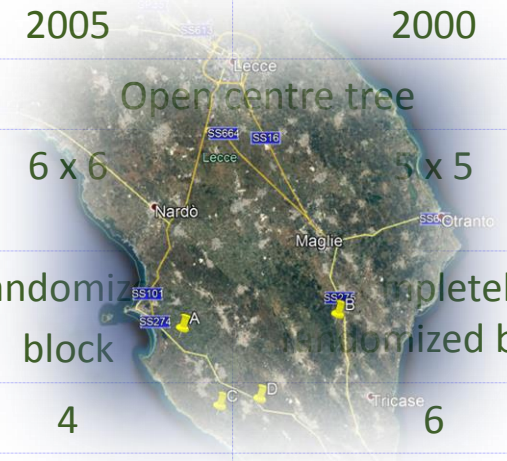
Evaluation of field treatments to reduce the impact of Xylella fastidiosa infections in olive trees

Dongiovanni E., Di Carolo M., Fumarola G., Ciniero A., Tauro D., Palmisano F., Silletti MR., Pollastro P., Altamura G., Morelli M., Coletta-Filho H.D., de Souza A., Saldarelli P., Boscia D., Saponari M., Faretra F.


Legenda
Zona infetta

Field location and trials setup

TRIAL:	A	B	C	D
FIELD LOCATION:	Gallipoli (Le)	Nociglia (Le)	Taurisano (Le)	Ugento (Le)
CULTIVAR:	Cellina di Nardò	Cellina di Nardò	Carolea; Gioconda; Pesciolen; Leccino; Nocellara.	Carolea
PLANTING DATA:	2015	2005	2000	1986
TRAINING SYSTEM:	Open centre tree			
DISTANCE BETWEEN ROWS (m):	5 x 5	6 x 6	5 x 5	7 x 7
TRIAL DESIGN:	Randomized block	Randomized block	Completely Randomized block	Randomized block
REPLICATIONS:	3	4	6	4
N. PLANTS/TREATMENT:	15	24	52	32



Trial A

FIELD LOCATION:	Gallipoli (Le)
CULTIVAR:	Cellina di Nardò
PLANTING DATA:	2015
TRAINING SYSTEM:	Open centre tree
DISTANCE BETWEEN ROWS (m):	5 x 5
TRIAL DESIGN:	Randomized block
REPLICATIONS:	3
N. PLANTS/TREATMENT:	15

Trial b

FIELD LOCATION:	Nociglia (Le)
CULTIVAR:	Cellina di Nardò
PLANTING DATA:	2005
TRAINING SYSTEM:	Open centre tree
DISTANCE BETWEEN ROWS (m):	6 x 6
TRIAL DESIGN:	Randomized block
REPLICATIONS:	4
N. PLANTS/TREATMENT:	24

Trial B: February 2016 (at the beginning of the trial)

Fosetyl Alluminium IV		Cerevisanae IV					Protein of Harpin IV	Organic fertilizer IV

	Untreated check IV		COS-OGA IV	NAC endotherapy IV		Acibenzolar S-methil IV	NAC endotherapy adsorbed on organic fertilizer IV

		Organic fertilizer III	NAC endotherapy adsorbed on organic fertilizer III	Cerevisanae III		NAC endotherapy III	

	COS-OGA III	Fosetyl Alluminium III	A. tenuissima - low dose III	Laminarin - low dose III	Protein of Harpin III			Untreated check III

Protein of Harpin II	Acibenzolar S-methil II	COS-OGA II	NAC endotherapy II		NAC endotherapy adsorbed on organic fertilizer II		Acibenzolar S-methil III	

		Cerevisanae II		Organic matter II	Fosetyl alluminium Al II			

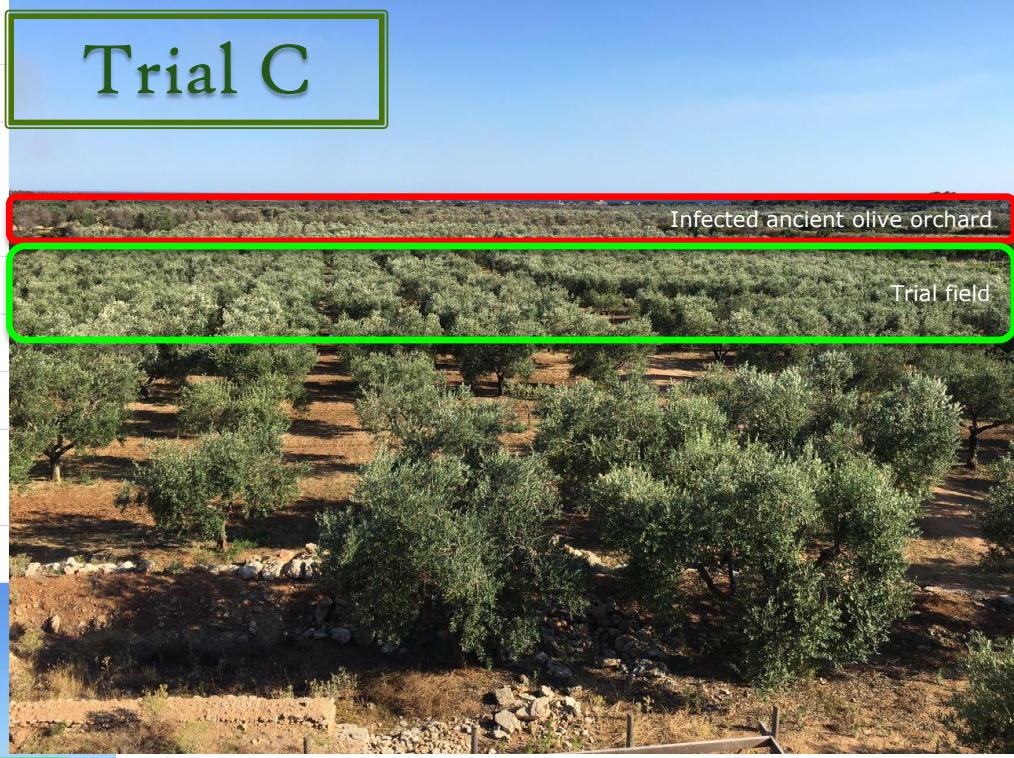
NAC endotherapy I			Fosetyl Aluminium I	NAC endotherapy adsorbed on organic fertilizer I	Untreated check II		

Organic fertilizer I	Acibenzolar S-methil I					Protein of Harpin I

Untreated check I			Cerevisanae I		COS-OGA I

Trial C

FIELD LOCATION:	Taurisano (Le)
CULTIVAR:	Carolea; Gioconda; Pesciolen; Leccino; Nocellara.
PLANTING DATA:	2000
TRAINING SYSTEM:	Open centre tree
DISTANCE BETWEEN ROWS (m):	5 x 5
TRIAL DESIGN:	Completely randomized block
N. PLANTS/TREATMENT:	52



The farmer implemented the best agricultural practice, with:

- adequate control of the weeds;
- frequently pruning, both during the winter in the season by removing desiccation shoots;
- Insecticides applications against mainly pests of olive (Dacus oleae; Prays oleae; Prays oleae);

Trial D

TRIAL:	D
FIELD LOCATION:	Ugento (Le)
CULTIVAR:	Carolea
PLANTING DATA:	1986
TRAINING SYSTEM:	
DISTANCE BETWEEN ROWS:	7 x 7
TRIAL DESIGN:	Randomized block
REPLICATIONS:	4
N. PLANTS/TREATMENT:	32


TESTED
PRODUCTS

ELICITORS OF PLANTS DEFENSE

Product name or code	Active substance (a.s.)	Content a.s. (% or g/L) and formulation	Applied volume (mL/ha)	Formulate rate (g or mL/hL)	Mode of application	Trial			
						A	B	C	D
ALD 1901	Cerevisanae	(100%) WP	1000 L/ha	75 g/hL	Spray	X	X		X
Aliette	Fosetyl alluminium	(80%) WG	1000 L/ha	300 g/hL	Spray	X	X	X	X
HP400	Protein of Harpin σ – β	(1%) PB	1000 L/ha	20 g/hL	Spray	X	X	X	X
Ibisco	COS-OGA	(12 g/L) L	1000 L/ha	500 mL/hL	Spray	X	X	X	
Bion	Acibenzolar S-Methyl	(50%) WG	1000 L/ha	20 g/hL	Spray	X	X	X	X

- Intervals applications: 15–20 days;
- Starting on the end of the winter (new shoots emergence) until July, interruption on august, 2 applications in September/October;
- Starting trials:
  - Trial A: 2015 until 2017;
  - Trial B: 2016 to the end of february 2017;
  - Trial C: 2015 until 2017;
  - Trial D: 2016 until 2017;

N-ACETYLCYSTEIN

Product name or code	Active substance (a.s.)	Content a.s. (% or g/L) and formulation	Mode of applications	Trial			
				A	B	C	D
NAC	N-acetylcystein	(22.5 g/L) L	Endotherapy	X	X		
NAC + [NAC + Organic fertilizer]	N-acetylcystein + [N-acetylcystein + organic fertilizer]	(45 g/L) L + [organic N (4%); organic C (41%); organic mater (70%)] Pellet	Endotherapy and incorporated in the soil, adsorbed on organic fertilizer	X	X		
Pollina	Organic fertilizer	[organic N (4%); organic C (41%); organic mater (70%)] Pellet	Incorporated in the soil	X	X		

