Walter Goldstein

Experimental Proof for the Effects of Biodynamic Preparations

The biodynamic preparations were suggested by Rudolf Steiner in 1924. They consist of fermented materials that are used as field sprays or in manure or compost piles. In practice, the preparations have been associated with a numbering system; the numbers and the system are as follows:

- 500 – Manure spray made from manure that is fermented in a cow horn.
- 501 – Silica spray made from silica that is fermented in a cow horn.
- 502 – Fermented flower heads from yarrow (*Achillea millefolium*).
- 503 – Fermented flowers from German chamomile (*Matricaria recucitata*).
- 504 – Fermented stinging nettle plants (*Urtica dioica*).
- 505 – Fermented oak bark (*Quercus robur*).
- 506 – Fermented dandelion flowers (*Taraxacum officinale*).
- 507 – A fermented juice made from an extract of the flowers of valerian (*Valeriana officinalis*).
- 508 – A spray made by boiling horsetail plants (*Equisetum arvense*).

The horn manure and horn silica preparations are applied routinely as sprays, the manure before planting and the silica when the crop is forming the organ that will be harvested. The herbs (502–507) are applied to manure or compost piles. The horsetail spray is applied only in excessively wet years as a prophylactic against fungal diseases.

The biodynamic preparations were intended to:

- stimulate or regulate a healthy crop growth that would reduce problems with diseases and pests;
- affect the decomposition of manure and reduce nitrogen losses;
- cause treated manures to affect plants in such a way that they better regulate and balance their relationship to various nutrients;
- and increase crop quality.

The thoughts and insights behind the preparations are unconventional and are based on a holistic approach to nature. A description of these thoughts is presented in a companion pamphlet called *The Biodynamic Preparations, What They Are, What They Do, How to Use Them* (Goldstein, 1989).

Use of these preparations has been shown to stimulate crop growth, especially in early stages of development. This may be in part be due to the presence of phytohormones. A review of older experiments on this subject was presented by Goldstein (1979). Furthermore, results from studying the effects of preparations on winter wheat grown in nutrient solutions indicated that small amounts of preparations could regulate crop/nutrient relationships (Goldstein and Koepf, 1982).

Crop Yields

Steiner did not indicate that the preparations would increase yields (Steiner, 1972). Nevertheless, the stimulatory effects of the preparations do often, but not always, result in yield increases. Table 1 gives an overview on results of field experiments carried out by numerous researchers on twenty-one crops in Germany, Sweden, Denmark, Norway, and the USA.

The reader is urged to be cautious when interpreting results from the data presented here. Interpretation of the older experiments, and even some of the newer ones, is often handicapped by the lack of descriptive information on the experiments, replications, and indications of the margin of error. Thus many of the experiments are not up to the quality of research demanded in our time. Furthermore, though statistical indications of the margin of error were given in many of the trials that are summarized here, only an average deviation from the relevant control is presented in this summary in the form of a percent difference. It was often necessary to average many trials or treatments without having access to the original statistics; this made generation of between-experiment margins of error impossible. For more detailed information, the reader is referred to the original authors. It can be safely said that in many trials the preparations did cause yields to significantly differ from controls, though surely not in all cases.

Inspection of the results reveals several phenomena. The preparations had mostly positive effects on yields, though in several cases the preparations appeared to reduce yields. However, the overriding impression is the erratic nature of the results. The effects of preparations on yields of several crops showed the following wide ranges:

- oats: +0% to +30%

- barley: -8% to +19%
- wheat: -4% to +32%
- rye: +0% to +25%
- potatoes: -4% to +26%
- carrots: -1% to +13%
- beets: +4% to +25%

The erratic nature of the results is probably characteristic of substances that act as growth regulators. Undoubtedly more in-depth research is necessary to understand the mode of action of the preparations and how it is influenced by the environment and quality of the preparations.

Earlier researchers tended to have larger yield increases due to the preparations than later authors. Whether this was due to faulty technique or other factors such as differences in sites, quality of preparations, or methods of application, is not clear.

