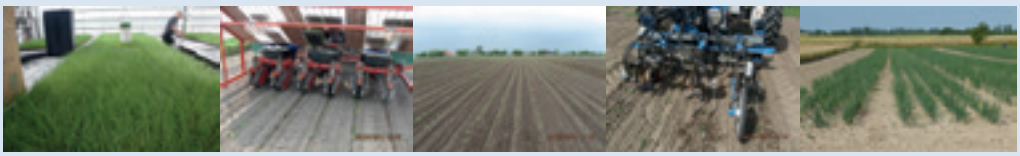
Aarhus University
Science and Technology, Department of Agroecology
Forsøgsvej 1, DK-4200 Slagelse, Denmark
www.au.dk

Arbuscular mycorrhiza in an IPM strategy for field-grown vegetables

Sabine Ravnskov[1], Annie Enkegaard[1], Klaus Paaske[1], Ivanka Tringovska[2], Niels Henrik Spliid[1]and Bo Melander[1]
[1]Department of Agroecology, Aarhus University, Research Centre Flakkebjerg, DK-4200 Slagelse, Denmark. [2]Maritsa Vegetable Crops Research Institute, 32 Brezovsko shosee Str., Plovdiv 4003, Bulgaria. Contact e-mail: Sabine.Ravnskov@agrsci.dk



Introduction

Soil-borne arbuscular mycorrhizal fungi (AMF) form mutualistic symbiosis with 80-90 % of all crops under field conditions. The symbiosis is a natural integrated part of plant functioning and can increase plant growth, nutrient uptake and tolerance against (a)biotic stress. To be optimally beneficial for the plant, the symbiosis should be formed in the initial plant growth phase with roots of the germinating seed. However, many Danish vegetable producers pre-grow their vegetables in peat-based growth media without AMF in the greenhouse before these are transplanted to the field and the producers thereby delay the establishment of the AM symbiosis.

Aim

The objective of the present work was to test the influence of inoculation of pre-grown vegetables with AMF and to study the influence of IPM strategies with chemical and non-chemical control of plant disease on AMF colonization of vegetables in the field. Furthermore, to detect the influence of the different IPM strategies on disease development, yield and quality of yield as well as pesticide residues on the plants were investigated.

Experimental design

Onion and lettuce were selected as model crops, and two field trials were performed with each crop in 2012; one in a conventional grower´s field and one in a trial field at Research Centre Flakkebjerg. All plants were pre-grown in the greenhouse, part of them inoculated with AMF by replacing 10 % of the growth media with AMF inoculum with expanded clay as carrier. The AMF inoculum Symbivit® contained a mixture of 6 AM fungi and was purchased from Symbiom Ltd (Lanskroun, Czech Republic). To control downy mildew, Serenade ASO (*Bacillus subtilis* strain QST 713, 1.34%) was selected as biocontrol agent, and the chemical spraying strategy was based on the involved grower´s practice (Tables 1+2). Serenade ASO was sprayed on the same days as chemical compounds. Timing of sprayings in the single trial was planned according to the developmental stage of the plants; spraying program in onion started at the 6-7 leaves stage and in lettuce after plant establishment in the field, and thereafter in scheduled intervals adjusted to weather conditions. Each trial had 12 treatments + untreated with four replicate plots in a randomized block design (Table 3). Weeds were controlled by robotic weeding.

Table 1. Chemical spray strategy against downy mildew (*Peronospora destructor*) in onion

Treatment	Chemical fungicide and 1/1 dose/ha	Treatment dates	
		Trial 1 Experimental field	Trial 2 Growers' field
1	Dithane NT 2.5 kg (mancozeb 750 g/kg)	13 July	4 July
2	Acrobat WG 2.0 kg (dimethomorph 75 + mancozeb 667 g/kg)	25 July	18 July
3	Dithane NT 2.5 kg	8 August	26 July
4	Amistar 1.0 l (azoxystrobin 250 g/l)	17 August	8 August
5	Acrobat WG 2.0 kg	24 August	17 August
6	Amistar 1.0 l	31 August	24 August
7	Signum 1.0 kg (boscalid 267 + pyraclostrobin 67 g/kg)	8 September	31 August

