BANANA RESEARCHES IN COSTA RICA (CENTRAL AMERICA) WITH EFFECTIVE MICROORGANISMS

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Abstract

Effective Microorganisms (EM) were used as a tool to develop an organic banana farming technology at EARTH University in Costa Rica, C. A. The work was designed to deal with the black sigatoka disease (*Mycosphaerella fijiensis*), the nematode *Radopholus similis,* the nutritional requirements, the green life of the bananas at post-harvest and the cost of production with the EM regimen.

Excellent results were obtained in quality and productivity. Black sigatoka and nematode infestation were minimized. The costs were slightly higher, the profitability motivates an organic banana production regimen in Central America.

Keywords: bananas, nematodes, fungus diseases, post-harvest, nutrition, profitability, effective microorganisms.

INTRODUCTION

Bananas have been a major economic base for Central American, Caribbean and some South American countries for the past century and this is expected to be so in this new millenium due to some special advantages of these countries such as a favorable climate and an added advantage of proximity to the growing markets for fruits in Europe and North America. These importing countries, however are demanding more organic bananas.

The market demand has not been met by the major banana growers whose existing technologies are oriented to synthetic fertilizers and pesticides and whose response to the demand has been to leave the organic market to the small operators, and to watch for substitute technologies to apply in massive/extensive monoculture.

Extensive monoculture has serious problems with biodiversity and needs strategies to restore natural equilibrium. We therefore designed our research project to use EM as an aide to restore microbial biodiversity, coupled with compatible cultural strategies and in-situ biodiversity.

Five major specific objectives were set: (1) management of the black sigatoka fungus disease *Mycosphaerella fijiensis*, (2) management of the toppling disease of bananas, *Radopholus similis*, (3)evaluating the dosages of bokashi, the fermented organic matter, (4) determining the green life of the bananas at post-harvest, and (5) evaluating the comparative cost of the bananas under an EM regimen.

REVIEW OF LITERATURE

Black sigatoka fungus disease, *Mycosphaerella fijiensis*, has ravaged the banana plantations in Latin America since it was detected in Honduras in the 1960's (Stover, 1974, and Gauhl, 1992) and now it is present in all of the Americas (INIBAP, 1999) and the Caribbean region. At EARTH, and in general in Central America, the cost to control it with all the chemicals, the spraying and the manpower for attending operations ascends to some$1,250 per year per hectare, or about 50% of total production costs in the field and about 20-25% of total cost of bananas ready for export (Tabora, l997).

The toppling nematode, *Radopholus similis,* is another serious problem whose direct effect is not readily quantified, but it is estimated that its combined impact on reduction of yields and in the reduction in quality can mean a loss of as much as 55% of total productivity. In a study by Luc, *et al.* (1990), yields went up by 275% when nematicides were used, a clear demonstration of the impact of nematodes. Thus, the nematodes rival the black sigatoka in magnitude of its impact, and may in some cases be the major cause for reduced profitabilities of the banana producers.

Nutritional requirements of bananas have been well studied in many places (Soto, 1992; Lopez and Espinoza, 1995), and based on nutrient extraction of 45 tons of bananas produced and their stalks, it was determined that bananas will remove 80 kg N, 9.6 kg. P and 256 kg K. per hectare per year. This extraction means a replacement of the same quantities plus an additional amount to re-enrich the soil. Thus, most recommendations in Costa Rica range from an annual per hectare applications of 350-400 kg of N, 50 kg of P and 500-600 kg of K (Soto, 1992; Lopez and Espinoza, 1995).

It has been observed that premature ripening occurs during the transit period (13-18 days to Europe) especially if bananas with heavy black sigatoka infection are packed. This premature ripening has been attributed to the black sigatoka toxin, a phytotoxin that forms distinct elongated chlorotic zone surrounding the lesions on the leaves (Molina & Krausz, 1989). This means a triggering of ethylene production that causes chlorosis in the leaves and also fast ripening of the fruits in an enclosed container. Most plants with less than 5 green leaves at harvest time are considered to be heavily infected and therefore prone to have the toxins that cause premature ripening. Since toxins are oxidants, the application of EM and EM-products on the leaves were expected inhibit oxidation. EM has anti-oxidation substances(Higa, l997) from its fermentation.

