Implications of wastewater irrigation on soil physicochemical properties and tomato fruit quality

(First Year Assessment)

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S.B.L.A. Workshop

RECYCLED WATER – APPLICATIONS IN AGRICULTURE

Lemesos, April 27th, 2012

Research project: Environmental and public health risk assessment from long-term wastewater reuse for irrigation, in Cyprus

Partners: Agricultural Research Institute
Department of Civil and Environmental Engineering, University of Cyprus

Period: 2011-2016

Project scopes:

- **Evaluate wastewater reuse implications on soil physicochemical properties**
- **Evaluate impacts on commodities produced when crops are irrigated with wastewater**
- **Public health risk assessment (*e.g.* microbial, pathogens, heavy metals)**
- **Evaluate wastewater reuse guidelines in Cyprus and propose modifications if needed**

Tomatoes irrigated with 3 different irrigation water resources

Completely randomized block design

3 treatments (Water resources)

- **Control** (water pumped from a well near the experimental station)
- **Wastewater from Anthoupoli W.W.T.P.** (Membrane Bioreactor (*MBR*) treatment process + chlorination)
- **Wastewater from Lemesos W.W.T.P** (Slow sand filtration treatment process + chlorination)

5 replication (20 plants in each replication) : total of 300 tomatoes


Tensiometers


MAPTYPAS
Control

Chemical and microbial analysis of the three sources of irrigation water

Parameter	Measurement Unit	Control Well water	Waste water– Anthoupoli W.W.T.P.	Waste water– Lemesos W.W.T.P.
pH		8.45	8.3	8.54
EC	μS/cm	3.13	1.59	1.81
BOD_5	mg/L	<5	<5	<5
S.S	mg/L	<7	<7	<7
Total N	mg/L	0.603	1.56	7.57
Total P	mg/L	0.178	0.444	1.150
Faecal coliforms	/100mL	non detected	non detected	non detected

	Zn	Ni	Mn	Co	Fe	Cu	Pb
Well water	**0.1098±0.0022**	**n.d.**	**0.0118±0.0007**	**0.0212±0.0014**	**0.1183±0.0028**	**0.0045±0,0003**	**Non detected**
Anthoupoli W.W	**0.0783±0.0004**	**0.00312±0.0003**	**0.0138±0.0009**	**0.0312±0.0004**	**0.1223±0.0033**	**0.0059±0,0001**	**Non detected**
Lemesos W.W	**0.0322±0.0010**	**0.0061±0.0001**	**0.0125±0.0004**	**0.0355±0.0019**	**0.0913±0.0038**	**0.0026±0,0001**	**Non detected**
USEPA threshold	**2**	**0.2**	**0.2**	**0.05**	**5**	**0.2**	**5**

Variables estimated

Soil physicochemical properties:

1. EC
2. pH
3. Cl^-
4. Nitrates (NO_3^-)
5. Heavy metal content (Co, Cu, Ni, Zn, Mn)
6. Total Organic C

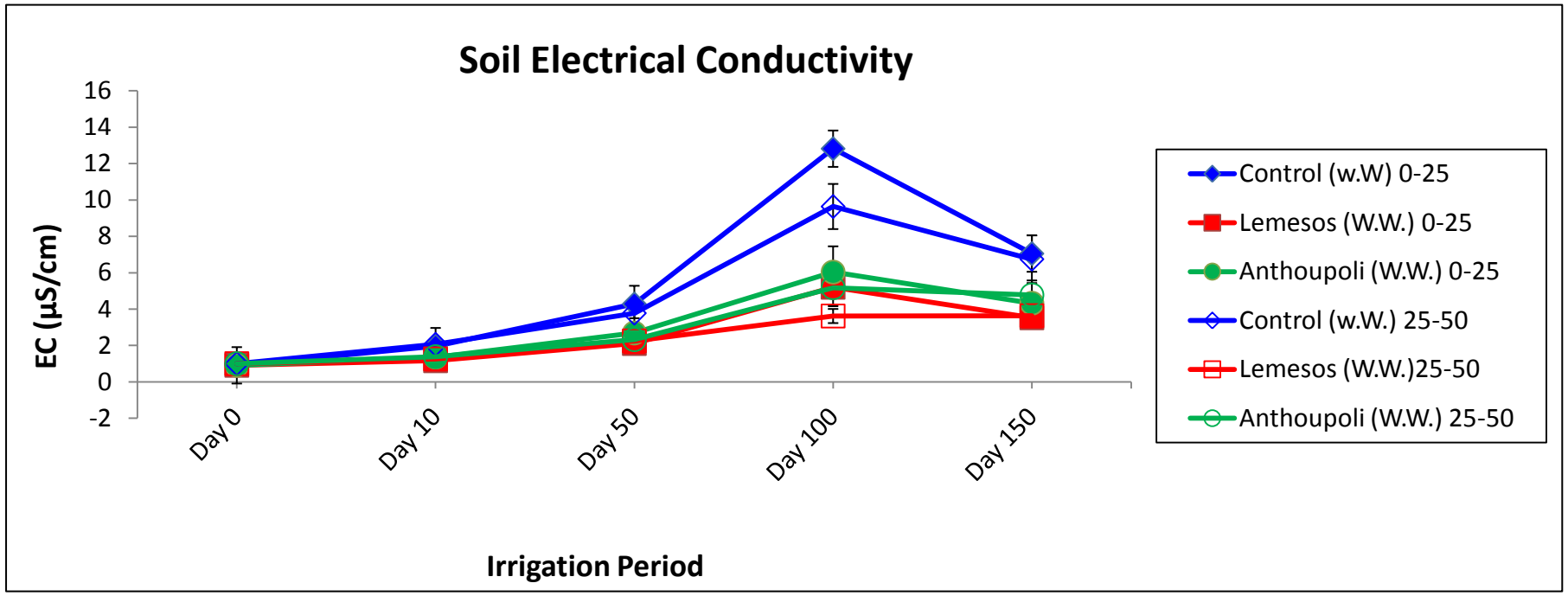
Tomato crop productivity:

