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Microbial basis of organic farming systems with special reference to biodynamic preparations

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ABSTRACT

Organic agriculture systems aim primarily at use of naturally occurring ecological processes rather than external inputs, to manage crops and livestock. These farming systems emphasize on ecofriendly methods of insect, pest and weed control. Biodiversity is the key component of organic agrisystems responsible for its efficacy. According to IFOAM (International Federation of Organic Agriculture Movements) organic production methods are those where at least 95% of the ingredients used for agriculture purposes are organic in nature. Latter content less than 70% may not refer to organic production methods. Organic farming systems work on nature's principles; improve agro ecosystem health including soil biological activity and product quality. The most followed organic farming systems are Permaculture, Panchagavya farming, Rishi Krishi, Natueco farming, Zero budget natural farming, Biodynamic farming etc. Enormous literature and supportive materials are available to justify the use of these farming systems to combat soil pollution created by use of various chemicals. However, when it comes to scientific explanation, the work is scattered. A common person may develop the assumption that these systems might possess some supernatural or magical curing ability. However, these preparations work on scientific principles mostly powered by microbes and their metabolic products. In the present review, research on various organic preparations, with special reference to their microbial properties, has been compiled and analysed. The review will be of immense benefit to students, researchers and strategy planners working in the field of organic farming.

Key words: Amritpani, Bijamrit, Biodynamic preparations, Jeevamrit, Organic farming, Natural farming, Panchagavya, Rishikrishi

Organic farming, as defined by FAO is a unique production management system which promotes and enhances agro ecosystem health, including biodiversity, biological cycles, biological activities and soil biological activity (www.fao.org).This is accomplished by using on-farm agronomic, biological and mechanical methods in exclusion of all synthetic off-farm inputs. The main aim of organic farming system is to effectively use local and renewable resources, efficient use of solar energy for production and improving the potential of biological system, improvement in soil fertility, recycling of plant nutrients and organic waste, maintain diversity in production system as well as agriculture landscape and avoid use of chemicals in any form (www.fao.org). To the maximum extent feasible, organic farming systems rely upon crop rotations, crop residues, animal manures, legumes, green manures, off- farm organic wastes, mechanical cultivation, minerals bearing rocks, and aspects of biological pest control to maintain soil productivity and tilth, to supply plant nutrients and to control insects, disease and weeds (Ram and Pathak, 2018).

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Types of organic farming

There are various systems of organic farming include Permaculture, Rishi Krishi, Panchgavya, Natueco, Zero Budget, Natural Farming and Biodynamic Farming being practiced in different part of country and in the world.

Permaculture is a system of agriculture which directly utilizes the patterns and features observed in natural ecosystems. The word Permaculture originally referred to "permanent agriculture" but was expanded to stand also for "permanent culture"(en.wikipedia.org/wiki/Permaculture).

The three core principles of Permaculture are:

- Healthy earth so that all life systems continue and multiply.
- The natural resources should be accessible to all human being.
- Agriculture waste recycling.

There are 5 zones in as shown in figure below :

Zone 0 represents house areas. Zone 1 represents frequently visited area like kitchen garden and microclimate.

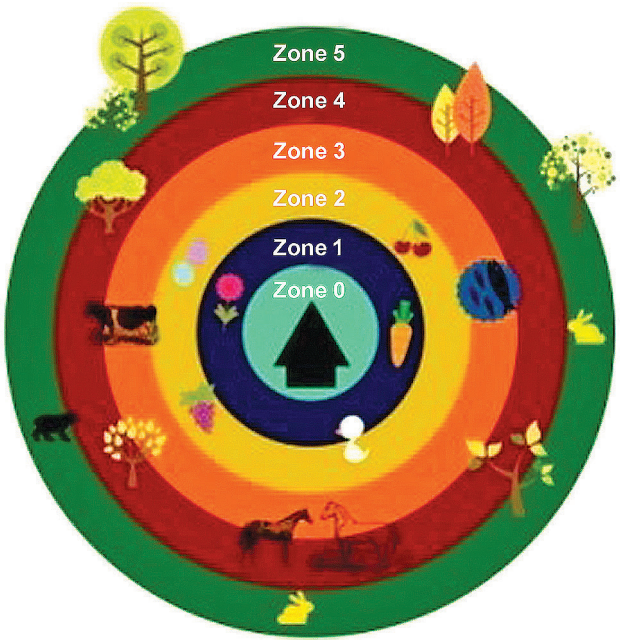

Fig 1 Zones in Permaculture. *Source:* (https://www.hyperbrain.me/compact-gardening-part-3/)