TRIAL A
N-ACETYLCYSTEIN

Active substance (a.s.)	Applied volume (mL/plant)	Formulate rate (g or mL/plant)	Mode of application
N-acetylcystein	50 mL/plant (2015-2016) 100 mL/plant (2017)	1.125 g/plant (2015-2016) 2.25 g/plant (2017)	Endotherapy
N-acetylcystein + [N-acetylcystein + organic fertilizer]	50 mL/plant (2015-2016) 100 mL/plant (2017)	2.25 g/plant (2015-2016) 4.5 g/plant (2017) + [4 g/plant + 400 g/plant]	Endotherapy and incorporate in the soil
Organic fertilizer	-	400 g/plant	Incorporate in the soil

- Endotherapy: single application in summer 2015; two applications in spring 2016 and 2017;
- NAC adsorbed on organic fertilizer and organic fertilizer alone: starting application in 2016, seven application both in 2016 and 2017, started in the spring to autumn with 15–20 days intervals;

TRIAL B: N-ACETYLCYSTEIN

Active substance (a.s.)	Applied volume (mL/plant)	Formulate rate (g or mL/plant)	Mode of application
N-acetylcystein	500 mL/plant	11.25 g/plant	Endoterapy
N-acetylcystein + [N-acetylcystein + organic fertilizer]	500 mL/plant	22.5 g/plant + [4 g/plant + 4000 g/plant]	Endoterapy and incorporate in the soil
Organic fertilizer	-	4000 g/plant	Incorporate in the soil

- Endotherapy: in 2016, four applications started in the spring with 20
- 30 days intervals;

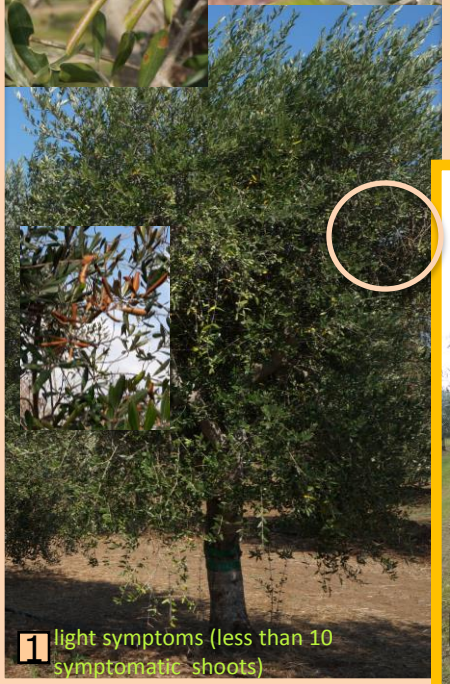
TRIAL B: N-ACETYLCYSTEIN

Active substance (a.s.)	Applied volume (mL/plant)	Formulate rate (g or mL/plant)	Mode of application
N-acetylcystein	500 mL/plant	11.25 g/plant	Endoterapy
N-acetylcystein + [N-acetylcystein + organic fertilizer]	500 mL/plant	22.5 g/plant + [4 g/plant + 4000 g/plant]	Endoterapy and incorporate in the soil
Organic fertilizer	-	4000 g/plant	Incorporate in the soil

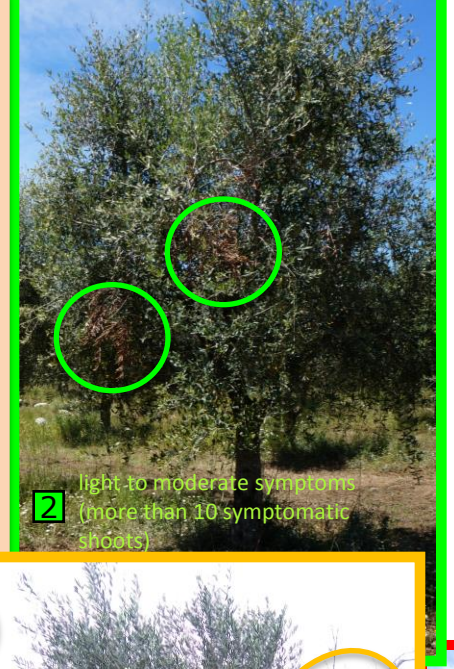
- In 2016: NAC adsorbed on organic fertilizer and organic fertilizer alone: eight applications from spring to autumn with 15–20 gg intervals;

0 = symptomless

Empyrical scale

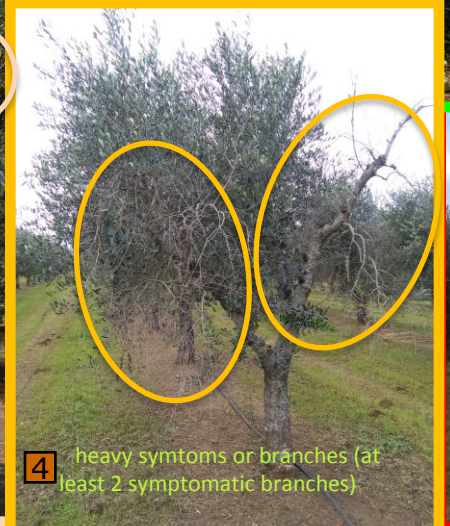


1 light symptoms (less than 10 symptomatic shoots)



2 light to moderate symptoms (more than 10 symptomatic shoots)

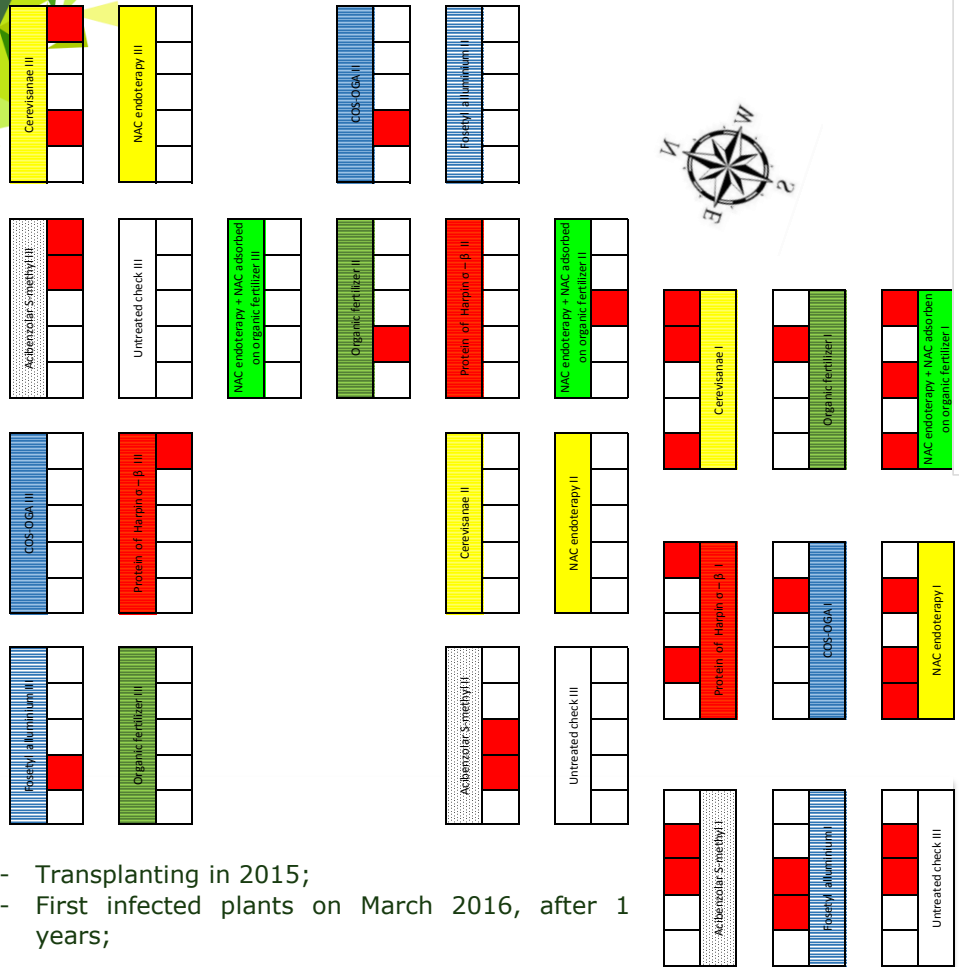
3 moderate to heavy symptoms (at least 1 heavy symptomatic branches)

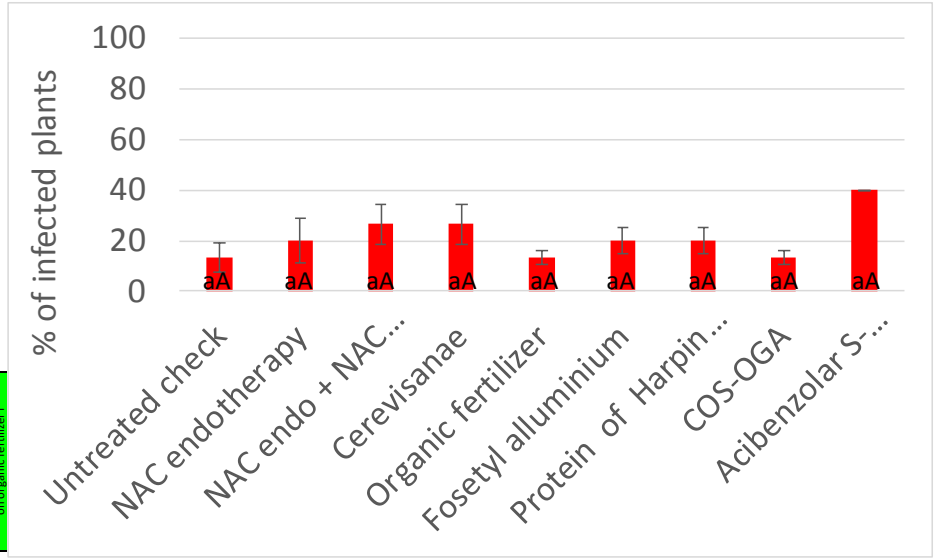


4 heavy symtoms or branches (at least 2 symptomatic branches)

