NORSØK

Norwegian Centre for Organic Agriculture

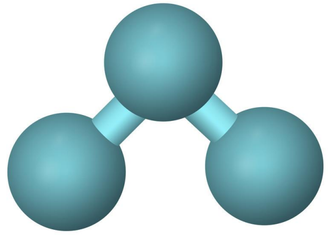
The use of ozonised water in plant production

Atle Wibe

What I will talk about:

- What is ozone (O_3)
- Strawberry open field production, spraying with of ozonated water (own study)
- Potato production, treating infected seed potatoes and spraying the leaves (own study)
- Strawberry greenhouse production, fogger spraying (MET study)
- Tomato production, ozone in irrigation water (IAV study)

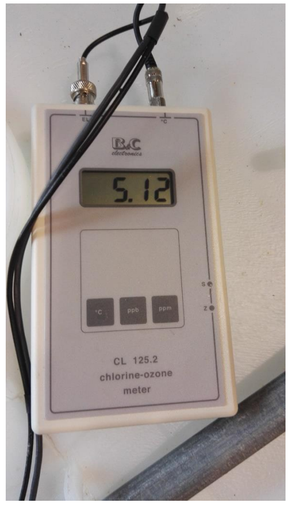
What is ozone (O_3)?



- A molecule of three oxygen atoms
- A pale blue gas with a specific sharp odour
- Naturally made by lightning and thunder. Can also be produced by UV-light or high voltage electricity from oxygen.
- May cause headaches, burning eyes and irritation to respiratory passages
- Unstable, half-life in air about 20-25 hours, in water 20-30 min.
- No harmful by-products when broken down: $O_3 + 2H^+ \leftrightarrow O_2 + H_2O$
- Reacts either directly as ozone or indirectly as hydroxyl ion
- Very strong oxidizer (stronger than chlorine)
- Strong disinfection effect against pathogenic organisms; fungal spores, bacteria and viruses
- Useful in sterilizing surfaces as e.g. heat sensitive medical equipment and instruments
- Used as water treatment all over the world
- The U.S. Food and Drug Administration (FDA) approved the use of ozone in aqueous and gaseous phases as an antimicrobial agent for treatment, storage and processing of foods

Testing ozonised water against Botrytis

NORSØK
Norsk senter for økologisk landbruk



Pre test to see if the plants suffered by the treatment

Treatments: 0, 5 or 10 ppm O_3

Dates: 31. March and 5. April

NORSØK
Norsk senter for økologisk landbruk

31. March, 1 hour after first treatment

NORSØK
Norsk senter for økologisk landbruk

Plants in a «growing tent» between treatments

NORSØK
Norsk senter for økologisk landbruk

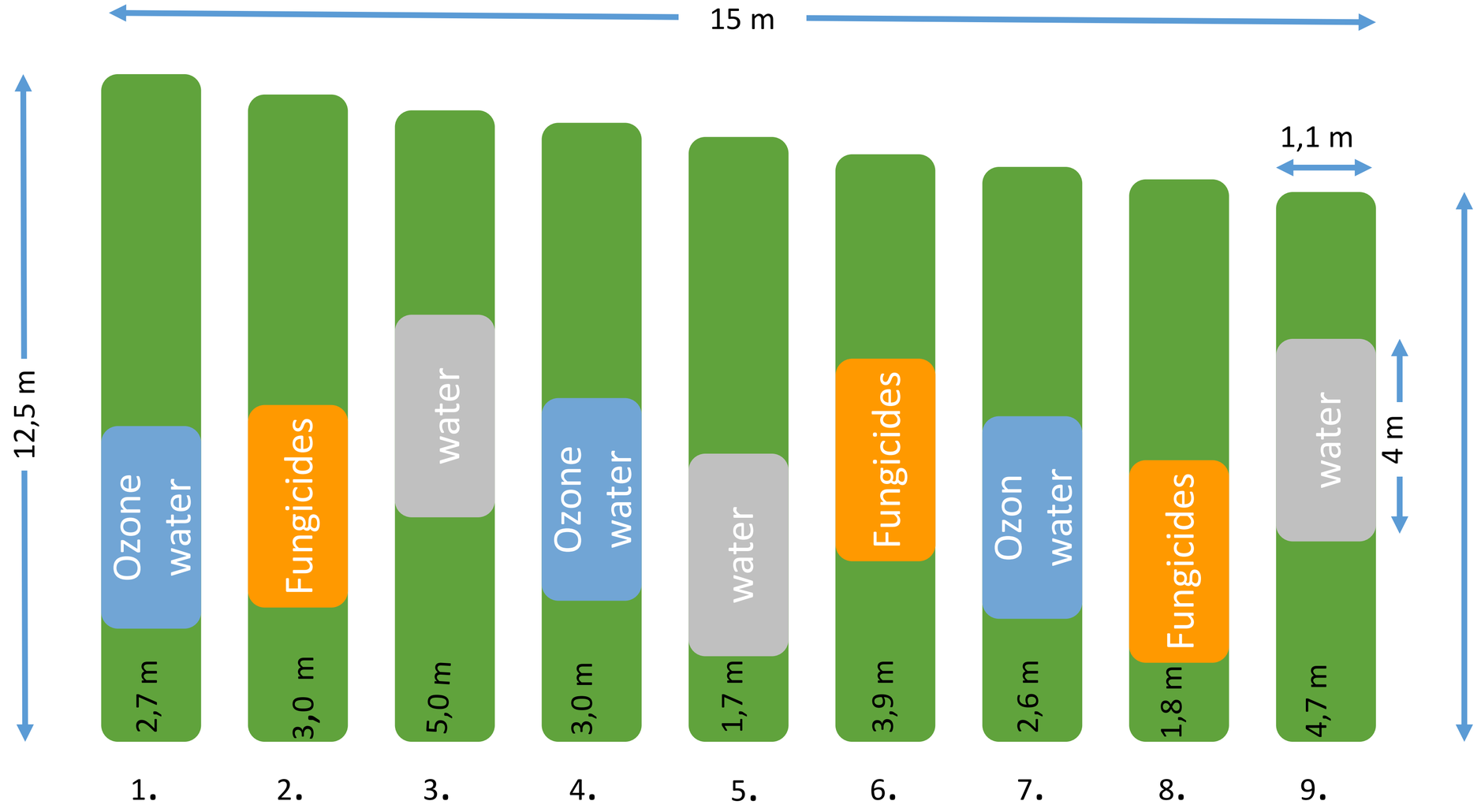
5. April, two days after second treatment

NORSØK
Norsk senter for økologisk landbruk

1. May, about one month after second treatment

NORSØK
Norsk senter for økologisk landbruk

Experimental field 2016

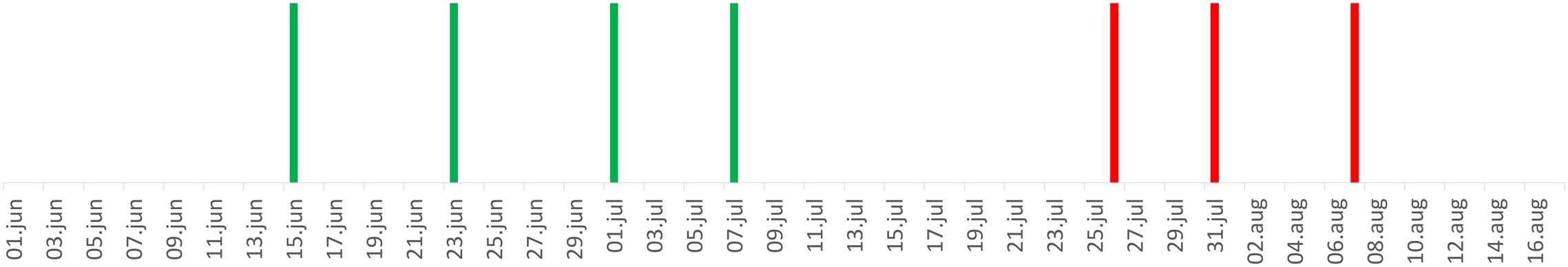


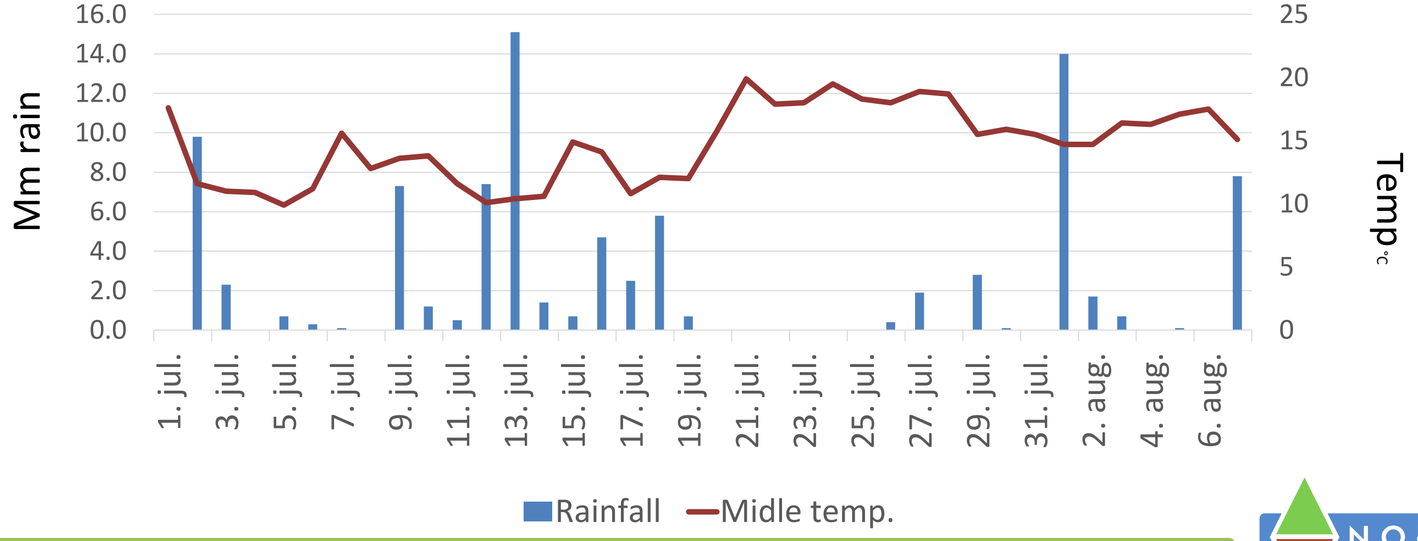
- Water med 10 ppm ozone (90 L/da, pressure 1 kg)
- Convetional fungicides (90 L/da, pressure 7 kg)
- Clean water (90 L/da, pressure 1 kg)

NORSØK
Norsk senter for økologisk landbruk

Treatments: 15. og 23. June og 1. og 7. July.