Zone 2 includes semi intensive cultivated area like food production, market crops and green house. Zone 3 represents occasionally visited area including large fruit and nut trees. Zone 4 involves minimal care area like wild food gathering, wood cutting for fruit and timber and zone 5 represent unmanaged zone involves wilderness zone, foraging, inspiration and meditation.

Permaculture draws it basis from several organic farming systems including agro forestry, integrated farming, sustainable development and applied ecology. It has been most commonly applied in designing of house, landscaping, integrating techniques such as agro forestry, natural building and rain water harvesting etc.

Panchagavya based farming system

Panchagavya is a blend of five cow based ingredients obtained from cow, viz. dung, urine, milk, curd and ghee in 1:3:2:2:1 ratio mixed thoroughly and fermented subsequently for 7 days with intermittent stirring (NCOF, Ghaziabad).For the Hindus, the formulation and use of fresh Panchagavya has been well-known, since the time of Puranas (c. 200 BCE to c.750 CE) for house purification after deaths, etc.

Application procedure: Generally, Panchagavya is recommended for all the crops, as foliar spray at 3% level (3 litres Panchagavya in 100 litres of water), in irrigation water (50 litres for one ha), as dipping seed and planting materials, or before seed storage (Nene 2017).

Rishi Krishi: It is a method of natural farming developed by farmers of Maharashtra and Madhya Pradesh. In this technique, there are four component practices (rishikrishi.co.in).

1. Angara (rhizospheric soil of banyan tree): Fifteen kg of soil from the rhizosphere of banyan tree is applied per acre of farmland.
2. Amritpani: The recipe of preparation of Amritpani includes 250 g of ghee from indigenous breed cow, half kg of honey and 10 kg of fresh cow dung from desi cow mixed with 200 l of water.The promoter of this agrisystem recommended dipping of sugarcane, turmeric, ginger into Amritpani before planting and in case of crops which seedlings are transplanted, dip the roots in Amritpani before planting.
3. Beej sanskar (Dressing of seeds): One kg of banyan tree (Angara) mixed with sufficient amount of amritpani to make a thick paste. Apply the paste over the seeds having hard coat, dry it in shade and store and use according to need, while those seeds which have thin coat such as hemp, cereals, moong, groundnut paste is sprinkled over the seeds and use the seeds immediately.
4. Acchadana (Mulching): There are four types of mulching:
   (i) *Soil mulch:* This protects top soil during tillage. It promotes aeration and water retention in the soil.
   (ii) *Straw mulch:* Straw material usually refers to the dried biomass waste of previous crops.
   (iii) *Live mulch:* It refers to symbiotic intercrops and mixed crops. It is recommended that multiple cropping patterns of monocots and dicots should be adopted grown in the same field to supply all essential nutritive elements to the soil and crops (rishikrishi.co.in, Nene 2017).

Natueco farming

Natueco farming emphasize on staying in synergy with nature, reducing dependency on external inputs to a farm, and working scientifically within the available resources in the surroundings of a farm, without harming its ecology and at the same time gaining high benefits from it. The main ingredients used in natueco farming including amrutmitti and amrutjal. Amrutjal (nectary water) is prepared by mixing 10 litres of water, 1 litre of cow urine, 1 kg of fresh cow dung, and 50 g of jaggery. This mixture is fermented for 3 days and stirred it well twice or thrice each day. On the 4th day, the concentrated suspension is ready. One part of this suspension is diluted to 10 parts with water. Amrut Mitti is prepared from green and dry plant biomass; both are dried and crushed well. The dried biomass is immersed in Amrutjal in a container and then kept as such for 24 hr (Nene 2017).

