Final SARE Report
Ag Professional and Producer Grant

SECTION 1
Cover letter

The following is the final grant report submitted by Henning Sehmsdorf, Project Coordinator (Producer), and Steve Fransen, Ag Professional.

Please remit final payment of $3,749.50

SECTION 2

Type of Report: Final

Project No: FW04-305

Purchasing Agreement No: 03-5135034

Project Title: "Bio-Intensive Forage and Hay Production"

Location of Project: Lopez Island, WA 98261

Funding Period: April 1st, 2004-October 31st, 2005

The project was extended for two years without additional funding

Total Grant Award: $7,499

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SECTION 3

Summary:

The primary goal of the project was to carry out replicated field trials on *S&S Homestead Farm* comparing the use of lime vs. application of non-commercial microbial stimulants in order to improve on-farm forage and hay production.

Objectives:

1) To carry out replicated field trials in a selected 1-acre parcel to establish whether biological stimulant materials that can be created on-farm are economically and ecologically viable alternatives to liming for the purpose of raising soil pH-levels and/or increasing soil N, P, K, micronutrients and soil organic matter in forage and hay production on small-scale, sustainable farms; 2) to put the soil fertility management of forage and hay production on *S&S Homestead Farm* on a new and improved footing,

thereby satisfying crucial food and fiber needs; 3) to enhance the natural resource base of the farm through optimum use of on-farm resources to replace economically and ecologically costly purchased inputs; 4) to extend the integration of biological cycles and controls now practiced on the farm in growing grain, fruit and vegetables to the production of forage and hay; 5) to enhance and sustain the economic viability of the farm; and 6) to model sustainable production methods for other small-scale producers on Lopez Island and in San Juan County, thereby strengthening local food security and the quality of life of farmers and the whole community.

Project Timeline:

Activities can be summarized as follows:

- Selected a 1-acre parcel randomly subdivided into 12 18'x 225' plots with 4 replications (4 reps x Control, Lime and BD treatments), 2003
- Took baseline soil tests in all plots prior to application of treatments, 2004
- Harvested baseline forage samples in all plots prior to treatment, 2004
- Installed 3 root tubes per plot for later removal to measure seasonal root growth, 2004
- Applied BD preparations based on supplier recommendations in designated plots at pre-determined intervals, 2003-6
- Applied lime based on soil test results in designated plots, 2004
- Implemented a rotational grazing plan coordinated with schedule of forage sampling, 2004-6
- Implemented on-farm production of BD preparations, 2004-6
- Took periodic soil and forage tests evaluated in WSU laboratories, 2004-6
- Analyzed research data, 2006-7
- Presented project results at farm workshops 2005-7, conference 2007, and publication (forthcoming).

Research Team and Tasks

The on-farm project to test the effectiveness of biodynamic preparations in comparison to lime involved farm collaboration with the following WSU research and extension faculty:

1. Dr. Steve Fransen, a forage specialist, who provided a predetermined schedule for grazing and mowing the field, and for taking random forage samples to be evaluated in his lab, and for measuring forage height and weights, all of these tasks to be carried by the resident farmer.
2. Andy Bary, M.S., a soil scientist working for the WSU Small Farms Program, who took base line pH tests of the field, and determined the rate and timing of applying agricultural lime on the designated plots.
3. Dr. Lynne Carpenter-Boggs, a microbiologist in the Department for Crop and Soil Sciences and Coordinator for the BioAg program in the Center for Sustaining Agriculture and Natural Resources (CSANR), and Jennifer Reeve, a Ph.D. candidate in microbiology, who together with the farmer, selected and layed out the experimental field, and carried out periodic soil tests at a depth

of 0-3” and 3-6” to measure pH, and rates of hydrogenization, phosphate and carbon mineralization, and microbial biomass.

4. The team also included Hugh Courtney, M.S., director of the Josephine Porter Institute of Applied Biodynamics, who selected and supplied the biodynamic preparations and determined their rate and frequency of application.
5. Finally, the team included the resident farmer, Dr. Henning Sehmsdorf, who coordinated the 3-year project while managing the designated field following established farm practices for grazing and mowing. He applied the lime and the Pfeiffer BD Field Spray, took forage samples, and measured forage weights and heights, as instructed. He also kept a central field record integrating all research data. After receiving the lab evaluations of Drs. Fransen and Carpenter-Boggs, Dr. Sehmsdorf wrote the summary report of findings (see attached).

