Commercial plant-probiotic microorganisms for sustainable organic tomato production systems

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Abstract

Selected plant-probiotic microorganisms, produced by the company CCS Aosta at a commercial scale, are being tested in the Italian Padana plain in open field conditions for their ability to provide adequate crop nutrition and to ensure durable soil fertility for organic tomato production. In this three-years-long project the QLIF-WP333 research team will investigate the potential of soil probiotics management as a tool to improve the quality of tomato fruits and the sustainability of organic tomato production systems.

Introduction

During the last 400 million years, terrestrial plants have not achieved the ability to grow independently from their own probiotic microorganisms (plant growth promoting bacteria, mycorrhizal and antagonistic fungi). Plant-probiotic microorganisms (PPMs) are well known for positively and directly affecting plants growth through several mechanisms, such as biological nitrogen fixation, solubilization of phosphorous, synthesis of siderophores, plant hormones, and plant hormone regulators (Picard and Bosco, 2006). The indirect promotion of plant growth can occur when soil beneficial microorganisms antagonize the action of phytopathogenic organisms. All these mechanisms are regulated by population density and diversity of microorganisms that are in direct contact with the root surface (Picard and Bosco, 2005) or in the close rhizosphere, a habitat where there is maximum microbial activity due to the release of organic components from the roots.

In fact, technological bottlenecks in organic production systems, which affect quality and safety in organic foods, as well as costs of production, still include untimely availability of nutrients and diseases biocontrol. As plants are still genetically dependent from their co-evolved soil probiotics, future applications in organic and low-input agriculture, to be sustainable, must seriously consider the biological need of plants to co-operating with PPMs.

The research approach of this study is to achieve a better understanding of the relationships between plant-probiotic microflora management, organic matter inputs, crop quality, and production costs. Our first year of investigation concerned effect of, and interactions between combined gradients of beneficial microbial inoculum (M), organic compost (C) on tomato fruit yield and quality.

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Materials and methods

Plant materials

Plant materials consisted of two tomato (*Solanum lycopersicum* L.) cultivars: 'Riogrande' and 'Gordon'. 'Riogrande' is intended for industrial processing and was chosen by the organic farmer because it already produced good yields in his own farm for the last ten years (Sabbioni, personal communication). 'Gordon' is intended for fresh use in salads and was chosen for research purposes. Seedlings of both cultivars were produced by an organic certified nursery, located near the experimental site, and transplanted at the age of 45 days.

Microbial inputs

Plantlets were treated with an experimental variant of 'MICOSAT F' by CCS Aosta, a mixed inoculum specially suitable for horticultural species, flowers, which protects them against *Pythium, Phytophthora, Verticillium, Agrobacterium, Meloidogyne, Pratylenchus*. The commercial product contains grinded mycorrhizal roots, spores and mycelia of arbuscular mycorrhizal fungi (AMF) *Glomus mosseae* GP11, *G. viscosum* GC41, *G. intraradices* GB67, as well as plant-growth-promoting-rhizobacteria (PGPR) like *Pseudomonas* sp. PN 01, *P. fluorescens* PA28, *Bacillus subtilis* BA41, *Streptomyces* sp. SB14, and the antagonistic saprophytic fungus *Trichoderma viride* TH03. For present field experiments, three selected Italian strains of free-living nitrogen-fixing bacteria belonging to the BUSCoB culture collection were also used. The inoculum was added to the soil at three increasing concentrations (zero, 40, 80 Kg per ha) just after transplanting.

Organic compost inputs

A commercial organic certified green compost (1.87 % total N, 30.8 % total C), produced by Nuova Geovis S.p.A near Bologna, was added to the soil at three increasing concentrations (zero, 5.5 ton per ha, 11 ton per ha).

Field experiments

Trials were performed at the Carioncella organic farm, in northern Italy, which holds the AIAB-ICEA certificate since 1993. Tomato seedlings were transplanted in four replication blocks, sharing the same cultural history. Each block was randomly divided into three main plots and treated with described levels of organic compost (C), equivalent to zero, 100 kg N per ha, and 200 kg N per ha, incorporated into the soil prior to planting. Each main plot was separated from the others, and protected externally, by a row of border plants. Then, three subplots of twenty plants were randomly established within each C main plot, and treated with zero and two increasing levels of plant-probiotic 'experimental MICOSAT F' inoculum (M). Each subplot was separated from the others by five border plants.

Evaluations

The effect of PPM inoculum, organic compost, on tomato fruit yield and quality were studied during the growing season by measuring the vegetative development of five randomly sampled plants per subplot, at the age of 5, 8 and 12 weeks; total and marketable fresh weight, number of tomato fruits per subplot were recorded and expressed as sums. Probiotic-microorganisms colonisation of tomato roots was monitored by molecular methods (Picard et al., 2004; Picard et al., 1992) before planting, 5 and 9 weeks after planting.

Results

The first of our three scheduled experiments was successfully established and completed although the 2006 summer was unusually dry. Drought effects were balanced by appropriate irrigation.

Prior to inoculation, the 15-years-long organically managed soil of the Carioncella farm was found to be very rich in PPMs. All checked tomato seedlings were found non-mycorrhizal before transplanting. After exposure to the experimental treatments, mycorrhization indexes were significantly different between the two varieties.. For both compost and inoculum inputs, mycorrhizal status was insignificantly higher for 'Riogrande', while insignificantly lower for 'Gordon'. However, these results should be confirmed by a second year experiment. Non-significant differences were recorded in this first year experiment for both total and marketable tomato fruit yields. Both cultivars showed non significant higher values for compost, while only 'Gordon' yields were positively influenced by inoculum (not significant). Plant development patterns were positively related with compost inputs in both cultivars, without significant variations among plant ages. 'Gordon' development was more responsive to inoculation than 'Riogrande' (not significant). Other recorded rhizosphere and fruit quality parameters are still under elaboration.

Discussion

Natural organic soil richness probably reduced the differences in microbial parameters within experimental plots, and a similar explication could be given for total and marketable tomato fruit yields. The significant differences for microbial colonization between varieties agree with previous findings on different crops (Bosco et al., 2006; Picard et al., 2005). Further research into microbial parameters such as community diversity and structure evaluation is necessary to understand the impact and interaction of natural soil microbial levels and inoculation.

Conclusions

A second and third year of field experiments are needed to give any scientifically sound conclusion.

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