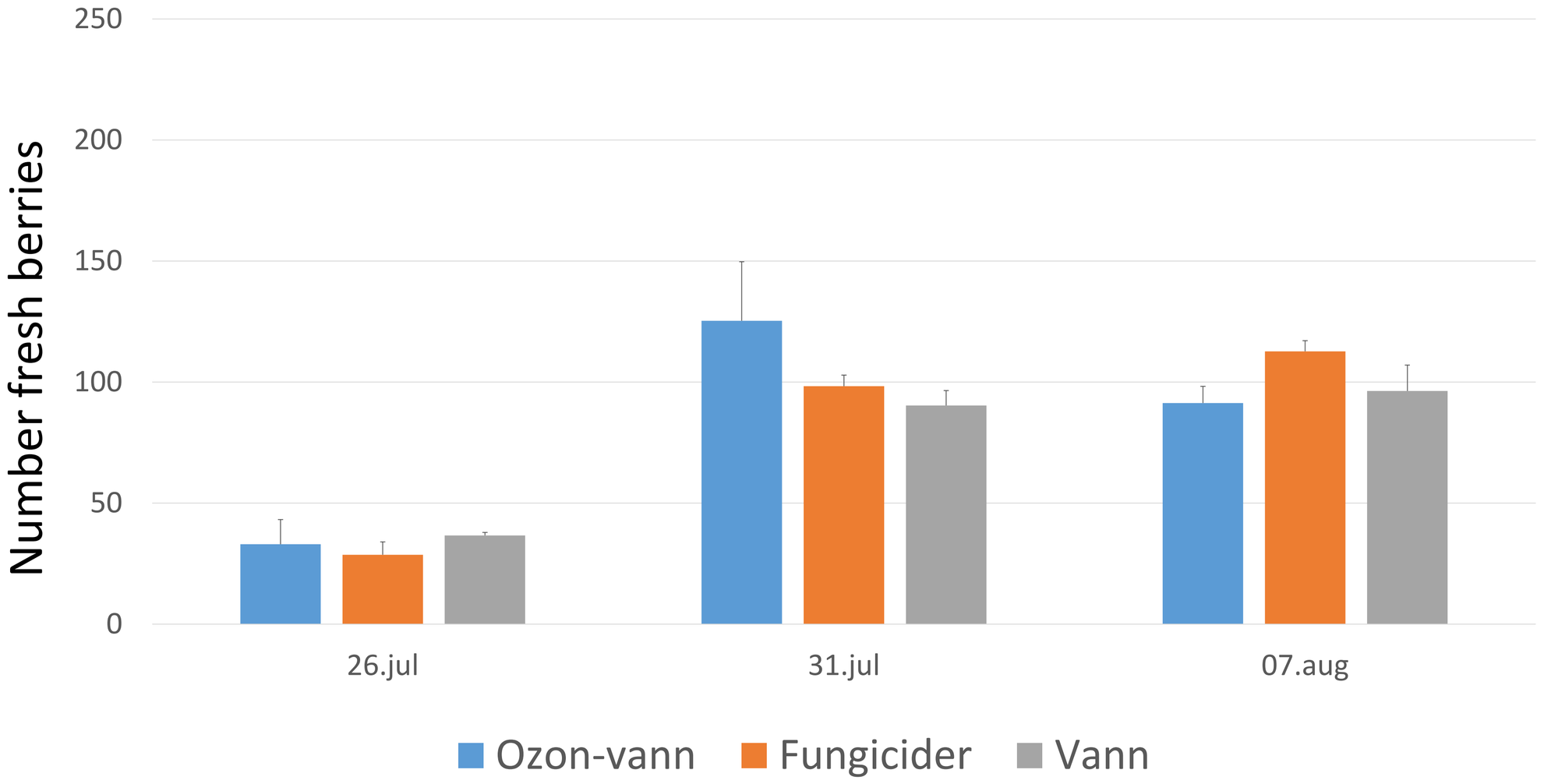
Harvest: 26. og 31 July og 8. August.





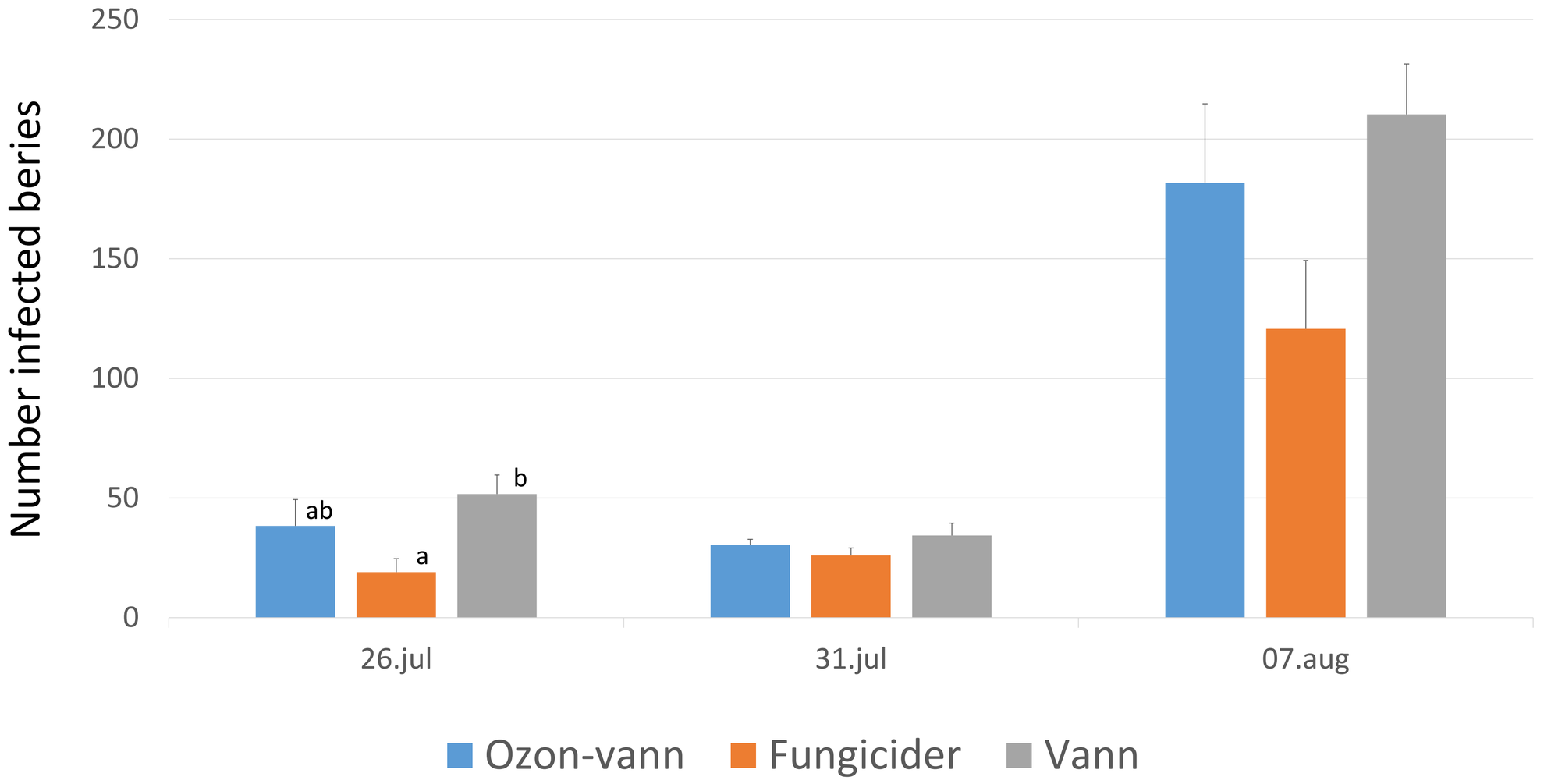
NORSØK
Norsk senter for økologisk landbruk

