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A Comparative Study of Alternative Methods of Soil Fertilization in United States and Venezuelan Agriculture

Since the practice of artificially fixing atmospheric nitrogen was introduced to the agricultural sector, farmers world-wide have grown dependant on chemical fertilizers to keep soils fertile. These inorganic fertilizers allow farmers to produce high crop yields on a regular basis even in poor soil conditions. Yet it has become evident that as more farmers use chemical fertilizers, the more exhausted their soil becomes. This repetitive practice increases dependence on synthetic fertilizers while furthering soil degradation. Furthermore, farms that use synthetic fertilizers are likely to employ other unsustainable practices. One such popular routine is the application of herbicides and insecticides to the plants, which in turn threaten the health of the workers who apply such pesticides and the customer who eats the chemically-infused harvest. The use of chemicals on the land brings about a cyclical dilemma in which farmers use chemicals to increase their yield, while they simultaneous degrade their soil, quality of food, and proper health.

The dependence on chemical fertilizers has finally taken its toll, and both farmers and consumers have shown interest in returning to the more traditional methods of agriculture, to what we know as sustainable agriculture. Although beginning as a grassroots movement in United States, the organic movement since has been blown along by a flurry of academic arguments, as the growing awareness of the benefits of organic agriculture is often taught through mass media. Through the publication of influential writers such as Rachel Carson, Michael Pollan, and Peter Singer, both producers and consumers are challenged to consider the environmental and ethical reverberations their decisions will cause. Farmer and academics read

literature, watch documentaries, and attend conferences; one such conference being the Pennsylvania Sustainable Agriculture (PASA) Conference, which shares information and spreads awareness in the Pennsylvania area. It is now common knowledge that the use of synthetic fertilizers degrades the quality of local watersheds, brings eutrophication and aquatic dead zones (attributed to nitrogen and phosphorus runoff), and leads to soil erosion and aridity due to loss of organic humus. The Dickinson College Organic farm, in of Boiling Springs, Pennsylvania, USA was inspired by the organic movement to begin production without synthetic fertilizers in an effort to be an environmentally conscious producer and consumer.

Venezuelan farmers have seen the negative effects of chemical fertilizers in different ways than in the US; the movement there is less media-based and focuses on community health and social justice. One farm in particular called Las Lajitas, part of the La Alianza cooperative located in Monte Carmelo, Lara, made the switch from conventional farming to organic sixteen years ago when a blood test revealed high levels of toxicity in all community members, including those who came in no physical contact with the farm's chemicals. The organic movement in Venezuela is a slow-moving one that has been sparked by a social health concern.

Because of the varying reasons behind the organic movements in either country, both movements have rejected synthetic fertilizers as a means to cultivate healthy crops. Instead, both the Dickinson College Organic farm and the Las Lajitas farm instead employ alternative methods to sustain fertility, in practices that vary between ancient and modern technology. The methods that are compared in this research are composting, vermiculture, styles of mulch, crop rotation, and purchasing commercial amendments. In reaction to the raised awareness of negative environmental and health effects brought by conventional farming, these farmers have looked to alternate practices to maintain soil fertility.

Compost

Composting could be classified as one of the oldest and most effective methods of returning fertility back to the soil. Composting in modern times is also known by the term "Controlled Fermentation." Controlled Fermentation combines dry matter (carbon) and wet matter (nitrogen) to decompose simultaneously through natural processes. Compost returns important elements such as nitrogen and phosphorus back into the soil, adds organic matter to the soil structure, and inoculates the soil to fill areas that might otherwise be home to pathogens. While decomposing, the organic matter goes through different heating phases before it is determined "complete." First, the Mesophilic phase heats to average temperatures of 25-40˚C and lasts for several days. Next, the Thermophillic phase begins in long-durations of high temperatures of 50˚C or above, further breaking down the cellular structure of the organic material and killing most all pathogens in the soil. Once the resources are exhausted, the pile finally begins to cool down (Halpin).