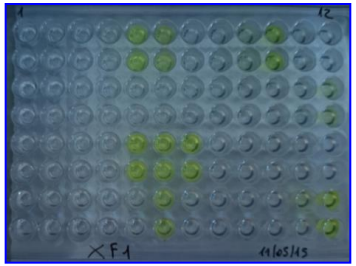
5 heavy symptoms on the whole tree

Trial A: March 2016

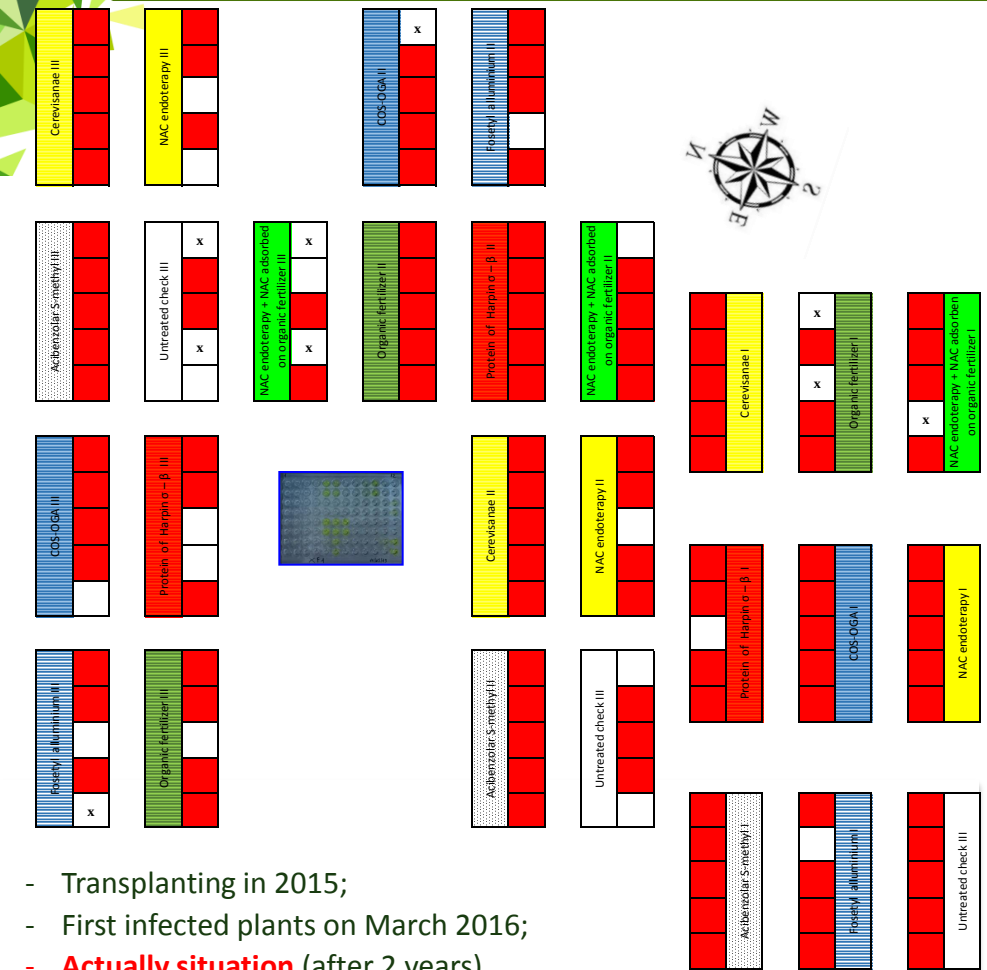




- Transplanting in 2015;
- First infected plants on March 2016, after 1 years;

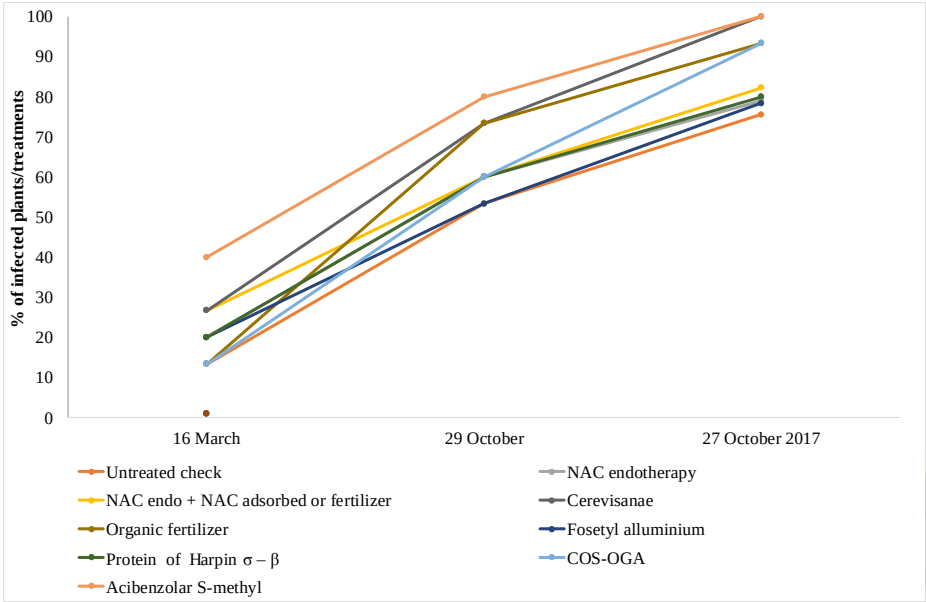


Trial A: September 2017

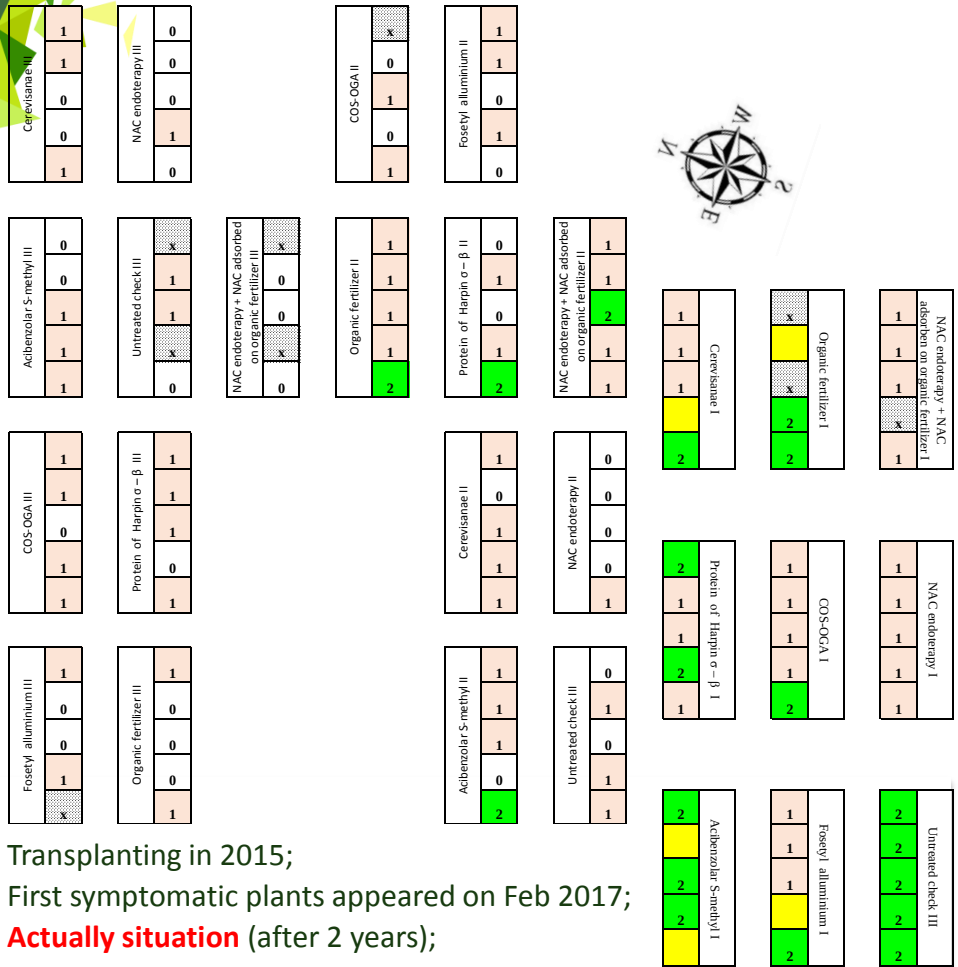


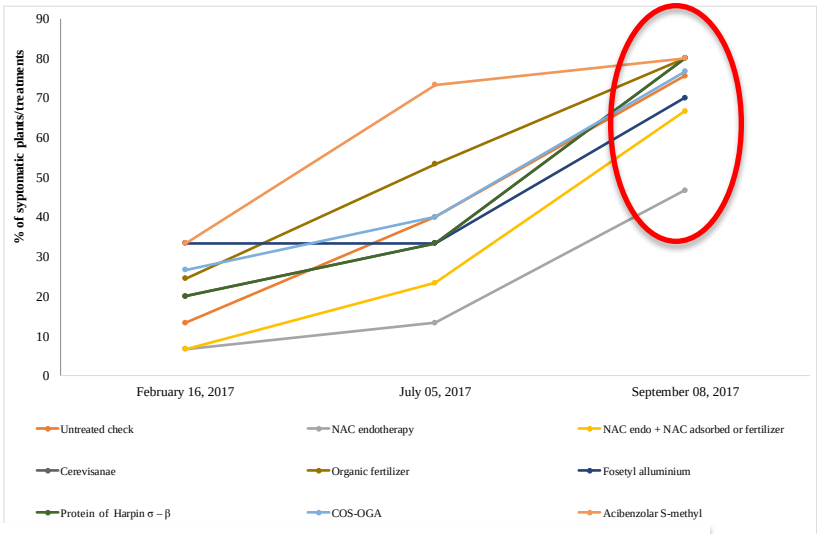
- Transplanting in 2015;
- First infected plants on March 2016;
- **Actually situation** (after 2 years)