Avarage number fresh semi-ripe and ripe strawberries



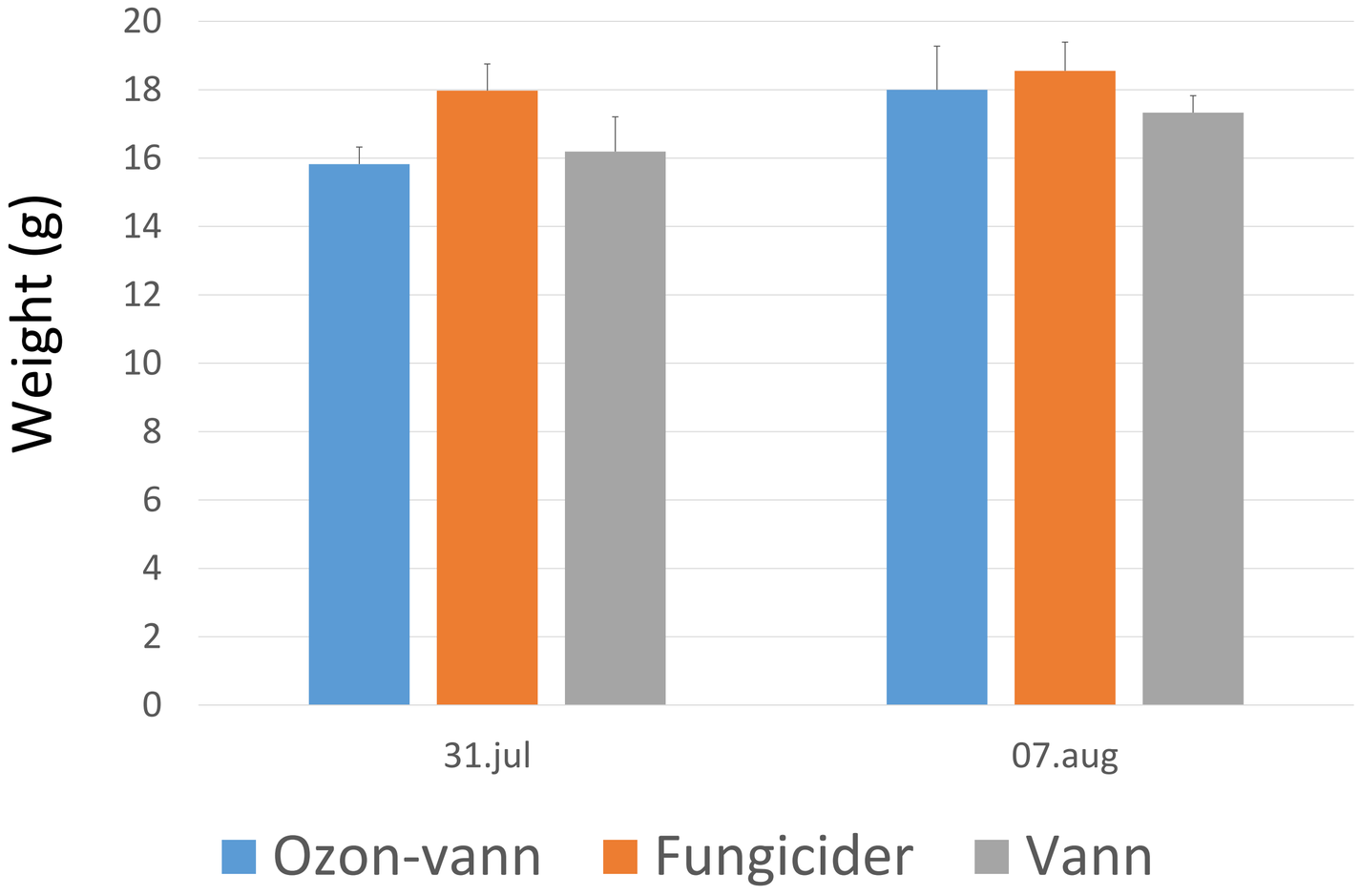
NORSØK
Norsk senter for økologisk landbruk

Average number semi-ripe and ripe strawberries infected with botrytis



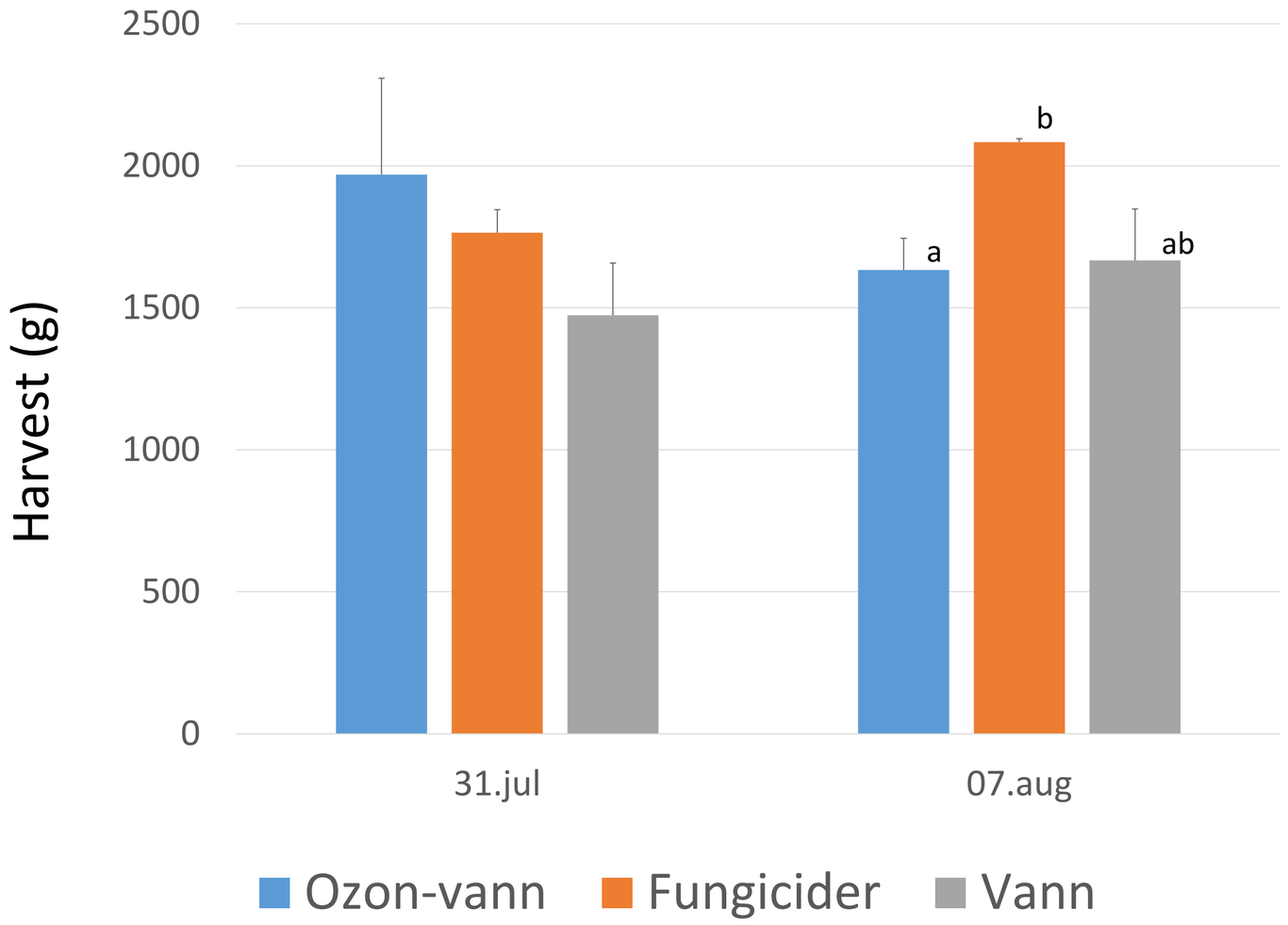
NORSØK
Norsk senter for økologisk landbruk