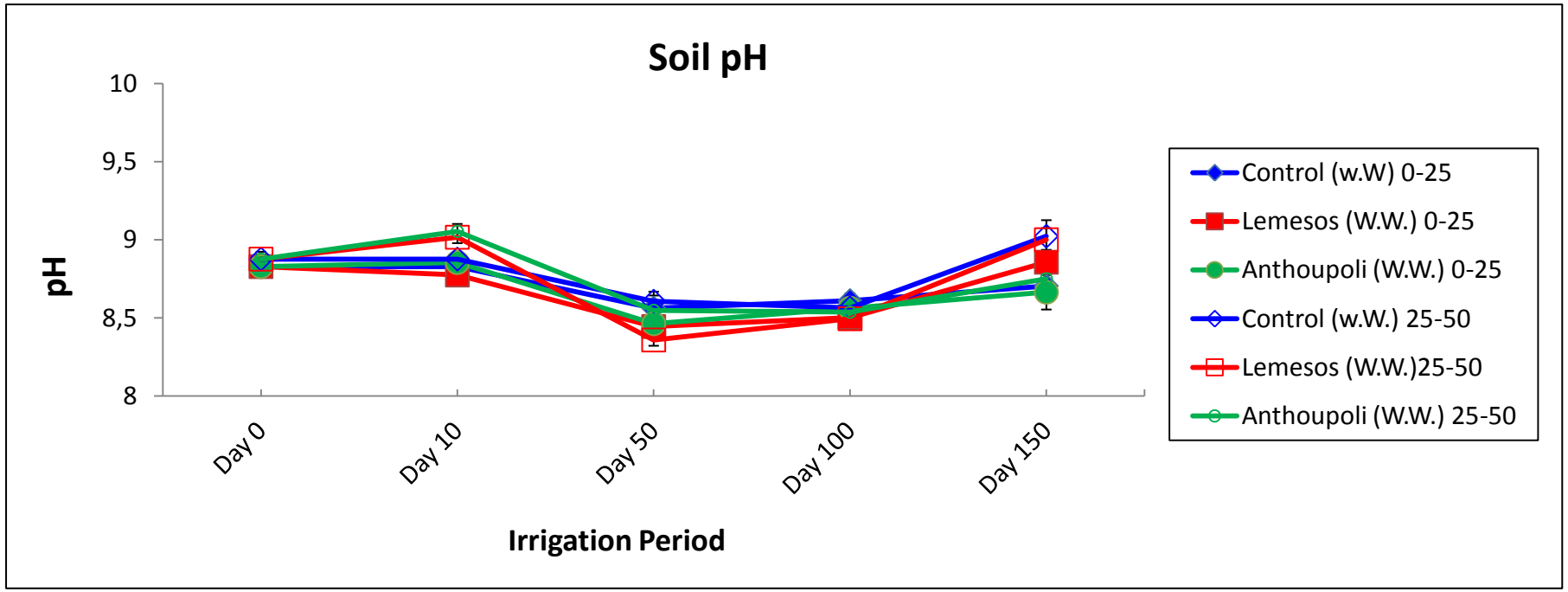
1. Mean fruit weight
2. Total weight in each harvest
3. Fruit max peripheral
4. Number of fruits in each harvest

