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A REVIEW

Sustainability of environment through biodynamic agriculture

■ V. PARAMESH, M. LAKSHMIPATHY AND P. ARUN KUMAR

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ABSTRACT : Biodynamic agriculture is a method of organic farming that emphasizes the holistic development and interrelationships of the soil, plants and animals as a self-sustaining system. One of the first modern ecological farming systems, it emphasizes a sustainable approach to agriculture. Biodynamics has much in common with other organic approaches. It emphasizes the use of manures and composts and excludes the use of artificial chemicals on soil and plants. Methods unique to the biodynamic approach include its treatment of animals, crops and soil as a single ecosystem. Biodynamic agriculture uses various herbal and mineral additives for compost additives and field sprays. Biodynamic agriculture has been characterized as pseudoscience. Its founder, Rudolf Steiner, and its developers characterize it as "spiritual science" and they advocate taking a holistic view rather than a reductionist view. Recently, there has been an increasing interest in biodynamic farming practices and systems because they show potential for mitigating some detrimental effects of chemical-dependent conventional agriculture. The studies have shown that the biodynamic farming systems generally have better soil quality, lower or equal crop yields, and equal or higher net returns per hectare than their conventional counterparts. However, more research is needed to determine whether the preparations affect soil physical, chemical, and biological properties and crop growth and, if so, their mode of action.

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Author for correspondence **:**
V. PARAMESH
Division of Agronomy,
Indian Agricultural
Research Institute,
PUSA, NEW DELHI
(INDIA)
See end of the article for
Coopted authors'

Biodynamic agriculture is a system of organic agriculture that has proved to be very effective throughout the world. The name "Biodynamic" refers to a working with the energies which create and maintain life. It is more concerned with consciousness expansion in regard to plants, animals and soil. The artful aspects of the elements that influence the farm and the spirit of nature are taken into consideration. This deeper awareness is based on observation of nature. Biodynamic techniques enhance, rejuvenate, add to and maintain soil quality. Biodynamic farming parallels organic farming in many ways but places greater emphasis on the integration of animals to create a closed nutrient cycle, effect of crop planting dates in relation to the calendar and awareness of spiritual forces in nature. A unique feature of this system is the use of eight specific preparation derived from cow manure, silica, and herbal extracts to treat compost piles, soils and crops. Biodynamic technology, with its informed use of the various preparations, will maintain soil fertility for years to come in a wholly natural way. It will support the growing of a plentiful supply of nourishing food. BD supports nature to intensify certain natural processes, creating optimal animal populations, making special compost preparations, and planting selected companion plants. Biodynamics is man's service to the

earth and its creatures, not just a method for increasing production or for providing healthy food.

Biodynamic farming means biological dynamics. It is a method of organic agriculture, which considers farm as a living system and where one activity affects the other. Biodynamic farming evolved in Europe in the 1920s following lectures on agriculture by the Austrian anthroposophist Rudolf Steiner. Biodynamic farming parallels organic farming in many ways but places greater emphasis on the integration of animals to create a closed nutrient cycle, effect of crop planting dates in relation to the calendar, and awareness of spiritual forces in nature. A unique feature of this system is the use of eight specific preparation derived from cow manure, silica and herbal extracts to treat compost piles, soils, and crops.

Biodynamics is considered by some to be the oldest organized alternative agriculture movement in the world. It began in 1924 following a series of lectures by Rudolf Steiner, the founder of anthroposophy, at the request of German farmers (Koepf, 1989). Within a few years, interest spread to several European countries. Today, farmers, gardeners, advisers and scientists are organized into biodynamic associations, some of which have their own research facilities. A certification programme was introduced in 1928 for marketing basic foodstuffs, which are now marketed under the trademarks Demeter and Biodyn. Most, if not all, certified biodynamic products would meet the criteria for certified organic, but certified organic would not meet the Demeter standards, mainly because the biodynamic preparations are not used in organic farming.

As of 2011 biodynamic techniques were used on 142,482 hectares in 47 countries; Germany accounts for 45.1 per cent of the global total. Biodynamic methods of cultivating wine grapes have been taken up broadly, including by notable vineyards. There are independent certification agencies for biodynamic products; most of these agencies are members of the international

Table 1 : The eight biodynamic preparations, which consist of fermented materials that are used as field sprays or in manure or compost piles