Average weight (g) of semi-ripe and ripe fresh strawberries



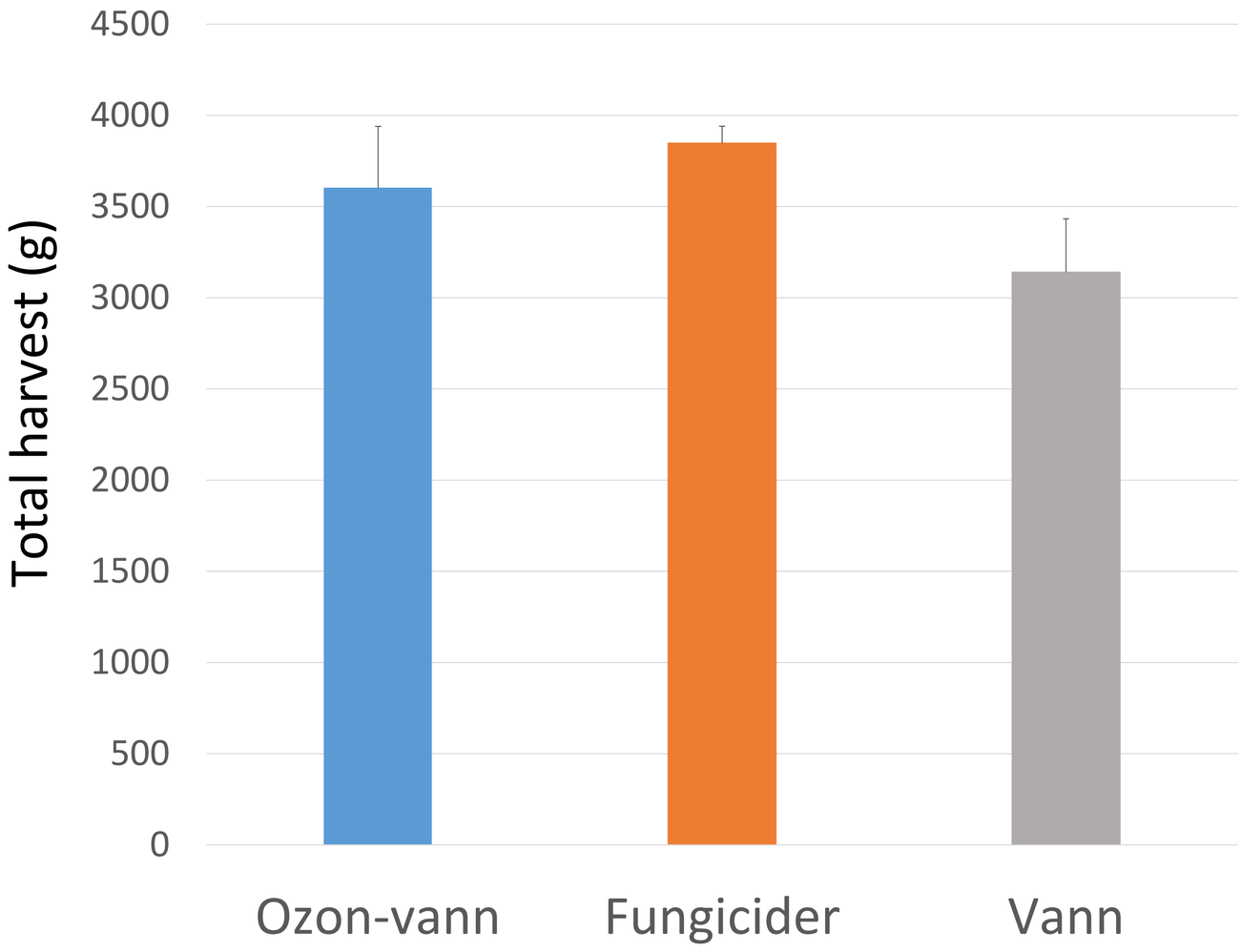
NORSØK
Norsk senter for økologisk landbruk

Harvest (g) of semi-ripe and ripe fresh strawberries



NORSØK
Norsk senter for økologisk landbruk

Total harvest (g) of semi-ripe and ripe fresh strawberries



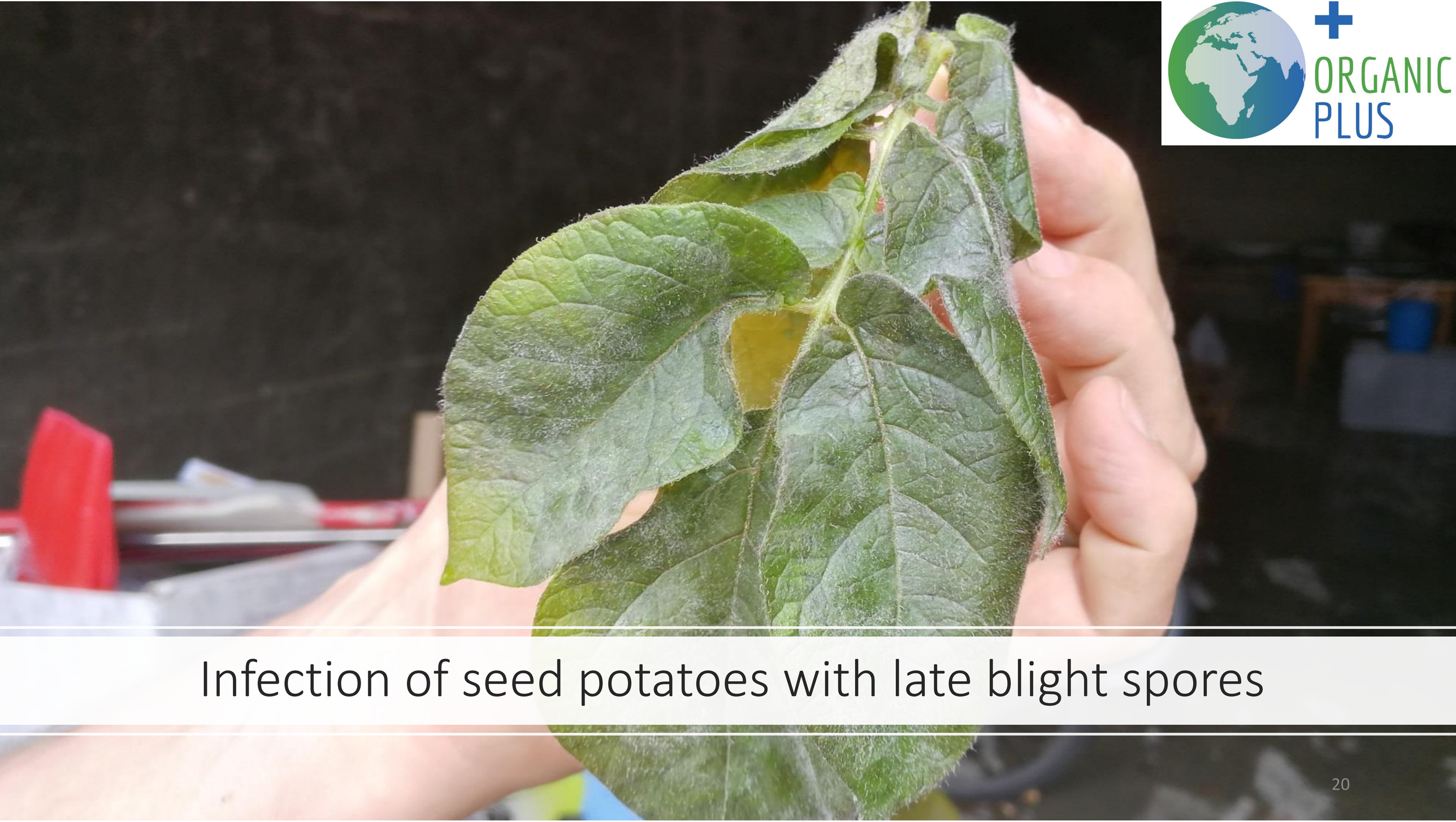
NORSØK
Norsk senter for økologisk landbruk

Discussion/conclusions

- The result showed large variations within the groups thus statistically significant differences between the treatments could not be detected.
- However, the results indicate that ozonised water can be an alternative to fungicides to control Botrytis in strawberry.
- More experiments has to be executed to optimise application method, timing and frequency

Ozonised water treatment of late blight infected potatoes pre harvest

2019

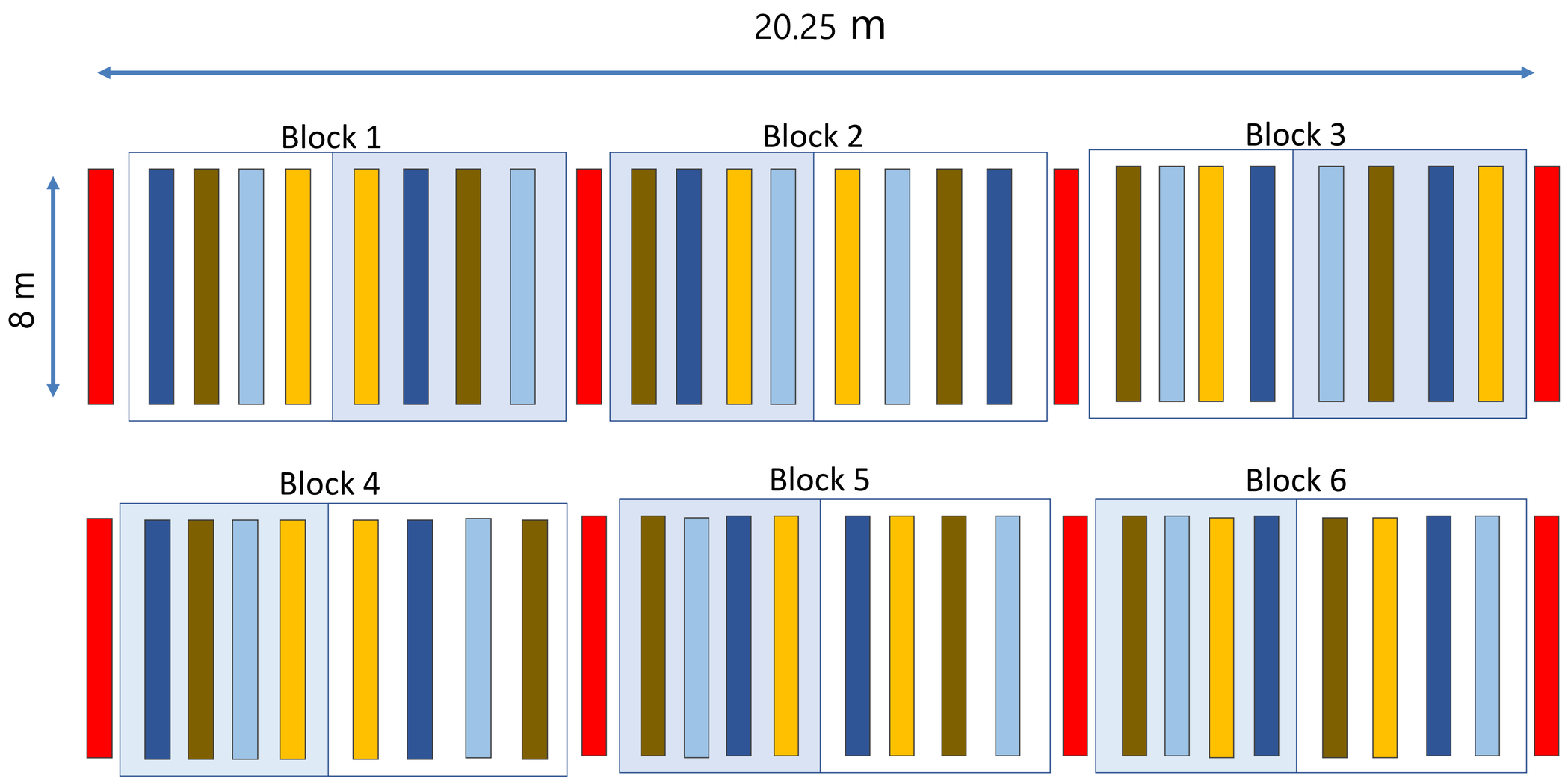


Infection of seed potatoes with late blight spores

Infection of seed potatoes with late blight spores

Ozone treatment of seed potatoes (10 sec or 3 min)

