Yield and Root Growth in a Long-Term trial with Biodynamic Preparations

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Key Words: Biodynamic preparations, root growth, yield balancing effect, long-term experiments

Abstract:
Crop yields and root growth were studied in a 6-year trial comparing conventional, organic, and biodynamic methods of fertilization. Intense use of a set of biodynamic preparations, including a nettle-containing compound preparation, was found to have a balancing effect on the yields of maize and winter wheat. This effect may have been caused by greater root growth and improved root health.

Introduction:
Biodynamic farmers use ‘preparations’ to improve soil and crop quality, including fermented herbs to inoculate manure and compost, and field sprays that are either made from cow manure and silica fermented in cow horns, or from special mixtures of cow manure with concentrated applications of herbs (‘compound preparations’) (Koepf et al. 1989). In several studies biodynamic preparations have had hormone-like effects on various crops (Stearn, 1976; Goldstein, 1979; Goldstein and Koepf, 1982; Fritz, et al., 1997) and they can increase root growth (Bachinger, 1996; Goldstein, 1986). In Germany the biodynamic sprays increased crop yields (cereals and vegetables) on years where yields were low (Raupp and Koenig, 1996). Very little research has been done on compound preparations. These materials are often utilized as compost ‘starters’ or as field sprays and various formulae exist for their production. Our objectives were to compare conventional, organic, and biodynamic systems of fertilization on the yields of crops, and to test a newly developed nettle-containing variant of the ‘compound preparation’ field spray commonly used in biodynamic management.

Methodology:
An experiment was carried out for 6 years near Elkhorn, Wisconsin in a precipitation zone of approximately 720 mm/annum, on a McHenry silt loam (alfisol) that had been in continuous, conventional maize production. In 1993 a crop of oats and alfalfa was harvested in a checkerboard, and test plots for conventional, organic, and biodynamic systems were set out in 1994 on uniform, equally yielding parcels of soil in a randomized, complete block design with 4 replications. Average soil characteristics for pH, % organic matter, available P and K were 6.9, 2.43%, 18.5 ppm, and 110 ppm, respectively. The biodynamic plots were partitioned into subplots and five different biodynamic treatments were compared, including a check without compound preparations, and treatments including four different compound preparations. Of all the treatments used in the study, root growth was examined on only four treatments (conventional, organic, the biodynamic check which did not receive compound preparations (BD), and the treatment that included the new nettle-containing biodynamic compound preparation (BD+)). Plots were approximately 4 m x 7 m in size for the organic and conventional and 4 m x 3.5 m for the biodynamic subplots. The biodynamic check treatment (BD) differed from the organic only by receiving biodynamic preparations according to normal practice (Koepf, et al., 1989). This entailed application of biodynamic herbal preparations to compost piles and application of horn manure and horn silica to soils and crops, respectively. The BD+ treatment was the same as the BD treatment except that it received two extra applications of a compound preparation field spray made from a fermented mix of cow manure, stinging nettle (*Urtica dioica* L.) and the biodynamic herbal preparations. The mixture consisted of 40 kg of fresh cow manure, 1% by weight of nettle and one set of biodynamic preparations (yarrow (*Achillea millefolium* L.), chamomile (*Matricaria chamomilla* L), stinging nettle (*Urtica dioica* L.), oak bark (*Quercus robur* L.), dandelion (*Taraxacum officinale* L.), and valerian

(*Valeriana officinalis* l.)). The nettle had been harvested when in flower and chopped to 2.5 centimeter long pieces. The mixture was allowed to compost in a wooden box inserted into the top 30 centimeters of a loamy topsoil with a loose fitting cover for at least ½ year before being used. The formula for this preparation had been developed at Michael Fields Agricultural Institute in laboratory trials involving bioassays with wheat seedlings grown in tap water and nutrient solutions according to Goldstein and Koepf (1982). In these studies the nettle containing preparation had shown both growth stimulating and regulating effects (Goldstein, unpublished data). Conventional management consisted of a maize-soybean rotation with annual applications of mineral fertilizer to corn (mostly 169-112-112 kg of N, P, and K per hectare). Organic and biodynamic systems used a 6-year rotation: 1) maize; 2) oats + sweetclover; 3) sweetclover for seed; 4) winter wheat + grass & alfalfa; 5) grass + alfalfa hay; 6) grass + alfalfa hay, and was fertilized with 22 t/ha of composted sheep manure before maize was grown. Mechanical cultivation controlled weeds in all systems. All crops in each phase of the two rotations were grown each year. Monoliths were excavated around the crown of three plants from each plot, 3-times in 1998 and twice in 1999. Root length and necrosis were determined on individual nodes of washed roots using the line intersect method (Goldstein, 2000) or 'WinRhizo' computerized measuring system. Data from samplings for individual root nodes were summed (Goldstein, 2000) to estimate root length and dry matter production. Results were analyzed using regression and analysis of variance tools available from Statistical Analysis Systems, Cary, N. Carolina.

