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IMPACT OF A MYCORRHIZAL INOCULUM ON TOMATO AND PEPPER ORGANIC PRODUCTION: A TRANSDISCIPLINARY APPROACH IN NORTHERN ITALIAN CONTEXT

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Abstract: The paper explores the impact of a mycorrhizal with microbial consortium inoculum on a tomato and bell pepper production, considering agronomic and qualitative parameters and sensory performance. The research was conducted in summer 2019 at the garden of the University of Gastronomic Sciences (Italy), which uses organic practicties.
Two varieties of tomatoes (“Costoluto” and “Cuore di Bue”) and one variety of bell pepper (“Quadrato di Carmagnola”) were cultivated in the greenhouse, comparing mycorrhizae (M) versus control (C) samples. Analyses included: quantitative analysis on fruits, qualitative analysis (pH, Brix measurements and NIRS on fruits) and sensory evaluations of tomatoes. Results show: a clear diversification of M versus C from NIR; a negative impact of the mycorrhizal inoculum on the quantitative yield; minimal perceivable differences between M and C in sensorial analysis, which did not negatively affect preferences.

Introduction: Arbuscular mycorrhizal fungi (M) enhance plant growth and fitness through improved uptake of water and mineral nutrients in exchange for carbon compounds from the plant and receive increasing attention in the areas of organic farming and sustainable food systems. Cases of negative plant-biota interactions in the ecosystem have been studied. Currently, only a few M genotypes are produced as biofertilizers and they are distributed globally, but evidence for their efficacy is scant, incomplete or lacking altogether. This research focuses on the effect of M biofertilizer on several aspects (soil, yield quantity and quality, taste) of two horticultural organic cultivations (tomato and pepper) with a transdisciplinary and holistic approach.

Material and methods:

1 Field trials

From April to August 2019 tomato and pepper plants were cultivated in a tunnel greenhouse on the native soil of the University of Gastronomic Sciences (UNISG) that has been using organic management for the last 13 years. Before the transplanting, vermicompost (75 kg*100 m^{-2}) was distributed in the field. Throughout the growing period the plants were drop-irrigated, and actively aerated compost was added. An experimental split-plot design with three repetitions compared mycorrhized (m) and control (c) plants of three crops: tomato (*Solanum lycopersivum L.*) A) variety "Cuore di Bue" cultivar GIGAWAK®; C) variety "Costoluto"; B) pepper (*Capsicum annuum L.*) variety "Quadrato di Carmagnola". In the tomato theses (Ac-Am, Cc-Cm) there were 6 plants per plot (total 36 plants for each variety) and in the pepper thesis (Bc-Bm) 6x2 plants in each plot (total 72 plants). Roots of the mycorrhized plants were soaked in treated water where the granular product MICOSAT MF (CCS, Aosta, Italy) had been dissolved at a dose of 10 g/l. Climatic conditions delayed the transplantation as spring was colder than the average past 10 years. The cold period was followed by an abnormal heat wave in June and July with local extremes of over 40°C. The following data were collected: plant height every two weeks; NIR-SCiO spectroscopy on the leaves, roots and hay-litterbags; raw pH of the leaves, as described in Giovanetti *et al.* 2019. The harvest period is July-August, twice a week. The overall number, number of discarded fruits, weighed and the volume were measured. Once a week a sample of each plot was selected for qualitative analyses. The fruits were pureed and passed through a fine mesh sieve (1 mm) before pH and Brix measures. A direct NIR-SCiO scan was performed on a sample of intact fruits.

2 Sensorial analyses on tomato

Two sensorial tests were performed in order to detect the impact of the microbial product on the taste of the fruit of the tomato. A simple difference test (Triangle test: n=90 number of participants (47.8% female, 52.2% male, age span from 18 to 70 years); P_d=50%, risk of error α 0,001, risk of error β = 0,01) was followed by a paired preference test (P_{max}=75%, n=100, risk of error α= 0.01, risk of error β= 0.01).

3 Statistical analyses

The data was analysed with the software SPSS for the height of the plant (cm): ANOVA one way, with Tukey as selected post-hoc analysis. The size, pH and Brix values were analysed with SAS-System using PROC mixed, while all the data regarding the fruits were elaborated with StatBox performing a non-parametrical ANOVA with Kruskal-Wallis Test. For the analysis of the NIR and NIR-SCIO results refer to Masoero *et al.* (2019) and Giovanetti *et al.* (2019).

Results:

1 Effect on soil and plant traits

The NIR yielded some positive results. The leaves of the "c" pepper, as well as both "m" tomatoes are clearly discriminated in pairwise comparisons. The NIRS carried out on the roots shows some signature of the "c" and "m" type overall, which suggests an effect of the mycorrhizal treatment on the chemical composition. The bell peppers "c" and "m" were clearly discriminated for a significant level of alpha (α<0,5).

2 Effect on berries

For the *"Cuore di Bue"* tomato most results were significant, showing clearly that the plants have produced more in weight, volume and numbers (Tab 1).

For the peppers only the density of the fruits seems to be significantly greater in the M samples, while the average weight of the fruit is 29% smaller in M. The results are not significant, they suggest that the "m" plants produced nearly as much as the "c", whereas the berries were more abundant, smaller and denser.