The price of organic bananas have been 2 to 2.5 times that of the conventional bananas in the retail markets (Sauvé, l998), and this has been attributed to its high cost of production. Recently, however, the prices have been going down due to aggressive competition for the same markets. Nevertheless, the prices are still higher than conventional bananas despite these competition.

Bananas continue to be criticized for its environmental problems (Dahlerus, 1995) such as soil and biodiversity erosion in clean culture and deforestation, massive applications of nematicides herbicides and other chemicals that have caused sterility and respiratory disease problems with its workers, and also the communities nearby. There is also a problem of waste disposal of banana rejects. While this is countered by banana professionals (Mirenda, 1998), there is also a tacit acceptance of the problems. Thus, the impetus for organic banana production.

MATERIALS AND METHODS

This work was undertaken at EARTH University in Costa Rica. The university owns and operates a 300 hectare banana farm used for income generation, student practice and for research. A 1-hectare plot formerly cultivated to bananas was selected. It had been abandoned due to low yields and poor quality, with a high population of nematodes, and of which the soils were sandy. This selection was made to have all the constraints of banana production be present. The commercial banana farm was about 100 meters in distance to minimize the drift due to chemical applications. Grand Naine Cavendish was the test variety, highly susceptible to black sigatoka and nematodes.

The selected plot was in fallow for one year before it was given to the project. At the start of 1997 the vegetation (principally grasses) was pharrowed under and the area was planted to corn in order to build up organic matter. The corn was harrowed under at emergence of the tassels and immediately planted to field beans, *Phaseolus vulgaris*. This was also done as a way of determining the capability of the soil. Soil analysis was done during the initial phase of land preparation. Planting was done on January 1998.

Several student graduation projects (theses) were established for this project from 1997 to 1999: The EM related practices were: (1) EM dips after hot water treatment, (3) EM sprays on the vegetation before plowing under, (3) activated EM for sigatoka control, (4) use of banana latex as EM sticker, (5) EM bokashi for nematode control, (6) EM soil sprays, (7) EM-FPE fermented repellent plant extracts sprayed on the bunch, (8) EM foliar booster sprays (bokashi tea), (9) EM-5 sprayed on the bags, (10) drip irrigation with EM, (11) alternate planting with green manure plant, *Flemingia* sp., sprayed with EM at cutting, (12) EM dips during dehanding after harvest, (13) use of EM-X in post harvest treatment to control crown rot.

There were other EM-compatible technologies incorporated such as: (1) double row planting [1 m between rows and 1.5 m on the row, and 5 meters between doble rows] to give a population of 2,222 plants per hectare, (2) use of *Moringa oleifera* and *Glericidia sepium* as partial shade cover and aerial props, (3) cover cropping with squash, *Cucurbita moschata* right after plantingto keep down the weeds, (4) keeping the weeds as source of biodiversity when plants are higher, (5) weed cutting using a weed whacker every 8 weeks, (6) removal of lower hands to have only a 5 hand-bunch, (7) early harvesting on the 10th week instead of the regular 14-15 weeks of the bunch, at caliper grade of 38-42, (8) use of a special transluscent paper bags as bunch protection, (9) installation of drip irrigation to avoid water stress during the dry periods.

Bokashi was prepared from two sources, one from the cattle excreta and the other from the crushed banana rejects. The cattle droppings were collected at the stables when the cattle were fed, during mid-days for 4 hours. The stables were covered with sawdust about 2 inches in thickness and this was sprayed with EM every day. The droppings and urine were trapped and mixed with the sawdust simply by the cattle feet trampling. After 2-3 weeks these were collected and put to ferment for another week (the high temperature kills all the seeds in the droppings). The banana rejects were crushed at the packaging house and put in windrows in the shed for bokashi, sprayed with EM and later covered with sawdust on the surface. After 5 days when the mass had fermented, a windrow-mixer was passed and this was repeated for another two times within a period of 15 days. The bokashi was ready between 15-21 days.

