Can Mycorrhizae Inoculants Improve Yield or Disease Resistance in Carrots?

Umbrin Ilyas, Lindsey du Toit, Manish Raizada and Mary Ruth McDonald

University of Guelph, Guelph, ON, Canada
Washington State Univ., Mount Vernon, WA, U.S.A.

Muck Crops Research Station, Ontario, Canada

44^{o} 5’ N, 79^{o} 35’ W

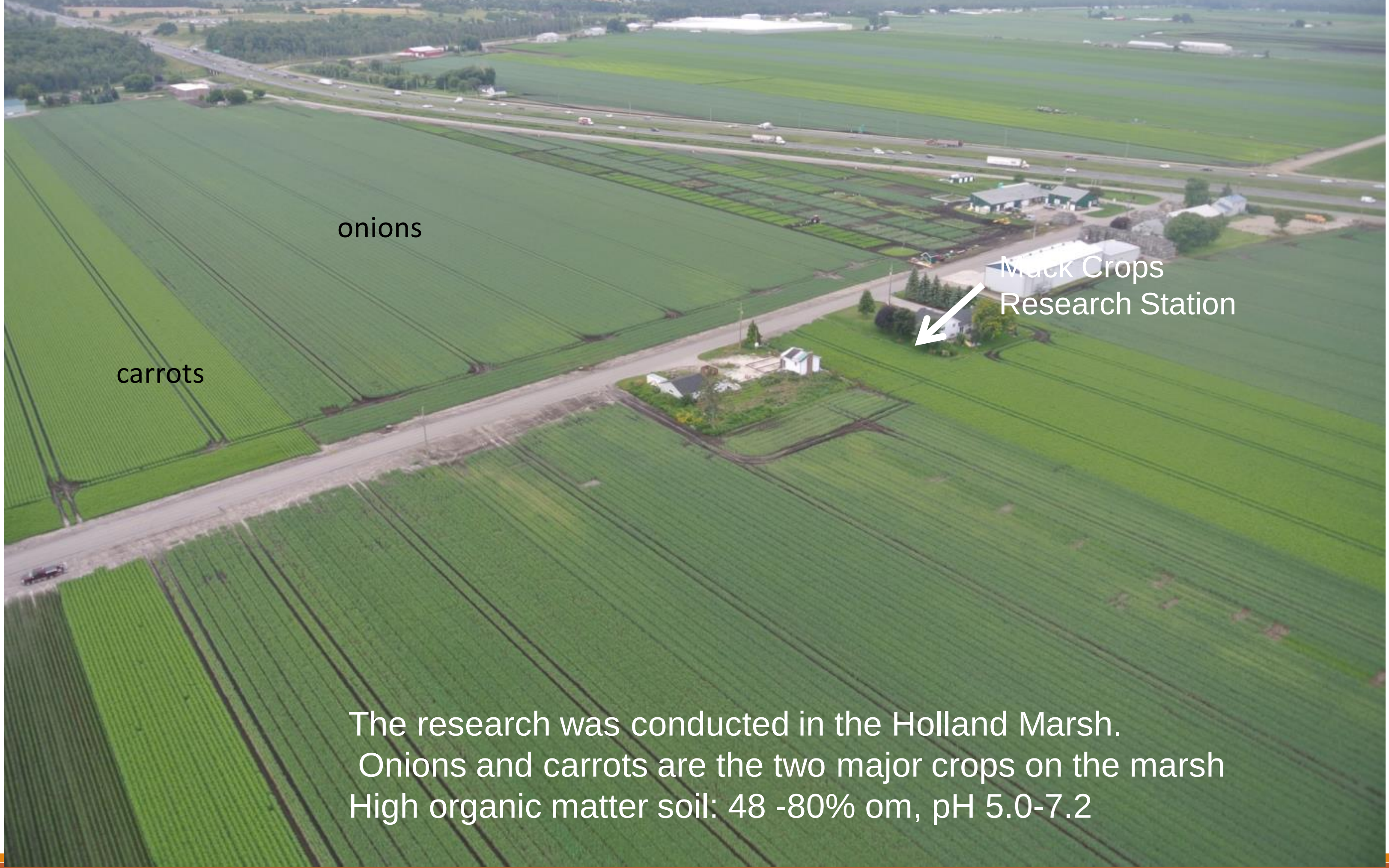
Mount Vernon 48.42° N, 122.34° W

Carrots in Ontario, Canada

Carrots are grown on 3,298 ha in Ontario (OMAFRA 2017)