During this process, a compost pile requires a variety of factors, such as: water, oxygen, macroorganisms, microorganisms, fungi, and bacteria. When the pile cools to the ambient temperature, it is prepared for application to a field. There are numerous ways to apply finished compost to a field, the most common being Top Dressing, Liquid Extraction, and Compost Tea. Top or Side Dressing entails placing the compost on the surface level of the soil, and mixing the humus with a hoe into the topsoil. To get the extract of compost to use for a liquid fertilizer spray, one gathers the fluid found at the bottom of a compost pile or squeezes the liquid extract from a mound of compost. This liquid is then used as a foliar spray to select crops that are vulnerable to pest or disease. Compost Tea, a very popular method today, involves steeping the finished compost in water, and brewing it with other microbial food sources such as molasses or

yeast in order to spur growth in populations of beneficial microorganisms. This brew, like the Liquid Extraction, is used as a liquid fertilizer spray to crops in need of a boost (Halpin).

In Pennsylvania, many composting operations are small-scale and communally-based, as most farmers make their own compost or buy it from regional suppliers. The Dickinson Organic Farm acquires organic waste from patron Dickinson College Dining Services, and in turn, supplies the College with a substantial amount of its harvest, in addition to educational and research programs. The Organic Farm takes the waste from food services and adds other dry matter like leaves from the local Township of South Middleton and woodchips from regional tree services. With these ingredients combined, the farm composts the waste in the manner previously detailed. The compost is then applied to the field by various methods, usually Top Dressing, to return nutrients, moisture, and microorganisms back into the soil. Compost Tea is applied as a foliar spray only on a case by case basis, when crops are performing especially feebly (Halpin).

Aside from being supported by Dickinson College, the Dickinson Organic Farm is also communally integrated through encouragement by governmental programs. A model of small-scale communal-based composting was made possible by the Pennsylvania Department of Environmental Protection which initiated a Composting Infrastructure Development grant program. The goal of this program was to divert materials from being sent to landfills, while helping small farms use organic materials as compost. The grant provided funding for Dickinson College to purchase specific equipment to improve the efficiency and productivity of managing compost (Halpin). For example, some money went towards the acquisition of a food pulper for its patron Dining Services, in order to acquire more food waste for its compost. The Dickinson

farm aided by the DEP program is able to keep their soil fertile while interacting with the community in positive ways.

Las Lajitas of Venezuela also uses the community to its advantage in the creation of compost. Nearly every family of Monte Carmelo grows its own coffee in its *conuco*, or home garden, and harvests its own beans. The community members then donate all of their coffee hulls from the bean harvest to the Las Lajitas farm. The bean hulls, which are considered a waste product to those growing in their *conucos*, are converted into healthy compost on the Las Lajitas farm. These coffee hulls are combined with horse, cow, and sheep manure that are sold by local ranchers, because the manure of these animals is rich in phosphorus, nitrogen, and potassium (P. Garcia, 5 Jan. 2009). The finished compost is then incorporated into the soil before plantings, for example, to create a more diverse topsoil in a newly established greenhouse.

Vermicompost

Despite the fact that the coffee-manure compost (used as Top Dressing) enriches the shale-like soil of Monte Carmelo, the Las Lajitas farmers tend to use most of their compost towards their vermiculture operation. Vermiculture uses worms, most often red wigglers (Eisenia foetida), to convert raw organic matter into humus. Traditionally, the way to reduce the volume of organic waste and to transform it into a valuable product is through compost. Vermicompost takes this a step further and employs worms to convert this material into a highly valuable soil amendment. Worms eat a variety of organic waste and excrete nutrient-packed castings, otherwise known as worm poop. These castings are beneficial to soil because they contain stable nutrients that are readily available for plant intake. They also contain plant hormones that stimulate growth in plants (Beetz 1). In a natural ecosystem, these castings would be mixed into the soil of a worm's habitat, but if collected, they can be applied to fields or marketed as

fertilizer. It is a method of organically restoring soil fertility that requires labor, but brings a phenomenal finished product. On the other hand, vermiculture turns out to be an expensive operation, due to the vigilance required. Usually, vermicompost is used for crops in distress, seedling nurseries, or in small gardens.