Active substance (a.s.)	October 2017	
Untreated check	75.6	b A
NAC endotherapy	79.0	b A
NAC endo + NAC adsorbed or fertilizer	82.2	ab A
Cerevisanae	100.0	a A
Organic fertilizer	93.3	ab A
Fosetyl alluminium	78.3	ab A
Protein of Harpin σ – β	80.0	ab A
COS-OGA	93.3	ab A
Acibenzolar S-methyl	100.0	a A



Trial A: September 2017: prevalence (%)

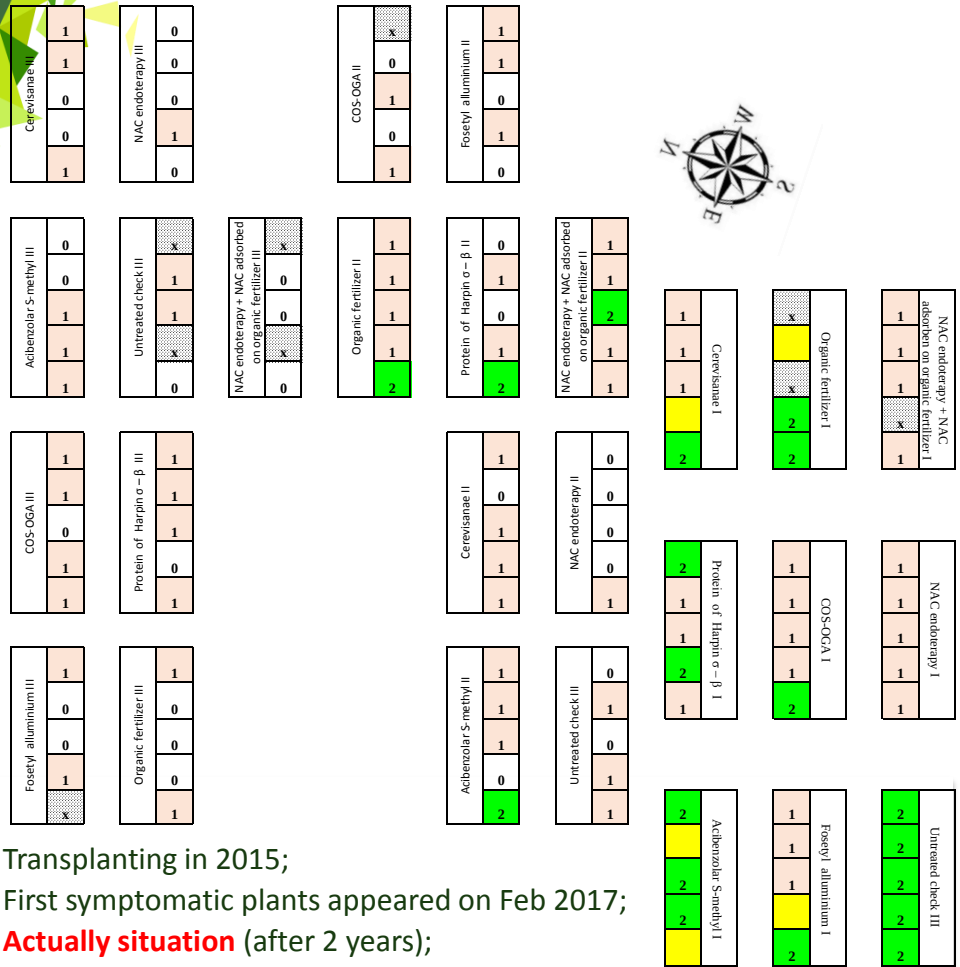




- Transplanting in 2015;
- First symptomatic plants appeared on Feb 2017;
- **Actually situation** (after 2 years);

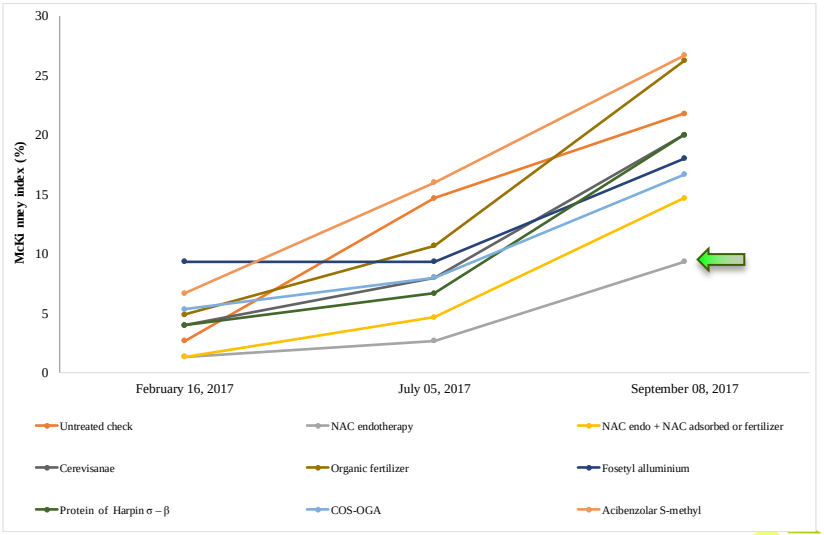
Empyrical scale: 0 1 2 3 4 5

Trial A: September 2017: McK (



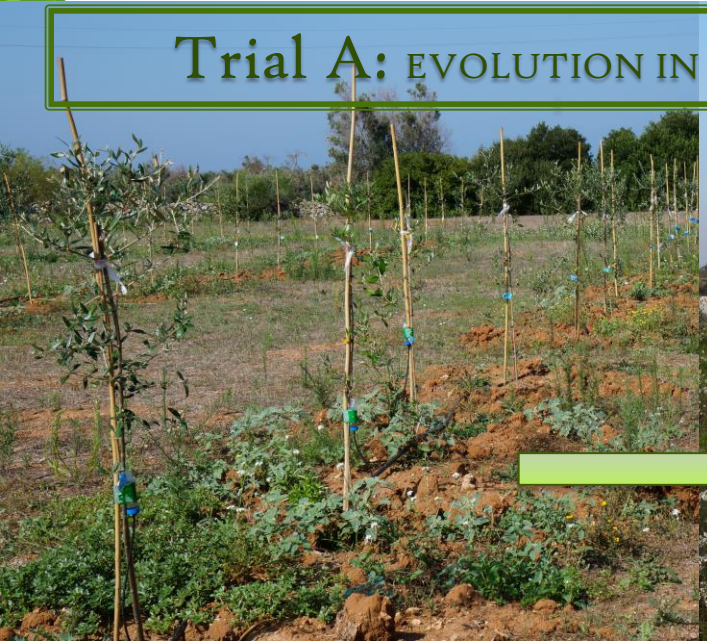
- Transplanting in 2015;
- First symptomatic plants appeared on Feb 2017;
- **Actually situation** (after 2 years);

McKinney Index (%)	
Active substance (a.s.)	**September 2017**
Untreated check	21.7 a A
NAC endotherapy	9.3 b A
NAC endo + NAC adsorbed or fertilizer	14.7 ab A
Cerevisanae	20 a A
Organic fertilizer	26.2 a A
Fosetyl alluminium	18 ab A
Protein of Harpin σ – β	20 a A
COS-OGA	16.7 ab A
Acibenzolar S-methyl	26.7 a A

