Effective Microorganisms (EM•1) Technology for Sustainable Large Scale Grain Agriculture

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Abstract—**Where to find the right tools for sustainable grain agriculture? A question not easy to answer. In large scale grain farming, sustainability could be achieved by helping farmers to answer the following questions: Can I do More With Less? (economic matter); For How Long can I Keep Doing it? (environmental matter); and Are We All Happy ? (social matter) In Brazil there are about of 200,000 hectares of soybean, corn, beans and cotton using a new technology based on beneficial microorganisms that are showing a high potential to answer those questiones. The technology called EM•1 (Effective Microorganisms) is a product made of a wide variety of effective, beneficial, non-pathogenic and non-genetic engineered microorganisms that are helping farmers to control weeds, caring seeds, caring soil, caring plants and also for pests and disease control. Data collected directly with the farmers show that: EM•1 is being very effective on potentialize the effects of the herbicides in 40%, which allows farmers to reduce the usage of chemicals; when used to treat seeds, its improves the effects of the seeds inoculants helping roots development; when applied in the soil, it helps the development of other beneficial microorganisms, bringing life back to the soil; it is also being applied directly to the plants to regulate plants growth as well is being applied mixed with agrochemicals to improve their efficiency, reducing 2 applications of fungicide and 1 application of insecticide. Those contributions is impacting positively in their business. By reducing agrochemicals, farmers are net saving around of US$ 39.00 per hectare, while keeping yield increased by 4%, which, in the case of soybean, is totalizing a net benefit of US$ 94.00 per hectare. Farmers also reported their happiness with EM•1 nor only because of the economy impact on the business, but also because of the happiness of the workers. They are commenting that EM•1 is bringing new perspectives, new hopes and that are encouraging them for new investments.**

Keywords — sustainable agriculture; effective microorganisms; em-1; agrochemicals; herbicides.

I. Introduction

WHERE to find the right tools for sustainable grain agriculture? That had been one of the most unanswered questions among hundred thousands grain farmers around the world. Not an easy, fundamental or specific answer. Cornered by the society´s demand for safe food and squeezed by the chemical industry´s economic demand, farmers are trying to survive, keeping their bank accounts under control, their soils healthy, their crops free of pests and diseases, praying for the stock exchange do not increase the fertilizer price or decrease the commodity´s prices, and praying for "God" to send regular rain! Well, it is insanely possible to write down a 4 page Introduction Section only with variables that farmers have to learn to deal with every day. But, it is possible for farmers to be sustainable among all those variable? The simple answer must be yes, and it´s based on finding an equilibrium among those variables that direct affect the 3 main pillars of sustainability.

In grainy agriculture we can basically analyze sustainability by focusing on Economics, the Environment and the Social.

In Economic we must simply answer to: Can I do more with less? That means, can the farmers get the same yield by reducing fertilizers, agrochemicals, fuel, etc? Yes, this is possible. If farmers can reduce 1% of their inputs, they are being sustainable, and if the reduction are more efficient on agrochemicals, yes, we possibly can get healthier food!

In Environment we must simply answer to: For how long can I keep doing it? That means, can the farmers keep working their lands forever, without losing soil fertility, without agrochemical contamination? Yes, this is also possible. By reducing agrochemicals and improving soil´s life, it is possible to keep yields stabilized. Most actions here are related to good soil management and life on soil.

In Social we must simply answer to: Are we all happy? That means, are the farmers happy? Are the workers happy? Are the consumers and the society happy? By achieving economic and environment sustainability, Social would be easy!

Once we can have all those statements clear, we can start working in favor of Grain Sustainable Agriculture, and here is where the EM Technology (EM•1) should play an important role.

EM•1 is a product of EMRO (EM Research Organization) developed by Professor Teruo Higa. EM•1 consists of a wide variety of effective, beneficial and non-pathogenic microorganisms produced through a natural process and not chemically synthesized or genetically engineered [1]. When hearing the words "microorganisms" or "bacteria", one may imagine harmful germs. However, there are many useful microorganisms which have been used by humans. Microorganisms used in EM•1 production are safe and exclude any pathogenic and genetically modified

microorganisms that are harmful to humans, animals and plants. EM•1 consists only of safe microorganisms that have been used, either intentionally or unintentionally, since ancient times and its basically work over organic matter while naturally fight against other pathogenic microorganisms.

In agriculture EM•1 has a wide range of applications, from soil conditioning to post-harvesting management, and the technology have shown an incredible potential to help farmers on sustainable large scale grain production.

