Effect of mycorrhizal fungus on thiamethoxam, azoxystrobin and fludioxonil behavior on maize rhizosphere under field conditions

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Introduction

Arbuscural mycorrhizal fungi (AMF), known for their beneficial effects on plant growth, provide direct links between soil and roots, and may have influences on the uptake and translocation of organics by plants, as well as the dissipation and degradation of pesticides in soils. Pesticides are used to increase productivity and improve the quality of food. However, they lead to concerns about their impact on human health and the environment [1]. Thiamethoxam is a systemic insecticide of second-generation neonicotinoid, controlling pests on a wide range of crops and vegetables [2]. Azoxystrobin is commonly used as a foliar fungicide, in furrow spray or for seed treatment with a broad spectrum activity. [3]. Fludioxonil is a non-systemic phenylpyrrole fungicide widely used as a foliar, seed and post-harvest agent to control various diseases [4]. We hypothesize that the AMF inoculation may contribute to pesticides degradation in a contaminated soil. Therefore, the aim of this study was to assess the fate of the insecticide thiamethoxam and the fungicides azoxystrobin and fludioxonil, on maize rhizosphere in the presence of AMF under field conditions.

Materials and methods

The cultivated maize genotype was AGN 717. Pesticides were applied by the drip irrigation. In the first application the pesticides were applied in their recommended dose, while during the second application a double dose was used (Table 1). The plots were established in randomized complete block design replicated thrice. (Figure 1). Soil samples in triplicate were collected on 7, 15, and 25 days after the application of the double dose from the rhizosphere of the maize plants. QuEChERS extraction method was used for sample preparation. A HPLC-DAD analysis was used for the determination of pesticides residues (Figure 2).

Table 1. Application rates of pesticides with spraying volume 10 mL per seed.

Commercial formulation	Active substance	Recommended dose on 6/5/2019	Twice dose on 22/5/2019
Geoxe	fludioxonil	1 g/L	2 g/L
Quadris	azoxystrobin	0.9 g/L	1.8 g/L
Actara	thiamethoxam	0.25 g/L	0.5 g/L

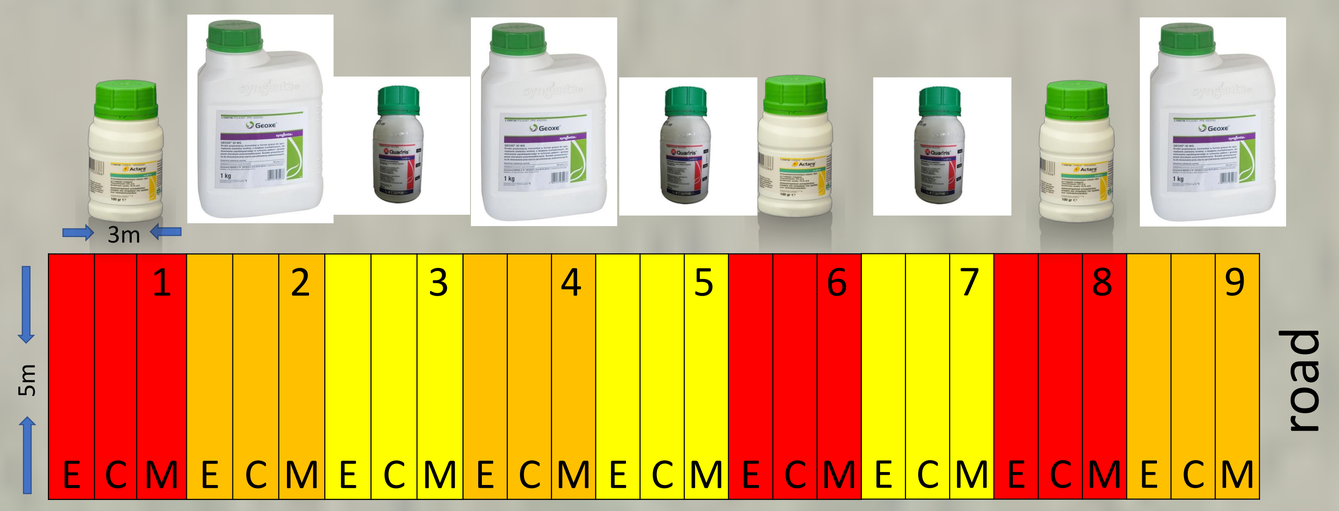

Figure 1. The experimental design in field, including 9 plots. Each color represents a different pesticide. (E = application with the pesticide, C = control, M = application of the pesticide plus an AMF inolucation