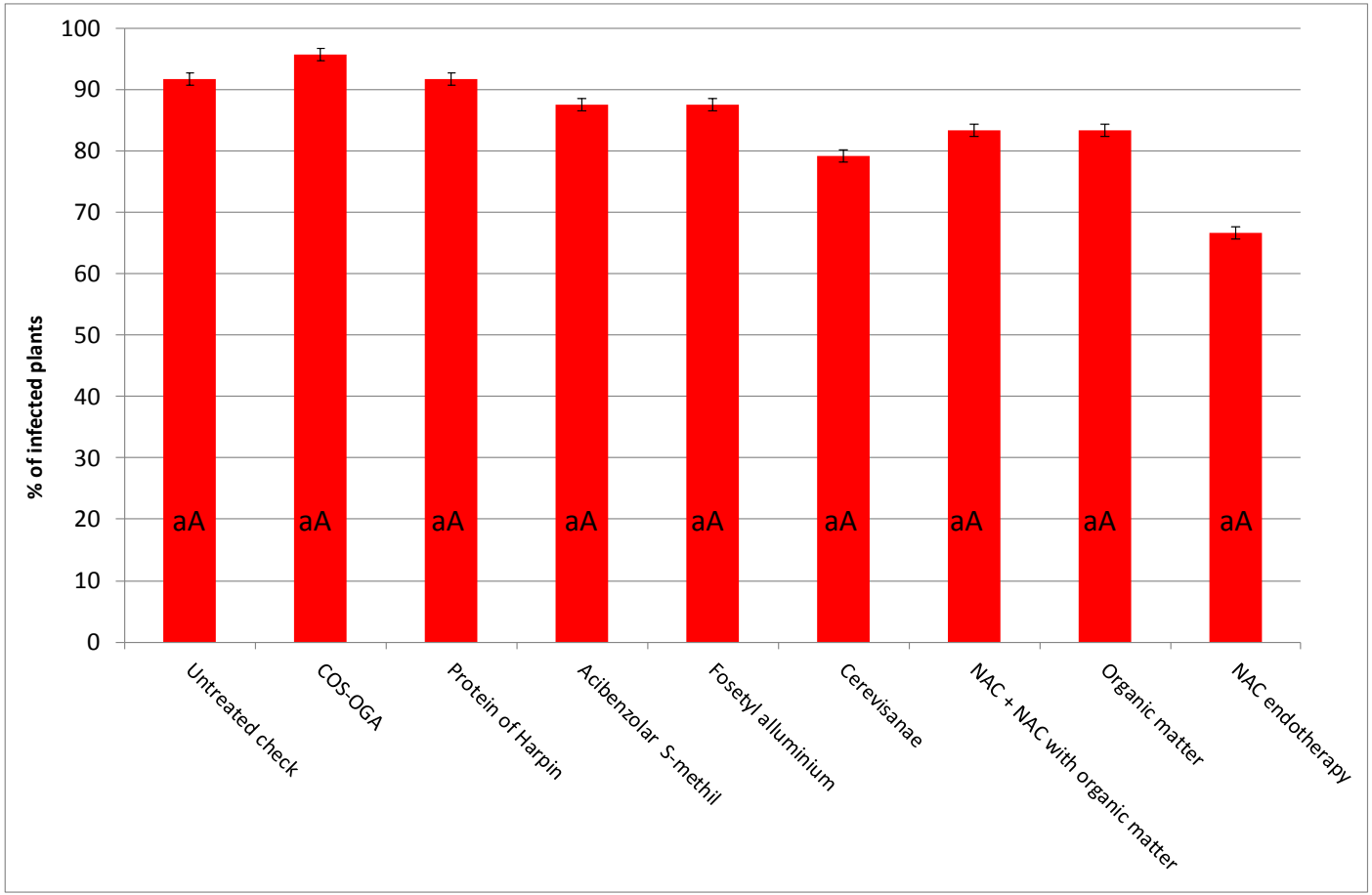


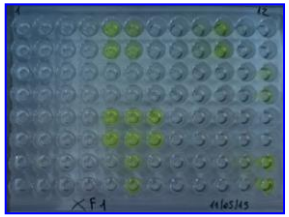
Empyrical scale: 0 1 2 3 4 5

Trial A: EVOLUTION IN the time



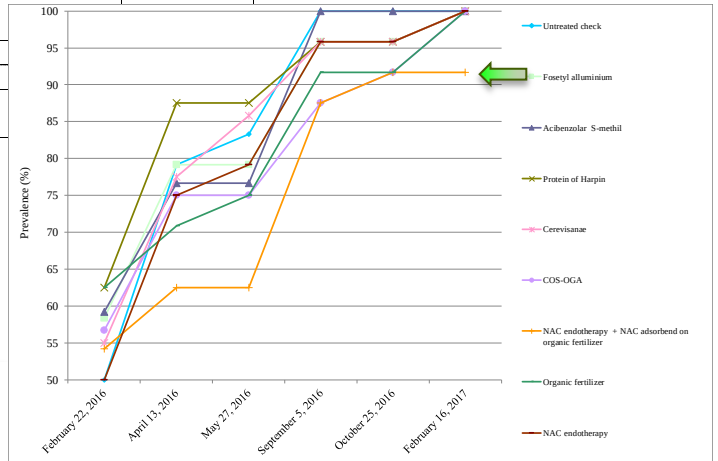
Trial B: november 2016 (infected plants after 10 months from the start the trial)





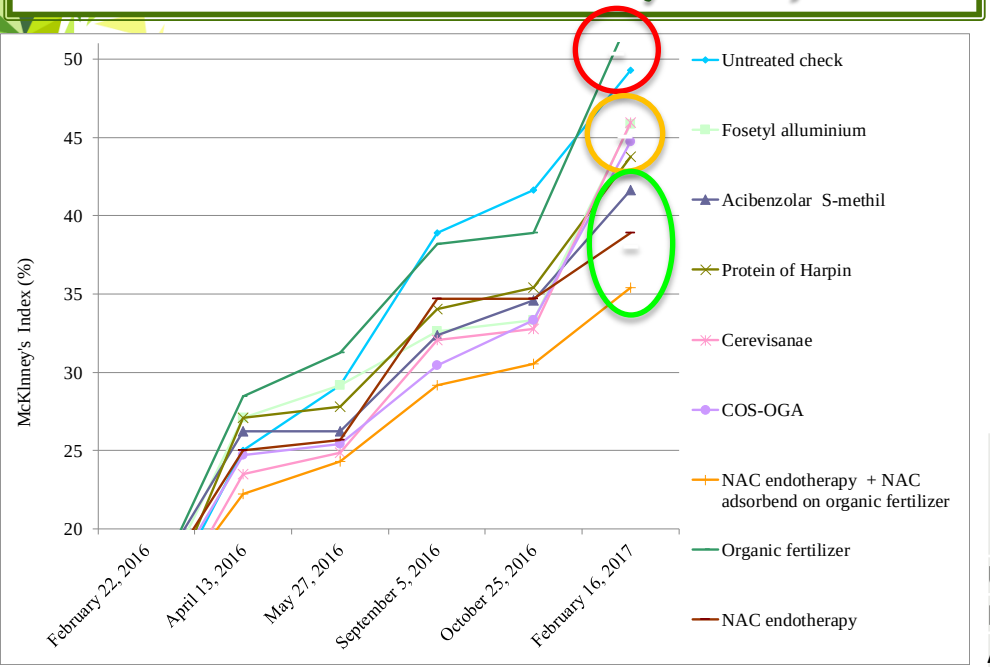
Trial B: February 2017 (after 1 years from the start the trial)

Treatment	Prevalence (%) 16/02/2017		
Untreated check	100	a	A
Fosetyl alluminium	100	a	A
Acibenzolar S-methil	100	a	A
Protein of Harpin	100	a	A
Cerevisanae	100	a	A
COS-OGA	100	a	A
NAC endotherapy + NAC adsorbed on organic fertilizer	91,7	b	B
Organic fertilizer	100	a	A
NAC endotherapy	100	a	A