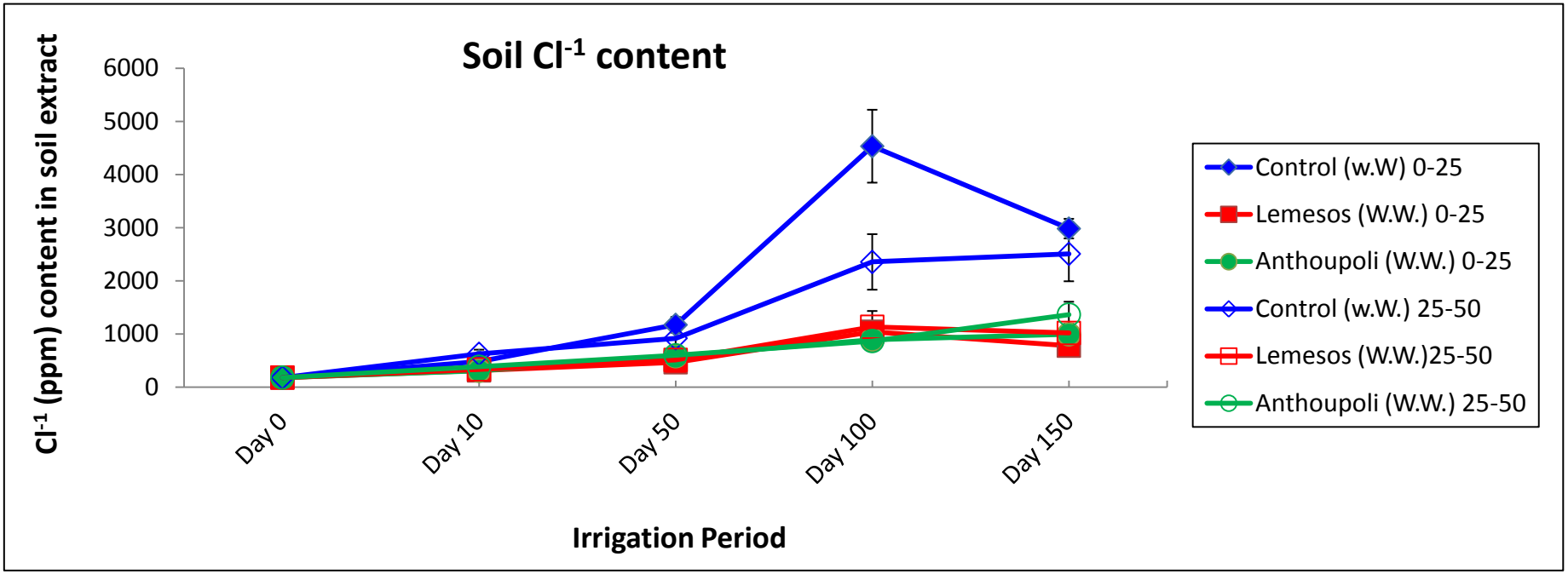
Tomato fruits:

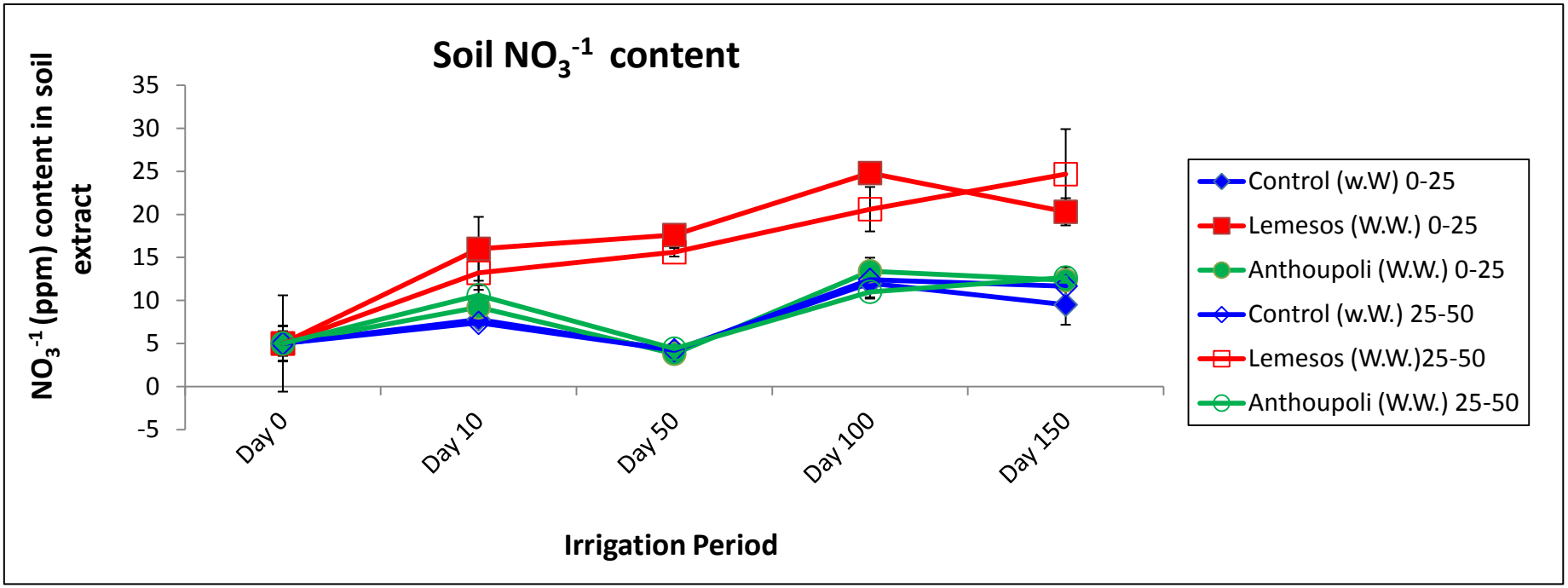
1. Heavy metal content
2. Microbial infection assay: in tomato fruit peel /or flesh
    1. Aerobic Plate Count cfu/g
    2. Total Coliforms cfu/g
    3. Fecal coliforms cfu/g