Half on mineral soil and half on high organic matter (muck) soil.

On muck soils carrots are usually grown in alternating years with onions.


onions
carrots
Muck Crops
Research Station
The research was conducted in the Holland Marsh.
Onions and carrots are the two major crops on the marsh
High organic matter soil: 48 -80% om, pH 5.0-7.2

Mycorrhizae and plants

- Symbiotic relationship
- <80% of terrestrial plants have mycorrhizal associations
- Arbuscular mycorrhizal fungi (AMF) associated with vegetables belong to Glomeromycota
- There are many commercial formulations of mycorrhizae available to growers
- AGTIV and others contain *Glomus intradices*- now called *Rhizophagus intradices*
-

R. intraradices

Several AMF

- Mycorrhizae inoculants are advertised as increasing yields and phosphorous use efficiency
- Growers are using AMF products, especially on seed, but there are no studies to assess yield or other effects under Ontario conditions
- Agricultural soils often have high phosphorus content
- High P in soil can inhibit colonization or activity of mycorrhizae

Objectives

1. To determine if mycorrhizae, on seed or as a granular formulation at seeding, increase yield and reduce leaf blight on carrots on muck and mineral soil
2. To determine if there is an interaction between mycorrhizae and phosphorous application

Field Trials: AMF inoculant on carrots on muck & mineral soils

Two soil types:

Mineral: pH 7.6, organic matter 2.6%, P 40 ppm

P (MESZ) applied to mineral soil at 0 or 50 kg/ha

Muck: a) high organic matter- pH 6.4, om 68%, P 136 ppm

b) pH 6.9, om 56%, P 46 ppm

cv Cellobunch (Stokes Seeds Ltd, ON, Ca)

AMF inoculants: Seed coated with AMF (2 to 4 propagules/ seed) on pelleted seed

AGTIV Granule (240 propagules/g, Premier Tech, Que, CA) applied in furrow at seeding at two rates:

Recommended: 0.5 g/ m of row, and 1 g/m

Mineral soil site

MESZ = Micro essentials SZ = 12-40-0-10S-1Zn

Phosphorous requirement of carrots on mineral and muck soil

Phosphorous soil test (ppm)	Category mineral soil	Phosphate kg/ha recommended
0 -3	Low	180
4 -7		170
8 -9		160
10 - 12	Medium	130
13 – 15		120
16 - 20	High	100
21 – 25		90
26 - 30	Very high	70
31 - 40		50
41 - 50		30
51 -60		0
Above than 60	Excessive	0

Phosphorous soil test (ppm)	Category of muck soil	Phosphate kg/ha recommended
0 -9	Low	100
10-15	Medium	90
16 - 20		80
21 – 25		70
26 - 30		60
31 -40	High	50
41 - 50		30
51 – 60		20
61 -80	Very high	0
Above than 80	Excessive	0

Nutrient analysis of soil and plant tissue

Soil analysis

Soil was sampled randomly to a depth of 15 cm from 10 different sites of a rep

Before seeding crop and after harvest

Foliar nutrient analysis

20 plants from two inner rows (10 consecutive plants/ row) per experimental unit

Carrots: One most recent mature petiole (60 days after seeding)