Seeding infected potatoes



A Split Plot Design with 6 blocks of 2 main plots (tap water spray (white background) or ozonised water spray (blue background)), each split into 4 sub-plots (1.-4. Pre-treatments, illustrated with different colours).

1. Unwashed
2. Washed
3. Washed + 10 sec O_3 treatment
4. Washed + 3 min O_3 treatment

Edge row

Ozone generator

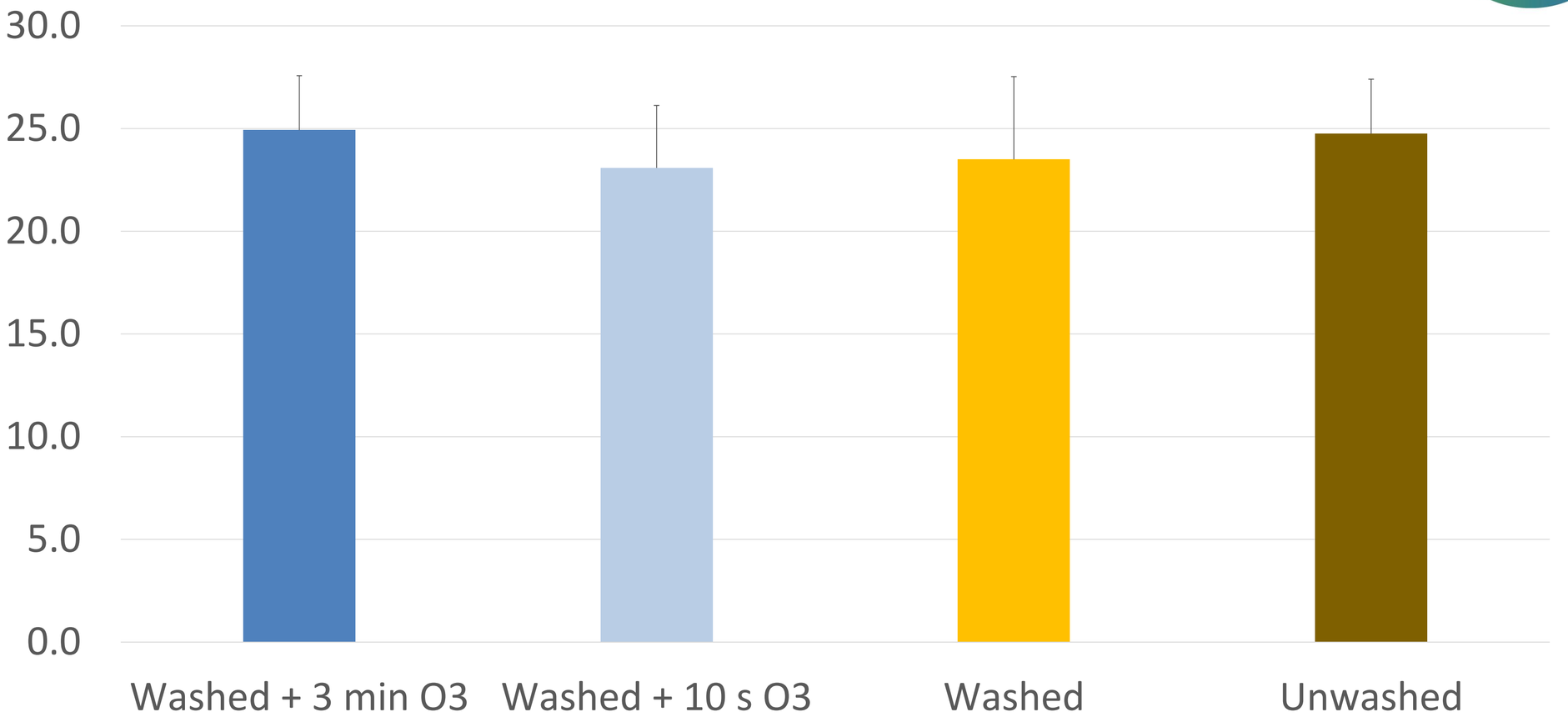
Field treatment

ORGANIC PLUS

Measuring of potato canopy height using a measuring rod

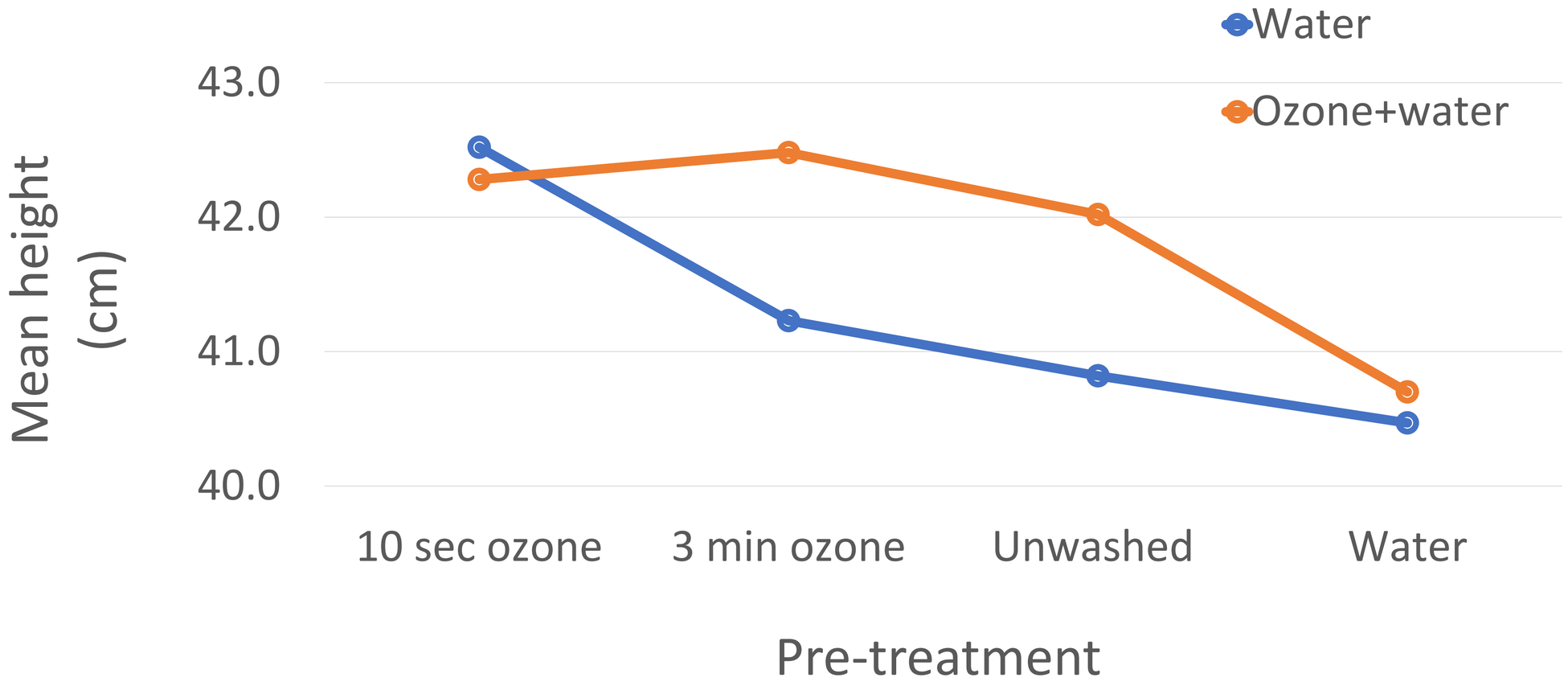
Manual harvest of potatoes in the experimental field 24th and 25th September