II. Materials and Methods

This study is based on evaluating the effectiveness of the EM Technology to help farmers to reduce the usage of agrochemicals, reduce costs of production and improve yields on large scale grain farming in Brazil. Evaluation was made by collecting data through interviews directly with the farmers that are using EM•1®. Interviews were made from March 2014 to March 2016, in Brazil in the States of Bahia, Goiás, Mato Grosso and Paraná, with 35 farmers that together are planting approximately 200,000 hectares of soybean, corn, bean and cotton. The data collected with each farmer was a brief declaration about their experiences, observations and after harvest results with EM•1, also covering their opinion and point-of-view on economic, environmental and social impact.

The protocol for preparing EM•1 for use were the same to all farmers, and consists of mixing 5% of EM•1 with 5% sugar cane molasses in 90% of clear water, letting it brew for at least 7 days. Instructions to use brewed EM•1 were: 80L/hectare on the first harvest, 40L/hectare on the second harvest and 20L/hectare after third harvest. The total amount of brewed EM•1 per hectare should be split in different uses like treating seeds (1mL/kg of seeds), preparing soil (20-80L/hectare), controlling disease and pest (1% of the dilution of the agrochemical used), and weed control substituting until 40% of the herbicide.

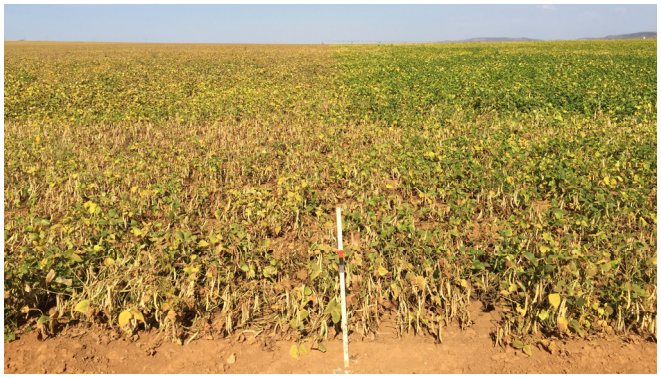
III. Results

In Brazil´s main grain farming fields (soybean, corn, beans and cotton), EM•1 is being successful used to help to control weeds, caring seeds, caring soil, caring plants and also for pests and disease control. At the present, there are around of 200,000 hectares of grain farms using EM•1 at some level of the production, and the results that will be presented in the next sections were collected directly from the farmers.

A. How EM•1 is Being Used to Control Weeds

EM•1 have shown a great value to potentialize the efficiency of the herbicides used by farmers to control weeds. The natural bioactive substances synthesized by the beneficial microorganisms during the brew process of EM•1 favors spreading and the absorption, reducing losses and the degradation of the herbicide. That is possible because the natural bioactive substances have affinities with the skin wax and other lipophilic molecules present on the leave surface.

The level of improvement of the herbicides effect reached by farmers are around of 40%. That means, if the farmers used 1 liter of herbicide to control weeds, now they can use only 0.6 liter and still having the same efficiency. That have been done by simply exchange the other 40% of the herbicide by EM•1 , for example, for the same original 1 liter, now the mix is 0,6 liter of herbicide and 0,4 liter of EM•1. Results shown in the Figure 1. illustrate the effects of EM•1 with the herbicides.



1. Desiccation of soybean with glyphosate. Right-side original directions. Left-side reducing 40% of original directions and substituting with EM•1. Photo by Rogério Aoyagui.

EM•1 is also being used to help control herbicide-resistant weeds. In this case, the farmer did not reduce the herbicide, instead, they add more 40% of EM•1 following the original instructions of the herbicide. Figure 2. shows the results of controlling herbicide-resistant weeds with EM•1.

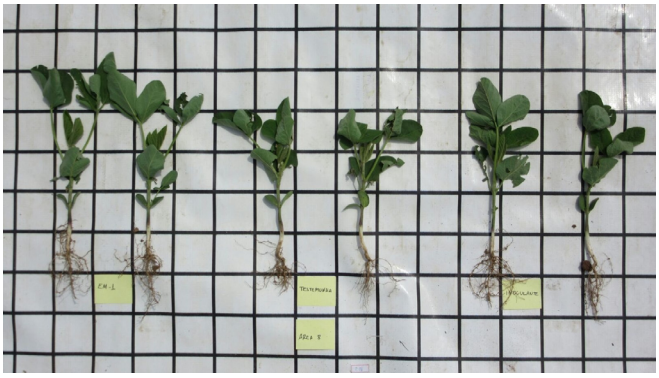
2. Desiccation of herbicide-resistant weeds with glyphosate. Left-side original directions. Right-side original directions plus 40% EM•1. Photo by Rogério Aoyagui.