Carrot root tissue at harvest

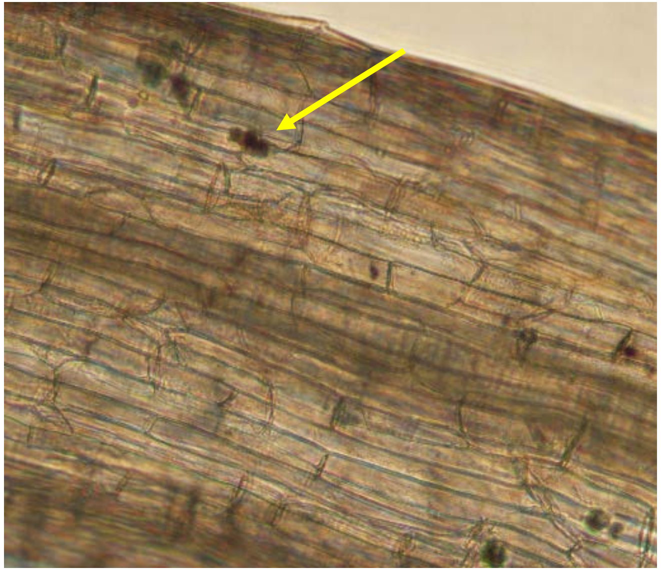
Soil and nutrient samples sent to SGS Agri-food Laboratories, Ontario

AMF colonization

Fine secondary roots (<2 mm diam) collected at 9 weeks (2017) and 8 weeks (2018) after seeding from 14 plants from 2 rows per rep.

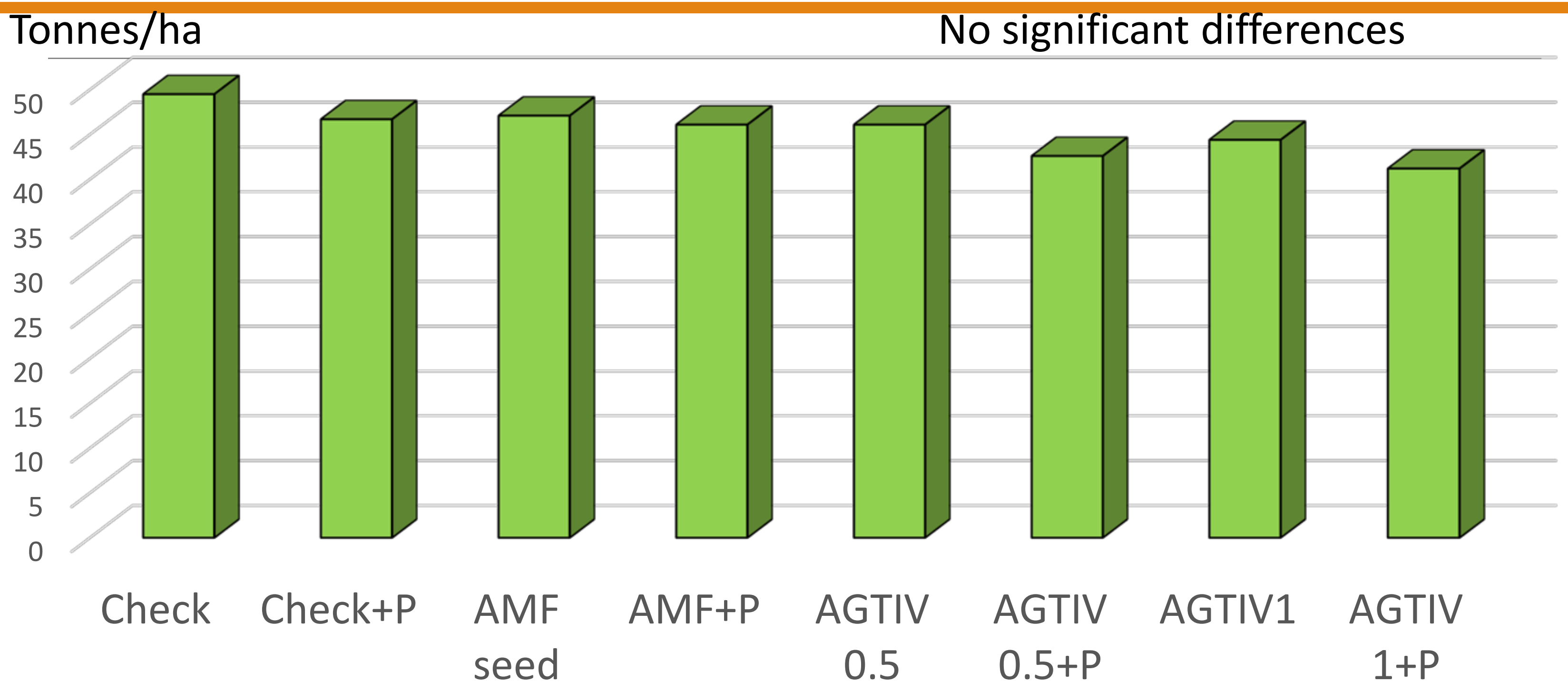
Roots were washed, cut into 2 cm pieces, stored in 95% isopropanol and stained with ink and vinegar.