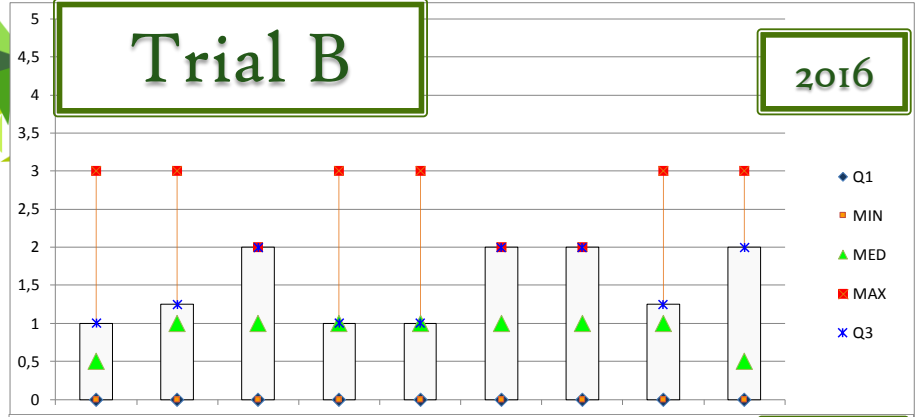
Empyrical scale: 0 1 2 3 4 5

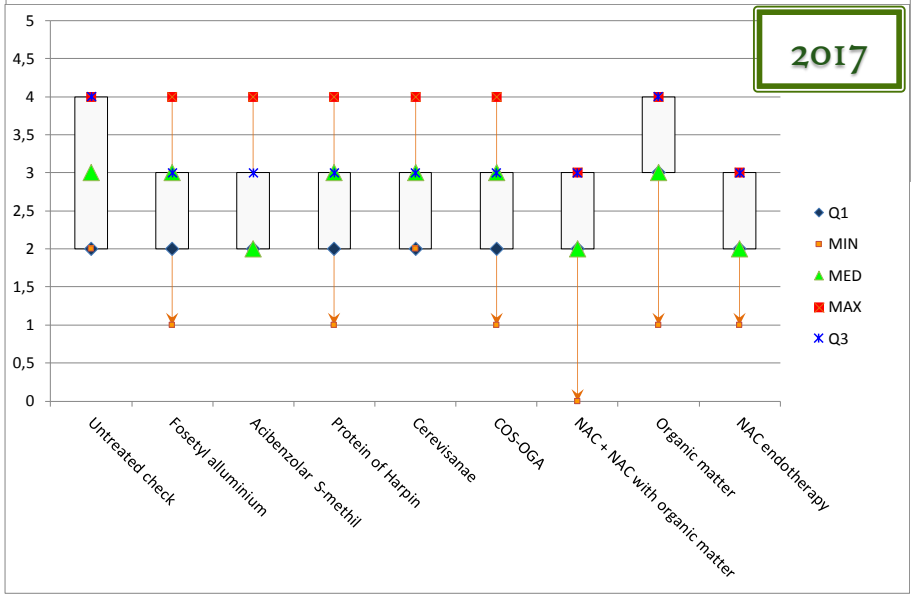
Trial B: February 2017

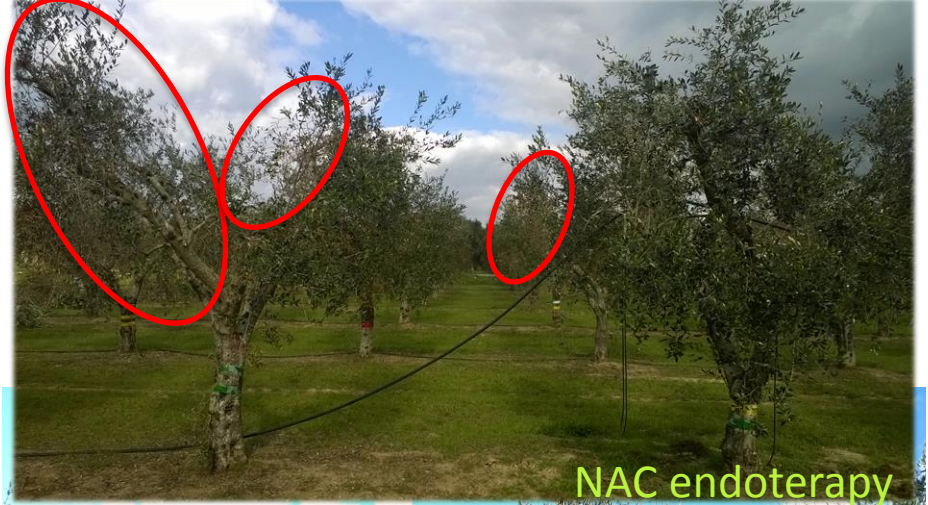


Treatment	Mckinney index (%) 16/02/2017		
Untreated check	49,3	ab	AB
Fosetyl alluminium	45,8	bc	ABC
Acibenzolar S-methil	41,7	cd	BCD
Protein of Harpin	43,8	bc	ABCD
Cerevisanae	46,0	abc	ABC
COS-OGA	44,7	bc	ABCD
NAC endotherapy + NAC adsorbed on organic fertilizer	35,4	d	D
Organic fertilizer	52,8	a	A
NAC endotherapy	38,9	cd	CD

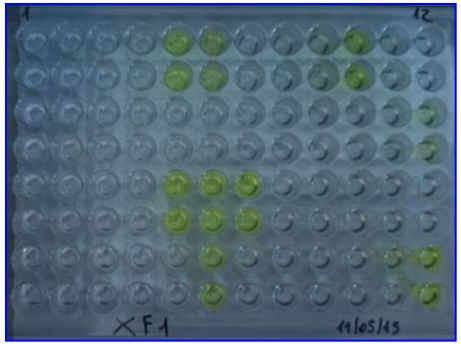
Trial B

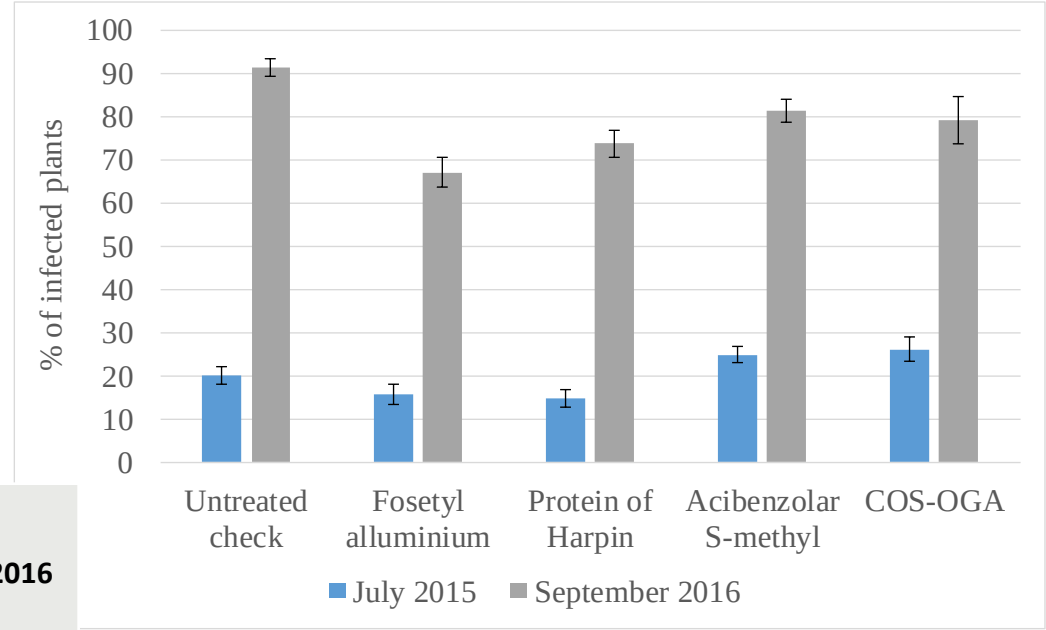

2016
5
4,5
4
3,5
3
2,5
2
1,5
1
0,5
0
Q1
MIN
MED
MAX
Q3


2017
5
4,5
4
3,5
3
2,5
2
1,5
1
0,5
0
Q1
MIN
MED
MAX
Q3
Untreated check
Fosetyl alluminium
Acibenzolar S-methil
Protein of Harpin
Cerevisanae
COS-OGA
NAC + NAC with organic matter
Organic matter
NAC endotherapy