Differences in the quality of preparations may play a role in the erratic nature of the results. Brinton (1983) showed that large differences could exist in the chemical composition of horn manure from different sources, and Stearn (1976) showed large differences in the content of cytokinin-like substances in horn manure and silica from different sources. Allowing the horn manure to dry out halved the content of cytokinin-like substances (personal communication, Christopher Stearn, Ohio State University Department of Soils).

Results from some laboratory trials indicate that the age of the preparations may also play a role. Bio-assays with wheat seedlings grown in nutrient solutions showed that while new chamomile preparation strongly stimulated root growth, an older preparation had no effects (Goldstein and Koepf, 1982). Similarly, Dewes found that newer preparations had greater effects on the decomposition of straw than old preparations (Dewes, 1985).

The number of applications of the spray preparations to a crop may also influence yields. Spiess (1978) and Abele (1973) showed that repeating applications of the spray preparations steadily increased yields of several crops.

Crop Quality

The biodynamic preparations can also affect crop quality. In *The Biodynamic Preparations, What They Are, What They Do, How to Use Them*, the conception of the preparations playing a role as mediators of cosmic and terrestrial forces was discussed. To make this concept more tangible, studies have been made with the relationship between light and darkness and the quality of crops. Crops have been grown by several authors in varying degrees of shade. Crops grown in shade are characterized by having thin leaves with long stems, long internodes, a horizontal growth habit, late maturity, watery tissues with high nitrogen but low sugar contents. These plants are susceptible to fungal diseases. Products from such plants show high enzymatic activity and a high respiration; they are physiologically immature and have poor keeping quality, little taste, and low vitamin C content. Plants grown under excessively strong light conditions show the opposite characteristics.

Even where light is adequate, the combination of moist conditions and soluble nitrogen fertilizers can cause a plant to form itself as if it has been grown under shaded conditions. The use of composted manure and the silica preparation influence crops as if they have grown under more light. These relationships are described for different biochemical and physiological parameters by Engqvist, 1963; Klett, 1968; Arman and Pettersson, 1979; Koepf, et al., 1980; Arvidsson, 1983.

The fact that application of the preparations can result in increased keeping quality is of great practical concern, especially with vegetables. Table 2 shows the effects of spray preparations on decomposition of different crops. Similar results to these were described by Samaras (1981), and Moll (1985). Why the preparations should do this may be due to increased resistance to microbial decomposition. In support of this theory it has been shown that the use of spray preparations reduces the growth of fungi on carrots (Samaras, 1978).

A nutritional factor of concern that appears to be modified by the preparations is the amount of nitrite in vegetables. Vegetables grown with soluble nitrogen fertilizers accumulate excesses of nitrogen in the form of nitrate, and some of this is transformed to nitrite during storage or in the digestive tract (Elsaidy, 1982). Nitrite inactivates hemoglobin, the enzyme that carries oxygen in our bloodstream. In adults, the enzyme is reactivated within hours, but the process is significantly slower for infants. The "bluebaby" syndrome, which is often fatal, has been caused by infants ingesting vegetables that had high nitrite contents. The fatal dose of nitrate for a three month old infant is only thirteen milligrams of nitrate. The problem is often associated with spinach, which is a nitrate accumulator, but can also occur with many other leafy and root vegetables.

The significance of the nitrite problem is that even when it is not present in high enough levels to cause clinical symptoms, it may act on a subclinical level to lower human health. Furthermore, nitrite in plants or in the human digestive tract can also combine with amines to form carcinogenic nitrosamines.

Vegetables fertilized with composted animal manures have generally much lower nitrate contents than those grown with mineral nitrogen fertilizers and also form less nitrite in storage (Elsaidy, 1982). The use of biodynamic preparations appears to affect spinach so that it produces less nitrite (Table 4). Use of the preparations also slows down the decomposition of vitamin C.

Manure, Compost, and Soils

Several effects of the herbal preparations on the decomposition of manure and compost have been noticed by farmers (Bartsch, 1934). These are:

- The manure and straw seem to decompose faster and take on a darker, more humified appearance.
- The manure does not "steam", and does not stink as much as before.
- The manure is easier to spread evenly.