Vermicompost is unlike traditional compost, in one way because it does not ever reach the high temperatures of decomposition through the Thermophillic phase. Worms would die if they lived in such conditions. Rather, Vermiculture is often seen as a type of livestock production. A vermiculturalist can feed different feedstock (organic matter) to his/her worms, such as animal manures from other farming industries, crop residues, or food/fiber industry byproducts (Beetz 2). Furthermore, a farmer must sustain livable conditions for his/her worms; a farmer must maintain moisture (80-90%), a safe pH (between 5 and 9) and aerobic activity to keep maximum worm productivity. The high temperatures that accompany decomposing material must be monitored by the farmer, who can maintain a cool temperature by continuously adding layers to the heap (Beetz 3).

Las Lajitas prides itself in being one of the rare large-scale vermiculturalist farms in Venezuela. The farm keeps its California red wigglers in large 3-6 foot cement bins full of compost. Central to its operation is “feeding” the worms pre-composted organic matter, which speeds the breakdown process. Additionally, using pre-composted organic matter reduces the need to intensive management as many of the factors for concern, like temperature and moisture, have been eliminated. Las Lajitas keeps its California red wigglers in the bins, adding partially-finished compost in 15 cm increments to the bins until the worms have processed all of the matter into stable humus. To remove the worms from the finished vermicompost, the farmer puts a fine mesh blanket over the top of the bin and then a layer of fresh compost over the blanket to

lure the worms to the surface and through the mesh (Figure 1). The worms remain on top of the mesh blanket so the farmer can easily remove the blanket to transfer the wigglers off the finished vermicompost and to a fresh container. The vermicompost is then applied as a Top Dressing to the fields in Las Lajitas, as a far richer soil amendment than regular compost or animal manure (P. García, 5 Jan 2009).

The bins that keep the vermicompost are slanted approximately to a 20˚ angle so as to allow the excess liquid to drain out into buckets below the container (Figure 2). This vermicompost extract, or *agua de lumbriz*, is a concentrated form of the worm compost, and is therefore is exceptionally high in minerals, nutrients, and hormones that boost plant health and development. Las Lajitas produces about three liters per container per day, or about 36 liters. This extract is concentrated insofar that it is usually mixed in a 1:25 ratio of extract to water, before being applied as a foliar spray to leaves. It is usually applied to crops on a case by case basis, to plants in need of a boost. This "worm water" is so valuable that Las Lajitas uses only 20% of the extract it produces, and sells the remainder to small local farmers and conventional large farmers (P. Garcia, 9 Jan. 2009).

The Dickinson College Organic Farm in Pennsylvania has its eyes on vermiculture for its own farm. Currently, the farm purchases its potting soil from an outside vendor, but has plans to create a small operation in order to supply enough vermicompost for rich potting soil for its seedlings (Halpin). The fact that La Alianza has the capacity to produce enough vermiculture to sell to its community emphasizes its success. In comparison, the Las Lajitas vermiculture process is large and progressive by both United States and Venezuelan standards.

Cover Crops/Crop Residue

Although Las Lajitas and the Dickinson College Organic Farm share in the methods of composting, they employ different practices to supply a mulch cover for their crops. During the "off" seasons of cash crops, the Dickinson Farm grows cover crops, which are not grown for consumption purposes, in order to give the soil time to rejuvenate. Often during the winter months, cover crops are planted to protect the soil for the coming spring.

Cover crops are mowed at the flowering stage, and then are either left on the top of the soil as mulch or will be worked into the soil. Leaving crop residue will reduce water evaporation and protect the soil from erosion. When the residues are worked into the earth, the organic matter content and moisture retention capability are drastically increased (Elia). The benefits to cover crops are many; the practice replenishes missing nutrients from the soil, such as Nitrogen, adds organic matter, improves soil aeration for less runoff, allows for better root growth, and increases water infiltration. Alfalfa, as well as other legumes, is often planted for the nitrogen-fixing bacterium that accompanies their root system. This bacterium replenishes nitrogen levels in the soil, making the nitrogen available for the cash crop during the following growing season. Cover crops also suppress weeds by reducing light exposure, prevent erosion by holding down soil year-round, and attract beneficial macroorganisms to inhabit the area (Sarrantonio). Aside from alfalfa, other popular legumes of the northeast are hairy vetch, cowpeas, various clover, field peas, and the common bean. Other common cover crops are cereal rye, wheat, ryegrass, mustard, oats, and barley.