Zero budget natural farming

Zero budget natural farming is farming practice that believes in natural growth of crops without adding any fertilizers and pesticides or any other foreign elements. The word zero budget refers to zero net cost of production of all crops (inter crops, border crops, multi crops).According to Palekar (2005) Zero Budget Natural Farming (ZBNF) has 4 key elements, viz. Bijamrit (seed treatment), Jiwamrit (microbial culture), Achhadana (mulching), Whapasa (soil aeration).

Bijamrit: It is used for seed dressing or root-dipping. It is prepared as per following protocol: Cow dung (50 g), cow urine (50ml), fresh cow milk (50 ml), lime stone (2 g) and water (1 liter). All the ingredients are mixed thoroughly in a plastic jar and left for fermentation overnight (http:ncof.dacnet.nic.in).

Application: It is applied to the seeds of any crop. Seeds are coated with bijamrit by thoroughly mixing by hand and left it for drying. Dried seeds were used for sowing. It helps in protecting young roots from fungus as well as from soil borne and seed borne disease (Nene 2017).

Jeevamrit: Jeevamrit is a fermented microbial culture. It is prepared by mixing cow dung (5 kg), cow urine (5 litre), pulse flour (1 kg), fertile soil (1/2 kg) and water (50 litre) in a plastic drum and left it for 5 to 7 days fermentation with regular stirring 2 – 3 times per day with help of a wooden stick (http:ncof.dacnet.nic.in). During the 48-hour fermentation process, the aerobic and anaerobic bacteria present in the cow dung and urine multiply as they decompose the organic ingredients (like pulse flour). A handful of virgin soil is also added as native microflora. Jeevamrit also helps in preventing fungal and bacterial plant diseases (Nene 2017).

Application procedure: It is applied to the crops twice a month in irrigation water or as a 10% foliar spray. It helps to prevent fungal and bacterial plant disease. Two hundred litre of jeevamrit is sufficient for one acre of land.

Acchadana: (Sanskrit- *acchadana* means ("to cover") means Mulching. The details have been described in earlier section of Rishi Krishi.

Whapasa: It is vapour moisture. Whapasa is the condition where there are both air molecules and water molecules present in the soil (Nene 2017).

Biodynamic farming

Biodynamic farming was spawned by late anthroposophist Rudolf Steiner and has gained popularity since 1922. The term biodynamic is taken from the greek word bios (life) and dynamic (energy). Hence, biodynamic farming refers to working with energies which create and maintain life.

Biodynamic farming system maintains sustainable soil fertility and builds relationship between plant growth and cosmos rhythms (Ram 2013).

Basically there are two types of biodynamic preparations

1. Biodynamic field spray (BD 500 – BD 501)
2. Biodynamic compost preparations (BD 502–BD 507)

General protocol followed for making of BD preparations

BD 500: It is prepared from fresh cow dung dually incubated in cow horn.The preparation method of BD 500, cow horn is filled with cow dung in the month of October /November and placed in a pit, 1 inch apart with base downwards, surrounded with 50% compost and soil. Pit is covered with moist soil and left it for 4 to 6 months. After 4 months if the cow dung has turned into dark smooth earthy smelling humus (BD 500), it is considered as ready to use, otherwise it is incubated further (agritech.tnauac.in/org- farm/orgfarm- introduction.html).

BD 501: Its preparation procedure involves cow horn filled with silica paste and buried during the summer time from April/May to September in soil pit, 1 inch apart with base downwards surrounded with 50% compost and soil (agritech.tnauac.in/org-farm/orgfarm-introduction.html).

BD 502: It is prepared from yarrow (*Achillea millifolium*) flowers. In its preparation protocol, bladder is moistened and flowers are filled up to top with the help of small cut and after filling cut sealed with cotton thread and buried it from September to March in a mud pot with earth inside (agritech.tnauac.in/org- farm/orgfarm- introduction.html)

BD 503: It is prepared from the flowers of the chamomile (*Matricuria chamomilla*) plant. In its preparation protocol, unwashed intestine of cow or bull is cut into 15 cm bits and one end of bit is closed with a cotton string and another end is used to fill dry flowers in it with the help of funnel. Bundle of filled sausages are placed in mud pot surrounded with fertile soil. Bundles were buried in soil in the month of October and let remained till February/ March (agritech.tnauac.in/org- farm/orgfarm- introduction.html).