The observation that addition of herbal preparations appears to visually increase decomposition of manure has been made by several scientists (Heinze and Breda, 1978; Wistinghausen, 1986;. Goldstein, 1986; Abele, 1987). These observations have been somewhat confirmed by chemical tests. Preparations have been shown to:

- increase the cation exchange capacity of manure and compost piles;
- decrease carbon/nitrogen ratios in manure piles and straw;
- decrease ammonium and increase nitrate in manure piles;

These phenomena are all signs that the preparations enhance the decomposition of raw organic materials. In the following paragraphs these results will be described in more detail.

Four series of trials with manures and manure composts by Heinze and Breda (1978) showed that preparations increased the exchange capacity of the organic matter fraction an average of 13 percent relative to unprepared manure. Two trials with manure compost by Wistinghausen (1986) showed that biodynamic preparations increased the exchange capacity of manure piles an average of 36 percent relative to unprepared manure.

One set of trials with manure composts showed that biodynamic preparations lowered the carbon/nitrogen ratio 5 percent more than untreated piles (Heinze and Breda, 1978). However, in other experiments with three sets of trials, use of the biodynamic preparations had much larger effects in lowering the ratio. Initial ratios were 25:1; the biodynamic preparations caused ratios of 17:1 while the unprepared piles only lowered the ratio to 23:1. At the end of these experiments the biodynamically treated piles had on average 17 percent less carbon and 11 percent more nitrogen in the dry matter than did the unprepared piles (Wistinghausen, 1986).

Though total N losses from manure piles were found in two trials to be about the same, the biodynamically treated piles were found in four trials to have only 44 percent as much ammonium in the piles as the untreated piles (Wistinghausen, 1986). Thus the biodynamic manure and the control had an average of 85 and 192 milligrams of ammonium nitrogen/100 grams of dry material, respectively. Seemingly more of the nitrogen in the biodynamically treated manure was incorporated into organic forms. The biodynamically treated manure had also more nitrate than the untreated piles (12 and 7 milligrams of ammonium nitrogen/100 grams of dry material, respectively). These differences in ammonium and nitrate indicated that the biodynamically treated manure was further decomposed. However, a later trial by the same researcher showed no effect of biodynamic preparations on ammonium and nitrate (Wistinghausen, 1986).

Studies with liquid manure indicated that use of preparations decreased offensive smells to some extent and also partly reduced ammonium levels. Studies with individual preparations showed a 10 and 12 percent reduction in ammonium levels in liquid manure caused by the chamomile and stinging nettle preparations (Abele, 1976). These reductions are in line with indications by Steiner (1924) as to the purpose of the different preparations.

Use of biodynamic preparations accelerates the decomposition of straw (Table 3). According to Ahrens (1984), straw treated with preparations appeared darker and more fungi appeared to grow on it. Greater decomposition was also evidenced by a higher ash content, lower carbon content, and narrower carbon/nitrogen ratio for the preparation treated straw (see Table 3).

Some of the differences in results between the two trials summarized in Table 3 may have been caused by the fact that the carbon/nitrogen ratio for the straw used was 90:1 for the Ahrens experiment, and 128:1 for the Dewes experiment.

The effect of manures in the soil appears to be modified by the addition of preparations. A nineteen-year field experiment in Sweden (Pettersson and Wistinghausen, 1979), showed that the use of spray preparations increased carbon dioxide respiration (10 percent), earthworm counts (49 percent), dehydrogenase activity (27 percent), and organic matter in the top fourteen inches of soil (41 percent). Unfortunately, this experiment was not replicated; nevertheless, it suggests that biodynamic preparations may play a role in affecting soil biology.

A four-year experiment carried out in West Germany compared vegetable production under organic and biodynamic management practices (Abele, 1987). This experiment involved application of large amounts of manure composts. Soil tests at the end of the experiment showed that use of preparations caused 14 percent higher organic matter, 11 percent higher nitrogen, higher dehydrogenase and cellulolytic activity, more humic acids, greater humification of organic matter, and higher levels of Azotobacter and nitrogen fixation by free-living nitrogen fixers. These differences were all statistically significant. The differences in organic matter between the organically and biodynamically treated plots were visible by the end of the experiment.