100 intercepts on 20 – 25 roots segments were assessed



Onion roots under compound microscope at 20X

Marketable yield of carrots with mycorrhizae on mineral soil with and without added P: 2017 and 2018 combined



Carrot leaf blight assessed as a combination of *Alternaria dauci* and *Cercospora carotae*.

Cercospora carotae Pass.

Alternaria dauci Kuhn.

All leaves on 10 plants/ rep assessed at harvest

Assessed on a 0 – 6 scale, where 0 = no disease and 6 = > 75% blighted

Colonization by AMF and tissue analysis for carrot on mineral soil 2017 and2018

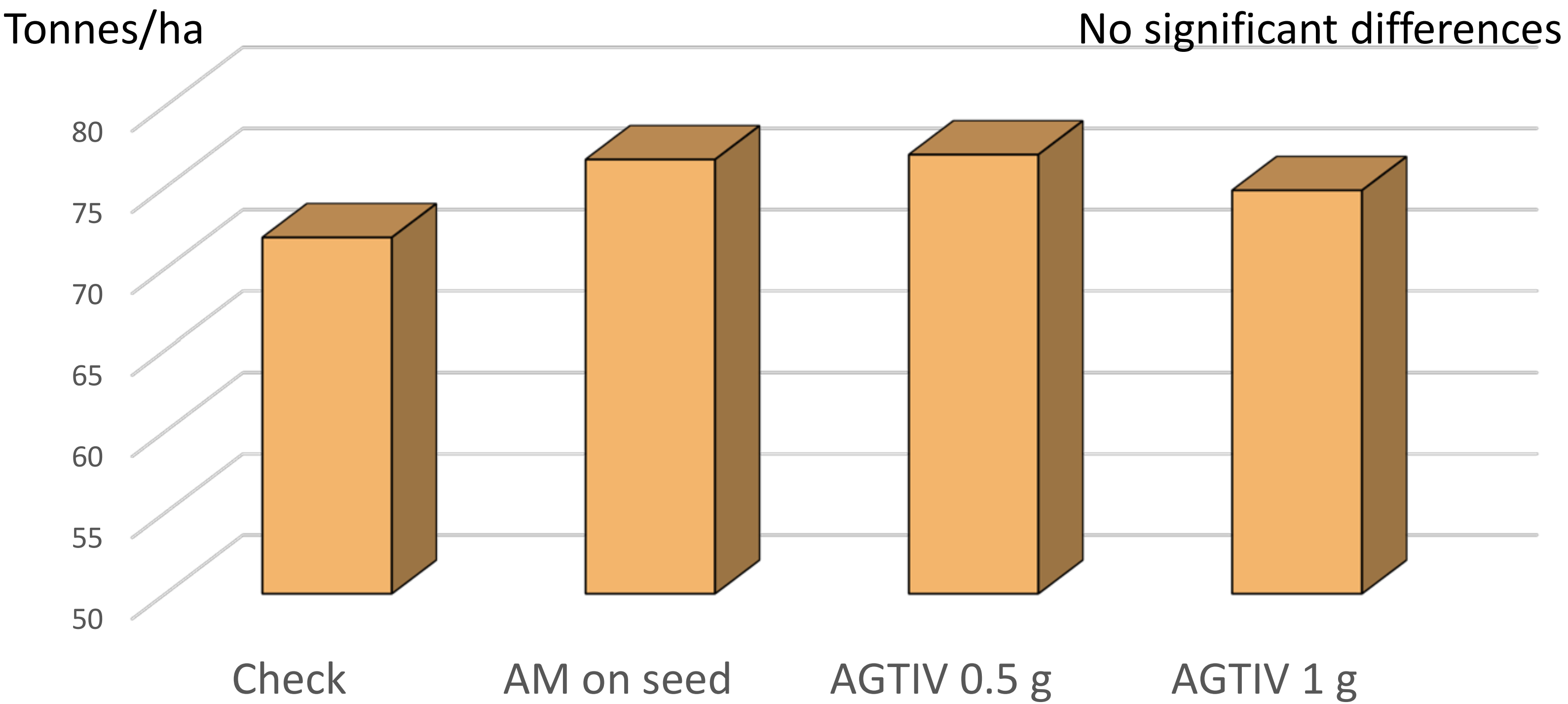
Treatment	% AMF		Leaf tissue P (%)		Leaf blight severity
	2017	2018	2017	2018	
Check	**31.6 ns**	**34.2 ns**	0.36 b	0.31 c	**69 a**
P only			0.38 ab	0.36 a	
AMF on seed			0.39 ab	0.32 b	**60 b**
AGTIV 0.5		**40.2**	0.39 ab	0.29 c	**68 ab**
AGTIV 0.5 +P	**35.6**		0.40 a	-	**66 ab**