BD 504: It is prepared from Himalayan stinging nettle (*Urtica parviflora*). In its preparation procedure terracotta pipes or mud pots are filled with dried leaves of stinging nettle and lid is kept open and the preparation is lifted in September after a year.It stimulates soil health, by providing plants with the individual nutrition components (agritech.tnauac.in/org- farm/orgfarm- introduction.html).

BD 505: It is prepared by filling the brain cavity of skull of any domestic animal with crushed bark of the oak tree (*Quercus glauca*). The opening is closed with a well shaped bone piece. It should be placed in a location where there is exchange of water such as rain drain/swamp. It should be noted that a foul smell is emitted on lifting the preparation and removing it from the skull. This gradually reduces with drying after removal in a dark dry place. The preparation is buried in September and lifted in March (agritech.tnauac.in/org- farm/orgfarm- introduction.html).

BD 506: In its preparation the dandelion (*Taraxicum officinalis*) flowers are used. The unwashed mesentery of cow is filled with dried flowers of dandelion and wrapped into a parcel and tied with a jute thread. The parcel is placed in a good mixture of soil and compost into a pot in the month of September while lift in March (agritech.tnauac.in/org- farm/orgfarm- introduction.html).

BD 507: The juice of valerian flowers (*Valeriana officinalis*) is used for this preparation. A paste is prepared after grinding of flowers into a mortar and pestle. The paste is added to water in ratio of 1:4 in a bottle and kept it in cool place (agritech.tnauac.in/org- farm/orgfarm-introduction.html).

Uses and application procedure of BD preparations

BD 500: It is usually sprayed at the time of late afternoon or evening in the field. The 25 g of BD 500 is required per acre in 15 l of warm water (15–20°C) for spray.

After addition of BD 500 in water, it is stirred for one hour alternatively clockwise and anti clockwise forming a vortex. Generally preparation is sprayed 4 times in a year during the beginning and after rains, i.e. Feb- May- Nov- Dec**.** It is sprayed to vitalize the soil, enhance seed germination, root formation and primary root development **(**agritech.tnauac. in/org- farm/orgfarm- introduction.html).

BD 501: BD 501 is usually applied after one or two sprays of BD 500. It is sprayed in early morning 6 to 8 am at sunrise. The 1 g of BD 501 is dissolved in 15 l of warm water, stirred for 1 hour before sunrise, alternately in clockwise and anticlockwise direction forming a vortex. This is sprayed on the plants using a low pressure sprayer. It is sprayed twice during planting cycle at the beginning and again just before harvest. It improves photosynthesis activity in plants. It strengthens the immune system of plant, quality of fruits and seeds **(**agritech.tnauac.in/org- farm/ orgfarm- introduction.html).

Uses and application procedure of BD 502 - BD 507 **(**agritech.tnauac.in/org- farm/orgfarm- introduction.html).

BD 502 helps the plants to attract trace elements in extremely dilute quantities for best nutrition. It is rich in Sulphur (S) and Potassium (K). BD 503 is said to help in stabilizing nitrogen (N) within the compost and increases soil life so as to stimulate plant growth. It is rich in Calcium (Ca) and Sulphur (S). BD 504 is rich in Sulphur (S), Potassium (K), Calcium (Ca) and Iron (Fe).BD 505 helps in protecting harmful plant diseases. It is rich in Calcium (Ca).BD 506 helps in Si and K absorption to the soil while, BD 507 helps in regulating availability of phosphorus to the soil.

One gram of each (BD502-506) is added directly to every 5 cubic meters of compost and 10 ml of BD 507 is mixed at 5% in 2-5 l of water can be used. These could be added to liquid manures and cow pat pits also.

Microbial characterization of organic preparations

Microorganisms are very important for different farming system and they help in increasing the quality of soil. Ademir *et al.* (2009) showed that soil organic carbon was higher in organic area than in conventional area. Lower soil bulk densities and high soil microbial activity measured by soil respiration and organic carbon, was found in the area where organic farming was practised.