A three-year experiment was carried out in Washington state to compare organic and biodynamic practices under different rotations in a dryland winter wheat producing area (Goldstein, 1986). Relative to organically managed plots, the soils of the biodynamically treated soils had approximately 7–10 percent higher carbon dioxide respiration, 7 percent higher microbial biomass, and 2–4 percent higher organic matter. Furthermore, the biodynamically treated soils caused 18 percent higher root density in the top six inches of soil.

Discussion

The amount of work done on preparations is astonishing. Of course, not all the work was of high scientific quality; nevertheless, enough information is in to indicate some broad positive effects.

The preparations seem to manifest their most striking effects in ecological relations such as those of manure decomposition, soil biology, and keeping quality of different products. Progress in understanding the ecology effects of preparations on keeping quality and soil nutrient dynamics has been greatest where interdisciplinary teams of researchers have combined a "see what is out there" and the "question-asking, hypothesis-testing" approaches. Such situations may prove optimal for research on the preparations.

Major stumbling blocks to a widespread acceptance that the preparations might have a positive role to play in agriculture are as follows:

- Most people have probably not heard of biodynamics or biodynamic preparations.
- Biodynamic preparations have been derived from an approach to agriculture that practically attempts to apply spiritual-physical principles. However, many draw the line when any mention is made of spiritual matters because they feel they are too subjective to discuss.
- Making preparations involves fermenting manure and herbs, sometimes in animal organs such as cow horns. This seems strange or unsanitary to many.
- Small amounts of preparations are applied; thus an effect seems unlikely to those who believe that larger quantities of substance are necessary to obtain a biological effect.
- No chemical-physical mode of action has been proposed for the preparations.

Most of these questions are cultural and have yet to be resolved as they are based on the inability of many in our present, scientific-materialistic philosophy of life to come to grips with a different world view that has practical consequences. However, it might help if the mode of action of the preparations could be determined.

To what extent the effects of preparations are due to microbial effects, hormonal effects, or radiative effects of a biological nature needs to be clarified. The following results seem to indicate that all three factors might be involved.

In tests on the effects of preparations on straw, Ahrens (1984) reported effects on fungi that were proportional to the amount of preparations applied. Early studies on microbial decomposition indicated that preparations increased bacterial populations in manure piles (Bartsch, 1934). However, later studies were unable to confirm this (Heinze and Breda, 1978). Nevertheless, the fact that preparations increased decomposition of manures and straw and biological activity in soils indicates that some effect is exerted on microbial ecology.

On the basis of microbial responses to different preparations, Pfeiffer (1956) suggested that preparations might contain hormones that affect microbial development in manure piles. Lippert (1944) found that several herbal preparations could antagonize the action of ethylene on different legumes. Stearn (1976) found that both spray preparations contained high levels of cytokinin-like compounds and he attributed stimulatory affects on plants to such compounds. Both Abele (1973) and Jost and Jost (1983) found that application of the silica spray strengthened the straw of cereals and thus reduced lodging. In summary, these results, plus the results with the increased keeping quality and the light-like effects mentioned above suggest that the preparations influence hormonal relationships in crops.

Steiner (1972) indicated in 1924 that the preparations could exert formative, living forces in a radiative fashion, and that the presence of microorganisms was secondary to the activity of forces in the preparations. Hagel (1981, 1984, 1986) found effects of preparations on soil respiration and plant growth even when preparations were sealed in glass tubes, suggesting some kind of biologically-effective radiations were operative.

Several other major issues need to be dealt with by those who concern themselves with researching biodynamic preparations. One is to identify and understand the factors that cause the variation in results obtained by different researchers with the same preparations. A second important issue is the development and use of quality controls for preparations; some promising chemical tests and bio-assays have been developed, but their use demands further field validation (Brinton, 1983; Goldstein and Koepf, 1982).

Lastly, more good research could undoubtedly be done on specific questions derived from studying Steiner's original intentions for the preparations. Many of these intended effects, such as those relating to crop/nutrient or crop/pathogen relationships, have been incompletely tested or not tested at all for their validity. Experimentation up to date has been largely empirical, as witnessed by the large number of field trials that had the goal of testing whether the preparations had effects on the field-scale yields of crops. Perhaps if Steiner's original intentions are seriously tested in the field and laboratory, more insight will been gained into how the preparations specifically act in the farming system.

