shaikh, 2017). Presence of cow dung in these liquid organic formulation acts as a medium for the growth of beneficial microbes resulted in more microbial population (De Britto and Girija, 2006).

The application of organic inputs like *Glomus fasciculatum*, *Trichoderma harzianum*, Panchagavya, Amrit pani, Agnihotra ash also improved the soil biological properties (Sushma *et al*., 2012). Similarly, a remarkable increase in microbial population such as bacteria, fungi and actinomycetes was also observed due to integrated supply of jeevamrutha @ 1000 L ha^{-1} and panchagavya at 7.5% in field bean (Devakumar *et al*., 2018).

The inclusion of organic matter in soil enhances the activity of heterotrophic bacteria and fungi and consequently the soil enzyme activity which leads to more nutrient availability due to conversion of organic to inorganic form.

Table 5: Nutrient content of some oil cakes.

	N (%)	P_2O_5 (%)	K_2O (%)
Mustard oil cake	5.1-5.2	1.8-1.9	1.1-1.3
Sesame oil cake	6.2-6.3	2.0-2.1	1.2-1.3
Mahua cake	2.5	0.8	1.2
Groundnut cake	7.3	1.5	1.3
Sesame cake	6.2	2.0	1.2

Source; FAI (2012).

Other remarkable benefits are decrease of harmful pathogen and soil bulk density, increase in organic carbon and CEC *etc* (Bulluck *et al*., 2002).

CONCLUSION

Organic farming has been globally accepted as the modern farming practices mainly to cope up with the soil and environmental degradation and also for sustenance of natural resources for present and future needs.Organic fertilizer sources such as animal manure, panchagavya, beejamruth, sanjibani, fish based formulation, plant-based formulations *etc*. being the prime source of nutrients in organic farming has gained the potentiality in the worldwide market platforms. Therefore, there is the need for detailed study as well as research in order to find out the effect of different organic nutrient sources on growth and development of different crops as well as on soil health.

Conflict of interest: None.

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