Project Procedures and Dates:

In autumn of 2003, a designated level field located at the center of the farm and measuring 225x144 feet was divided into 12 randomly selected plots to be treated with lime or biodynamic preparations, or left untreated (for control). Unlike the garden soils, this field had never been treated biodynamically before.

The entire field was fenced, grazed by sheep on a rotational basis over three years (2004-6), and intermittently mowed.

In December, 2003, Pfeiffer BD Field Spray, a proprietary compound preparation which includes BD 500 & 502-507, was applied to the selected plots at the rate of 2 oz/acre (0.185 oz/18’x225’ plot). BD 508 (*equisitum arvense*) was applied at the rate of 2 ozs./10acres (0.0185/plot). The same selection and rate of Pfeiffer BD Field Spray were repeated in November, 2004, July 2005, and May 2006. One unit of BD 501 (horn silica) was applied in July 2004.

Soil tests measuring hydrogenization, phosphate and carbon mineralization, basal respiration and microbial biomass were taken in March 2004, May 2005, and July 2006.

In May 2004, three root tubes were installed in each of the 12 plots to gauge seasonal root development and sloughing. One tube from each plot was lifted in November 2004 and sent to the lab for evaluation; however, subsequent deterioration of the markers made it impossible to locate the remaining tubes.

After initial pH tests were taken to establish a liming rate of 2000 lbs/acre, 225 lbs were applied to each of the designated plots in November, 2004.

Forage samples were collected by harvesting all the forage inside a randomly thrown 2-foot wooden square in April 2004, May 2005, and August 2006. The samples were weighed to establish forage quantity, and lab-tested for crude protein, total dry matter, calcium, phosphorus, potassium, magnesium, ash, and other indicators.

Relative forage height was measured in May and August 2006, using a rising plate meter.

Project Data and Results:

The soil and forage samples collected over the course of the project were evaluated in WSU laboratories by Dr. Fransen, and by Dr. Carpenter-Boggs with the assistance of Jennifer Reeve. Below are tables 1-3 showing the statistical analysis of the data collected over the course of the project:

TABLE 1. Means (n = 24) for soil analyses (depth 0-3 inches) conducted in years 2005 and 2006.

Parameter	Biodynamic	Control	Lime
pH	6.4b	6.2c	6.6a
Dehydrogenase (µ TPF/g soil)	11.2a	11.4a	11.1a
Phosphatase (µ p-nitrophenol/g soil)	517a	494a	518a
Readily Mineralizable Carbon (µg C/g soil)	102a	98a	118b
Microbial Respiration (µg C/g soil)	7.3a	5.0a	5.5a
Microbial Biomass (µg C/g soil)	926a	836a	771a
Cmic/Cmin	9.5a	10.2a	7.3b
QCO2	0.008a	0.006a	0.008a

TABLE 2. Means (n = 24) for soil analyses (depth 3-6 inches) conducted in years 2005 and 2006.

Parameter	Biodynamic	Control	Lime
pH	6.4a	6.3a	6.5a
Dehydrogenase (µ TPF/g soil)	9.0a	8.9a	9.3a
Phosphatase (µ p-nitrophenol/g soil)	287a	386a	298a
Readily Mineralizable Carbon (µg C/g soil)	48a	52a	54a

Microbial Respiration (µg C/g soil)	3.6a	3.9a	4.4a
Microbial Biomass (µg C/g soil)	505a	568a	562a
Cmic/Cmin	11.2a	11.7a	11.9a
QCO2	0.007a	0.007a	0.007a

TABLE 3. Means (n = 24) for forage analyses conducted in years 2005 and 2006.