Germination



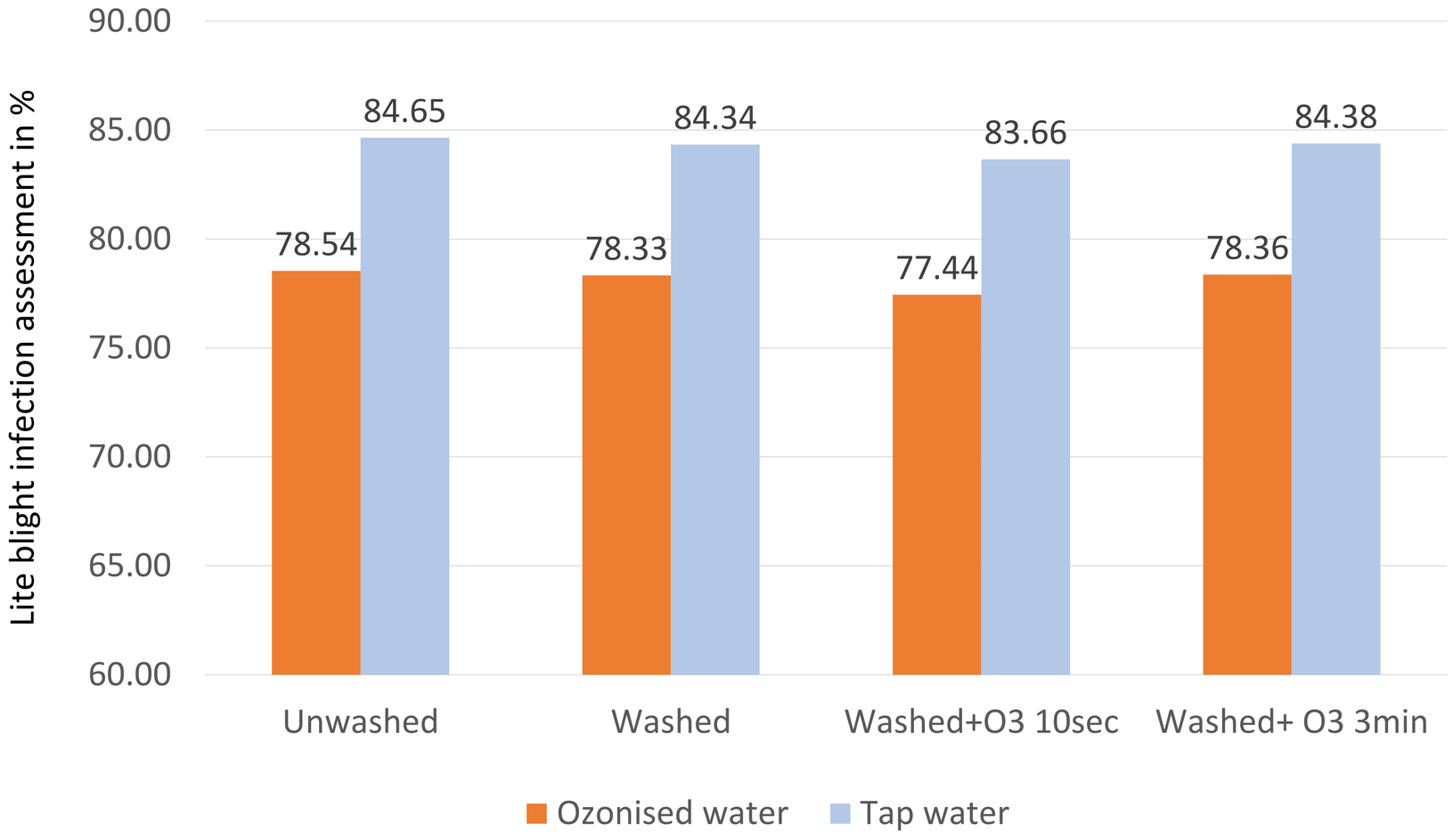
Mean number of germinated potatoes with different pre seeing treatments. Each bar represents twelve rows. Standard deviation (SD) is indicated for each bar

Canopy height



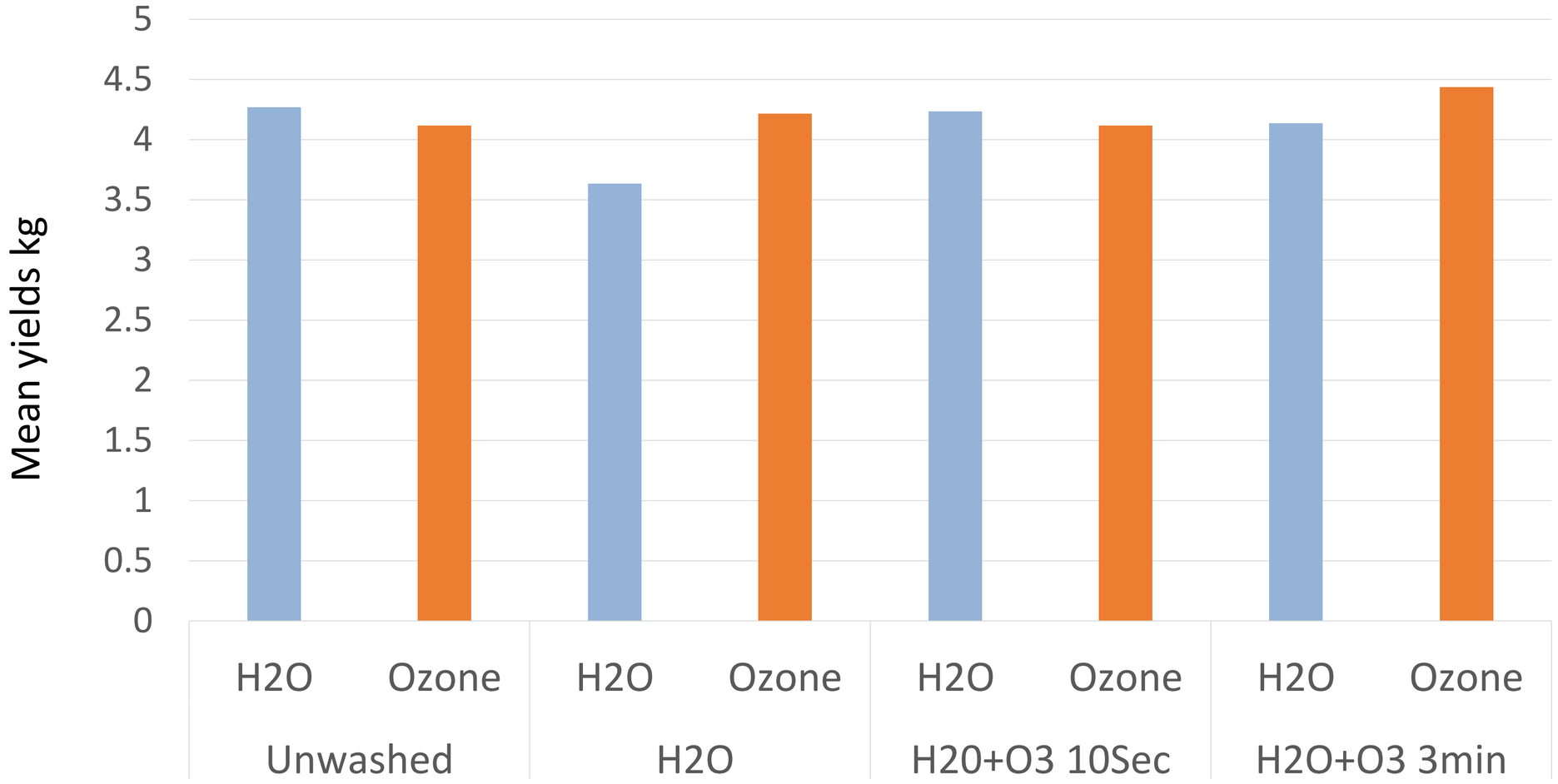
Mean height of the potato canopy in all six blocks. The two lines represent potatoes sprayed with either tap water or ozonized water

Lite blight assessment



Assessment of Lite blight infection (in %) of potatoes with four different pre seeding treatments and sprayed with ozonized water or tap water. Date for assessment 30th august 2019.

Potato yields



Mean potato yields of 5 m row in altogether 6 blocks arranged according to four different pre seeding treatments and two spraying regimes, tap water or ozonized water

Discussion/conclusions

- Data need statistical analysis!
- Pre-treatment of the seed potatoes
  - Infection of seed potatoes necessary to ensure lite blight in the field
  - Should also added rows with not infected seed potatoes in the blocks to see if it is possible to prevent infection from one plant to the other
  - Expected ozone pre-treatment would be more effective
- In commercial potato production professional equipment for ozonised water application is needed (e.g. from MET)
- Preventing development of lite blight on heavily infested seed potatoes by using ozone water treatment seems not possible
- Ozone treatment of heavily lite blight infested potato leaves seems not efficient
- Still not studied if ozonated water can prevent transfer of pathogens from one plant to another