Substance from which preparation is produced	Application of preparation
Cow manure fermented in a cow horn	A spray for soils before planting
Silica fermented in a cow horn	A spray for growing crops
Flower heads from yarrol (*Achillea millefolium*) fermented in the bladder of a stag	Preparations 502 through 507 are applied to manure or compost piles
Boiling the horsetail plant (*Equisetum arvense*)	To prevent fungal diseases in wet years
Stinging nettle (*Urtica dioica*) fermented in the soil	
Oak bark (*Quercus robur*; in north America *Quercus alba*) fermented in the skull of a domestic animal	
Flower heads of dandelion (*Taraxacum officinale*) fermented in a cow mesentry	
Juice pressed from valerian flowers (*Valeriana officinalis*)	
Flower heads from German chamomile (*Matricaria recutita*) fermented in a cow intestine	

Table 2 : Crop yields relative to no FYM application on experimental plots maintained since 1993 with differently prepared FYM applications

Crop	Year	Relative yield (yields without FYM=100)		
		FYM without preps	FYM + *Achillea* prep	FYM + all preps
Spring wheat	1993	109 ± 4	106 ± 3	109 ± 4
Grass-clover	1995	90 ± 5	100 ± 5	103 ± 5
Potatoes	1996	110 ± 5	110 ± 2	109 ± 3
Winter wheat	1997	137 ± 8	132 ± 11	138 ± 8
Field beans	1998	103 ± 4	102 ± 3	95 ± 4
Spring wheat	1999	126 ± 6	118 ± 4	126 ± 5
Winter rye	2000	99 ± 3	98 ± 3	99 ± 3
Grass-clover	2001	112 ± 8	113 ± 7	118 ± 6
Spring wheat	2002	102 ± 3	101 ± 7	103 ± 5

biodynamics standards group, Demeter International.

Organic farming vs. biodynamic farming :

The biodynamic farming is more than just another organic method. It stands for a truly scientific way of producing humus. It does not involve in the application of organic matter in a more or less decomposed form but the use of completely digested form of crude organic matter known as stabilized and stable humus. In this aim, the method differs from organic farming. In the case of biodynamic fanning the organic material to be used as basis for compost is transformed either by means of the biodynamic compost preparations or by means of the biodynamic compost starter.

Principles of biodynamic farming :

- Biodynamic farming aims to restore humus status of the soil ecosystem to hold its fertility and productivity.
- Also it helps to restore the soil for a balanced functioning of flora and fauna because soil is a living system, wherein, the microbes can be fully established and maintained.
- The biodynamic farming does not deny the role and importance of mineral nutrients of the soil like nitrogen, phosphate, potasium, calcium, magnesium etc. and it considers the skillful use of organic matter as the factor for soil life.
- It involves skillful application of all the factors contributing to soil life and health because a plant grows under the influence of abiotic factors like temperature, oxygen, CO_2 light, water etc. and these energies are transformed in the plant system into chemically active energies by way of photosynthesis.
- Biodynamic farming considers a plant as living entity which consists not only of mineral elements (like N, P, K, Ca, Mg, Mn, Cl, Fe, etc.) but also of organic matter such as protein, carbohydrates, cellulose and starch.

Table 3 : Mean values of aggregated soils data **(Reganold *et al.*, 1993)**

Soil property	All biodynamic farms	All conventional farms
Bulk density (mg/m^3)	1.04	1.15
Penetration resistance (0-20 cm) (MPa)	2.84	3.18
Mineralizable nitrogen (mg/kg)	140.0*	105.9
CEC (cmol/kg)	21.5*	19.6
Total N (mg/kg)	4840*	4260
Extractable P (mg/kg)	1560	1640
Extractable S (mg/kg)	10.5	21.5*
Extractable Ca (cmol/kg)	12.8	13.5
Extractable Mg (cmol/kg)	1.71	1.68
Extractable K (cmol/kg)	0.97	1.00
pH	6.10*	6.29*

* indicate significance of value at P=0.05

Table 4 : Mean values of soils data from adjacent paddocks and plant data from pot trials, New South Wales Farm Pair, Australia Forman (1981)

Soil and plant properties	Biodynamic farm	Conventional farm
C (%)	1.43	0.94
Total nitrogen (%)	0.23	0.13
Extractable P (mg/kg)	44.9	27.8
Extractable Mg (cmol/kg)	1.65	1.86*
Extractible K (cmol/kg)	1.33	1.39
Extractable Na (cmol/kg)	2.17	4.63*
pH	6.12*	5.57

* indicate significance of value at P=0.05

- Biodynamic farming gives importance to enzymes and growth substances.
- To restore the soil fertility, biodynamic farming gives priority to proper crop rotation. Soil exhausting crops should be cultivated alternatively with fertility restoring crops. It also provides recognition to green manuring and cover cropping.
- To restore the soil environmental conditions, forests, wind protection and water regulation are important.
- Biodynamic farming also gives importance to maintain the soil structure (physical characters like bulk density, pore space, water holding capacity and texture).