Herencia *et al.* (2008) reported that organic farming management resulted in higher soil organic carbon, N and available P, K, Fe and Zn. Biodynamic agriculture uses specific manure and fermented herbal preparations as compost additives and field sprays in comparison to organic agriculture. Higher concentrations of soil microbial biomass and diversity were observed in farming system where organic manure applied regularly in comparison to the systems where mineral fertilizers were used (Hartmann *et al.* 2006)

Some microorganisms are responsible for the suppressive activity of the composts due to their antagonistic behaviour to plant pathogen (Aviles *et al.* 2011). The suppressive activity of microorganisms may be help in degrading polymers through the production of extracellular enzymes. Their presence in the finished product is important as it reflects the compost quality, and its properties as a nutrient supplier and pathogen suppressor (Hadar and Papadopoulou 2012). Ram (2013) has described the microbial load of different organic preparations in Table 1.

Table 1 Microbial load of different bio enhancers

Microorganism	Panchgavya (CFU*/g)	Jeevamrita (CFU*/g)	Beejamarit (CFU*/g)	Biogas slurry (CFU*/g)
Bacteria	2.61×10^6	1.54×10^6	2.04×10^5	1.29×10^6
Fungi	1.8×10^4	1.05×10^4	1.38×10^4	9.2×10^3
Actinomycetes	4.2×10^3	6.8×10^3	3.6×10^3	3×10^3
P solubilzers	5.7×10^2	2.7×10^2	4.5×10^2	1×10^2
Free living nitrogen fixers	2.7×10^2	3.1×10^2	5×10^2	2.1×10^2

*CFU- Colony forming units. *Source:* Ram (2013)

Panchagavya

Panchagavya is being utilized since long time by the farmers to provide nutrients to the plants and soil microorganisms. Microbial analysis of bio-enhancers (Ram *et al.* 2018) revealed that Panchagavya contained highest number of total bacteria (6.25×10^9 cfu/ml) as compared to Jeevamrita (3.24×10^9 cfu/ml), biodynamic liquid pesticide (2.27×10^9 cfu/ml) and Amritpani (5.49×10^8 cfu/ml). Panchagavya had also higher number of *Pseudomonas* (4.7×10^7 cfu/ml), *Rhizobium* (2.43×10^6cfu/ml), *Azotobacter* (1.4×10^5 cfu/ml) and *Azospirillum* (1.03×10^5 cfu/ml). Ram *et al.* (2018) reported that fungal population was highest in Jeevamrita (1.20×10^7 cfu/ml) as compared to biodynamic liquid pesticide (2.64×10^6 cfu/ml), Amritpani (0.46×10^5 cfu/ml) and Panchagavya (0.20×10^5 cfu/ml). Actinomycetes, *Pseudomonas*, P-solubilizing microbes, *Azotobacter* and *Azospirillum* population were highest in biodynamic liquid pesticide (1.37×10^8, 3.28×10^8, 8.50×10^6, 2.0×10^6 and 1.4×10^5 cfu/ml). Similarly, gram positive bacteria, gram negative bacteria and *Rhizobium* were highest in Jeevamrita (1.6×10^8, 2.2×10^8, 7.51×10^7 cfu/ml) (Ram *et al.* 2018). Amritpani had higher number of actinomycetes (1.31×10^7cfu/ml), gram negative bacteria (1.35×10^8cfu/ml) and P-solubilizing microbes (4.8×10^6 cfu/ml). Among all bio-enhancers, Panchagavyawas rated most effective bio-enhancer followed by biodynamic liquid pesticide, Jeevamrita and Amritpani. Results revealed (Ram *et al.* 2018) that these bio-enhancers could play a potent source of beneficial microbes which could improve soil fertility, crop productivity and produce quality.

Panchagavya spray at 6% rate improves the efficacy of P-solubilizers (Boraiah *et al.* 2017).Sreenivasa *et al.* (2009) revealed that Panchagavya, Beejamruth and Jeevamruth prepared by using cow products are known to contain beneficial microflora like *Azospirillum*, *Azotobacter*, phosphobacteria, *Pseudomonas*, lactic acid bacteria and Methylotrophs in abundant numbers and also contained

some useful fungi and actinomycetes.