Parameter	Biodynamic	Control	Lime
Forage weight ($g/2m^2$)	244a	219a	238a
Crude Protein	7.9a	7.6a	7.4b
ADF	41.6a	40.6a	41.9a
NDF	67.8a	66.3a	67.6a
TDN	55.0a	56.2a	54.8a
REF	77.8a	81.1a	77.9a
Ca	0.44a	0.44a	0.45a
P	0.15a	0.15a	0.15a
K	2.1a	2.1a	2.0a
Mg	0.18a	0.19a	0.19a
Ash	8.7a	7.9a	8.3a

What follows is a summary description of some of the implications of the above data as provided by Dr. Carpenter-Boggs and Jennifer Reeve:

"This study compared 3 treatments with 4 replicates in a completely randomized design. This design gives it statistical and scientific validity. It means: If/when the data show a treatment effect, that effect has happened in a reliable manner in most plots, not just one instance.

Several questions can be addressed from this work. All results are site-specific because this work was not replicated at other sites.

I. Do the BD preparations or lime affect soil pH?

Yes, and yes.

Initial pH prior to treatments averaged 6.15 which is slightly acidic. Ideal soil pH is approximately 6.5 - 7.0. At a low pH many plant nutrients are less available (chart on next page), some microbial activities are reduced, and many plants have reduced productivity. Control (untreated) plots had a pH of 6.2 at the end of the study, showing no significant change in the native soil pH over time.

As expected and normally observed, liming the soil did increase soil pH to 6.6. What has never been documented before is that there was also an increase in soil pH with the BD preparations, to 6.4. Statistically, the untreated plots had the lowest pH, BD plots had higher pH than untreated plots, and limed plots had higher pH than both the untreated and limed plots. However, the pH difference between limed and BD plots was small, and in both instances sufficient to improve the availability of essential nutrients. This increase in pH in the BD plots was consistent, not just in one plot. It cannot be explained by drift or effects from the neighboring plot, since the control plots were also randomly distributed in the field, sometimes neighboring the limed plots, and did not significantly change in pH. This is the first time it has been shown that BD treatments increase soil pH sufficiently to improve nutrient availability.

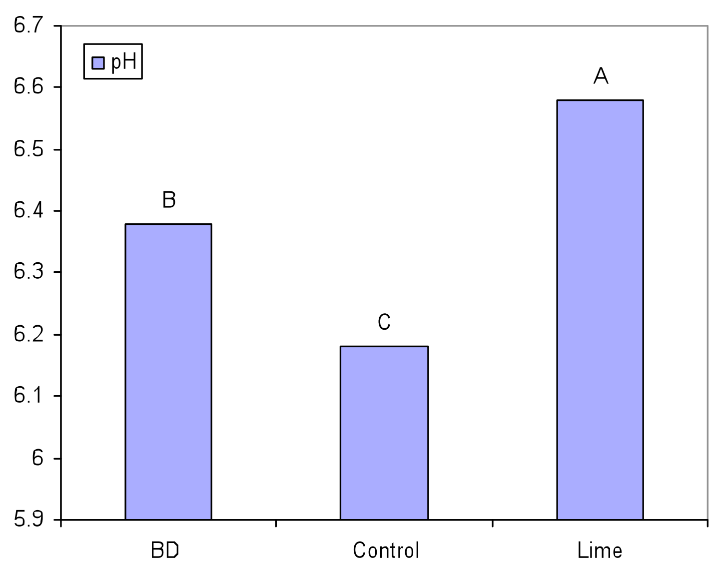
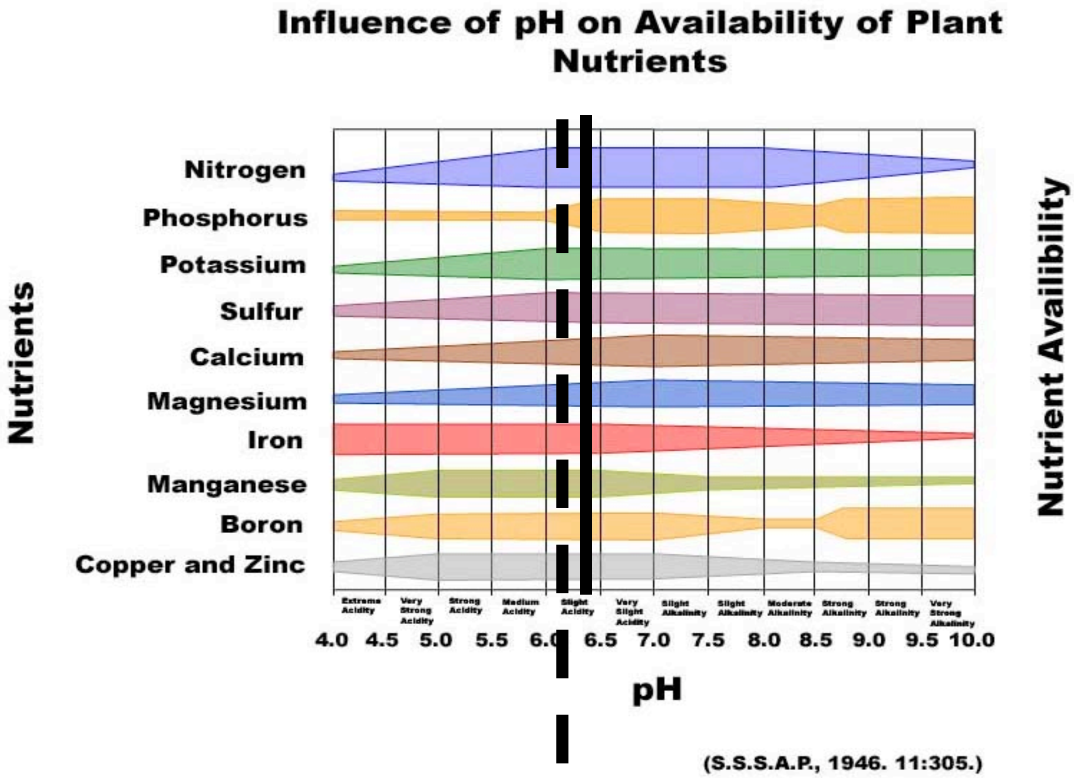