The steps to be taken :

- Build and properly treat manure and compost piles. Do not waste any organic waste. Do not burn leaves and trash but compost them. Collect everything. Do not apply crude, under-composted organic matter to the fields or garden but make use of the beneficial effects of microlife by first composting manure and all other organic material. Apply – immediately prior to planting or seeding – only predigested material, which will not tie down nitrogen, phosphate and other fertilizer elements, but will increase their availability.
- Introduce soil-protecting crop rotations and cover crops.
- Introduce green manuring, but take care that the green manure crop is properly plowed or disced under without tying down the soil life and nitrogen.
- In a garden, or wherever feasible, introduce mulching.
- Improve your soil cultivation practices.
- Establish proper environmental control, wind protection, good drainage and control of the watershed.

This paper summarizes data from several previous investigations comparing biodynamic and conventional farms or research plots in different countries. The objective of each study reported here was to determine the effects of biodynamic and conventional farming on crop productivity, soil quality and economic performance.

Production studies :

A field experiment was carriedout for 6 years near Elkhorn, Wisconsin. In this experiment, four treatments tested were conventional, organic, biodynamic (BD) and biodynamic+ (BD+). The trials showed average yields of 5.58, 6.71, 6.77 and 7.15 mg/ha of grain yield of maize for the conventional, organic, biodynamic control and

Table 5 : Earthworm count in plot soils (0–15 cm depth) in eastern Washington in 1996 after two cropping seasons under management varying by fertilizer type and application of biodynamic (BD) field sprays

Treatments	Earthworm population (no. M^{-2} topsoil)	Earthworm biomass (g M^{-2} topsoil)
Fertilizer		
BD compost	95.6ab*	51.2ab*
Non-BD compost	145.1a	88.0a
Mineral fertilizers	46.0b	26.9ab
None	49.6b	22.8b
BD sprays		
Yes	92.0	48.7
No	76.1	45.8

* indicate significance of value at P=0.05

Table 6 : Rotations (1989-1992), wheat yields (1992), and gross revenue, variable costs and gross margin (1989-1992) of biodynamic, conventional, integrated, and organic plots in Australia (Penfold, 1993; 1994)

	Biodynamic	Conventional	Integrated	Organic
Wheat yield (1992) (t/ha)	2.3	3.5	2.7	2.9
Total over rotation 1989-1982 (A$/ha)				
Gross revenue	1399	1196	823	992
Variable costs	391	436	553	352
Gross margin	1008	760	270	635

biodynamic + treatments, respectively (Fig. 1). Yields from the conventional plots lagged behind the organic and biodynamic plots throughout the experiment. Conventional maize did especially poorly in the first 2 years (Fig. 1). This may have been because it received 150 lbs/acre of N the first year, 150 and 100 lbs of N and P in 1995, and a complete NPK fertilizer only in 1996.

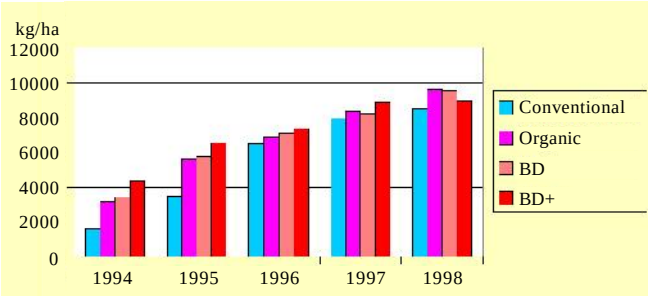

Fig. 1 : Effects of different management systems on the yields of corn var. Golden eagle

Johann and Ulrich (2004) studied the effects of applications of traditionally composted farmyard manure (FYM) and two types of biodynamically composted FYM over 9 years on crop yield. The treatments tested were :

- No FYM application,
- Application of FYM without addition of biodynamic compost preparations (further called FYM without preparations),
- Application of FYM with biodynamic compost preparation of yarrow blossoms (FYM + *Achillea*),
- Application of FYM with biodynamic compost preparation of flowers of yarrow, chamomile, dandelion, stinging nettle shoots, oak bark and valerian extract (FYM + all preps).

The experiment revealed that, crop yields on experimental plots were significantly affected by the FYM treatment applied and varied significantly between years (Table 2). However, yields among plots which received FYM remained in all years unaffected by biodynamic preparations (Table 2).