Table 2. Chemical spray strategy against downy mildew (*Bremia lactucea*) in lettuce

Treatment	Chemical fungicide and 1/1 dose/ha	Treatment dates	
		Trial 1 Experimental field	Trial 2 Growers' field
1	Previcur Energy 2.5 l (fosethyl-al 310 + propamocarb 530 g/l)	31 August	4 September
2	Amistar 1.0 l (azoxystrobin 250 g/l)	10 September	17 September
3	Aliette WG 3.0 kg (fosethyl-al 800 g/kg)	19 September	27 September
4	Revus 0.6 l (mandipropamid 250 g/l)	1 October	16 October

Analyses

- Disease assessment (primarily downy mildew)
- AM fungal colonization of root
- Yield
- Quality of yield (size and weight of single vegetables)
- Pesticide residue in harvested products

Other analyses of onion only

- Nutrient contents in shoots
- Drying and curing time after windrowing
- Phenols and antioxidants

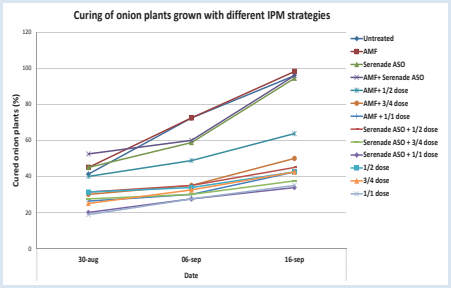
Table 3. Trial design

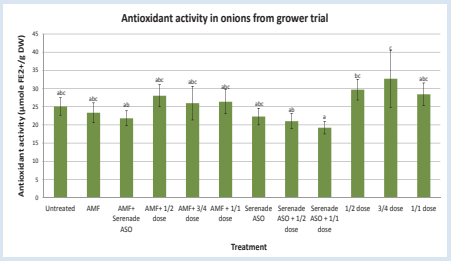
Treatment	AMF inoculation	Sprayings	
		Serenade ASO 8 l/ha	Chemical
1	-	-	-
2	+	-	-
3	-	+	-
4	+	+	-
5	+	-	1/2 dose
6	+	-	3/4 dose
7	+	-	1/1 dose
8	-	+	1/2 dose
9	-	+	3/4 dose
10	-	+	1/1 dose
11	-	-	1/2 dose
12	-	-	3/4 dose
13	-	-	1/1 dose

Main results

For each crop one of the trials was not infected by downy mildew. The results below are based on the trials where infections were recorded.

- In Trial 1 with onion, 72.5 % of the untreated control plants were infected with downy mildew, whereas 43.8 % of the untreated control plants in Trial 1 with lettuce were infected on average by 4.1 % with downy mildew on the outer leaves in untreated control plants
- Inoculation with AMF and application of Serenade ASO controlled downy mildew in lettuce, but had no effect against downy mildew in onion. Strategies involving chemical spraying controlled downy mildew in both onion and lettuce with all doses except in onion where ½ dose was not sufficient
- AM fungal colonization of plants transplanted to the field was 17 %. After 36 days the AMF colonization was still significantly higher in AMF-inoculated plants as compared to non-inoculated. At harvest there was no significant difference in AMF colonization of the roots from different treatments
- Biological and chemical sprayings had no effect on AMF colonization of plant roots
- None of the treatments affected yield or quality of yield for either crop
- In general, only low levels of pesticide residues were found in both onions and lettuce
- None of the treatments affected nutrient contents in shoots of onion
- Onion treated chemically cured slower after windrowing as compared to untreated onions and to biologically treated onions (Fig. 1)
- Spraying with Serenade ASO lowered the content of antioxidants in onions (Fig. 2)





Conclusions

- **AMF inoculation of pre-grown plants was beneficial to control downy mildew in lettuce but not in onion**
- **Chemical spraying strategies and spraying with Serenade ASO did not influence AMF colonization of the plant roots**
- **Spraying with Serenade ASO influenced antioxidant activity in onion**