Sufficiency for petiole P (0.2- 0.5 %)

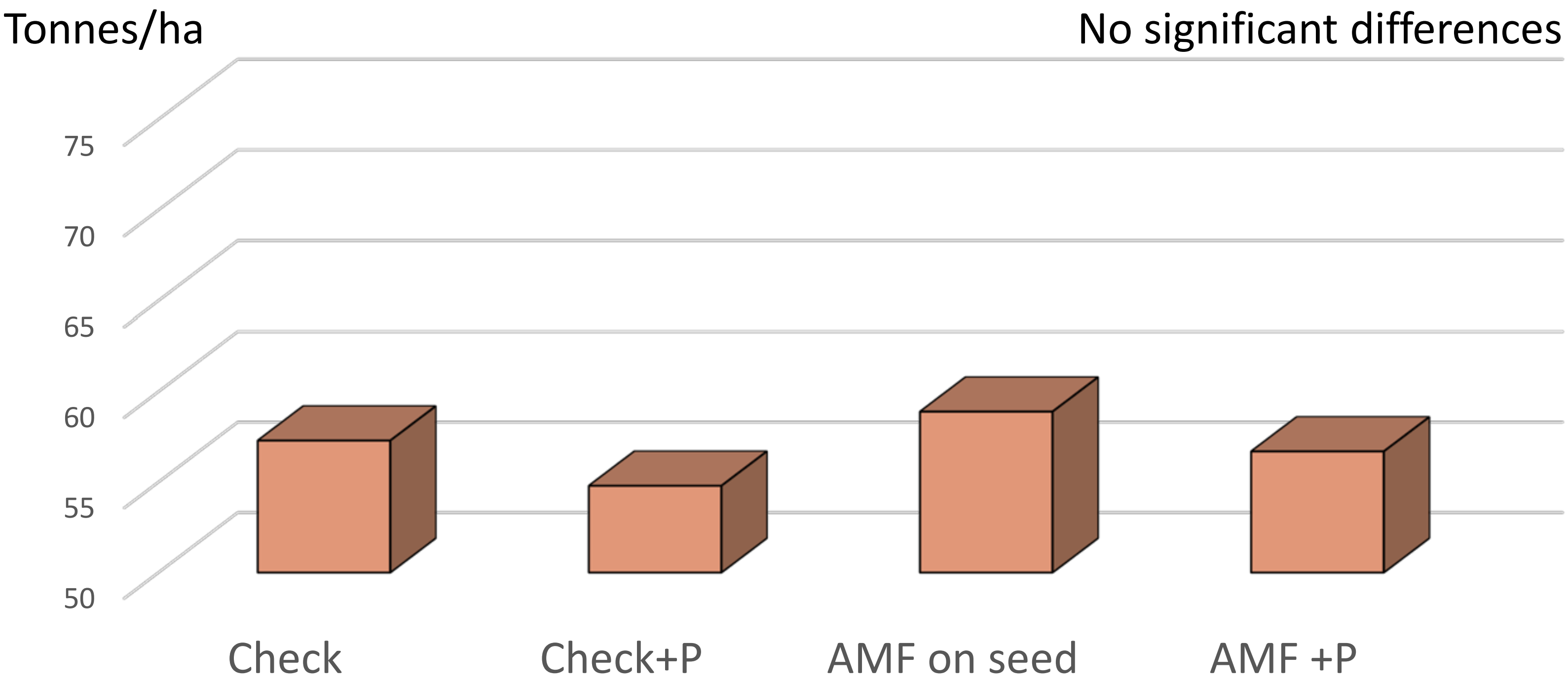
NO differences in P content of carrot roots range 0.32- 0.37 ppm)