Results and Brief Discussion:
Five years of data are available for wheat (1995-1999) and maize (1994-1998). In 1999, the maize crop was damaged badly by deer before harvest and yield data was not used. Yields of other crops will be reported elsewhere. *Yield of Wheat:* The BD+ system resulted in 403 to 605 kg /ha more grain than did the organic system. A negative linear relationship existed (Diagram 1). When the organic plots yielded below 4.5 Mg/ha, the biodynamic + treatment had a positive effect on wheat yields. If the organic wheat yielded 2, 3, 4, 5 Mg/ha, the predicted yield increase from using the preparations was 0.89, 0.54, 0.12, and –0.15 Mg/ha, respectively. *Yield of Maize:* Five years of trials showed average yields of 5.58, 6.71, 6.77, and 7.15 Mg/ha of grain for the conventional, organic, BD, and BD+ treatments, respectively. Yields from the conventional plots lagged behind the organic and biodynamic plots throughout the experiment. As had been the case with wheat, the largest differences between organic and BD+ treatments occurred in those years where yields were low (Diagram 2). These happened to be the first two years of the conversion period. When the organic plots yielded below 7.78 Mg/ha, the BD+ treatment had a positive effect on maize yields. A negative effect occurred when maize yields were higher than this. If the organic maize yielded 2.5, 5, 7.5, or 10 Mg/ha, the expected yield increase from using the preparations was predicated to be 1.95, 1.02, 0.1, or –0.82 Mg/ha, respectively. *Maize Roots:* In 1998, the organic system had significantly less total root length than the conventional treatment. The two biodynamic treatments were intermediate for length. There were no significant differences in the length of healthy and diseased roots between treatments. The conventional and BD+ treatments produced significantly more root weight than the other two systems (Diagram 3). The organic treatment produced only 75% and 69% of the root weight achieved by the BD+ and conventional treatments, respectively. In 1999, maize grown in BD+ had significantly more total root length and healthy root length than did the organic and conventional treatments. Both of the biodynamic treatments had significantly more root weight than the organic and conventional treatments (Diagram 3).

Conclusions:
Our results show that the set of biodynamic preparations that were tested in BD+ had a yield stabilizing effect on wheat and maize. The kind of response as exemplified by the response slopes is practically identical for wheat and maize, indicating that the effect is of the same magnitude for both crops. Our results suggest that preparations increased root growth strongly in maize and that the magnitude of the effect was greatest with the biodynamic treatment that received the most preparations. This 'yield-

balancing' effect could be important for reducing financial risk, and it may indirectly due to enhanced soil quality and rooting.

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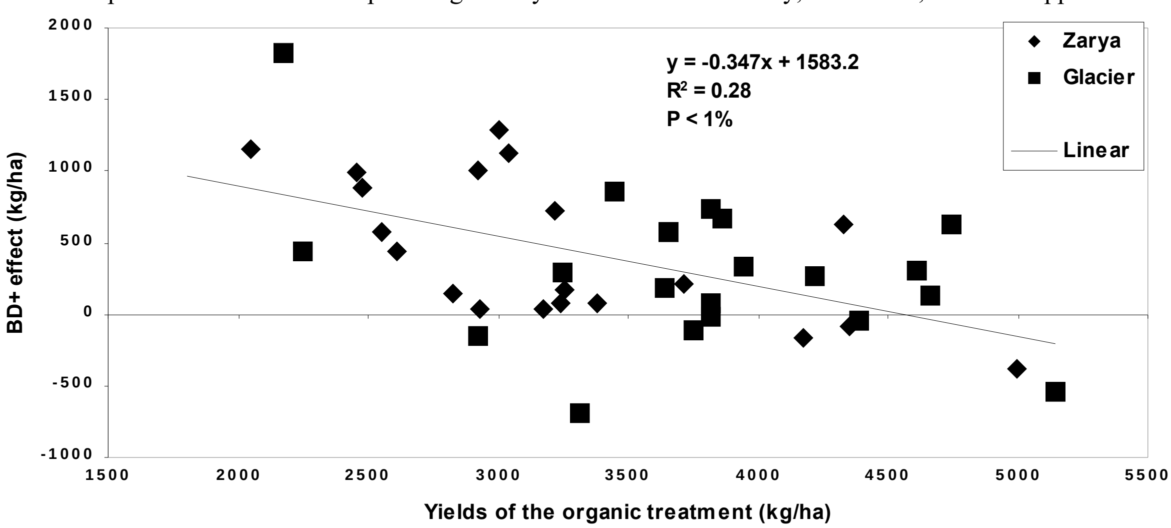

Diagram 1. The effects of the biodynamic + treatment on the yields of winter wheat (2 varieties) relative to the organic treatment including data for replications (1995-1999).