FIGURE 1. Soil pH as measured in 12 field plots over two years treated with biodynamic preparations, lime, and nothing.



Soil pH of 6.1 is slightly acidic. Increasing pH to 6.5-7 should increase availability of Nitrogen, Phosphorus, Calcium, Magnesium, and Molybdenum.

II. Do the BD preparations or lime affect forage yield?

No, and no.

In this study neither BD preparations nor lime treatment significantly affected forage yield as compared to the untreated plots. Control plots had just as great a yield as treated plots. This calls into question the need and benefit of liming the slightly acidic soils on Lopez Island.

III. Do the BD preparations or lime affect forage quality?

Yes, and yes.

Both BD and limed plots had different forage quality than the untreated plots. However, the direction of change was different between treatments. BD plots improved in forage quality, shown by higher forage protein, while limed plots declined in forage quality, shown by lower forage protein. Neither change was very large, but they are statistically significant. This is the first time that it has been shown that BD treatments increase forage quality as measured by protein levels to a statistically higher level than in plots treated with lime.

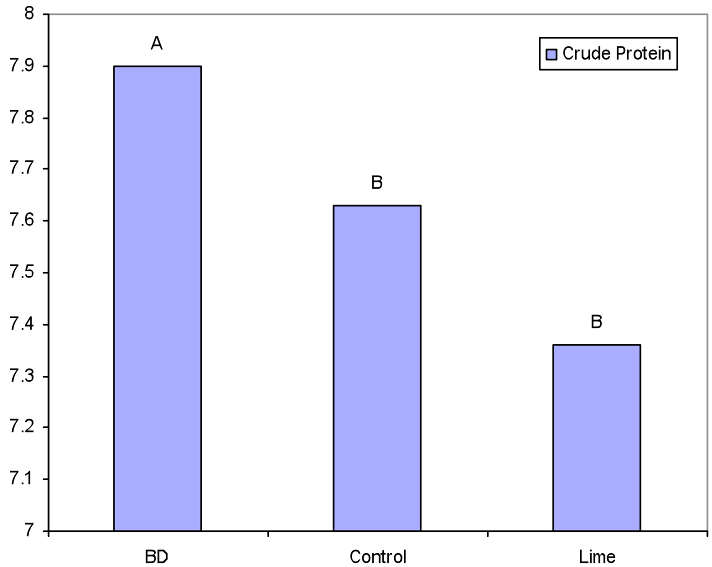


FIGURE 3. Crude protein content of forage as measured in May 2005 (sample b) in 12 field plots treated with biodynamic preparations, lime, and nothing.