NAC endoterapy

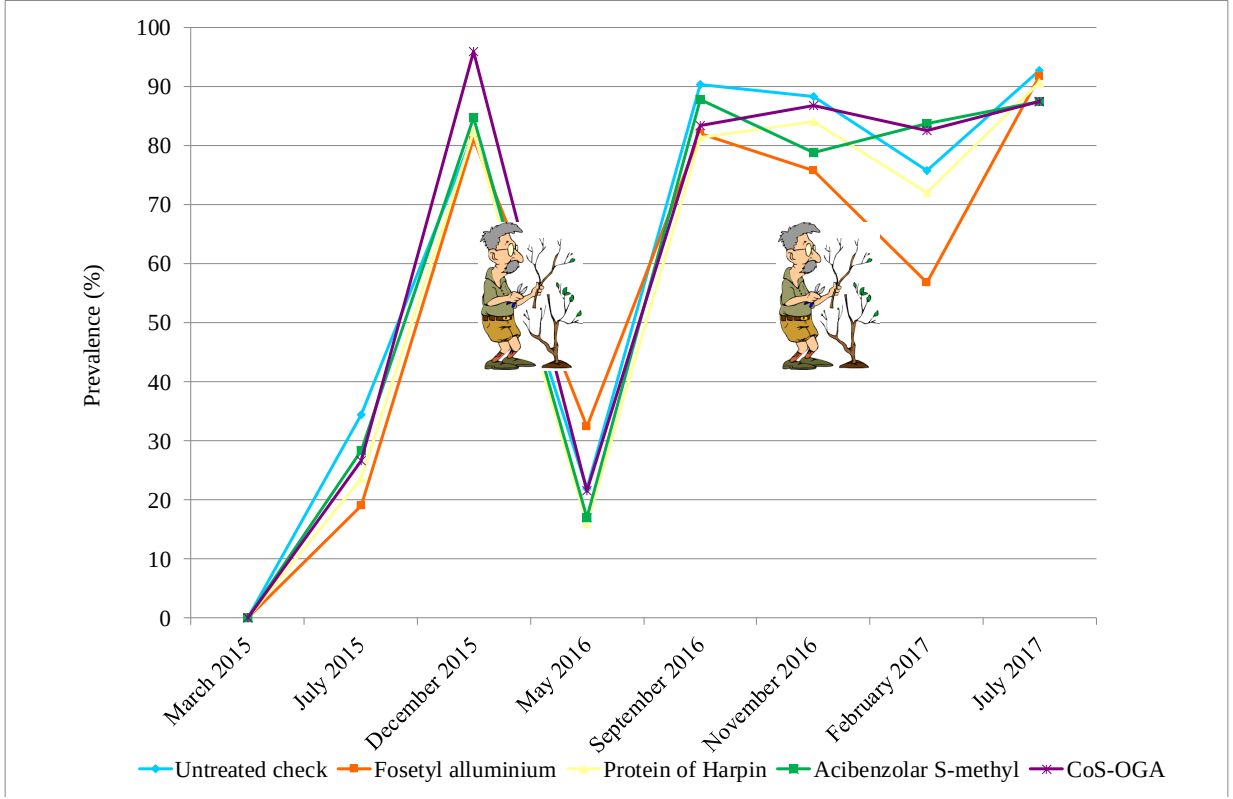
Trial C





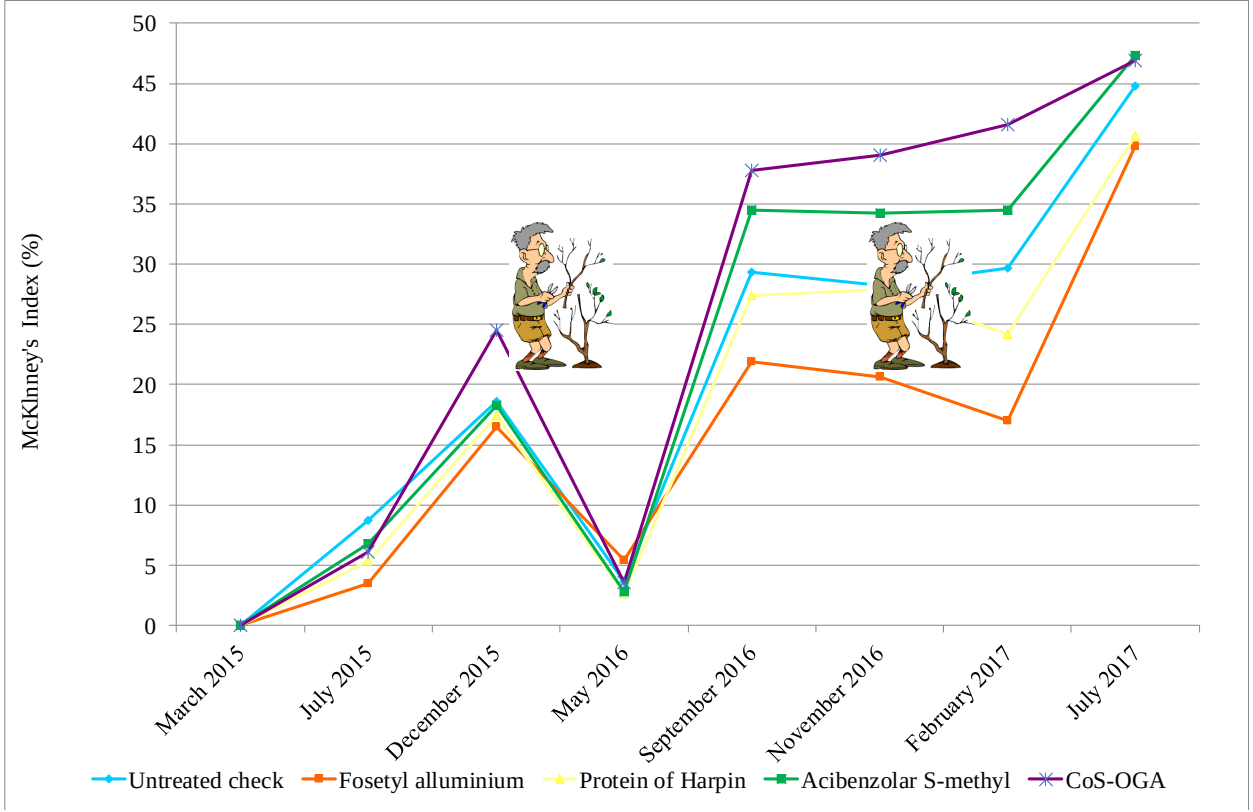
Active substance (a.s.)	July 2015		September 2016	
Untreated check	20,1	a A	91,3	a A
Fosetyl alluminium	15,7	a A	67,1	b A
Protein of Harpin	14,9	a A	73,7	ab A
Acibenzolar S-methyl	24,9	a A	81,3	ab A
COS-OGA	26,2	a A	79,2	ab A

Trial C



Thesis	Prevalence (%)															
	March 2015		July 2015		December 2015		May 2016		September 2016		November 2016		February 2017		July 2017	
Untreated check	0	a A	34,4	a A	81,9	b A	21,9	a A	90,3	a A	88,2	ab A	75,7	ab A	92,7	a A
Fosetyl alluminium	0	a A	19,0	a A	81,1	b A	32,4	a A	82,1	a A	75,8	b A	56,8	b A	91,7	a A
Protein of Harpin	0	a A	23,6	a A	82,4	b A	15,9	a A	81,3	a A	84,0	ab A	72,0	ab A	90,6	a A
Acibenzolar S-methyl	0	a A	28,3	a A	84,8	b A	16,9	a A	87,8	a A	78,8	ab A	83,7	a A	87,5	a A
CoS-OGA	0	a A	26,6	a A	95,8	a A	21,5	a A	83,3	a A	86,7	a A	82,5	a A	87,5	a A

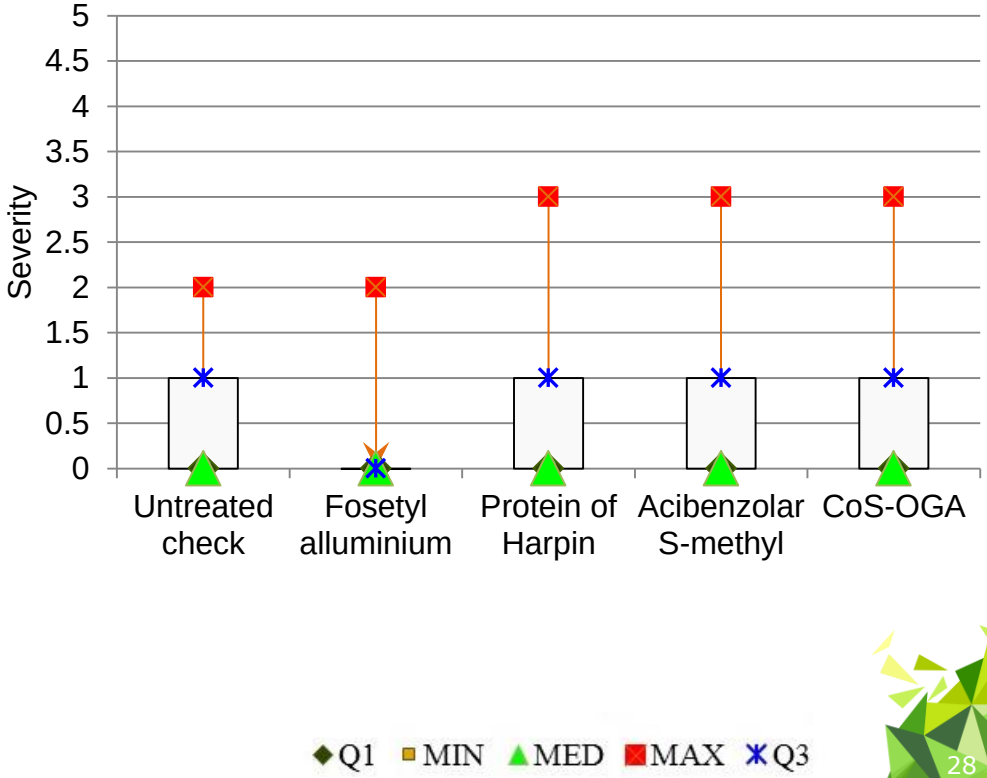
Trial C



Tesi	McKinney Index (%)															
	March 2015		July 2015		December 2015		May 2016		September 2016		November 2016		February 2017		July 2017	
Untreated check	0	a A	8,7	a A	18,6	ab A	3,6	a A	29,3	a A	28,3	ab AB	29,7	ab ABC	44,8	a A
Fosetyl alluminium	0	a A	3,5	a A	16,5	b A	5,4	a A	21,9	a A	20,6	b B	17,0	c C	39,8	a A
Protein of Harpin	0	a A	5,3	a A	17,4	b A	2,7	a A	27,4	a A	27,9	ab AB	24,2	bc BC	40,6	a A
Acibenzolar S-methyl	0	a A	6,8	a A	18,2	ab A	2,8	a A	34,4	a A	34,2	a AB	34,5	ab AB	47,3	a A
CoS-OGA	0	a A	6,1	a A	24,5	a A	3,6	a A	37,8	a A	39,0	a A	41,6	a A	46,9	a A