The Dickinson Organic Farm employs cover crops as one of its principal methods of maintaining soil fertility. The farm plants crops such as oats and winter peas in the Fall. The crops will die by the winter frost, therefore leaving a cover of organic matter over the soil to provide a food source for microorganisms and produce a fine humus layer. In the Spring, the

cover is chopped and raked with a tractor in effort to further break it up and prepare the plot for its subsequent crop (Halpin). In the northeastern United States it seems natural to plant cover crops to a field during the cash crops off season, for there is no prominent winter-growing crop. Cover crops are a simple method of balancing soil fertility and protecting existing soil between harvest seasons.

In comparison, La Alianza's Las Lajitas opts for a different means of producing mulch for the soil, by way of crop residue. Las Lajitas chooses not to plant cover crops because it harvests year-round in its temperate climate. At the end of one harvest, there is always another set of seedlings from the nursery ready to be transplanted, therefore leaving no time for a cover crop (O. Garcia). Instead, the farmers leave plant residue on the fields to create more organic matter. The farmer would leave all but the fruit on the field after a harvest, for example, corn stalks and husks, or the farmer might leave the freshly removed weeds out on top of the soil (instead of removing and/or composting the material as would be done at the Dickinson farm). This procedure allows for the soil to acquire a layer of organic material, to turn into humus and provide home for beneficial insects. Unfortunately, Las Lajitas does have a significant weed problem, possibly due to this practice and runs the risk of increasing the weed seed bank in its soils, by leaving the weed refuse on the ground. Nevertheless, leaving crop residue on the fields is the simplest method to maintain healthy crop cover and build humus, especially in fields that are constantly in production.

Crop Rotation

Nearly every sustainable farm practices crop rotation, or the method of rotating different crop species within a plot, from season each season. The aim is to plant crops that are not related botanically, do not share the same nutrient requirements, and do not share the same pest

problems. Crop rotation provides numerous benefits to maintain fertility in soil. Disease pathogens can build up if the same crop in grown in a certain area every season, along with the inhabitance of pesky insects and weeds. Changing the location of one's crops will thus interrupt this seasonal sequence (Gershuny 193). Furthermore, crop alternation prevents exhausting the soil of a specific nutrient, since each newly introduced crop requires a different recipe of nourishment from its soil. For example, corn needs high doses of nitrogen to flourish, whereas soybeans return that nitrogen to the soil. Rotating in cover crops improves soil structure in two ways: firstly, cover crops build up organic matter in a particular area to prevent erosion. Secondly, by varying between shallow-rooted and deep-rooted crops, these plants create aeration channels and extract nutrients at different depths in the soil (Gershuny 196).

The Dickinson College Organic farm practices crop rotation according to a very strict schedule. At the beginning of each year, the farm coordinators draw up a map that plans each fields' cultivation for the rest of the year. This plan incorporates the crops that Dickinson College demands for its food services, the crops the farm wants to grow for its CSA members, its cover crops, etc. The farm makes sure not to plant similar-family crops in the same plot of land repetitively, such as to not plant the tomato (*Solanaceae* family) and the pepper (*Solanacae* family) one year right after another. Instead, it might plant the crops next to each other for the same season, because they require similar irrigation needs. Also, the Dickinson farm will alternate vegetative crops with flowering crops, and alternate cool season crops with warm season crops. Furthermore, the farm attempts to alternate deep-rooted crops, like watermelon, with shallow-rooted crops, like lettuce (Hitt). All of this information is compiled to craft a cropping map that distributes the crops so that they complement each other and maximize soil health. An example of the cropping schedule is as follows: In the first year the farm would plant

oats and peas in the fall, and in the in the spring plant onions and peas, which have similar irrigation needs. This would be followed in the summer with lettuce, radishes, carrots, and a salad mix, which all have the same irrigation needs. In the fall the farm would plant rye with vetch as a cover crop, which would be worked into the soil as a green manure by the upcoming spring (Halpin).