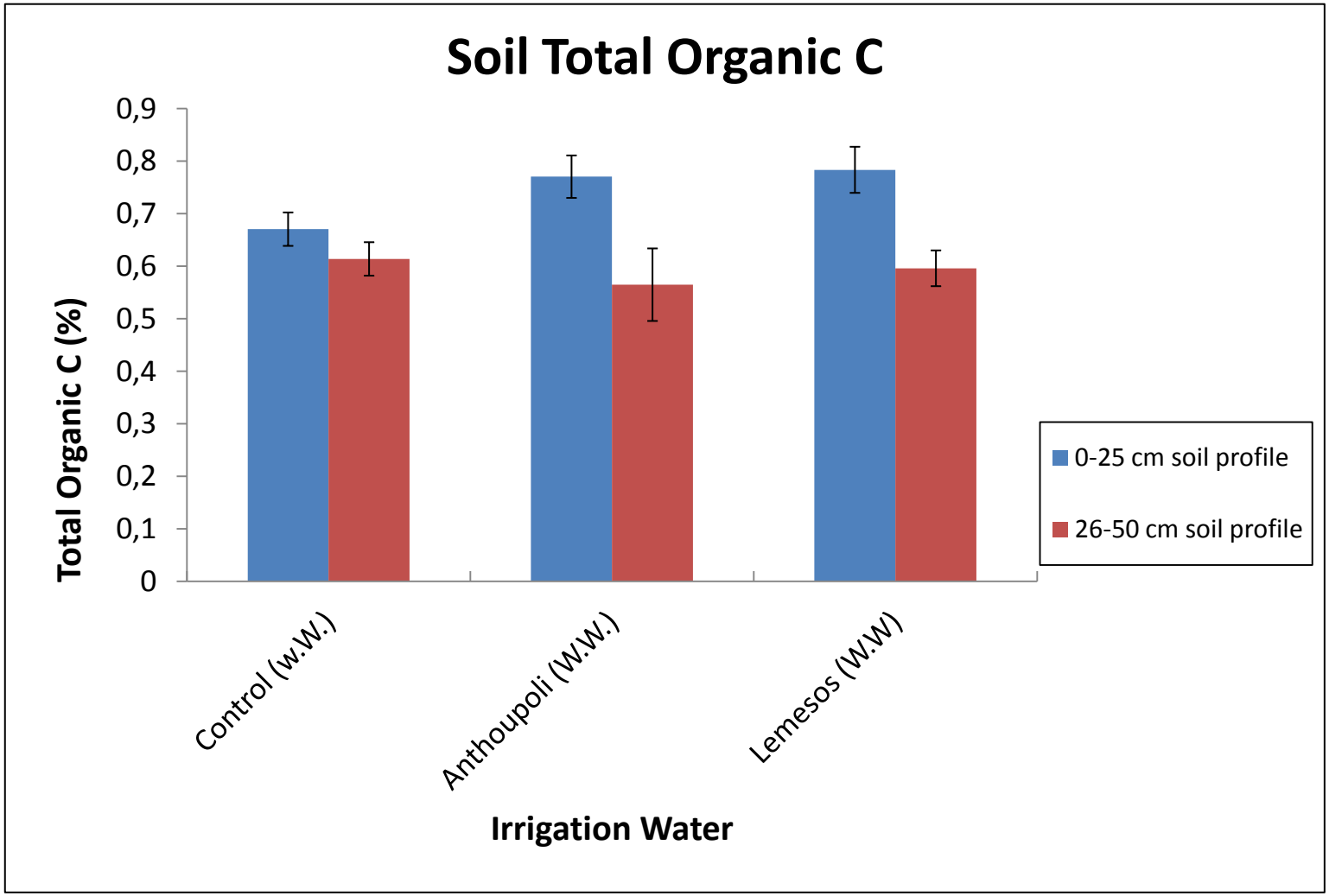
    in tomato fruit
    1. *Salmonellaspp. +ve/-ve in 25 g*
    2. *Listeria spp. +ve/-ve in 25 g*
    3. *E.coli 0157:H7 +ve/-ve in 25 g*


Soil Electrical Conductivity
EC (µS/cm)
16
14
12
10
8
6
4
2
0
-2
Day 0
Day 10
Day 50
Day 100
Day 150
Irrigation Period
Control (w.W) 0-25
Lemesos (W.W.) 0-25
Anthoupoli (W.W.) 0-25
Control (w.W.) 25-50
Lemesos (W.W.)25-50
Anthoupoli (W.W.) 25-50