Soil quality studies :

High quality soils not only promote the growth of plants but also prevent water and air pollution by resisting erosion and by degrading and immobilizing agricultural chemicals, organic wastes and other potential pollutants. The quality of a soil is determined by a combination of physical, chemical and biological properties such as the soil's texture, depth, porosity, capacity to store water and nutrients, organic matter content and biological activity (National Research Council, 1993). Some studies are presented below :

To examine the effects of biodynamic and conventional farming systems on soil quality, Reganold *et al*. (1993) examined seven biodynamic farms on the North Island of New Zealand, each of which was matched with one or two adjacent conventional farms on the basis of soil characteristics and crop or livestock enterprises (total of 16 farms). The farms included a range of representative enterprises in New Zealand: market garden (vegetables), pipfruit (apples and pears), citrus, grain, sheep/beef and dairy. Farm fields within each pair or three farm set had the same crop or livestock enterprise and soil type. The biodynamic farms had been biodynamically managed for at least 8 years; the oldest for 18 years. The biodynamically managed surface soils (0- 10 cm), had significantly higher organic matter content and microbial activity, lower bulk density, easier penetrability, and thicker topsoil than their conventional neighbours (Table 3). Differences in chemical properties were mixed: cation exchange capacity and total N were higher on the biodynamic farms, while available P, available S and soil pH were higher on the conventional farms. Levels of Ca, Mg and K were similar in the two systems.

In a comparison of a biodynamic and an adjacent conventional farm in Australia, Forman (1981) examined soil chemical properties. The two farms were in the Breeza plains area in new south Wales. The seven-year old biodynamic farm used a crop rotation of wheat/ rye/ fallow/wheat/fallow/wheat/wheat a wheat/wheat/fallow rotation. Before the conventional paddock was put into arable crops, it first had been farmed for 10 years, then was in pasture for about 35 years. Organic matter, extractable P and pH were all significantly higher on the biodynamic farm than on the adjacent conventional farm (Table 4). Levels of K were similar; only Mg and Na were lower on the biodynamic farm.

Earthworms were more abundant in compost-fertilized plots, especially in plots receiving non-biodynamic compost (Table 5). Earthworm population and biomass were greater in compost-fertilized plots than non- compost plots. The weight of individual earthworms was similar among mineral and compost-fertilized plots

but lower in unfertilized plots Boggs *et al.* (2000).

Economic studies :

In the Penfold's study (1993) in Australia conventional yields were highest (3.5 ton/ha) and biodynamic yields were lowest (2.3 ton/ha) in 1992, when all four treatments were in wheat (Table 6). However, the biodynamic treatment had the highest total gross margin per ha for the first four years (1989-1992), followed by the conventional, organic and integrated treatments (Table 6). This included a 20 per cent premium on organic and biodynamic wheat from the 1992 harvest. The biodynamic and conventional treatments had the highest gross margins mainly because they had three cash crops, whereas, the organic and integrated treatments had only two.

As pointed out by Lampkin (1990), a major flaw in the Nagele study is that the biodynamic unit was established as a labour-intensive mixed dairy and arable system (11-year crop rotation) in an area that is almost exclusively arable. The conventional and integrated units were set up as arable farms with the same four-year crop rotation. Labour costs for the biodynamic farm were almost three times higher than for either the conventional or integrated farm, causing most of the difference in net returns and he concludes that a less labour intensive organic system could have been developed that would have been more competitive given the conditions in the region.

Discussion :

To stimulate life in the soil and in plants, the biodynamic farmers use eight specific amendments, called preparations, on their soils and crops and in their composts. Their system includes practices such as green and animal manuring, composting, biological pest controls, reduced tillage, complex crop rotations, and diversified crops and livestock. The above studies reveals that the biodynamic farming systems generally had better soil quality, lower or equal crop yields and equal or greater net returns per hectare than conventional system.

The economic studies showed that biodynamic farming systems can do work. Many biodynamic farmers stay in business because of the price premium received for their produce. The long term practice biodynamic farming system reduces the damge of soil erosion, surface and ground water pollution and hazards to animal health (Holmes, 1993).

The application of biodynamic preparations positively influences the soil biological activity, crop root growth and keeping quality of produce (Goldstein, 1986 and 1990). However, very little has been published in the refereed scientific literature and not all the work was of high scientific quality. More research is needed that specifically examines whether the biodynamic preparations affect the soil's physical, chemical, and biological properties and crop yield and quality and if so, their mode of action.

Conclusion :

The application of biodynamically prepared compost can significantly alter microbial turn-over, decomposition rates and earthworm community composition in soil. The principles and practices of biodynamic farming can contribute significantly to achieve the goal of sustainable agriculture and environment.

Coopted Authors' :

M. LAKSHMIPATHY, Division of Floriculture and Landscaping, Indian Agricultural Research Institute, PUSA, NEW DELHI (INDIA)

P. ARUN KUMAR, Department of Dairy Extension, National Dairy Research Institute, KARNAL (HARYANA) INDIA

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