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Effectiveness of seed coating with microbial inoculants as an alternative to agrochemicals in sustainable agriculture

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INTRODUCTION:

Intensive agriculture is highly dependent on agrochemicals and in order to increase crop production, environment integrity is disturbed with biodiversity loss, emergence of pathogens, and soil and water resources negatively affected. The abuse of agrochemicals in agriculture constitutes a major worldwide problem as it does compromise environment and public health. Reducing the use of chemical fertilisers with increased application of organic onesis considered a required and natural route to ease the pressure on the environment derived from agricultural practices (Malusá et al., 2012).Plant growth-promoting soil microorganisms (PGPM) such as arbuscular mycorrhizal fungi (AMF) and plant growth-promoting rhizobacteria (PGPR) may replace or reduce many destructive, high-intensity practices in agriculture. AMF are probably the most abundant fungi that are commonly present in agricultural soils. AMF support plant growth directly by enhancing nutrient (P, Zn and others) and water uptake and indirectly by improving soil structure and resistance to certain root pathogens (Nadeem et al., 2014).On the other hand, PGPR play a significant role in enhancing plant growth and development both under non-stressful and stressful conditions by a number of direct and indirect mechanisms. The mechanisms that promote plant growth include: N fixation, production of siderophores and phytohormones and solubilisation of minerals such as P(Ramasamy et al., 2011).The microbial interactions and associations might be crucial for sustainable agriculture as they mainly depend on biological processes rather than agrochemicals to maintain plant growth and development of a proper soil health under stressful conditions.Direct inoculation of free PGPR cells into the soil aiming atcolonise plant roots has proven not to be efficient due to PGPR vulnerability to environmental variations (edaphic conditions, salt stress, pH, temperature and others) (Wu et al., 2012). Large scale inoculation with AMF in agriculture is limited due to the relatively high cost of inoculum and the need to attain a sufficient number of propagules per plant (Vosátka et al., 2012). Both AMF and PGPR application by broadcasting in open agricultural fields is not economically feasible because non-target spreading of inoculum over large areas results in high cost per plant. The solution may lie on seed coating, a technique in which finely-ground solids or liquids are adhered around the seed with a sticky material that has been promptly developed and gained great acceptance by the seed industry. Coating seeds can improve performance and physical properties of seeds, but more importantly, can allow the use of minor amounts of inoculum resulting in a reduction of costs and efficiency increase.

OBJECTIVES:

In this study there were two main goals: the first, is through seed coating technology reduce the amount of inoculum needed for an effective inoculation, making the application of these beneficial soil microorganisms in open field extensive agriculture possible; and the second is to minimise the dependence and use of agrochemicals in agriculture by using PGPM, such as PGPR and AMF.

MATERIALS AND METHODS:

Being one of the most diffused crops worldwide due to its high economic and nutritional value maize was selected for the seed coating tests. *Pseudomonas fluorescens* F113 (PF113) was grown Luria Bertani medium and it was selected as the PGPR, not only due to its proprieties as a plant growth promoter, but also because it is consider to be a mycorrhiza helper bacterium. The inoculum of *Glomusintraradices* BEG140, the selected AMF, was prepared in open pot cultures. Maize seeds were coated with either single BEG140 isolate (BEG) or mixture of BEG140 and PF113 (Mix). Plants were maintained in a greenhouse under controlled environmental conditions and the experiment was performed with sterile agricultural soil. For the greenhouse trials four treatments were tested: seed coated with BEG140; non-coated seed inoculated withBEG140 (positive control); seed coated with BEG140 and PF113; and non-coated seed inoculated with BEG140 and PF113 (positive control). After 4 weeks of plant growth, maize roots were stained and root colonisation by AMF evaluated by microscopy.

RESULTS AND DISCUSSION:

Maize seeds were successfully coated with the microbial inoculants. After 1 week of growth the maize seeds presented a high rate of germination and after 4 weeks it was possible to evaluate the percentage of colonisation of the roots. The AMF colonisation was evaluated by the presence of vesicles, arbuscules and hyphae. All maize seeds inoculated with BEG140 had their roots colonised by AMF. Treatments with single BEG140 isolate and Mix (BEG140+PF113) presented no significant differences. The percentage of root colonisation was higher than 40% for all the treatments and statistically the coated seeds had the same result than seeds with normal inoculation (positive control). These results indicate that seed coating is a good tool for using low amounts of AMF inoculum. In Figure 1 maize plants after 4 weeks of growth are presented, while Figure 2 shows stained roots with and without AMF colonisation.

Fig.1 - Maize in the greenhouse trials.

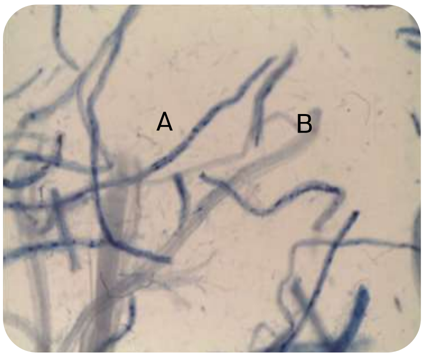

Fig.2 - Colonisation of maize roots by BEG140. **A**- colonised roots; **B**- non-colonised roots.

CONCLUSION:

Seed coating may be the key for a more efficient application of AMF and PGPR, which may allow the large scale application of these beneficial microbial inoculants while aiming to reduce the input of agrochemicals. Seed coating represents an innovative approach to enhance sustainable agriculture, which might result in economic and environmental benefits.

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