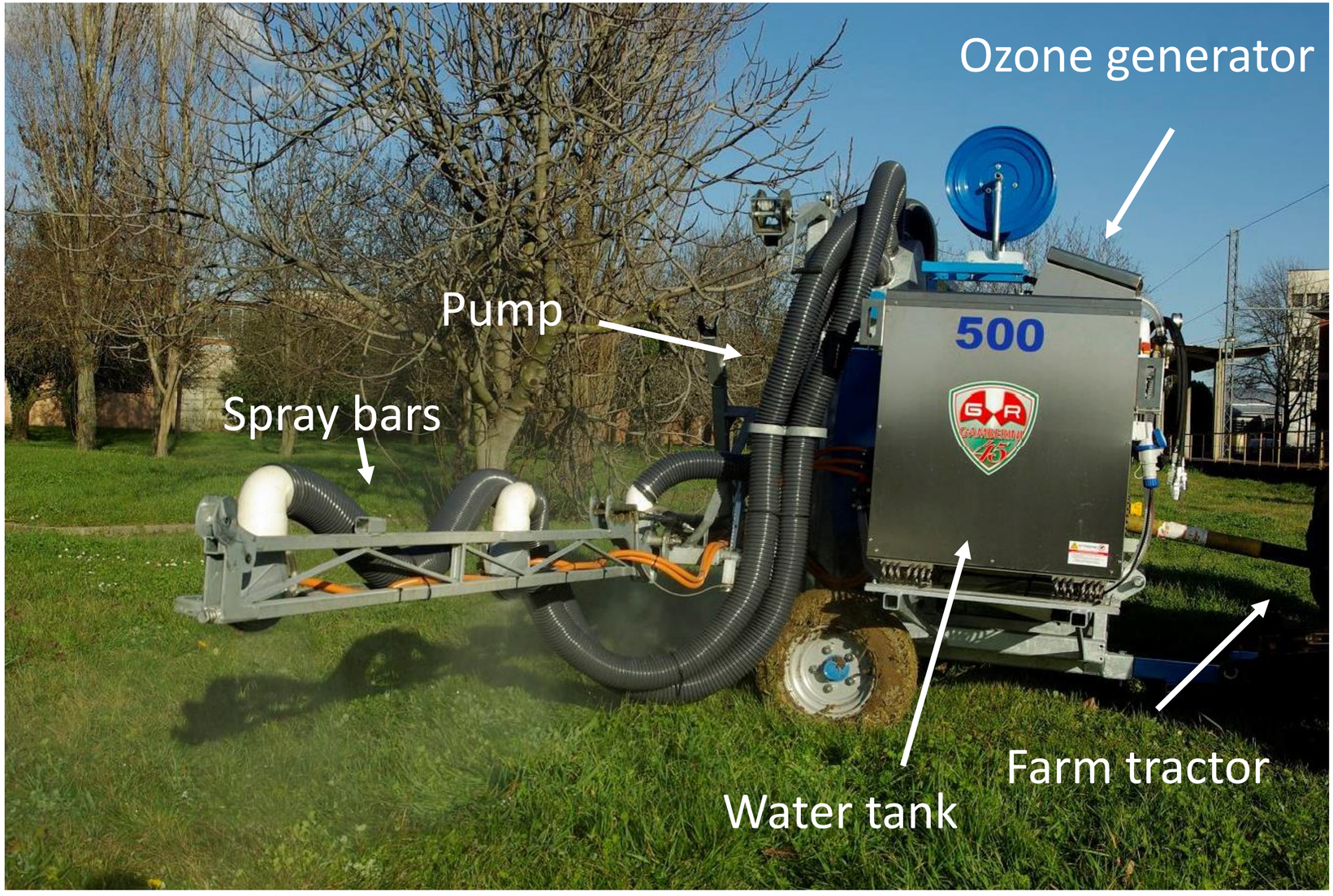
Medical Equipment Technology,
Bologna, Italy

Ozone fields of application:

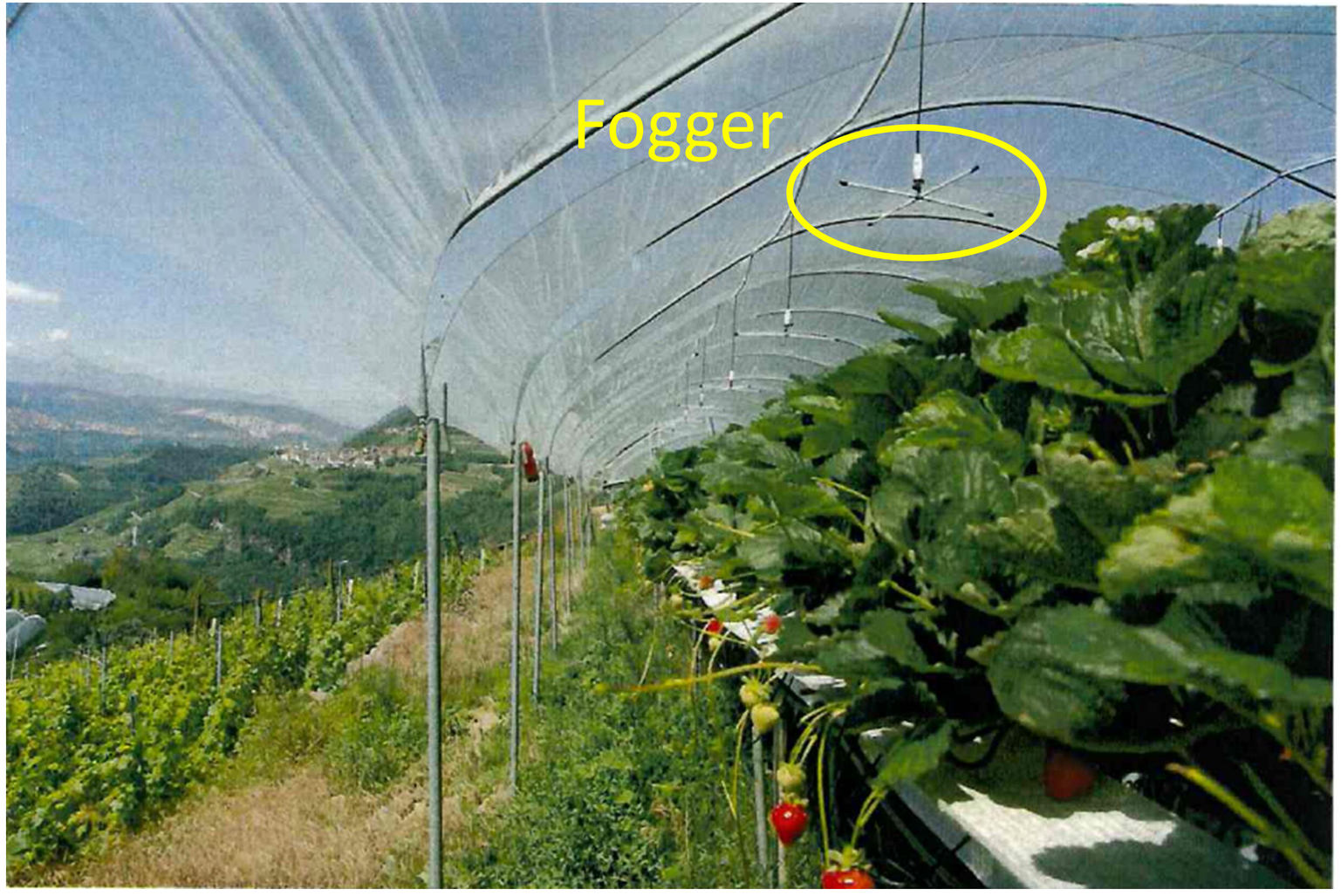
- Agrofood
- Transportation and logistics
- Water treatment
- Sanitization of areas
- Other sectors

Agrofood

- Fruits and vegetables
- Food and beverage
- Dairy
- Minimally processed vegetables
- Meat processing



To perform the treatment with ozonated water in open field cultivation



Application of ozonated water in greenhouses strawberry production via the fogger.

In June/July every 2-3 days for 3 min.,

in August every 4-5 day for 5 min.

A grower in Italy started with ozonized water treatment. He could reduced the application of fungicides from about 15 to 2.

Controlled test of the efficacy of ozonised water against strawberry OIDIUM (Powdery mildew)

- Testing ozonized water against the fungicide Nimrod® and control
- Observation of 1000 strawberries leaves grown in different tunnels according to treatment
- Data collected every 7-10 days from 22th June to 12th of September 2016
- For every observation the number of Oidium stains and the gravity of infection recorded

  - Class 0 = healthy leaf, no stains
  - Class 1 = 1 stain per leaf
  - Class 2 = 2 stains per leaf
  - Class 3 = 3 or more stains per leaf

June

July

Data Collection 06/22/2016

Ozone — Tot

Class	0	1	2	3	
Number of Leaves	963	27	8	2	1,000
%	96,3	2,7	0,8	0,2	100%

Nimrod® — Tot

Class	0	1	2	3	
Number of Leaves	972	21	6	1	1,000
%	97,2	2,1	0,6	0,1	100%

Control — Tot

Class	0	1	2	3	
Number of Leaves	565	65	135	235	1,000
%	56,5	6,5	13,5	23,5	100%

Data Collection 07/18/2016

Ozone — Tot

Class	0	1	2	3	
Number of Leaves	958	31	9	2	1,000
%	95,8	3,1	0,9	0,2	100%

Nimrod® — Tot

Class	0	1	2	3	
Number of Leaves	968	26	5	1	1,000
%	96,8	2,6	0,5	0,1	100%

Control — Tot

Class	0	1	2	3	
Number of Leaves	525	62	109	304	1,000
%	52,5	6,2	10,9	30,4	100%

August

Data Collection 08/19/2016

Ozone — Tot

Class	0	1	2	3	
Number of Leaves	971	19	9	1	1,000
%	**97,1**	1,9	0,9	0,1	100%

Tesi Nimrod® — Tot

Class	0	1	2	3	
Number of Leaves	975	19	4	2	1,000
%	**97,5**	1,9	0,4	0,2	100%

Tesi di Controllo — Tot

Class	0	1	2	3	
Number of Leaves	542	76	127	255	1,000
%	54,2	7,6	12,7	**25,5**	100%

September

Data Collection 09/12/2016

Ozone — Tot

Class	0	1	2	3	
Number of Leaves	968	23	5	4	1,000
%	**96,8**	2,3	0,5	0,4	100%

Nimrod® — Tot

Class	0	1	2	3	
Number of Leaves	976	18	5	1	1,000
%	**97,6**	1,8	0,5	0,1	100%

Control — Tot

Class	0	1	2	3	
Number of Leaves	540	69	119	272	1,000
%	54,0	6,9	11,9	**27,2**	100%