B. How EM•1 is Being Used for Caring Seeds

EM•1 is significantly used for treating seeds before planting them [2]. Farmers are mixing EM•1 with other inoculants and even fungicides at the ratio of 1mL/Kg. Seeds are germinating faster and the effects of the inoculants on root growth have been improved. Figure 3. illustrate the results.

C. How EM•1 is Being Used for Caring Soil

EM•1 is being used to reestablish life on soil, favoring a better decomposition of organic matter as well as favoring the development of other good microorganisms like mycorrhizal fungi, actinomycetes and others beneficial microorganisms [3]. Results are visible on field, Figure 4. illustrate an example.



3. Effects of EM•1 when mixed with seeds inoculants. The left first 2 seedlings with EM•1 and inoculants, the middle 2 seedlings Control, and the right 2 seedlings only inoculants. Photo by Lúcio Magalhães de Jesus.

4. Life back into the soil in the farms where EM•1 is being applied to soil. On detail, a colony of mycorrhizal fungi development. Photo by Cid Simões.

The applications of EM•1 on soil are based on a program following: a) first year, 80 liters per hectare, as a chock treatment sprayed directly on soil or injected on furrow during planting; b) second year, 40 liters per hectare sprayed directly on soil or injected on furrow during planting, and c) after second year, 20 liters per hectare, mainly injected on furrow during planting.

D. How EM•1 is Being Used for Caring Plants

EM•1 is being used to promote plant growth and health. The bioactive substances, like amino acids and antioxidants, present on EM•1 helps to regulate plants growth. On the other hand, the beneficial microorganisms seems to collaborate in fighting against other pathogenic microorganism by natural competition, resulting in keeping common diseases under control all long the crops life [4].

The applications are made to cover all foliar surfaces of the crops, and to achieve that, farmers are using big rotor-propelled pulverizers or even airplane pulverizers. The average of product applied during the crop development is 20 liters per hectare divided into 3 applications, one after seeds germinate, one when plants are almost "closing the lines" (stage on crop when soil becomes completely covered by the crops leave) and the last one before plants blooming.

E. How EM•1 is Being Used for Pests and Disease Control

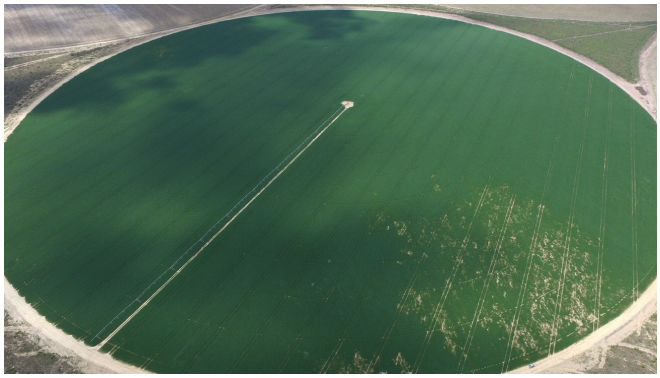
Surprisingly EM•1 is being mixed with agrochemicals to improve the effects of the chemicals while reduces it´s requirements on field. Farmers mix 1% to 5% of EM•1 into their original agrochemical recipe for fungicides and bactericides. Crops were EM•1 was mixed onto the agrochemical have shown a better control and have reduced the recurrence of diseases. On average, farmers were able to reduce 2 to 3 fungicide/bactericide applications from their 8 to 9 applications program.

There is also another method being used by farmers that are helping to control pests. The method consists on brew during 7 days, 10% of original EM•1 with 10% vinegar, 10% alcohol and 10% sugar cane molasses in 60% clean water. The result of the brew is a powerful natural repellent. The repellent is being applied itself or mixed with the insecticides. When used alone, the repellent is pulverized with water at the ratio of 5% to 10% each 15 to 20 days, depending upon the level of pests infestation. When mixed with insecticides, the ratio used is 3% to 5%, following up the insecticide instructions and program.

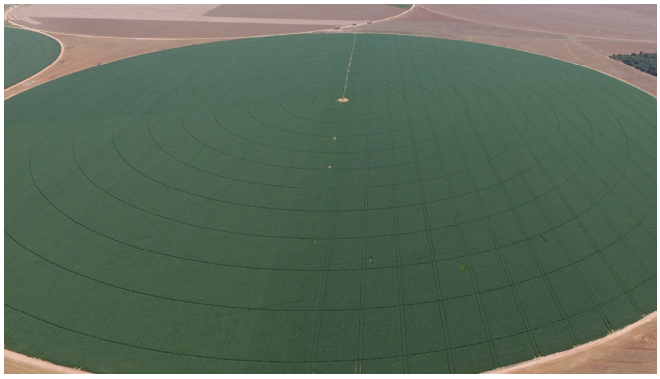
The use of the natural repellent is helping farmers to reduce 1 to 2 applications from their insecticide application program.