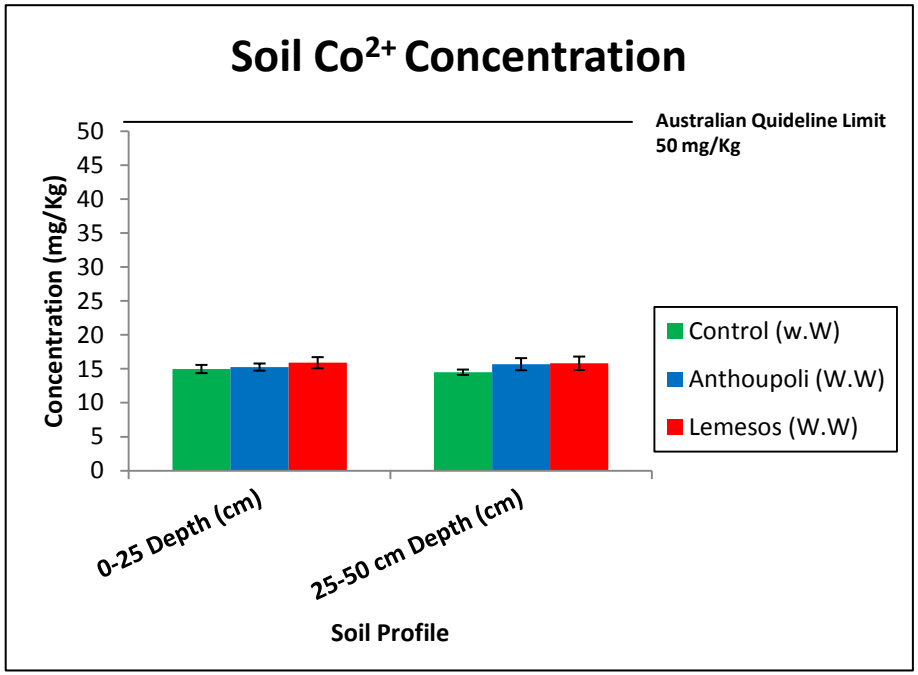

Soil pH
pH
10
9,5
9
8,5
8
Day 0
Day 10
Day 50
Day 100
Day 150
Irrigation Period
Control (w.W) 0-25
Lemesos (W.W.) 0-25
Anthoupoli (W.W.) 0-25
Control (w.W.) 25-50
Lemesos (W.W.)25-50
Anthoupoli (W.W.) 25-50

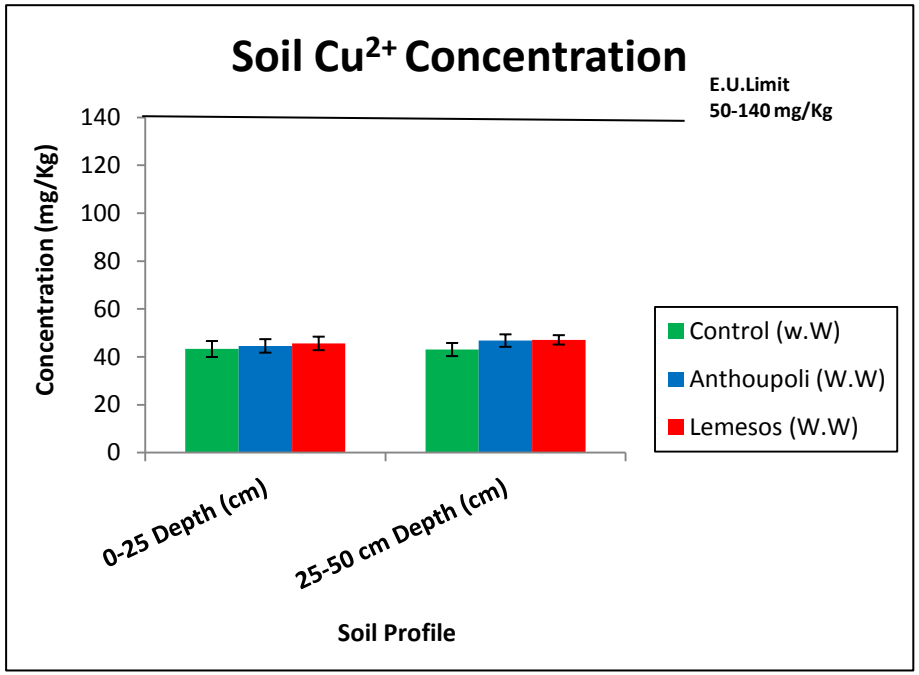

Soil Cl-1 content
Cl-1 (ppm) content in soil extract
6000
5000
4000
3000
2000
1000
0
Day 0
Day 10
Day 50
Day 100
Day 150
Irrigation Period
Control (w.W) 0-25
Lemesos (W.W.) 0-25
Anthoupoli (W.W.) 0-25
Control (w.W.) 25-50
Lemesos (W.W.)25-50
Anthoupoli (W.W.) 25-50

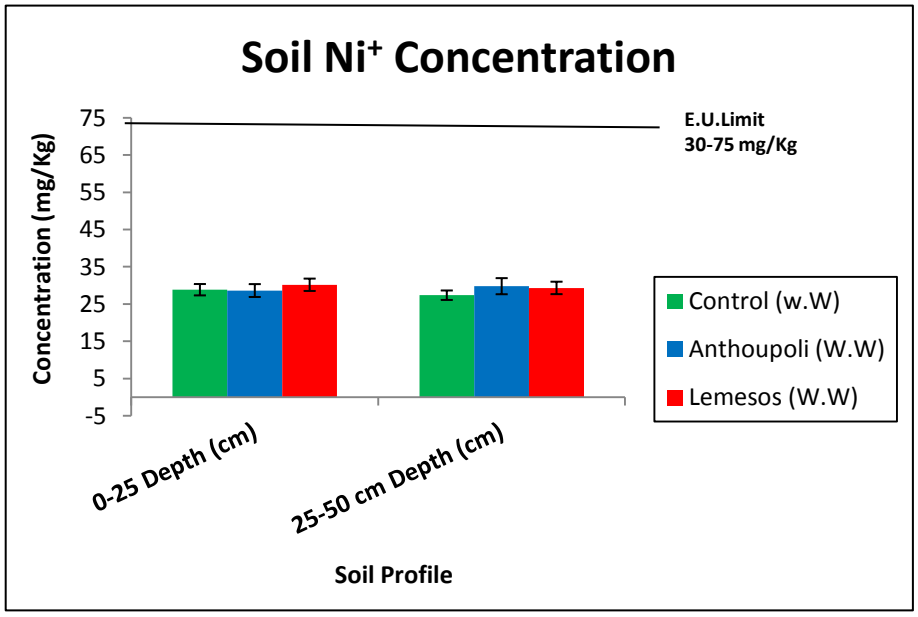

Soil NO3-1 content
NO3-1 (ppm) content in soil extract
35
30
25
20
15
10
5
0
-5
Day 0
Day 10
Day 50
Day 100
Day 150
Irrigation Period
Control (w.W) 0-25
Lemesos (W.W.) 0-25
Anthoupoli (W.W.) 0-25
Control (w.W.) 25-50
Lemesos (W.W.)25-50
Anthoupoli (W.W.) 25-50