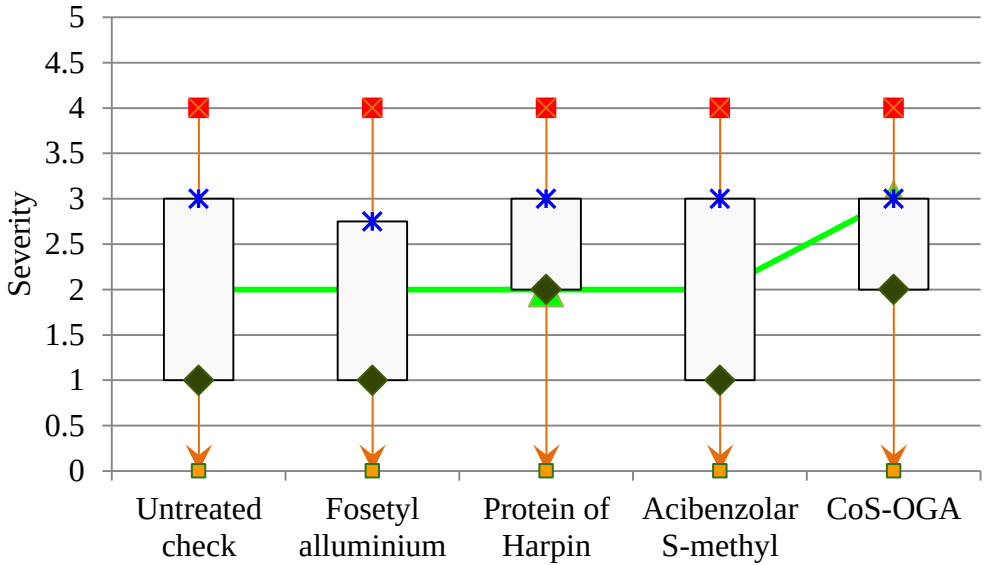
Trial C

July 2015

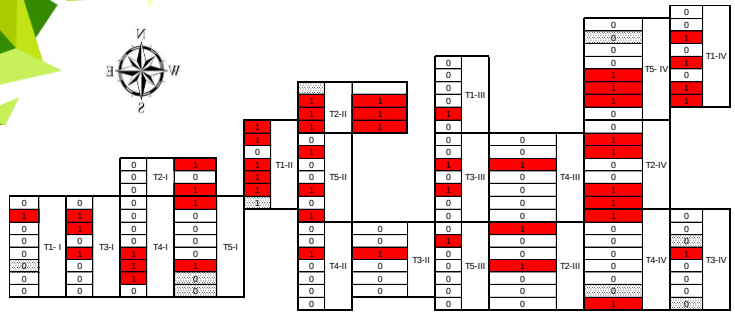


Trial C

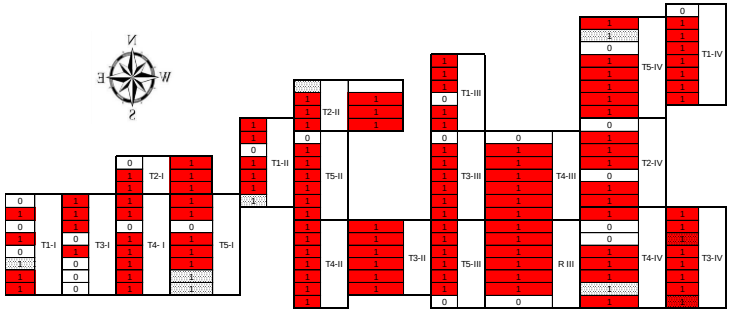
July 2017



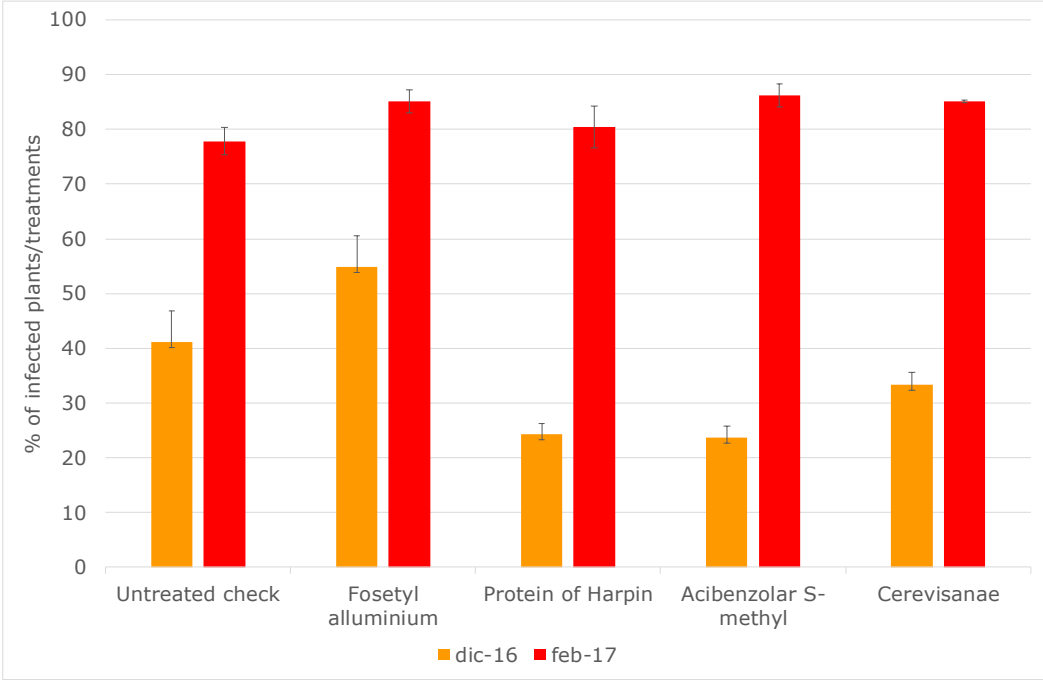
Trial D



Distribution of infected plants in the field trial 1 year after the start of applications

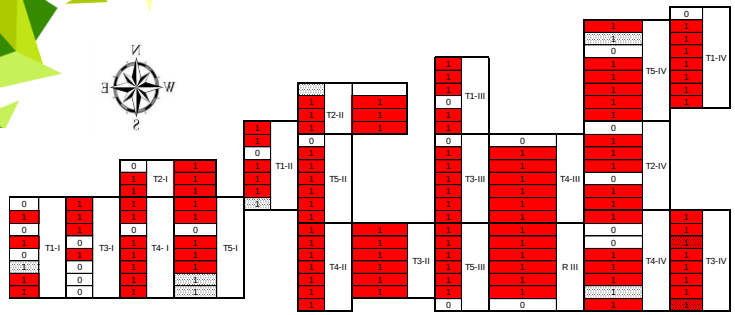


Distribution of infected plants in the field trial 2 year after the start of applications

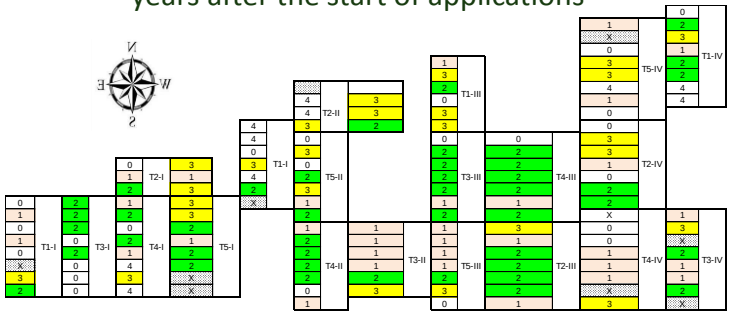


Thesis	Dic 2016	Feb 2017
Untreated check	41.1 a A	77.8 a A
Fosetyl alluminium	54.8 a A	85.1 a A
Protein of Harpin	24.3 a A	80.4 a A
Acibenzolar S-methyl	23.7 a A	86.2 a A
Cerevisanae	33.3 a A	85.1 a A

Trial D

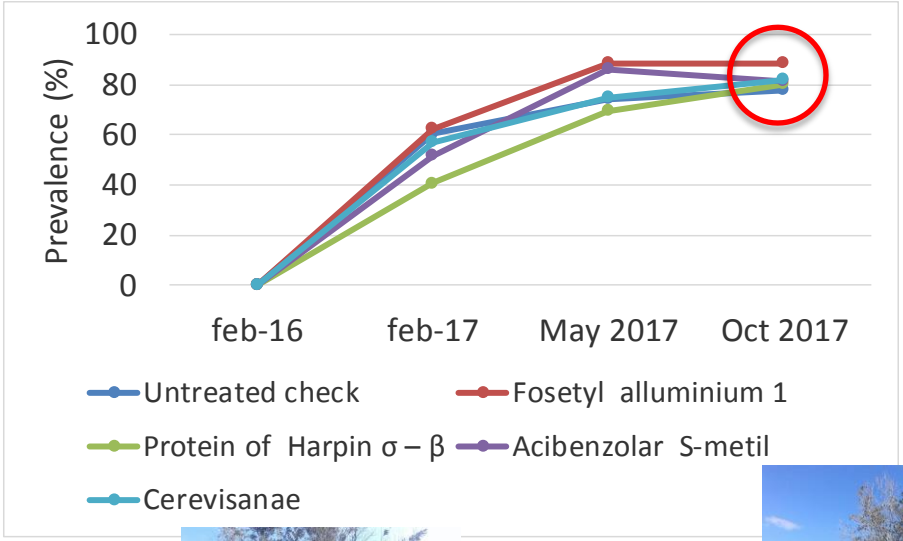


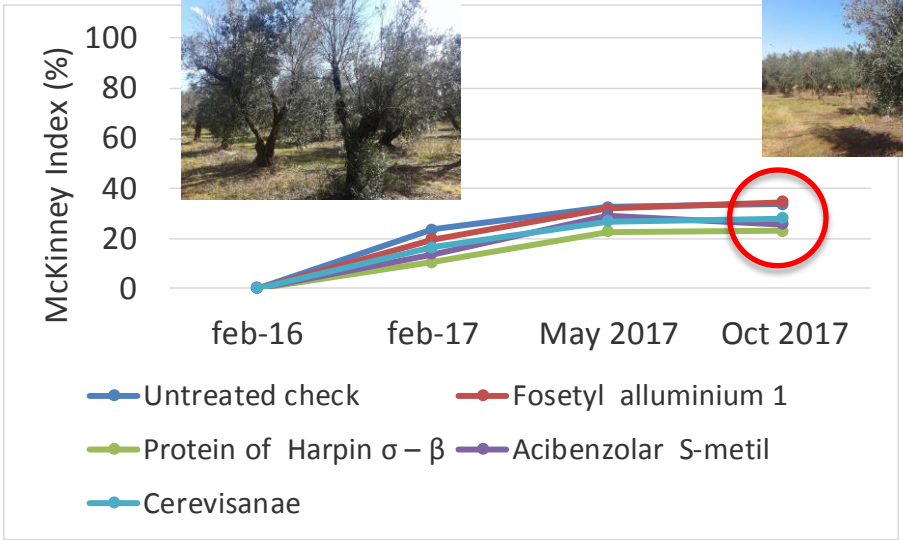
Distribution of infected plants in the field trial 2 years after the start of applications



Distribution of symptomatic plants in the field trial 2 year after the start of applications

Empyrical scale: 0 1 2 3 4 5





The trial field have been set up in different olive orchard, without or with evident symptoms of X. fastidiosa and for different periods of times.

- resistance inductors: fosetyl aluminium, Acibenzolar S-methyl;

- Resistance inductors: COS-OGA, Protein of Harpin, Cerevisanae;

- Organic fertilizer;

- NAC;

Others experiments regarding NAC are now ongoing, in order to verify:
- others methods of application (feritrrigation), less laborious and expensive as endotherapy;
- others substrate (inert substrate) for adsorption of NAC and slowly release of the molecules;
- possibility of combination with others products (es. Sylver ions) for increasing the positive remission effects;
- different rates, time and interval of applications;

In conclusion, although, results regarding NAC was promising, actually, none of the tested products can be indicated for the efficacy containment or remission of the disease symptoms of X. fastidiosa.

THANKS FOR YOUR ATTENTION!!!

THANKS TO ALLL MY COLLEAGUES FOR THE INTENSE AND FRUITFUL WORK THEY HAVE DONE

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