References

For a list of references cited, please contact the Managing Editor at the address given on the contents page.

Walter Goldstein holds a Ph.D. in agronomy and is Research Director and Education Coordinator at the Michael Fields Agricultural Institute, W2493 County Road, ES, East Troy, Wisconsin, 53120.

Table 1. Effects of biodynamic preparations on the yields of crops as reported by different researchers from field experiments. Results are reported as percent increase or decrease relative to a control that differed only in not receiving the given preparation or set of preparations. Where results from several trials or years are summarized, the means for the treatments were averaged before deriving the percent difference between a preparation treatment and a control. Preparations 502–507 were applied with manure, and controls to test this application consisted of manure without preparations. Multiple or single applications of 500 and 501 may or may not have been applied according to the experiment, and the reader is referred to the appropriate author for more information.

				Preparations				
				Sprays			Herbs	All
Crop	Researcher/Year	Country	Years/sites	500	501	500 + 501	502 – 507	500 – 507
				Percentage yield increase or decrease				
Oats	Voegele,1930	DDR	2	+7	+30			
	Voegele,1937	DDR	7		+17			
	Klein,1968	BRD	1		+4			
	Klett,1968	BRD	1		+11			
	Abele,1974	BRD	1		+13			
	Kotschi,1980	BRD	2	+2	+1	0		
Barley	Voegele,1930	DDR	2	+19				
	Voegele,1937	DDR	7		+14			
	Engqvist,1972	S	1	+17				
	Abele,1974	BRD	1	+4		+6		
	Abele,1974	BRD	3	+5				
	Rasmussen, 1986	DK	1		-8			
	Rasmussen, 1986	DK	2	+2				
	Rasmussen, 1986	DK	3			+1		
Wheat	Voegele,1930	DDR	1	+32				
	Voegele,1930	DDR	2		+31			
	Voegele,1937	DDR	3		+22			
	Klett,1968	BRD	1		+2			
	Wistinghausen, 1973	DDR	2					+30
	Abele,1974	BRD	1	+4		+6		
	Thun, 1977	BRD	1	+7		+13		

Table 1, continued

				Preparations				
				Sprays			Herbs	All
Crop	Researcher/Year	Country	Years/sites	500	501	500 + 501	502 – 507	500 – 507
				Percentage yield increase or decrease				
Wheat, cont.	Spiess, 1978	BRD	4	+7		+9		
	Pettersson & Wistinghausen, 1979	S	19			+10		
	Kotschi,1980	BRD	2	-3	+4	+2		
	Goldstein, 1986	USA	3					-4
Rye	Klein, 1968	BRD	1		+1			
	Klett, 1968	BRD	1		0			
	Wistinghausen, 1973	DDR	1					+25
	Abele, 1987	BRD	3					+3
Corn	Spiess, 1974	BRD	2	-3		+2		
Potatoes	Klett, 1968	BRD	1		+13			
	Klein, 1968	BRD	2		+3			
	Pettersson, 1970	S, DK,N	10	-6	-6	-2		
	Engqvist, 1972	S	1	+26				
	Wistinghausen, 1973	DDR	2					
	Abele, 1974	BRD	2			+8		
	Pettersson & Wistinghausen, 1979	S	19			0		
	Kotschi, 1980	BRD	1	-2	0	+5		
	Wistinghausen, 1984	BRD	1			-4	0	+2
	Abele, 1987	BRD	4					+11
Carrots	Klein, 1968	BRD	1		-1			
	Wistinghausen, 1973	DDR	1					-1
	Engqvist, 1972	S	1	-9				
	Spiess, 1978	DDR	3	+5		+7		
	Wistinghausen, 1984	BRD	1			+10	+13	+13
	Abele, 1987	BRD	4					+4
Beets	Klein, 1968	BRD	1	+4				
	Abele, 1974	BRD	2			+25		
	Abele, 1977	BRD	1				+18	
	Thun,1977	BRD	1	+6		+13		
	Spiess, 1978	BRD	2	+9		+11		
	Abele, 1987	BRD	4					+5
Radish	Lippert, 1935	BRD	1					+44
	Thun, 1977	BRD	1	+20		+35		
Celery root	Lippert, 1935	BRD	2					+26
Ryegrass	Wistinghausen, 1984	BRD	1			+18	+22	+12
Vetch & rye	Wistinghausen, 1986	BRD	1				+7	
Foxtail millet	Wistinghausen, 1986	BRD	1				-6	
Clover & grass	Abele, 1977	BRD	2					+15
Spinach	Lippert, 1935	BRD	3					+115
	Wistinghausen, 1984	BRD	1			+13	+31	+18
Field beans	Wistinghausen, 1984	BRD	1			-8	-6	+11
	Engqvist, 1972	S	1	+48				
Faba beans	Kotschi, 1980	BRD	1	+2	-1	+1		