RESULTS AND DISCUSSION

For **black sigatoka**, the total number of leaves were observed 14 weeks from emergence of the plants after planting (June 7) up to the stage of flower bud appearance on the26th week (August 24, 1998). The treatments with EM and EMFPE at 1% and 10% and their mixtures all were bundled at about the same positions, having about 8.8 leaves at flower bud appearance. This contrasted with the control (using the conventional practices and with chemicals) whose number of leaves fell down to 6.5 leaves at flower bud appearance (Moino, 1998). The above results in 1998 echo the previous results of Elango (1997) and Tabora (1996) where the total number of leaves was close to 9 leaves at bud appearance. Figure 1 presents this phenomenon.

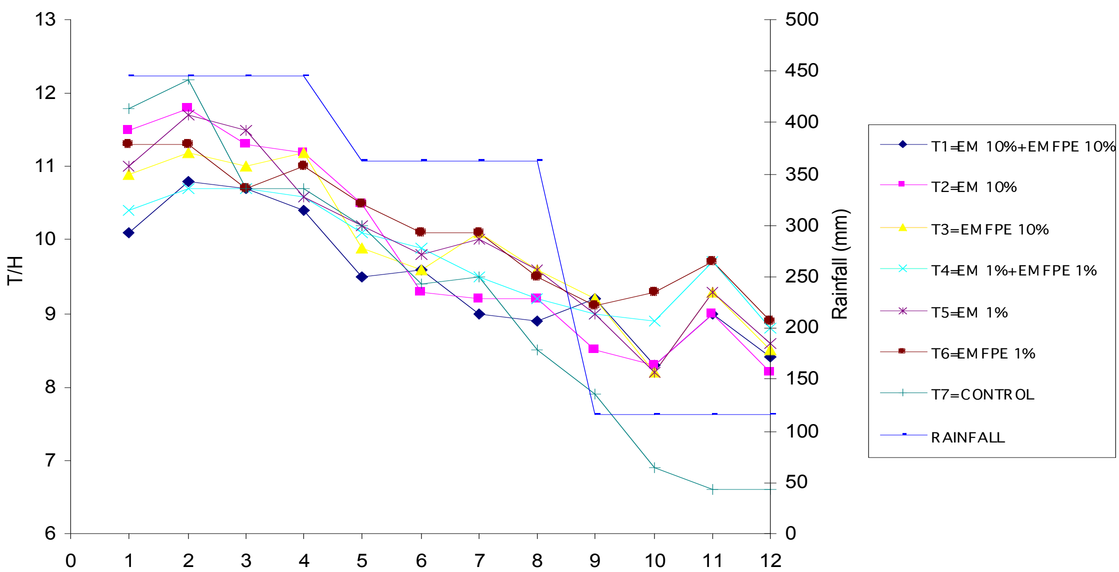

Figure 1. Total number of leaves from weeks 14 to 26 (critical period).

It is this number of leaves which allows us to determine the number of hands to retain on the bunch and to determine the quality of fruits (sizes) that would be harvestable some 10 weeks later. It was observed that upon harvest on the 10^{th} week, the plants still had 3 green leaves intact.

There was a change in the forms coalescence of the lessions in the leaves. In the control, the lessions would coalesce and be joined to give a large dry area. In the treatments with EM the lessions would not coalesce and would present several independent spots all over the leaves. This signifies a possible effect on the growth of the black sigatoka fungus or some kind of an anti-toxin that prevented the growth and eventual coalesence of the lessions. This is presented in Figure 1 below:

In a simultaneous study in the laboratory, it was found that the ascospores in EM treated plates were deformed. One particular treatment with simple 1% EM had the least germination of ascospores (Bayro, 1998).

In **nematodes,** of the 6 treatments compared: (1) Furadan, (2) Nemout, (3) *Paecilomyces lilacinus*, (4) *P. lilacinus* + EM Bokashi, (5) EM Bokashi and (6) the control, it was the EM Bokashi and the combination P. lilacinus and EM Bokashi that had the best control (Dubón, 1998). This is seen in Figures 2, 3 and 4 below:

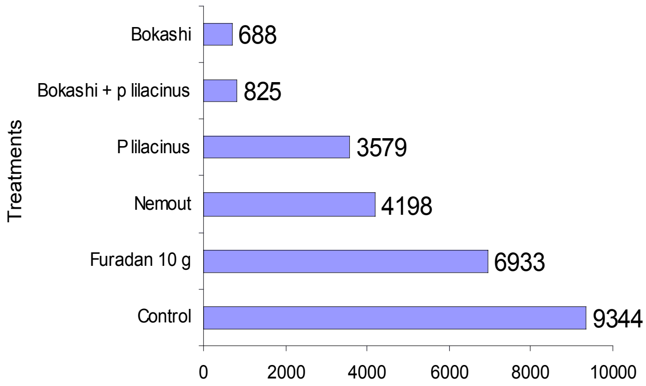

Figure 2. Averages of nematode population counts during 26 weeks of observation.