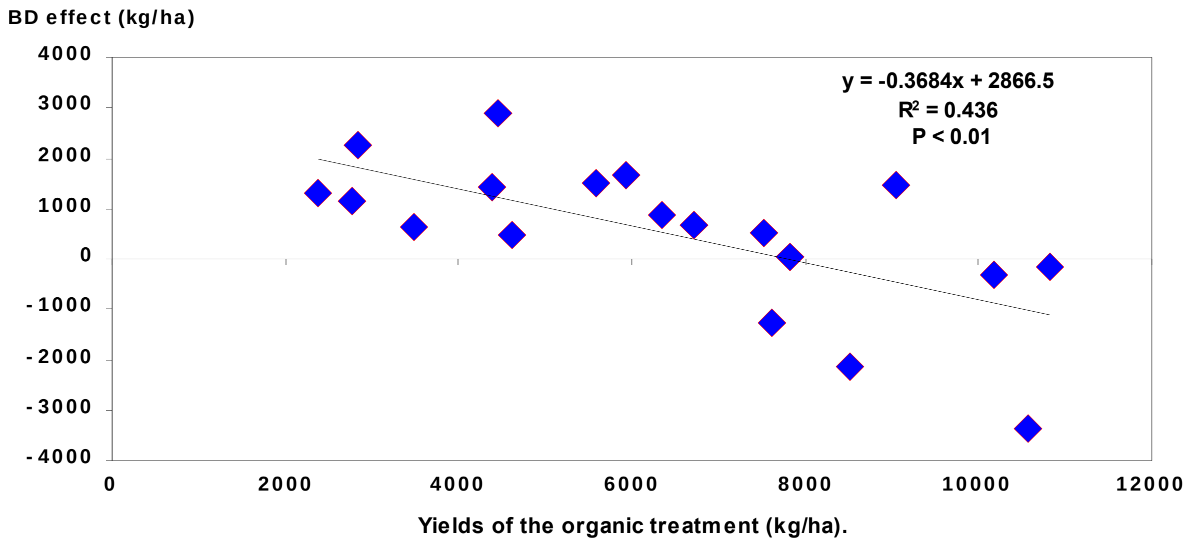

Diagram 2. Effects of the biodynamic + treatment relative to organic on the yields of maize (1994-1998).

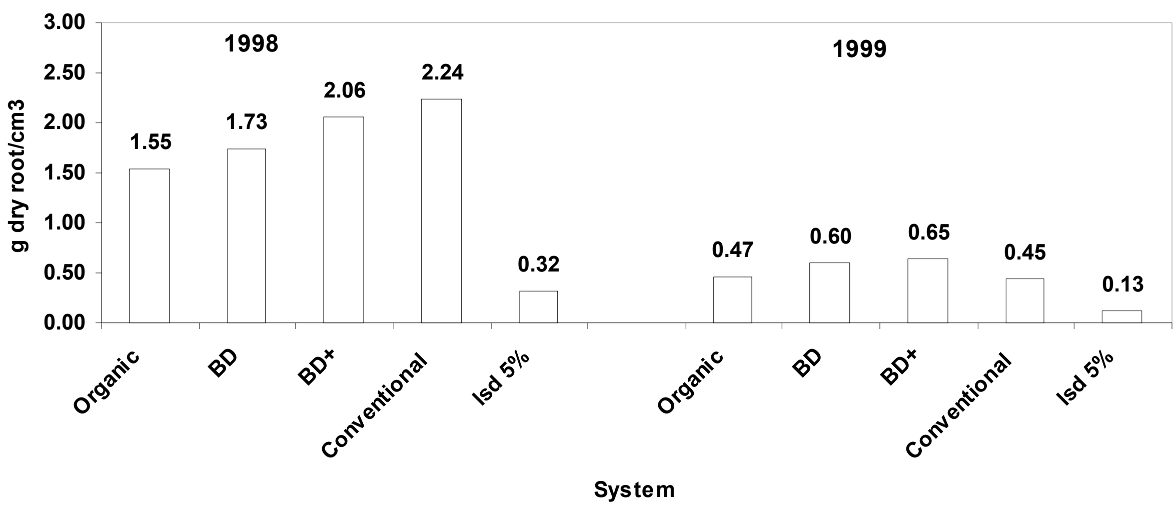

Diagram 3. Average root weight in 1998 and 1999 for maize grown in different farming systems.