The Las Lajitas farm in Venezuela takes not nearly as technical an approach. The farmers at Las Lajitas practice crop rotation, but do so on an observational basis rather than Dickinson's meticulous approach. Las Lajitas may grow the same crop for several harvests in the same field. Yet since the growing year is not broken into distinct seasons in Venezuela, aside from the wet season and the dry season, it is acceptable to grow the same crop for several "seasons." When it is time for the farmers to place a new crop in, they will plant the seedlings based on the local demand and what is good for the coming rainy or dry season. In an interview Las Lajitas farmer Omar Garcia discussed that the farmers observe by eye the plants to see when there is a nutritional deficiency in their crops, especially nitrogen. When the crops look feeble, the Las Lajitas farmers decide that there is a lack of nitrogen, and that it is time to grow beans next. The common bean that is grown, called Melilotus, carries nitrogen-fixing nodules on its roots which will return nitrogen back to the soil by the following harvest (O. García) (Figure 3). In this way, Las Lajitas rotates its crops but in a casual manner that reflects its constant growing season.

Commercial Soil Amendments

Farmers who care to carry the title of "organic," but still want to resort to applying marketed fertilizer to their crops, will opt for commercial organic fertilizers. Often, commercial organic fertilizers are by-products of the food and fiber industry whose excess (which might otherwise go to waste) can be used as fertilizers or added to compost. These fertilizers are also

derived from minerals or bacteria. Although these products do indeed return nutrients back to the soil, many are too expensive to be worth purchasing with the exception of some horticultural production. These fertilizers strive to achieve the nitrogen-phosphate-potash mix that science claims is the miracle ratio (Hall 2).

The Dickinson Organic farm purchases fish emulsion and sea kelp from the commercial supplier Fertrell, based in Pennsylvania. Fertrell buys its kelp from Canada and its fish emulsion from Louisiana, and converts them into a powder or fluid to be easily applied to plants. The fish is high in nitrogen, which aids plant development, and kelp is known to be high in nutrients with growth stimulation properties as well (Fertrell Co.). The Dickinson College Organic farm uses these commercial products on an as-needed basis. The farmers will apply a kelp-fish emulsion blend as a foliar spray when they see a struggling plant, or a plant that is susceptible to pests. They often dip the plants in this brew before transplanting the crops out in the field (Halpin). This transition between greenhouse to field is considered a "shock phase," when the immune system is more vulnerable. The Dickinson farm aims to be a self-sufficient farm yet still relies on this commercial amendment to give its crops an extra boost of immunity.

Las Lajitas purchases several products from local vendors, while being a local vendor of organic fertilizer itself. La Alianza produces and sells its extract collected from the vermiculture operation, selling about 80% of its production to locals, nearby towns, and other cooperatives (Figure 4). The remaining 20% is used on its own fields. It is a very successful enterprise, and La Alianza is currently attempting to receive governmental permission to transport and sell the "Las Lajitas Liquid Extraction of Worm Humus" nationally (P. Garcia, 9 Jan. 2009).

Aside from selling its own product locally, Las Lajitas also buys fungal soil inoculants from a laboratory in a neighboring town of Bojo. This laboratory cultivates the fungus

Trichoderma in Petri dishes on grains of rice, and then sells the rice to local farmers. Trichoderma is known to ward off other fungi, as well as attack nematodes that damage roots. The farmers at Las Lajitas buy this product cheaply, about one kilo for thirty Bolivares Fuertes, or for about $10. They combine the kilo of rice with 200 liters of water, mix it well, and then apply it as a liquid with a backpack sprayer. Using the fungal inoculants is cheaper for Las Lajitas than a chemical fungicide, as the inoculants stays in the soil and continues fighting harmful bacteria for up to six months. The Bojo lab is funded by an institution, but sells independently to both conventional and organic farmers, with a formal support of La Alianza (Lab Technician). Las Lajitas also purchases lime to mix in the outside and the greenhouse soil. Lime balances the pH to remove acidity in the soil, so that crops grow with greater ease. The Trichoderma inoculants and the mineral lime ease the minds of La Alianza farmers in maintaining a solid soil health without having to resort to artificial fertilizers (P. Garcia, 09 Jan. 2009).