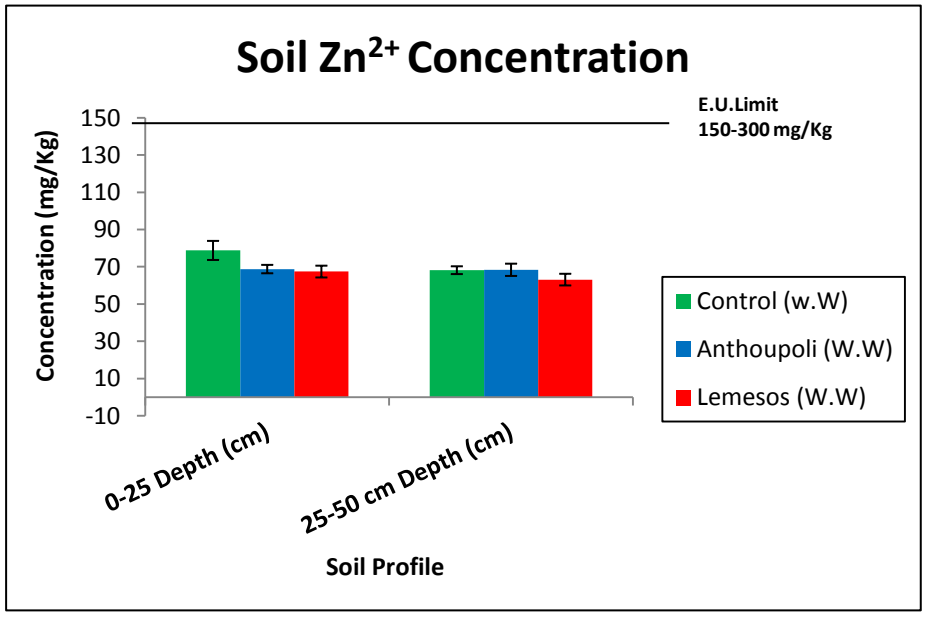

Soil Total Organic C
Total Organic C (%)
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0
Control (w.W.)
Anthoupoli (W.W.)
Lemesos (W.W)
Irrigation Water
0-25 cm soil profile
26-50 cm soil profile

