THE NITROGEN CHALLENGE:
BUILDING A BLUEPRINT FOR NITROGEN
USE EFFICIENCY AND FOOD SECURITY

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ROOT SOCIALIZATION: THE BASIS FOR IMPROVED PRODUCTIVITY AND NUTRIENT USE EFFICIENCY

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The world’s population is expected to increase from 7 billion now to 8.3 billion by 2025. Humanity will need 70-100% more food by 2050, so the production of cereals, especially wheat, rice and maize, which account for half of human calorie intake, must be increased. Plant growth has already been enhanced by the input of chemicals, which act as plant growth regulators and as nutrients. The nutrients nitrogen and phosphorus are, together with potassium, applied to the soil as chemical fertilizers to improve grain yield. According to Roberts (2009) the present annual uses of chemical nitrogen, phosphorus and potassium fertilizers is 130, 40 and 35 million tonnes. The high input of chemicals to the soil raises a number of concerns such as water contamination leading to eutrophication and health risks for humans. Moreover, it results in soil degradation and loss of biodiversity. In this work we describe the benefits of exploring the relation between arbuscular mycorrhizal fungi (AMF) and plant growth promoting bacteria (PGPB), which in association with fertilizers may improve productivity and nutrient use efficiency.

Materials and Methods:
A four-block randomized field assay was established on May of 2012 in Beja (Escola Agrária de Beja, Portugal). Maize (Zea mays L. cv Sincero) was used to test the synergies between distinct microbial inoculants and fertilizers on plant growth. In each block there were 5 treatments: A) 100% of the dose of fertilizer recommended for this culture and soil type, 150 kg/ha of NPK fertilizer (18-46-0); B) 67% of the fertilizer applied in A; C) B + AMC inoculum; D) C + AMF inoculum; E) B+C+D. Each block had an area of 330 m² and each treatment unit (within a block) had an area of 30 m², the total assay area per treatment was 120 m². The bacterial inoculant (AMC) consisted of Bacillus megaterium, Saccharomyces cerevisae, Azotobacter crococcum, Rhizobium loti, Bacillus licheniformis and Bacillus pumilus, which were incorporated in the fertilizer granules by the fertilizer company (1 L/t). The AMF inoculum was Glomus intraradices, which was directly applied in the field together with the seeds at a dosage of 5g/m² (2 000 000 propagules/kg).

During the growing cycle, nutrients were added to the irrigation system daily: (205 kg.ha⁻¹ N; 3.5 kg.ha⁻¹ Ca; 1.77 kg.ha⁻¹ Mg; 1 kg.ha⁻¹ Zn). A mixture with 9% N, 37% organic matter, 23% organic carbon and 24% of free amino acids was applied once at 5.5 kg.ha⁻¹.

Seventy-five days after sowing, the aboveground parts of the plants were harvested, and analysed for biomass accumulation and nutrient content. Soil samples were also collected and analysed for nutrient content. The nutrient use efficiency was calculated for each treatment. Data were statistically analyzed through one-way ANOVA followed by Tukey post-hoc test (SPSS).
Results and Discussion:

Results show that at the flag leaf stage, maize plants fertilized with 100% of the recommended dose of fertilizer accumulated more biomass than those fertilized with only 67%, showing that the recommended dose was not overestimated. No significant differences in biomass accumulation were found among plants treated with 67% of the recommended dose of fertilizer, bacterium inoculum (AMC) or mycorrhizal inoculum (AMF). Therefore all these treatments resulted in smaller plants than 100% of the recommended dose of fertilizer. However, the simultaneous use of 67% of the recommended dose of fertilizer, the bacterial and the mycorrhizal inoculant originated plants with biomass similar to those treated with 100% of the recommended fertilizer dose. Although these results refer to the accumulation of vegetative biomass they show that there are ways of reducing the amount of the fertilizer applied to crops without reducing the productivity. The higher biomass accumulation in the plants treated with 67% of the recommended dose of fertilizer, the bacterial and mycorrhizal inoculant may be explained in the light of the biotic and abiotic interactions established between plants and microorganisms in the rhizosphere. Exploring the positive interaction between organisms and stimulating the formation of microbial consortia may be a very important strategy in the way to reduction the fertilizer application in 33% (PAC recommendation), which represents a big potential to decrease the environmental impacts of agriculture. Further studies are needed in order to assess: 1) the effects of the distinct treatments on grain productivity, and 2) how sustainable the process is.

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Shoot biomass of maize plants 75 days of sowing. Values (means±SE of 4 replicates) followed by different letter are significantly different at $P<0.05$ (Tukey post-hoc test).