IV. Do the BD preparations or lime affect soil microbial activity?

No, and No.

The table below shows that the microbial biomass (the total mass of microorganisms in a gram of soil established by various enzyme assays) is the same among all treatments. However, the proportion of microbial biomass carbon to total mineralizable carbon was significantly lower in the limed treatment. It is possible the lime stimulated humus decomposition (an effect of lime noted by Peter Proctor, *Grasp the Nettle,* 1997, 124 as leading to eventual soil degradation), but it is also possible that the extra carbon came from the decomposition of the lime itself, a purely physical process.

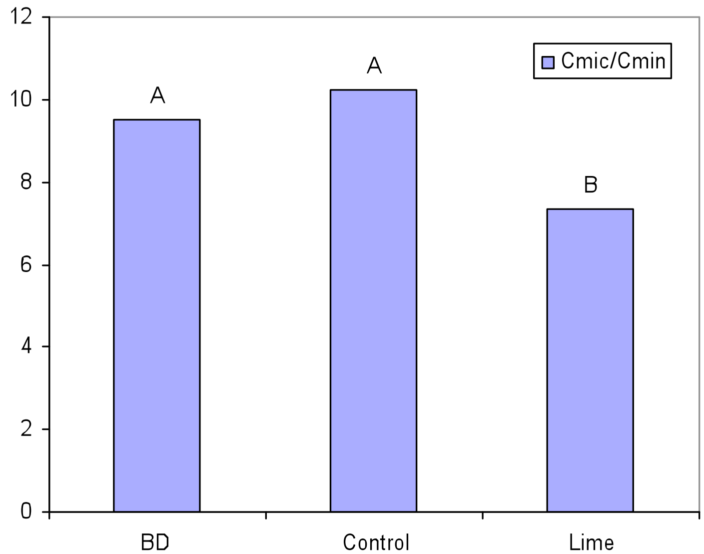


FIGURE 2. Microbial biomass carbon per unit soil mineralizable carbon as measured in 12 field plots over two years treated with biodynamic preparations, lime, and nothing."

Benefits and Impacts on Agriculture:

The goal of *S&S Homestead Farm* is to achieve ecological sustainability and resource self-sufficiency while remaining economically viable. The project results indicate that the farm can raise soil pH in fields sufficiently either through lime applications or by biodynamic sprays, and thereby increase mineral availability, but that the latter strategy appears preferable because it also reduces the need for purchased inputs that carry both economic and ecological costs to the farm and to the larger environment, and it increases farm self-sufficiency. The data further suggest that the forage quality, as measured by levels of crude protein, is higher in the BD-treated plots as compared to the lime-treated or control plots. It is not to be overlooked, however, that production and application of the BD sprays is fairly labor intensive, and requires a certain expertise, and therefore carries its own economic cost. This cost, involving growing, fermenting, processing and applying the sprays needs to be weighed on a farm-by-farm basis when considering the benefits and impacts of this approach to achieving ecologically and economically viable and scale-appropriate forage production.