Observations

After comparing the small organic farms of Dickinson College, USA to Las Lajitas, Venezuela, my research has allowed me to draw several conclusions. First and foremost, Pennsylvanian farmers tend more towards technology than Venezuelan ones. This tendency toward technology is in a large part financially based, as Pennsylvanian farmers have more capital (from loans, agricultural subsidies, or general prosperity) to dedicate to equipment and education. A prominent example is in the compost and vermicompost operations of Las Lajitas and the Dickinson farm. The Pennsylvanian farm utilizes special tools to monitor its compost, such as special thermometers to determine in which specific thermal phase it is, a tool to measure the pH acidity of the compost, and a device to measure the precise moisture content (Halpin).

The entire process is understood in scientific terms, taught through academic literature, and interpreted with technology. Las Lajitas, on the other hand, uses simpler techniques to regulate the progress of compost and vermicompost. The Las Lajitas farmers see how many drips of water squeeze out from a handful of compost so as to determine the moisture content of the soil (Figure 5). In order to see if the pre-compost is ready for the worms, the vermiculture expert Polilla Garcia commented, “It doesn’t smell as much.” Las Lajitas tries to use horse and sheep manure over cow manure in its compost, not because the farmers know the elemental composition of the manure, but rather, because horses and sheep have one stomach to a cow’s four, so the manures of the former will be richer in nutrients for the compost (P. Garcia, 09 Jan. 2009). Venezuelan farmers use observational learning or ancestral education in their crop cultivation, instead of the bounty of scientific information and tools available in the Pennsylvania area.

Unlike Las Lajitas farmers, Pennsylvanian farmers tend towards industry that is not necessarily locally based. The Dickinson College Organic farm purchases organic fertilizer from the company Fertrell that is centered in Pennsylvania, but receives most of its products from across the continent. The sea kelp that Fertrell purchases is imported from Canada, and the fish emulsion comes from the Gulf of Mexico. These products that the Dickinson farm applies come from far and wide to give Dickinson farm’s crop an immunity boost. Yet this is commonplace in the United States; many sustainable farmers purchase special organic fertilizers, many of which are made with industry by-products such as fruit pomaces or feathermeal. Farmers can even request a custom organic fertilizer blend that fits the specific needs of farm fields, based soil composition analysis of that farm’s soil (Fertrell). On the other hand, the Venezuelan farmers use materials that are more readily available close to their community. The fungal soil inoculants that

Las Lajitas buys come from the neighboring town of Bojo. The laboratory is run by three employees, is small-scale, and has a particular business association with the La Alianza cooperative. Las Lajitas takes advantage of regional resources to provide for its farm. Additionally, although the permission is pending to sell its Vermicompost extract to a national market, Las Lajitas still sells this product to gardeners in town and to neighboring farms, keeping this small industry regional (P. Garcia, 09 Jan. 2009).

Despite the fact that Dickinson College farm sometimes use services that are not locally-based, it is undeniable that both organic farms are communally integrated. The Dickinson farm and Las Lajitas receive compost materials from their communities. The Dickinson farm receives all of its wet matter from Dickinson College Dining Services, and collects its dry matter of leaves and wood chips from the township and local tree services. The members of Monte Carmelo donate their discarded coffee bean hulls to be incorporated into the Las Lajitas compost. In addition, both of these farms supply food for the community. The Dickinson College Organic farm provides Dickinson College Dining Services with fresh farm produce to feed to its students and faculty. Furthermore, this Pennsylvanian farm operates a Community-Supported Agriculture program for the Boiling Springs area, which allows individual patrons to subscribe to purchase a certain amount of the farm's weekly harvest (Halpin). This mutually beneficial relationship ensures the financial security of the farm for the upcoming growing season and provides patrons weekly fresh organic produce throughout the growing season (24 weeks). The Dickinson farm participates in regional farmer's markets, touting the oft-heard phrase "Buy Fresh, Buy Local." The Las Lajitas farm in Venezuela similarly provides food for its community. As part of the cooperative agreement, all members of the La Alianza cooperative at Las Lajitas take home a percentage of the crop during every harvest to feed their families. Las Lajitas also sells at

farmer's markets in larger towns such as Barquisimeto and Sanare, to make available fresh organic food to the city-dwellers of the region.