Table 1, continued

				Preparations				
				Sprays			Herbs	All
Crop	Researcher/Year	Country	Years/sites	500	501	500 + 501	502 – 507	500 – 507
				Percentage yield increase or decrease				
Tomatoes	Lippert, 1933	BRD	3					+14
	Lippert, 1935	BRD	2					+16
Peppers	Lippert, 1935	BRD	1					+42
Cucumbers	Thun, 1977	BRD	1	+20		+49		
Cauliflower	Lippert, 1935	BRD	4					+39

Table 2. Decomposition losses of different crops as influenced by biodynamic spray preparations. Figures are given in percentages with the relevant controls set at 100 percent.

Source:	Samaras (1978)	Spiess (1978)	Kotschi (1980)	Wistinghausen (1979)
Crop:	Carrots	Spring wheat, winter wheat and corn	Potatoes	Carrots
Parameter:	Storage loss after 164 days	Dry matter loss after 25–35 days	Storage loss after nine months	Storage loss after approximately six months
Percentage losses:				
Untreated control	100	100	100	100
Treated with preps				
3 × 500	86	56	99	–
3 × 500 + 4 × 501	85	78	102	13
6 × 500 + 4 × 501	78	89	100	–

1. Normal storage conditions.

2. Ground grain was moistened with water to 50 percent moisture content and allowed to decompose in a petri dish.

Table after Rasmussen, 1986

Table 3. Effects of biodynamic preparations on the decomposition of straw. Figures are given for the straw treated with preparations as a percentage change from the control straw that did not receive preparations. In both trials, straw was decomposed in glass containers at 20 degrees Centigrade, and preparations were added at a rate of 0.3% of the weight of the straw. Straw was allowed to decompose 393 and 340 days for the Ahrens and Dewes experiments, respectively.

	Parameter				
Experimenter	Carbon dioxide respiration	Ash	Carbon	Nitrogen	Carbon/nitrogen ratio
	(Percentage change relative to unprepared control following decomposition)				
Ahrens, 1984	+42	+55	-35	-15	-24
Dewes, 1985	0	+6	-6	+3	-8

Table 4. Effects of fertilization and biodynamic preparations on the composition of spinach (cultivar "Monopa") stored for four and eight days at twelve degrees Centigrade without air. The contents of dry matter, nitrate (NO_3), nitrite (NO_2), and vitamin C are presented.

Agronomic treatment	Values following harvest				After four days		After nine days	
	Dry Matter (Percent)	NO_3	NO_2	Vitamin C	NO_2	Vitamin C	NO_2	Vitamin C
		(Milligrams/100 grams dry matter)						
Mineral fertilizer (1)	9.9	741	2.0	570	2.4	67	22.0	
Manure compost (2)	9.4	107	0.7	737	1.1	167	7.6	22
Compost and preps 502–507 (3)	10.8	74	0.6	625	0.7	193	1.4	109
Compost and preps 500 & 501 (4)	11.3	62	0.6	766	1.1	487	2.2	40
Compost and preps 500–507 (3)	10.7	69	0.6	932	0.7	196	0.5	223

1. Mineral fertilizer was applied at the rate of 89, 80, and 107 pounds/acre of nitrogen, phosphorus, and potassium.
2. Manure compost was applied at the rate of 8.2 tons/acre (68 pounds/acre of nitrogen were applied).
3. Manure compost was applied at the rate of 8.7 tons/acre (73 pounds/acre of nitrogen were applied).
4. Manure compost was applied at the rate of 8.2 tons/acre (69 pounds/acre of nitrogen were applied).