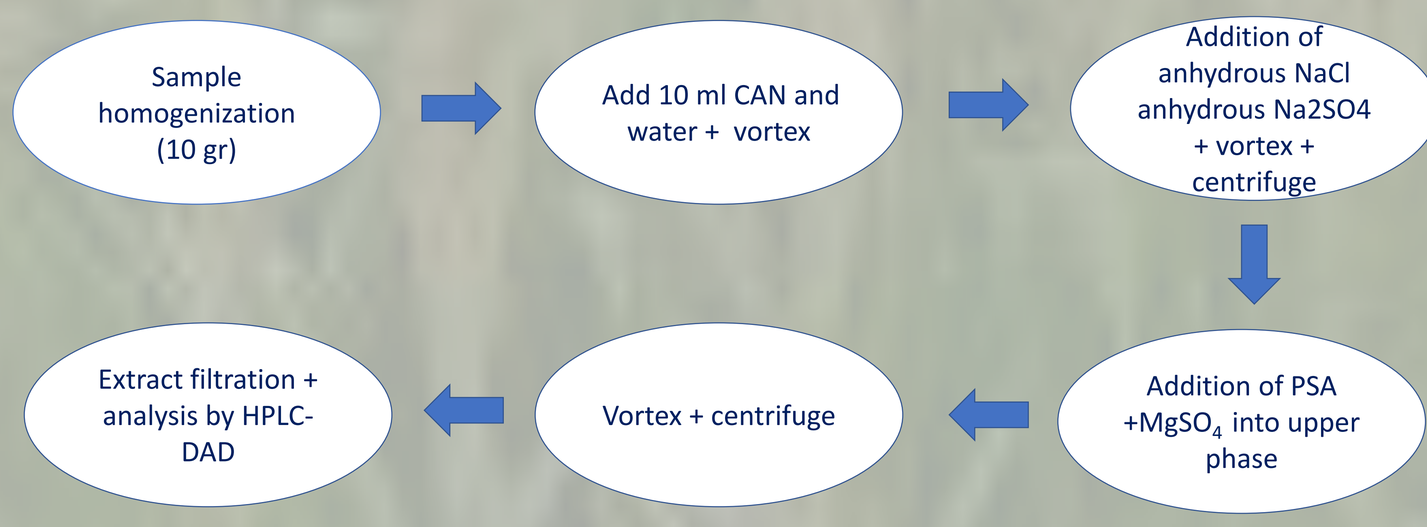

Figure 2. Description of QuEChERS extraction method was used for the extraction and clean-up.