Amritpani

Amritpani is one of the important input used in Rishi Krishi system of organic farming prevalent in Maharashtra and Rajasthan. It is prepared with cow dung, cow ghee and honey with preparation time of 7-10 days. It contains a consortia of beneficial microorganisms.Garg *et al.* (2017) reported two pigmented bacteria, B1 (yellow) and B2 (orange) isolated from Amritpani. These bacteria exhibited UV resistance since only one log reduction in bacterial population was observed after 20 minutes of exposure to UV light. The isolates possessed high pectinase activity 2.23 and 2.66 IU/ml for B1 and B2, respectively. These bacteria had antimicrobial activity against *Colletotricum gloeosporioides* and *Fusarium solani*. These bacteria might be responsible for specific properties of organic preparation 'Amritpani' as seed dresser and for decomposition of organic waste (Garg *et al.* 2017).Antimicrobial property of bio-enhancers viz. Amritpani, Panchagavya, cow pat pit, Jeevamrita tested against some selected pathogens under *in vitro* conditions revealed significant reduction in the growth of *Aspergillus fumigatus* and complete growth inhibition of *Colletotricum gloeosporioides* and *Fusarium solani* (Ram *et al.* 2020)

Beejamruth and jeevamruth

Beejamruth and Jeevamruth, prepared by using cow products, are known to contain beneficial microflora like *Azospirillum*, *Azotobacter*, phosphobacteria, *Pseudomonas*, lactic acid bacteria and Methylotrophs in abundant numbers and also contain some useful fungi and actinomycetes (Sreenivasa *et al.* 2009). A field experiment was conducted to evaluate the effect of organic liquid formulations on growth and yield of capsicum (Boraiah *et al.* 2017). The experiment consisted of 12 treatment combinations with three factors including Jeevamrutha (2 levels), Cow urine (2 levels) and Panchagavya (3 levels). Among their different organic liquid formulations, application of jeevamrutha recorded significantly higher fruit yield.

Microbial characteristics of biodynamic preparations

Cow dung is an important component of biodynamic preparations. Swain and Ray (2006) reported that *Aspergillus niger*, *Trichoderma harzianum*, *Bacillus cereus* and *Bacillus subtilis* isolated from cowdung can reduce the growth of *Sclerotium rolfsii*, *Fusarium oxysporum*, *Pythium aphanidermatum*, *Helminthosporium maydis* and *Rhizoctonia solani* with inhibitory zones of up to 58%. Furthermore, *B. subtilis* isolated from cow dung can enhance plant growth, sulphur oxidation, phosphorus solubilisation and was found to produce industrial enzymes such as amylase and cellulose (Swain and Ray 2006). Gummosis disease of mango caused by *Lasiodiplodiat heobromae* is one of the economically important diseases. Garg *et al.* (2003) reported that cow dung is the most economical and ecofriendly treatment for the management of gummosis disease of mango.Garg *et al.* (2003) revealed that actinomycetes *Streotosporangium pseudovulgare* isolated from cow dung can act as effective tool against *Laisdiplodia theobromae* the casual agent for rot disease in guava.

Garg *et al.* (2004) reported that application of organic fertilizers including BD 500, vermiwash, vermicompost and CPP in papya orchards resulted in substantial population build up of mold and bacteria

Veeresh *et al. (*2012) determined the effect of cow dung and a biodynamic microbial consortium (jeevamrutha) on the microbial population during the conversion of paper mill and sugar factory sludge into beneficial vermicompost. The bacterial and actinomycetes densities were highest in jeevamrutha treated group while fungal density was higher in the treatment group related with cow dung.The study by Valdez and Fernandez (2008) revealed that the application of BD 500, 501 and 508 resulted in the disappearance of tungro symptom (it is caused by combination of two viruses which are transmitted by leaf hoppers. It causes leaf discolouration, stunted growth, reduced tillar numbers and sterile or partly filled grains) present in the rice crops and the recovery of crop vitality.

Reeve *et al.* (2011) reported that wheat seedlings receiving 1% BD-treated compost extract had similar root and shoot biomass as the fertilized seedlings and found to be significantly higher than the untreated compost. Sharma *et al.* (2012) reported that the application of BD 500 and BD 501 in combination with farmyard manure gave significantly higher yield and harvest index in cumin in comparison to other treatments and control.