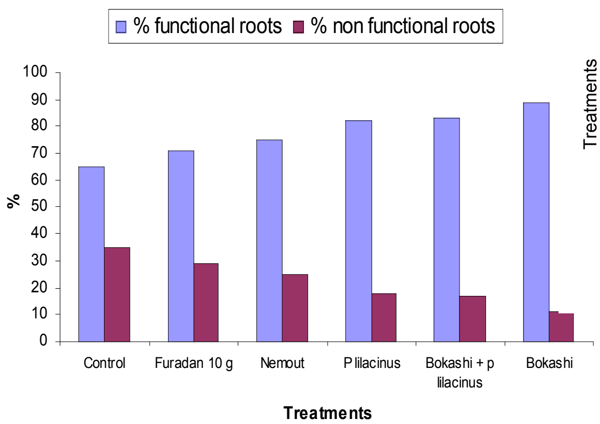

Figure 4. Functional and non-fuctional roots with the treatments of Bokashi, P. lilacinus, Nemout and Furadan.

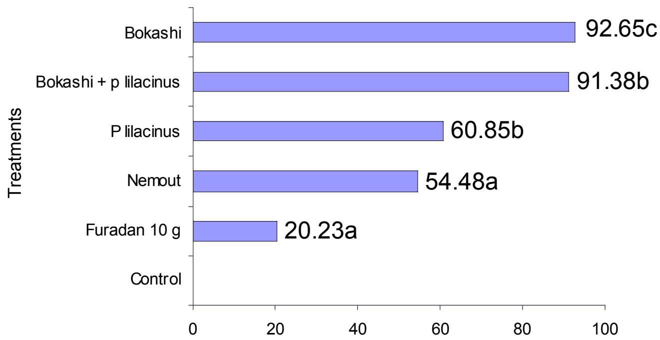

Figure 3. % of efficiency in the control of nematode population.

The success of just plain EM Bokashi was attributed to both biodiversity and anti-oxidation capability of the EM. When bokashi is applied on the soil, it hosts a myriad of organisms that is apparent in the mushrooms, the earthworms and the birds that follow them.

It was also noted when a windstorm occured just after the experiments that the treatments with bokashi withstood the winds and those of Furadan and the Control had the most plants blown down. This means that the organic bnana plants had very strong roots. This is explainable from the Figure 4 where the number of healthy roots of the bokashi treated plants definitely had more roots that those treated with Furadan and the control. This also means that savings can be obtained by eliminating the propping operation, now that the healthy roots themselves serve as the natural props.

In **nutrient suppy** the application of 23 kg of bokashi per plant was slightly better than that with 15 kg (the recommended dosage based on requirements). The double application of 30 kg. of bokashi did not show any better result than that of the 23 kg. (Alvarado and Chaves, 1998). As expected, the half dosage of 7.5 kg. did poorly. This is seen in height and girth as in Fig. 5 and 6, below:

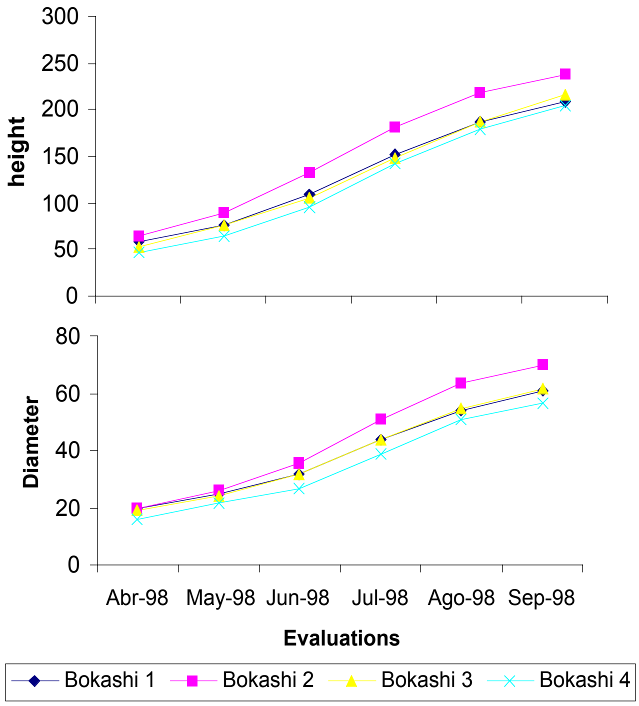

Fig. 5 and 6. Height and girth of bananas pseudostems with the bokashi dosages.

This was also seen in the size and thickness of the leaves. Those treated with 23 kg of Bokashi had 5-18% longer and 7-20% wider leaves than those of the control. The thickness of the leaves registered was 15-25% more. On the whole, the volume of the leaves remained high. There was just as much volume of leaves as those from the conventional (chemically-treated) plants, indicating that even with only 9 leaves, these plants can support normal sized fruits and therefore the reduction in size of the bunches should not have to be that severe.

In **cost of production** the most limiting aspect was the cost of the bokashi which ended up ten times the cost of the chemical fertilizer at the time of the experiment. While this had the potential of being reduced in the future the high cost was retained to reflect the present conditions. The use of bokashi also meant that there was a reduction in nematicides, and even in the fungal disease control. Nevertheless, the costs still tended to be approximately 43%more per unit product on a cost analysis of 5 years. This is reflected in Table 1, below:

Table 1. Field costs (US$) of producing (up to cutting the bunches) of exportable bananas, based on a 5-year project from conventional and in transition to organic bananas.

Production system	Field costs	Number of boxes	Field costs/box
Conventional	22 278.70	9680	2.30
Transitional	34 193.28	10412.20	3.28

The sensitivity analysis on organic fertilizer costs indicates that major improvements in the supply of nutrients could be the key to making organic bananas a competitive enterprise to the conventional bananas (Alvarado and Chaves). At present, however, this 43% difference has been covered by the higher price of organic bananas in the market. Over time, efficiencies in production as well as in the operations should be worked out in order to bring down the prices of bananas.

The **green life of the bananas** from the project registered 18-23 days without any change in five successive trials, indicating that the bananas can be shipped successfully to Europe on the faster boats The bananas refrigerated at 13°C in the normal banavac bags, did not show any fungal growth.

. During the harvesting of the bananas all the flesh was white and had no indication of the regular yellow flesh that indicates premature ripening. This, despite harvesting with only three green or functional leaves. During the ripening of the bananas from the stored samples after 18-23 days (afrter showing a slight change in color), the rate of ripening was the same as those of the bananas from the conventional production regimen. The ripened fruits appeared to be very similar between the organic and the conventional bananas.

In the field,, the bananas which were kept standing and had no more leaves, still remained green up to 18-20 weeks of age of the bunch. This is quite unusual because premature ripening under conventional banana production regimen usually occurs even before harvesting, on the 14-15 weeks of age of the bunch, or about the time of harvesting of the conventional bananas. The color of the flesh of the organic banana fruits were monitored during harvest and all were very white, without any discoloration indicating that there was no premature ripening.

The absence of premature ripening is an indication that the black sigatoka toxin had not proliferated and had not been transported to the fruits. This is an important development and could have been an effect of anti-oxidation of the EM.

CONCLUSIONS

This study on organic bananas shows that it is in organic fertilizers where is a serious limitation, not only because of its elevated quantity and the resulting high cost of production, but also because it has impacts on nutrition, nematodes, pre-mature ripening, quality of the fruit and even the black sigatoka.

It is also revealed that the serious problems of black sigatoka, nematodes and premature ripening at post-harvest can be readily overcome with the technologies with the use of EM. These indications have far-reaching impacts and therefore worth pursuing in-depth in order to assure a more perfect technology.

RECOMMENDATIONS

Production of organic bananas with EM is now feasible and should be pursued. There are still many refinements to make and these should be done as production goes along. Hand-in-hand with modest production, experience should be built based on the properties of anti-oxidation, increased volume of the leaves and in the stronger roots.

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