F. Nematodes Control in Soybean and Bean Farms

Areas of soybean and bean where EM•1 had been used for soil during more than 2 years, had shown an increasingly reduction of nematodes problems. With the development of



5. Area affected with nematodes. Before apply EM•1. Photo by Rogério Aoyagui.



6. Area affected with nematodes. After apply EM•1. Photo by Rogério Aoyagui.

natural and beneficial fungus on soil, most of them ends up being antagonist to nematodes or even became natural nematode´s predators. Around 90% of the farmers with nematodes problems have reported that after using EM•1 the problems with nematodes had decreased significantly. Figures 5 and 6 illustrate the results.

IV. Discussion of Economic, Environmental and Social Impact

The implementation of EM•1 program in the grain farms had allowed farmers to start reaching sustainable results. Most of the benefits where observed on the roots health and development, followed by a better plant development, and with the crop field loaded with beneficial microorganisms, the pressure on disease control have reduced drastically. On farms using EM•1, and crops are healthier than ever.

With all small contribution to the plant development, since germination, growth, blooming and caring, yields were also increased. Farms using EM•1 at the ratio of at least 20 liters

7. Yield increased. Plant and pods on left produced with EM•1. Plant and pods on right produced without EM•1. Photo by FertBio Ltda (Alexandre Sperotto).

per hectare have increased their yield average by 4%. See results on Figure 7.

The increase on the efficiency of the herbicides had allowed a better, faster and cheaper weed control, which also contributed to yield quality at some level.

A. Economic Impact

The average costs of EM•1 for farmers is US$ 0.50 per liter. Using an average of 40 liters per hectare, total costs with EM•1 is about of US$ 20.00 per hectare.

EM•1 is a low cost alternative, and it also pays back itself. In average, reducing 40% of herbicide, represents an economy of approximately US$ 16.00 per hectare. Farmers reported that they have reduced at least 2 applications of fungicide and 1 of insecticide, that in terms of economy represents about of US$ 22.00 per hectare in savings with fungicides and about of US$ 21.00 per hectare in savings with insecticides and nematicides.

Economy balance comes to be very positive, because total savings with agrochemicals reach about of US$ 59.00 per hectare, while total costs with EM•1 is US$ 20.00. That is generating to the farmers a net saving of US$ 39.00 per hectare.

If we consider the increase of 4% on yield, in soybean for example, that increase represent about of US$ 55.00 per hectare, and in that case, added to the agrochemical economy, the final balance can reach about of US$ 94.00 per hectare.

B. Environmental Impact

Environmental impact of EM•1 on large scale grain farming is also very positive. For example, if we consider that the average on using herbicides is around of 4 liters per hectare per year and with EM•1 we can reduce 40% of that amount, in 200,000 hectares we are avoiding the usage of about 320,000 liters of herbicides per year.

With fungicides, bactericides and insecticides is not possible to estimated the reduction in liters due to the immense quantity and variability of chemicals available on market and their different advices. But if we can consider number of applications, we can say that EM•1 is helping to avoid 2 applications of 8 in fungicides and 1 of 6 in insecticide, that represents avoiding 25% of fungicides and 16% of insecticides.

Nor even EM•1 are helping reducing agrochemical but its also bringing life back to the soil again. Farms that are using EM•1 for more than 2 years are reporting better soil quality, better organic matter on soil and better levels of nutrients. A deep study about the benefits on soil are being conducted, but preliminary results have shown a very positive impact on soil conservation. If soil is the main patrimony on agriculture, then EM•1 could provide an invaluable impact for the future of agriculture [5].

C. Social Impact

EM•1 is well known as a probiotic product very safe to use. Microorganisms in EM•1 are all beneficial and safe to human, animals and to the environment. It´s appearance is liquid brown with nice smell. All those safe and easy-to-use characteristics have been approved and welcomed by workers. They all reported that it very pleasant working with the product, and for the first time they were happy by handling a natural and safe to use product with no first aid equipments and long list of precautions.

On the other hands, farmers also reported their happiness with EM•1. EM•1 is helping to save money and the the workers are happy working with a safe product.

They are commenting that EM•1 is bringing new perspectives, new hopes and that are encouraging them for new investments.

V. Conclusion

As observed directly on the farms, the use of EM Technology is helping farmers to reduce the usage of agrochemicals at significant levels, that also are helping to reduce costs of production while improve yields expressively. As reported, EM•1 directly help plants for a better development, impacting positively on health and on yield. Economic, environmental and social results are very encouraging, and EM•1 are showing to be a very promising tool for large scale grain farming.

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