Effect of biodynamic preparations on plant growth promoting activities

Valdez and Fernandez (2008) reported that plant growth stimulatory hormones, auxins and cytokinins in BD preparation 500. Higher root length and biomass was observed in rice in biodynamic farming system in comparison with the organic and conventional farming systems which might be due to microbes with PGPR activity.

Matteo *et al.* (2013) reported the dominance of gram positive bacteria in BD 500. The manure also exhibited a strong auxin-like effect on plants and exhibited elevated values of enzymes, viz. alkaline phosphates, chitinase, esterase and β-glucosidase. The microorganisms present in the biodynamic preparation acted as bio stimulant in the soil.

Table 2 depicts microbial load of different biodynamic preparations (Pathak *et al.* 2010). Garg (2013) reported presence of large number of beneficial microorganism in BD 500 which further increased in number by vortexing. The result revealed that for the first 15 minutes there was almost two times increase in the number of microorganism but afterwards the increase was slow and steady after 90 and 120 min in case of bacteria and actinomycetes, respectively. The study indicates that vortexing for 90 minutes instead of 60 min (normal practise) may further increase the efficiency of BD 500.There was increase in bacterial, fungal and actinomycetes 8.2×10^3, 2.5×10^2 and 3.9×10^3 cfu/g,respectively (Garg 2013). Radha and Rao (2014)

Table 2 Microbial load of different biodynamic preparations

Biodynamic preparations	Bacteria (CFU/g)	Fungus (CFU/g)
BD 500	1.2×10^5	8.5×10^3
BD 501	2.3×10^5	2.2×10^3
BD 502	3.4×10^6	6.8×10^4
BD 503	2.2×10^6	1.0×10^5
BD 504	1.8×10^6	8.9×10^4
BD 505	6.8×10^5	4.9×10^4
BD 506	1.2×10^5	7.2×10^4
BD 507	5.3×10^4	3.2×10^5

Source: Pathak *et al.* (2010)

reported the occurrence of *Lysinibacillusx ylanilyticus* and *Bacillus licheniformis* in biodynamic preparations. The isolated bacterial strains exhibited plant growth promoting attributes like IAA production, P solubilisation and antagonism to *Rhizoctonia bataticola* and improved the growth of maize plants.

The bacteria isolated from BD 501 were identified as *Bacillus amyloliquefaciens* and *Bacillus toyonensis*. The bacterial isolate *Bacillus amyloliquefaciens* recorded for a strong antifungal activity against *Rhizoctonia solani* and moderate activity against *Pyricularia oryzae* (Jayachandran *et al.* 2016).

Recently, Goldstein *et al.* (2019) conducted two experiments in Washington and Wisconsin, and reported that preparations appeared to have strong effects on root and vegetative growth. The Washington study showed 13% greater root dry matter and 18% greater root length of winter wheat associated with the use of biodynamic herbal preparations in manure and the spray preparations horn manure and horn silica. In the Wisconsin study the biodynamic and biodynamic + NCP treatment showed increase in maize root length 10% and 10% in 1998, but 23% and 37% in 1999 relative to the organic treatment while in case of maize root weight found 12% and 33% increase in 1998 and 28% and 39% in 2019 relative to the organic treatment.Vaish *et al* (2019) reported high enzymatic and siderophores production behaviour of fungal isolates from various biodynamic preparations.

Conclusion

Though, limited studies are available on exact functioning of microbial diversity. It is one of the key factors that may govern the functioning of organic farming systems. Efficient microorganisms present in these preparations are constantly working as renewable bio inoculums to perform mineralization for restoring or maintaining soil fertility. These may act as nitrogen fixers, phosphate solubilizers, produce some bio active compounds which promote the plant growth and inhibit soil pathogens. The organic soils have a higher index of soil fertility. These bio stimulants also act as a reservoir of important labile pools of carbon and mineral nutrients from which the nutrients get librated following the death of microorganism. Seed treatment with some preparation manages many soil and seed born diseases as well as enhances nutrient availability. Synergistic interactions among microbes improve soil productivity and functioning. Further exploration and use of unidentified microbes in these preparations is required to further explain the interactions between microbes and soil ecosystem in organic farming.

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