Soil heavy metal content

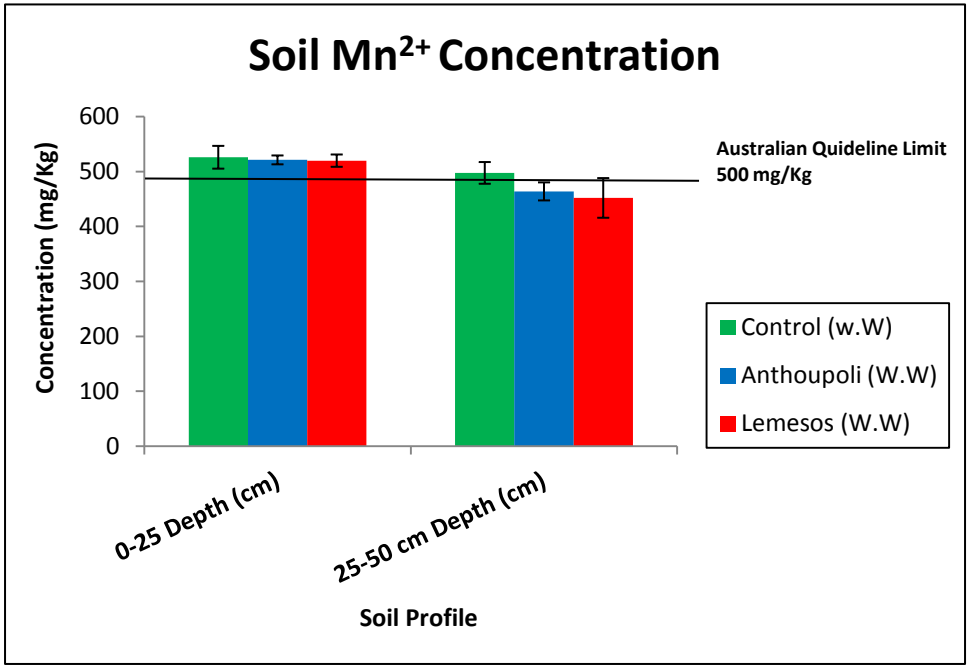








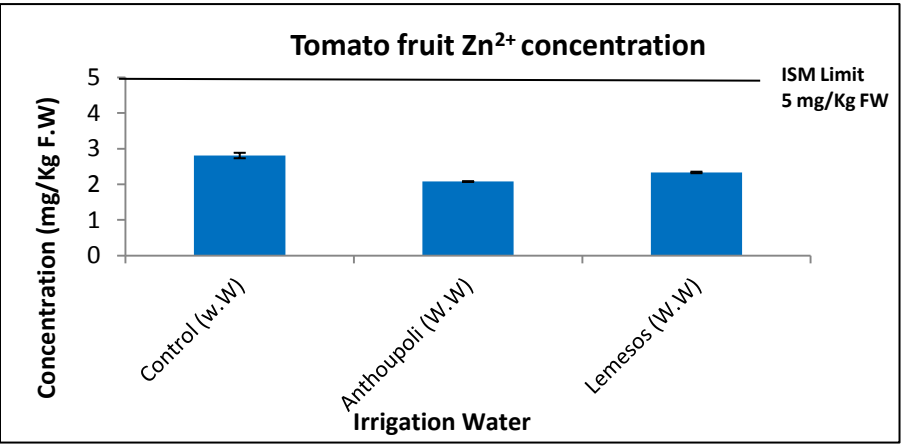
Soil heavy metal content

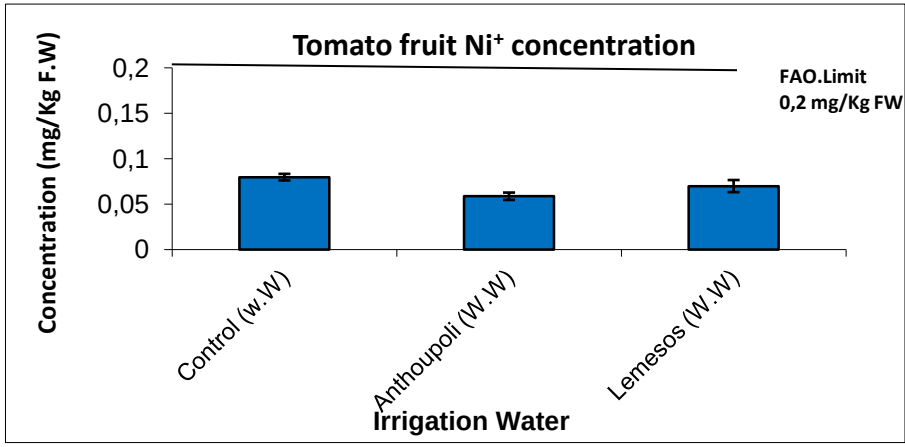


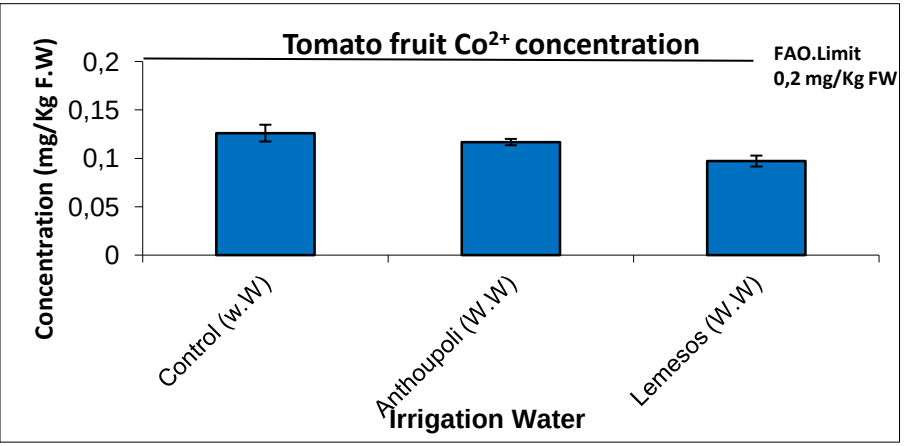
Heavy metal concentrations (mg/Kg) in 0-25 cm and 25-50 cm soil profile

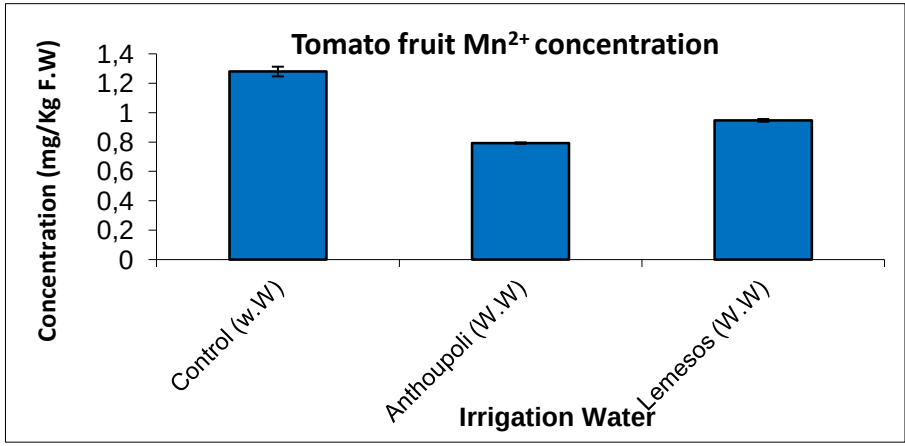
	0-25			25-50		
	Control (w.W)	Anthoupoli (W.W)	Lemesos (W.W)	Control (w.W)	Anthoupoli (W.W)	Lemesos (W.W)
Co	14.98±0.60	15.26±0.39	15.90±0.82	14.50±0.53	15.68±0.89	15.81±0.99
Cu	43.28±3.35	44.58±2.74	45.62±2.81	43.06±2.82	46.80±2.61	47.10±1.96
Ni	28.84±1.53	28.62±1.27	30.16±1.66	27.36±1.73	29.78±2.16	29.32±1.67
Zn	78.77±5.12	68.77±2.09	67.42±3.17	68.16±2.26	68.36±3.29	63.10±3.14
Mn	526.05±20.73	521.28±19.80	519.88±11.20	497.56±8.08	463.89±16.39	451.98±36.14
Fe	33829.25±1125.82	33493.17±978.98	32836.57±685.81	31895.77±676.11	29200.34±522.42	28042.05±1302.57