P applied at 50 Kg/ha of phosphorous as MESZ (12-40- 0- 10S-1Zn)

Marketable yield of carrots with mycorrhizae on muck soil with 136 ppm P: 2 years combined



Marketable yield of carrots with mycorrhizae on muck soil with 44 ppm P: 2 years combined



P 100 kg/ha applied as MESZ

Colonization by AMF and tissue analysis for carrot on muck soil (44 ppm P) 2017 and 2018

Treatment	% AMF pooled	Leaf tissue P (%) 2017	Leaf tissue P (%) 2018	Leaf blight severity
Check	**35.0 ns**	0.26 b	0.28 ns	**40 a**
Check- P only	**38.1**	0.32 a	0.26	**38 ab**
AMF on seed	**37.6**	0.29 ab	0.27	**33 b**
AMF on seed +P	**39.5**	0.29 ab	0.27	**39 ab**

No differences in P content of carrot roots: range 0.21-0.22 ppm)
P applied at 100 kg/ha of phospohorous as MESZ (12-40- 0- 10S-1Zn)

Sufficiency range for leaf tissue 0.20 – 0.50%

Summary

- No effect of AMF application on yield
- No effect of AMF or P on AMF colonization in carrots
- Average colonization in check (native AMF) on muck soil was 35 -45 %, and on mineral soil was 32 %
- Application of P did not increase yield on soils with P content of 40 - 44 ppm (or 138 ppm)
- Reduced severity of carrot leaf blight at harvest with AMF coated seed on muck and mineral soil
  - when there was moderate to high disease pressure

The increase in input cost was estimated based on cost of phosphorus and mycorrhizal treatments.

- The use of seed coated with mycorrhizae increased input cost to \$230/ha
- Adding AGTIV Granular at rate of 0.5g m^{-1} increased cost by \$121/ha .
- Addition of phosphorus at rate of 50 kg of P_2O_5 ha^{-1} increased input cost by \$100.

Canadian dollars and 2018 costs

Acknowledgments

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Thesis and data available at https://atrium.lib.uoguelph.ca/xmlui/bitstream/handle/10214/16144/Ilyas_Umbrin_201905_MSc.pdf?sequence=1&isAllowed=y

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Questions?

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Seed sowing and application of fertilizers

AM inoculant

Seeds

Adjusting two rates of AM

The nitrogen and potassium based fertilizers added to all treatments

Phosphorous with two levels of application (0 and 50 kg /ha)