The ecological impacts of applying lime to agricultural soils are little understood by most farmers. The soils in San Juan County, carved out of forests in the nineteenth century, tend to be somewhat acidic, which encourages the growth of intrusive mosses. Conventionally, local farmers rely on agricultural lime to correct the acidity levels. However, lime is an industrial product prepared from mined, sedimentary rock derived from marine invertebrates (calcium carbonate, $CaCO_3$). Because calcium carbonate is insoluble in water, it has to be digested by soil organisms (thereby releasing an estimated 50% of the CO_2 into the atmosphere or the groundwater), before becoming chemically effective in adjusting soil pH. Alternatively, the limestone is heated in special kilns to decompose it into calcium oxide (CAO), which is readily soluble in water, and carbon dioxide, which is released during the refinement process. Calcium oxide, also called quick lime, acts swiftly to change soil pH in plowed soils, for example, but it cannot be applied to pastures or hayfields because it would burn the living plants (one wonders, of course, what the application of quick lime does to soil organisms in unplanted fields). Whether in the form of calcium carbonate or calcium oxide, however, the lime has to be ground, bagged, and shipped through various commercial channels to the end user, the farmer, who applies it to the field with special machinery. In other words, while relatively inexpensive to purchase, the indirect energy costs of agricultural lime are substantial and appear low only because the U.S. government subsidizes energy consumption. Furthermore, the CO_2 released into the atmosphere when applying calcium carbonate to the soil, or during the process when refining calcium carbonate into calcium oxide, is a greenhouse gas that contributes to global warming. In 2001, the estimated emissions of CO_2 from agricultural lime in the U.S. was 4.4-6.6 Tg. (Reference: McBride, A.C. and West, T.O. "Estimating Net CO2 Emissions From Agricultural Lime Applied to Soils in the U.S." *American Geophysical Union*, Fall Meeting 2005, abstract #B41B-0191).

Producer Adoption:

Since its inception in 1970, *S&S Homestead Farm* has been managed in response to the potential of the local ecosystem that includes species of native and domesticated animals, plants and living biomass interacting in the physical environment. This small farm (15 acres owned, 35 leased from neighbors) produces beef, pork, lamb, chicken, dairy products, fruit, vegetables and fertilizer, meeting the needs of the farm and the family, and selling the rest to the local community. As an integrated organism, the farm aims to be self-organizing, self-correcting, self-sufficient, and self-capitalizing. After nearly four decades of production, properties resulting from interactions within the complex farm system have emerged: for instance, place-specific immunities that make disease suppression, pest control, and most veterinary or medical interventions unnecessary; time- and labor-saving habits of mind and practice that arise from years of observation of living processes; and community dynamics that strengthen local food security and independence.

On this background, adoption of the forage production practices investigated by this project is a given for *S&S Homestead Farm.* Adoption of the practices enhances farm self-sufficiency by reducing the need for purchased inputs while also minimizing harmful ecological impacts. Specifically, the project has demonstrated that: 1) biological stimulant materials (BD preparations) can be created on-farm as economically and ecologically viable alternatives to liming for the purpose of raising soil pH-levels and/or increasing soil N, P, K, micronutrients and soil organic matter in forage and hay production on small-scale, sustainable farms; 2) adoption of the practices demonstrated by the project improves soil fertility management of forage and hay production on *S&S Homestead Farm*, thereby satisfying crucial food and fiber needs; 3) these practices enhance the natural resource base of the farm through optimum use of on-farm resources to replace economically and ecologically costly purchased inputs; 4) the practices reinforce and extend the integration of biological cycles and controls now practiced on the farm in growing grain, fruit and vegetables to the production of forage and hay; 5) not having to purchase lime enhances and sustains the economic viability of the farm; and 6) the practices potentially model sustainable production methods for other small-scale producers on Lopez Island and in San Juan County, thereby strengthening local food security and the quality of life of farmers and the whole community.

Producer Reactions:

Biodynamic farming poses a dilemma in as much as its practitioners know from experience that the practices work, but natural science is at present at a loss as to how to explain the demonstrated effects of Biodynamic inputs. The current study is a case in point. Drs. Lynne Carpenter-Boggs and Jennifer Reeve, who took the soil samples in the designated research plots and analyzed them in the soil biology laboratory of the Department of Soil Sciences at Washington State University, emphasize the statistical and scientific validity of the project findings, but also that this is the first study comparing BD treatments with lime treatments:

"This study compared 3 treatments with 4 replicates in a completely randomized design. *This design gives it statistical and scientific validity*. It means: If/when the data show a treatment effect, that effect has happened in a reliable manner in most plots, not just one instance.