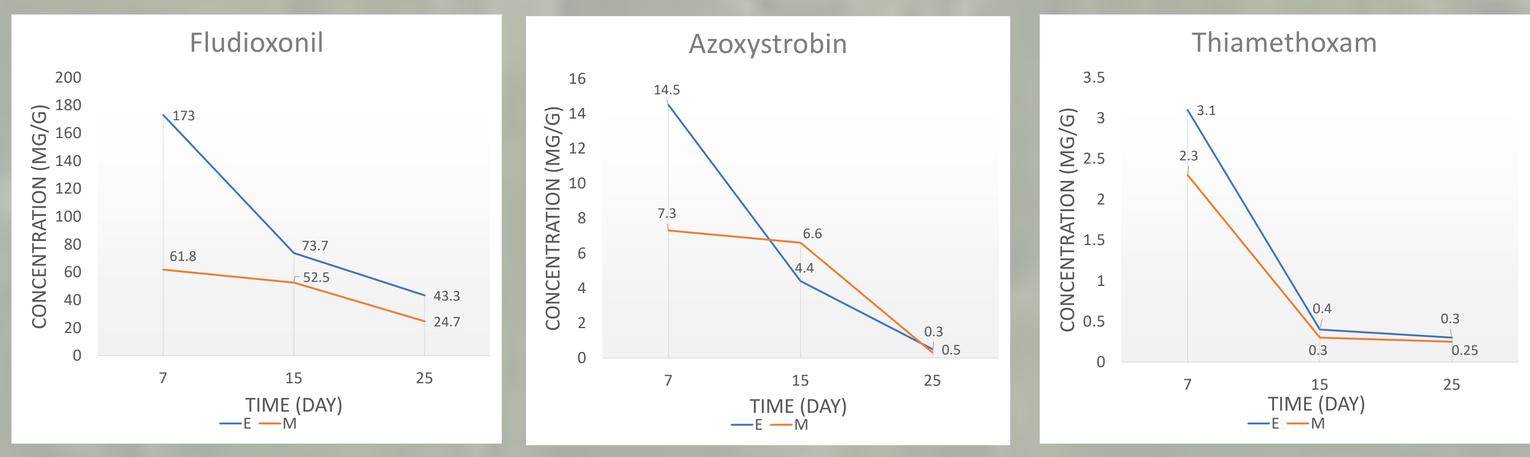

Figure 3. Dissipation of pesticides in maize soil.

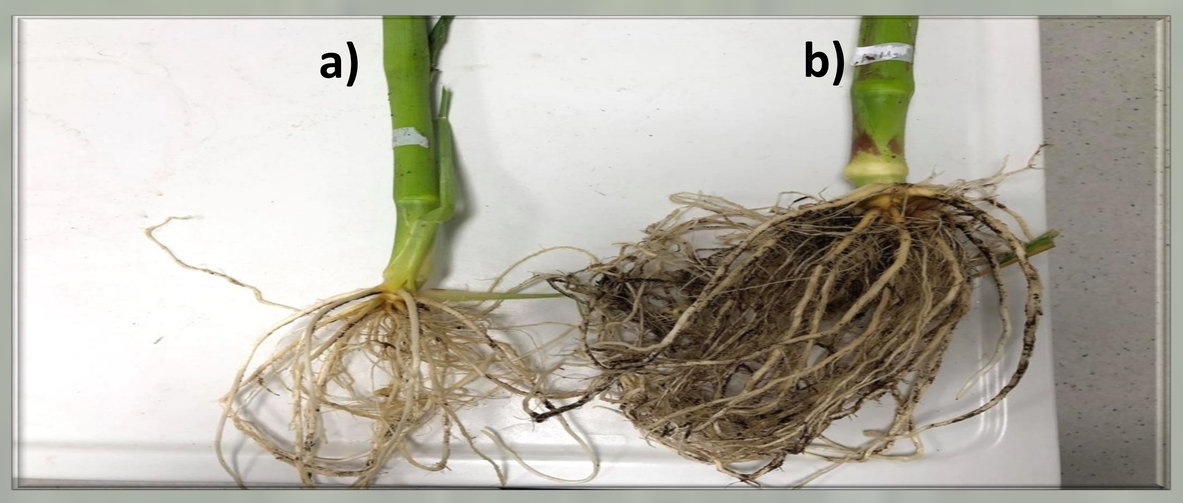

Figure 4. a): Application of a pesticide, b): Application of a pesticide with AMF inoculation.

Results and discussion

Thiamethoxam, azoxystrobin and fludioxonil concentrations in soil samples ranged from 3.1 to 0.3, 14.3 to 0.5 and 178 to 43.3 µg/g, respectively, while plants receiving AMF treatment showed decreased residue levels (Figure 3). Differential behavior of pesticides in the presence of AMF could be attributed to the development of a dense and extensive rhizosphere and its influence on uptake, leaching and degradation. An increased uptake caused by an enhanced plant growth higher biomass and larger root surface area due to an improved mineral nutrition, may explain the lower pesticide concentrations in mycorrhizal plants (Figure 4). Degradation including enhanced microbial degradation activity and enhanced enzyme activity in roots and rhizosphere soils is another mechanistic explanation. Also, the chemical properties of pesticides can affect the movement on soil (Table 2).

Table 2. Physicochemical properties of the tested pesticides.

Properties	Fludioxonil	Azoxystrobin	Thiamethoxam
Water solubility at 20 °C (mg/L)	1.8	6.7	4100
Octanol-water partition coefficient (25 °C) $LogK_{ow}$	4.12	2.5	-0.13
pKa	No dissociation	pKa1: <0; pKa2: approx 14.1	No dissociation
Molecular weight	248.19	403.4	271.91

Conclusions

Our results have provided the evidence that AMF could decrease the concentrations of studied pesticides in soils. Also, this study indicates a promising potential of AMF use for reducing the accumulation of pesticide in crops and for the phytoremediation of pesticide-contaminated soils, although such effects are needed to be further studied. In this context, it would be more valuable to study the relationships between more pesticides and further combinations of AMF and host plants.

References

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