Table 1 - Yield results (intra-varietal and between the two treatments overall) *A) tomato variety "Cuore di Bue" cultivar GIGAWAK®; B) pepper variety "Quadrato di Carmagnola"; C) tomato variety "Costoluto".*

		Berries										
Type	Myc	Weight (kg)	Number (n)	Discard (kg)	Discard (n)	Edible (kg)	Edible Volume (l)	Density (l/kg)	Edible Number (n)	Av.g 1 B1.w (kg)	pH B.pH	Brix B.Bx (°Bx)
A	c	42,6	160,7	5,8	27,7	36,8	40,5	1,17	133,0	0,305	4,46 a	3,89
	m	38,7	142,7	4,4	18,3	34,3	36,5	1,20	124,3	0,294	4,39 b	4,00
	m/c	-9%	-11%	-23%	-34%	-7%	-10%	3%	-7%	-4%	-2%	3%
	P	0,05	0,05	0,28	0,05	0,05	0,05	0,83	0,28	0,51	0,005	0,28
B	c	28,6	137,0	1,5	9,3	27,0	27,6	13,4	127,7	0,216	5,09 b	5,00 b
	m	22,7	120,0	1,9	10,3	20,8	20,8	13,8	109,7	0,190	5,25 a	5,50 a
	m/c	-21%	-12%	20%	11%	-23%	-25%	3%	-14%	-12%	3%	10%
	P	0,13	0,12	0,83	0,83	0,13	0,05	0,51	0,18	0,05	<,0001	0,004
C	c	3,6	23,7	0,8	7,3	2,8	5,4	2,1	16,3	0,338	4,22	3,51
	m	3,3	29,0	0,7	7,7	2,7	5,2	2,7	21,3	0,235	4,19	3,66
	m/c	-8%	23%	-17%	5%	-5%	-4%	30%	31%	-30%	-1%	4%
	P	0,51	0,51	0,51	1	0,51	0,51	0,05	0,51	0,05	0,17	0,16

Analysis of all samples showed a significant increase in Brix for the "m" samples, which is especially visible in the bell peppers (+10%). The analysis of the interaction between treatment and variety results in a significant pH drop of 1,6% in the "*Cuore di Bue*" tomato samples, while it was increased by 3,1% in the peppers.

A NIR-SCiO analysis showed that the "m" samples had a smaller average reflection than "c" but only for the "*Cuore di Bue*" (Fig 1), and the fingerprint % of the four types were significant (Fig. 1).

Figure 1 - NIR-SCIO spectrum for M and C samples of the "Costoluto" and "Cuore di Bue" variety (N.182)

3 Sensory analyses in tomatoes

The triangle test was significant for the "*Cuore di Bue*" variety. The preference for "m" increases with the age of the participant, which is not confirmed for the "*Costoluto*".

Discussion: There are two relevant aspects to this experiment: the assumption that inoculated microbial products enhance the production and yield of a plant cannot be confirmed; these products do somehow affect the chemical composition of the plant and fruit matter, even to such an extent that it becomes perceptible to our palate.

The quantitative yield analysis was not in favour of the M plants as the negative tendency became visible already during the plant height measurements and was confirmed after the harvest period. These results confirm the outcome of another field trial performed at UNISG in September-December 2018 and for which radishes and lettuce had been planted in turf bags.

Why? A first hypothesis is the probable competition between the introduced and the autochthonous microbiome. Regvar *et al.* (2003) reports the successful inoculation of selected local strains of AMF which results in a positive impact on the yield of different vegetables. The paper underlines the complexity of the AMF-host plant interactions and the need to proper study it in order to efficiently apply microbial products. As the soil at the UNSIG garden has been cultivated under organic regime for several years, the it is supposed to have an increased and more active microbiome (Reeve *et al.* 2010). The inoculated microbes will likely compete with the present ones and result in a negative impact on the plant. Further evidence for this hypothesis is the fact, that reported positive impacts of the product "Micosat F" (CCS, Aosta, Italy) have been achieved in conventionally managed fields (Raiola *et al.,* 2015).

Regarding the quality of the fruit, further biochemical analyses could reveal some positive impact on the nutritional value of the vegetables (Raiola *et al.,* 2015). This represents a *novum* for the research on biofertilizers as the presented approach comprises the impact on the soil, the yield, the quality and also the taste of the product.

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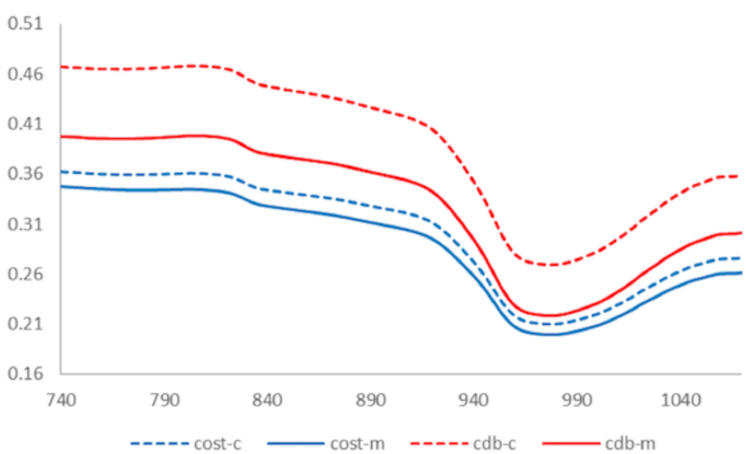
Image:



Disclosure of Interest: None Declared

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