In addition, each farm provides educational outreach programs for their communities. Because the Dickinson College Organic farm is funded by Dickinson College, the farm is always available for students, professors, and locals for education purposes. The farm employs student workers, often hosts class field trips to learn about biology, ecology, or agriculture, and will give presentations to educators by request. The Dickinson farm is involved in the campus club Students Interested in Sustainable Agriculture and hosts weekly Weed-n-Feeds to encourage student participation. Likewise, the Venezuelan Las Lajitas farm invites students and farmers to learn about how and why their small organic cooperative has been so successful. For example, in 2007 Las Lajitas hosted the "Intercambio nacional de experiencias agroecológicas," or the "National Exchange of Agro-ecological Experiences," conference, sponsored by the Venezuelan government. Las Lajitas was used as a model for other budding organic cooperatives, and remains a well-frequented educational scene.

Despite the fact that Pennsylvanian farms tend towards scientific technology and broadly based industries, the Venezuelan farmers have more innovative methods of maintaining fertility in their soil. A prominent example is Las Lajitas' vermiculture operation, which is extremely efficient. The vermicomposting at Las Lajitas is considered quite large for such a small farm, and is so productive that it affords to sell a great percentage of their product to other farms in the area. In Pennsylvania, most farmers are aware of the vermiculture technique for a method of soil fertility, and most keep worms in their compost. But such impressive operations like that of Las Lajitas are not well-known, at least to the extent for a farm to be able to market its excess. There is a growing interest among farmers in the Pennsylvanian region, such as the Dickinson College

farm which plan to introduce vermiculture for potting soil, but there are few vermiculture operations that are intensively managed like that in Venezuela.

Another innovative practice in which Las Lajitas farmers take advantage is the fungal breeding that is used to inoculate soil, that helps fight off other damaging fungi along root systems in the soil. The fact that the laboratory is in a neighboring town, is small-scale, and is an inexpensive product makes these soil inoculants readily available to Las Lajitas farmers as an alternate way to improve soil health. Such an operation is basically unheard of in the Pennsylvanian region. There is research in the University of Maryland being done on Mycorrhiza, a fungus that increases a plant's intake of water and nutrients. Yet these types of soil inoculants are expensive and difficult to access. The small organic farmers like those from the Dickinson College farm, would have trouble acquiring such technology. On the other hand, Las Lajitas and other farms in the area use this local resource with great ease and success.

Conclusion

From the research gathered from the Dickinson College Organic farm and the Las Lajitas organic cooperative farm, it is clear that organic methods of maintaining soil fertility vary between farms but are still deemed successful alternatives to chemical fertilizers. Their shared techniques, such as composting and crop rotation, are ancient methods that were known well before the introduction of synthetic nitrogen. The farms' differing techniques, such as vermicomposting, cover cropping, and fungal soil inoculation, may become methods that are shared across borders and adopted by other farms in the future. The reasoning behind choosing certain soil fertility methods often lies in financial grounding and local information. For example, a fungal soil inoculation laboratory is nearby and readily available for Las Lajitas, and it makes sense to take advantage of this production. Yet in the United States this technology is

still budding and would be very expensive for Pennsylvanian farmers to acquire. On the other hand, The Dickinson Organic farm plans for cover cropping during the year, because it helps preserve the soil during the field non-harvest season. Conversely, Las Lajitas tries to constantly be producing with its year-round harvest, and therefore cannot afford to take time off to grow cover crops for a field. Instead, Las Lajitas leaves crop residue on the fields to simulate the same type of organic matter coverage as would cover crops. Proper soil health is the prime factor for success in organic agriculture, despite national boundaries.

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Figure 1 - A Las Lajitas farmer removes the worms with a mesh blanket from the finished vermicompost.

Figure 1 – Las Lajitas' vermiculture operation. The slanted bins allow vermicompost extract to drip into buckets beneath.

Figure 2 - The nodules on the roots of the Melilotus plant give evidence to nitrogen-fixing bacteria.

Figure 4 – The Las Lajitas farm sells its vermicompost extract as a commercial product.

Figure 5 - Pedro Garcia tests the moisture content of compost by counting the drops of water that fall from a fistful of soil.