As expected and normally observed, liming the soil did increase soil pH to 6.6. What has never been documented before is that there was also an increase in soil pH with the BD preparations, to 6.4. Statistically, the untreated plots had the lowest pH, BD plots had higher pH than untreated plots, and limed plots had higher pH than both the untreated and limed plots. However, the pH difference between limed and BD plots was small, and in both instances sufficient to improve the availability of essential nutrients. This increase in pH in the BD plots was consistent, not just in one plot. It cannot be explained by drift or effects from the neighboring plot, since the control plots were also randomly distributed in the field, sometimes neighboring the limed plots, and did not significantly change in pH. *This is the first time it has been shown that BD treatments increase soil pH sufficiently to improve nutrient availability*" (see "Project Data and Results," above).

Drs. Carpenter-Boggs and Reeves also point out that "all results (of the project) are site-specific because this work was not replicated at other sites;" in other words, it would appear prudent before generalizing the results of this project to replicate the study on several, separate sites. This cautionary note does not negate the fact that *S&S Homestead Farm*, which has been managed biodynamically for years, accepts the project data and results as confirmation of the validity of those Biodynamic practices on which the productivity, health and ecological sustainability of the farm rests.

Producer Recommendations:

As a farm equally dedicated to community-based education, research and outreach, as it is to food and fiber production, *S&S Center for Sustainable Agriculture and Homestead Farm* recommends replication of certain aspects of this study at several sites and over minimally five years. Discussions are currently underway with participating farmers and WSU County Extension to find several suitable sites in the county to carry out this extended study that would track changes in soil pH, nutrient availability, forage yield and quality, and soil microbial activity, in response to BD soil treatments. Since the suitability of lime inputs in raising soil pH is a well established fact, there would be no need to include lime treatments in this new study project. On the contrary, the purpose of this new study would be to confirm the effectiveness of the BD preparations in achieving soil pH adjustments without the unintended consequences of CO_2 emissions involved in the use of lime.

Outreach:

Between 2004-7, *S&S Center for Sustainable Agriculture and Homestead Farm* offered three 3-day extension-sponsored workshops and five 1-day workshops at the farm to which all project participants, cooperators, students, teachers and administrators at the local high school, community members and representatives of local trade and non-profit organizations, farmers and extension personnel, and the general public were invited. Approximately 40 participants at each of the workshops learned about biodynamic processes in the general context of the farm and specifically about the "Bio-Intensive Forage and Hay Production Project."

In 2004, led by three specialists, Harold and Lloyd Nelson and Lauri Riccardi, from The Josephine Porter Institute for Applied Bio-Dynamics, workshop participants learned how BD preparations are produced on the farm.

In 2005, during a 1-day workshop for nutritionists and growers, which focussed on biodynamically produced foods, participants learned about the relationship between Biodynamic treatments of forages and the nutritional quality of meat and dairy products produced by such means.

In 2006, invited workshop participants included Dr. Walter Goldstein, Research Director at Michael Fields Agricultural Institute (MFAI); Janet Gamble, Student Director at MFAI; Christopher Mann, Director, Yggdrasil Land Foundation, and farmers from Washington, Idaho, and Wisconsin, who came to view the project.

In 2007, Dr. Jeffrey Endelman, bioengineer attached to Rudolf Steiner College in Sacramento, joined workshop participants to hear about the project results and analysis presented by Henning Sehmsdorf on behalf of the project research team.

On August 27, 2007, Henning Sehmsdorf gave a formal report on the project at the Research Section of the National Conference on Biodynamics held at Sacramento, California. The report, entitled: "On-Farm Research: Biodynamic Forage Production on *S&S Homestead Farm*," placed the project results in the context of the farm goal of ecological sustainability and self-sufficiency. The report, which will be published in a forthcoming issue of *Biodynamics,* has also been distributed to all project participants, and will be placed on the Washington State University Center for Sustaining Agriculture and Natural Resources (CSANR) website after it is published in print.

A presentation of the project at the annual Washington Tilth conference is planned, as is a presentation of the project at the Huxley College of the Environment at Western Washington University next spring.