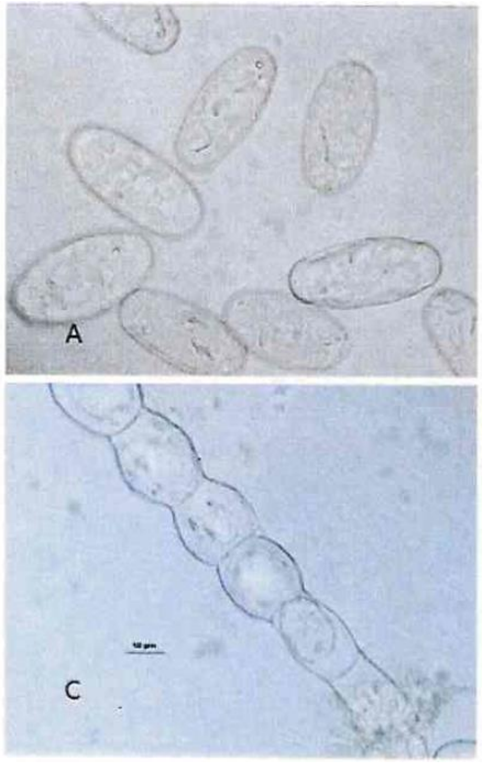
Oidium incidences in treated and not treated plants, calculated with the Mackinney index (same data)

	06/22/16	06/30/16	07/09/16	07/18/16	08/04/16	08/11/16	08/19/16	08/30/16	09/12/16
Ozone	0,049	0,056	0,032	0,055	0,041	0,039	0,040	0,049	0,045
Nimrod	0,036	0,046	0,037	0,039	0,039	0,041	0,033	0,041	0,031
Control	1,400	0,789	1,077	1,192	1,131	1,282	1,095	1,102	1,123

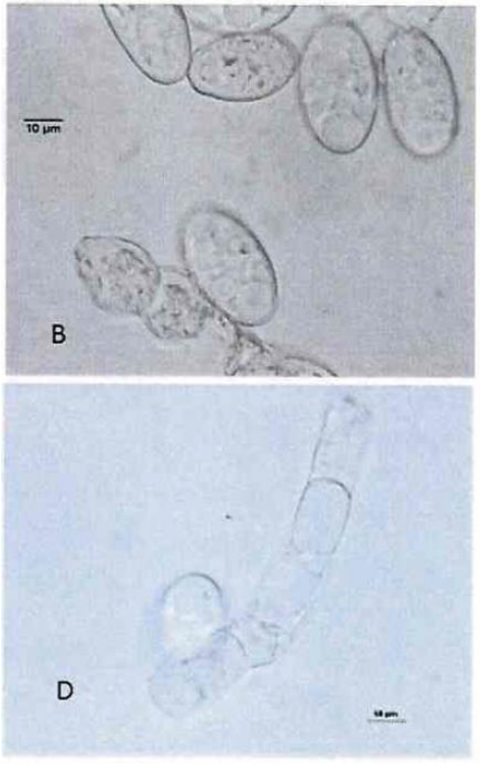
No significant difference between plants treated with ozone and pesticide, thus ozone can be considered as a valuable alternative to pesticides

Conidia in microscope observations

Not treated



Ozone treated



Wizended cells

Highly vaculated

Conclusions

Results of ozonated water treatment against strawberry Oidium are very promising. It proved an efficacy comparable to pesticides suggesting that ozone can be used against this fungus in greenhouses where its much more difficult to eliminate.

MET recently received funding from EU Horizon 2020 research program for experimentation and implementation of this matter!

1st EU/North-African Conference on Organic Agriculture (EU-NACOA)
11-12th November 2019, Marrakech-Morocco

Contribution to the assessement of the effect of ozonated water irrigation on the Root Knot Nematodes *Meloidogyne* spp. associated with tomato

By: Lamiae Khoubane

Hassan II Institute of Agronomy and Veterinary Science (IAV)
Agadir, Morocco

IAV Hassan II
Khoubane.lamiae@gmail.com

Material and Methods

- ***In vivo* essay:**

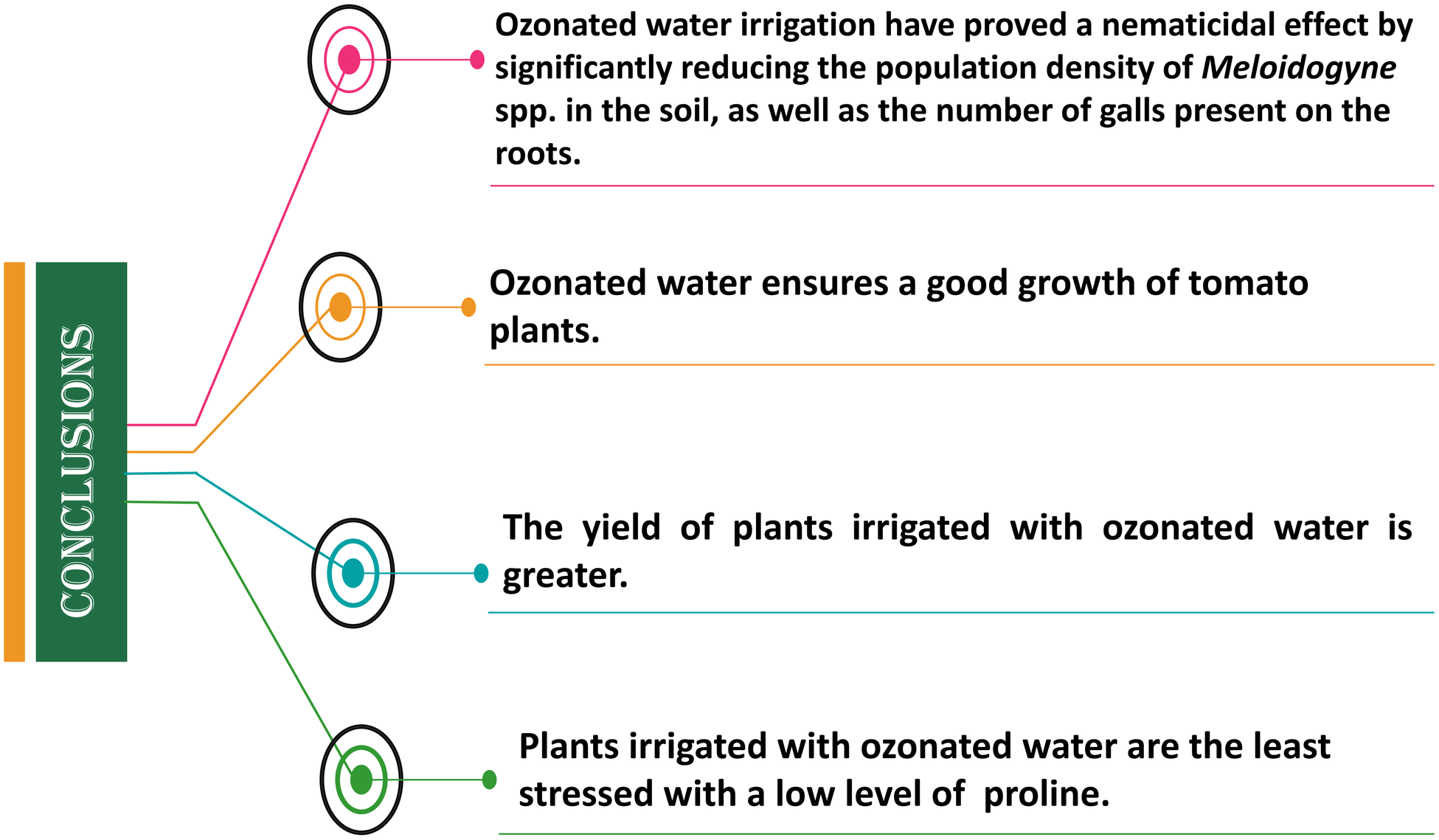
The irrigation water was added ozone with different number of doses. The effect was compared with the effect of a herb extract treatment, a pesticide and no treatment (infested soil). The study took place in a green house situated in the institute of agronomy and veterinary sciences Agadir, Marocco.

Tested on Tomato, Var. Bellatrix grafted on Beaufort.

Results

- The lenght of stem increased by ozone treatment compared to other treatments
- Stem diameter increased, most on more ozone doses
- Dry weight of the stem highest with ozone treatment
- The number of internodes was higher on those with ozone treatment
- The yield increased by ozone treatment
- The level of proline (a stress indicator) was reduced by ozone treatment

Conclusions



Ozonated water irrigation have proved a nematicidal effect by significantly reducing the population density of *Meloidogyne* spp. in the soil, as well as the number of galls present on the roots.

Ozonated water ensures a good growth of tomato plants.

The yield of plants irrigated with ozonated water is greater.

Plants irrigated with ozonated water are the least stressed with a low level of proline.

Summary

- Spraying ozonised water on strawberry plants may control Botrytis.
- Ozone water treatment of late blight infected seed potatoes seems not to be effective, nor do spraying of heavily infected potato leaves.
- Fog spraying ozonised water in greenhouses can control powdery mildew on strawberries.
- Ozone in the irrigation water may control nematodes in tomatoes and strengthen the plants.

Conclusion

In plant protection the use of ozonised water can be an alternative to pesticides