Section 4
Attachments

Educational or Information Materials Produced

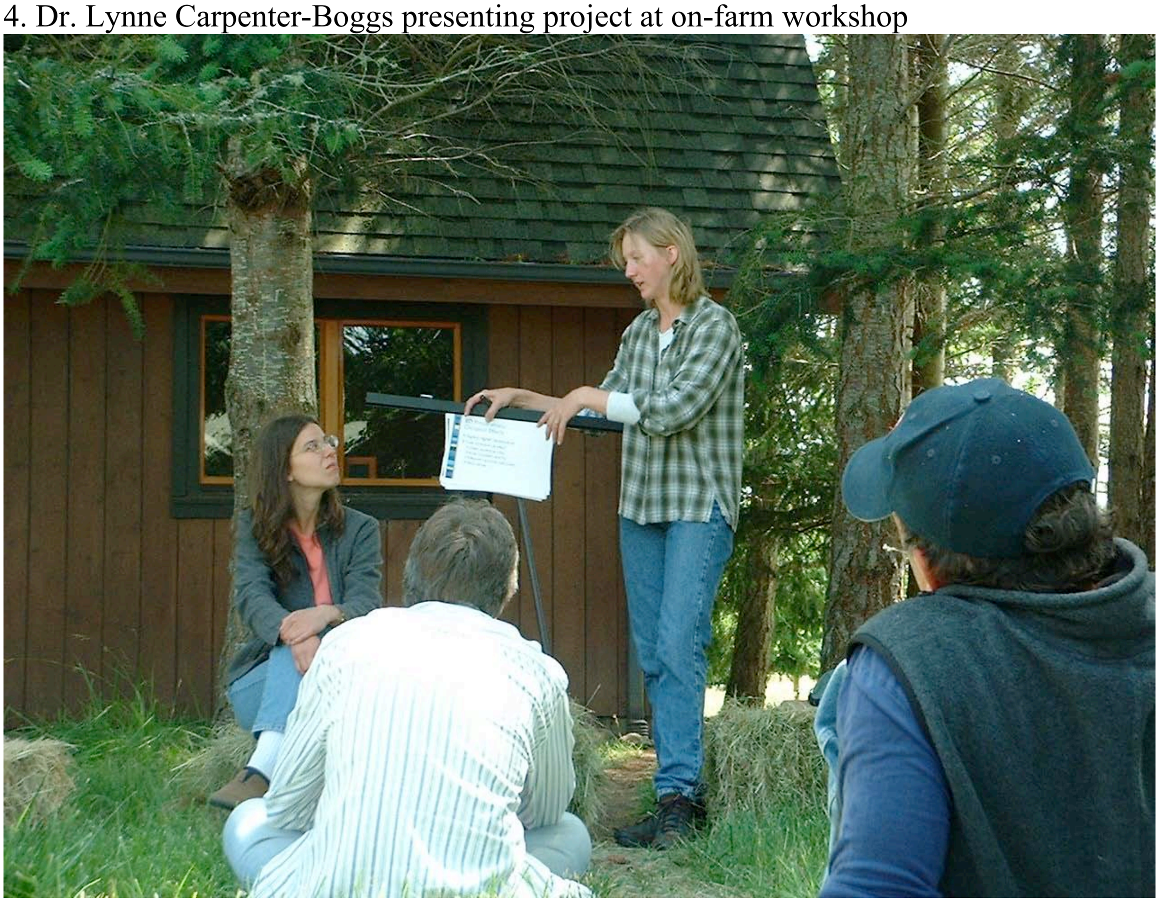
"On-Farm Research: Biodynamic Forage Production on S&S Homestead Farm;" presented at *Biodynamic Farming & Gardening Association 2007 National Conference,* August 24-26, 2007, Rudolf Steiner College, Fair Oaks, California.

Photos
1. Drs. Lynne Carpenter-Boggs and Jennifer Reeve taking soil samples

2. Students clipping randomized forage samples

3. Students measuring forage height using rising plate meter

4. Dr. Lynne Carpenter-Boggs presenting project at on-farm workshop



5. Dr. Henning Sehmsdorf discussing project in context of the whole farm organism

6. Lauri Riccardi and Lloyd Nelson teaching making of silica preparation

7. Harald Nelson teaching making of oak bark preparation

8. Sheep on project site