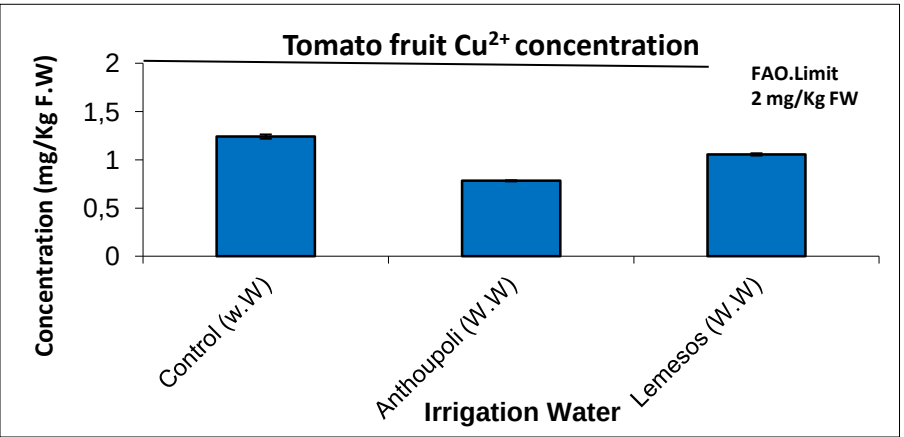
Tomato fruit heavy metal content

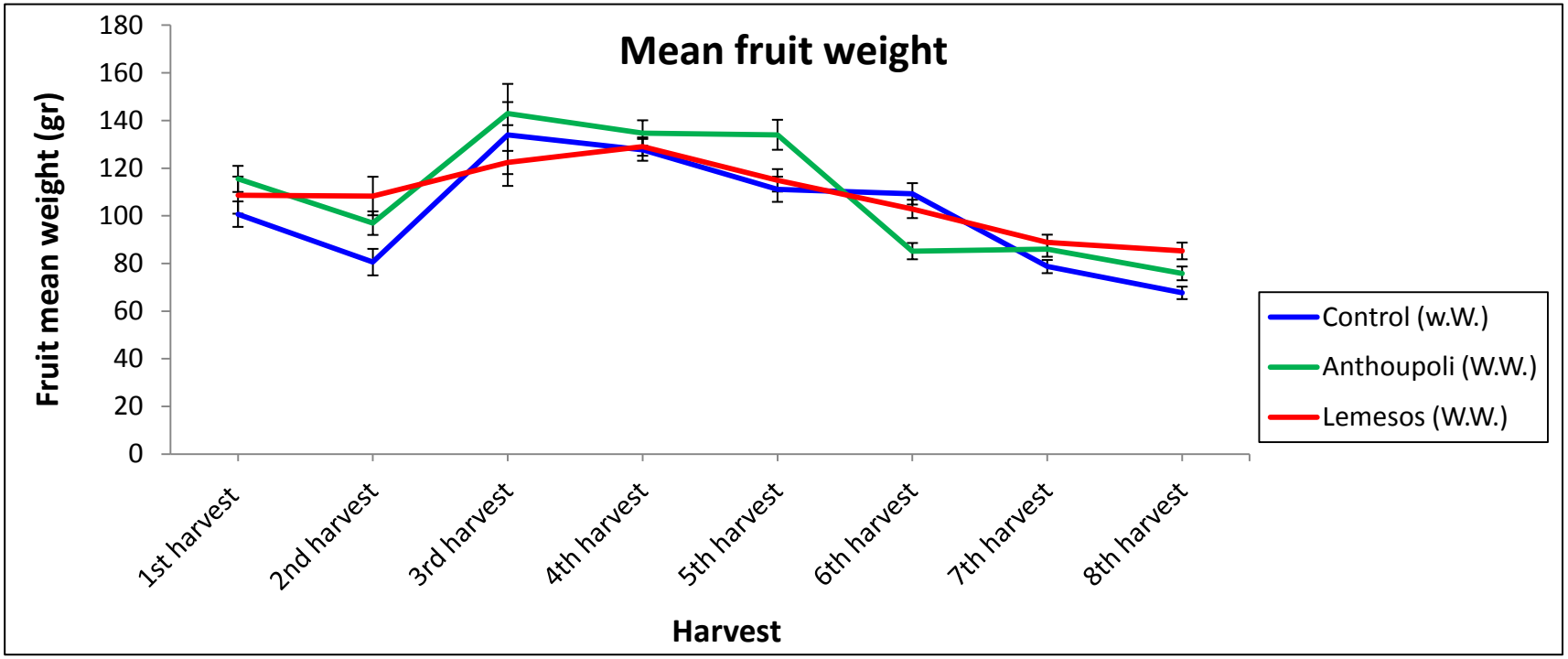


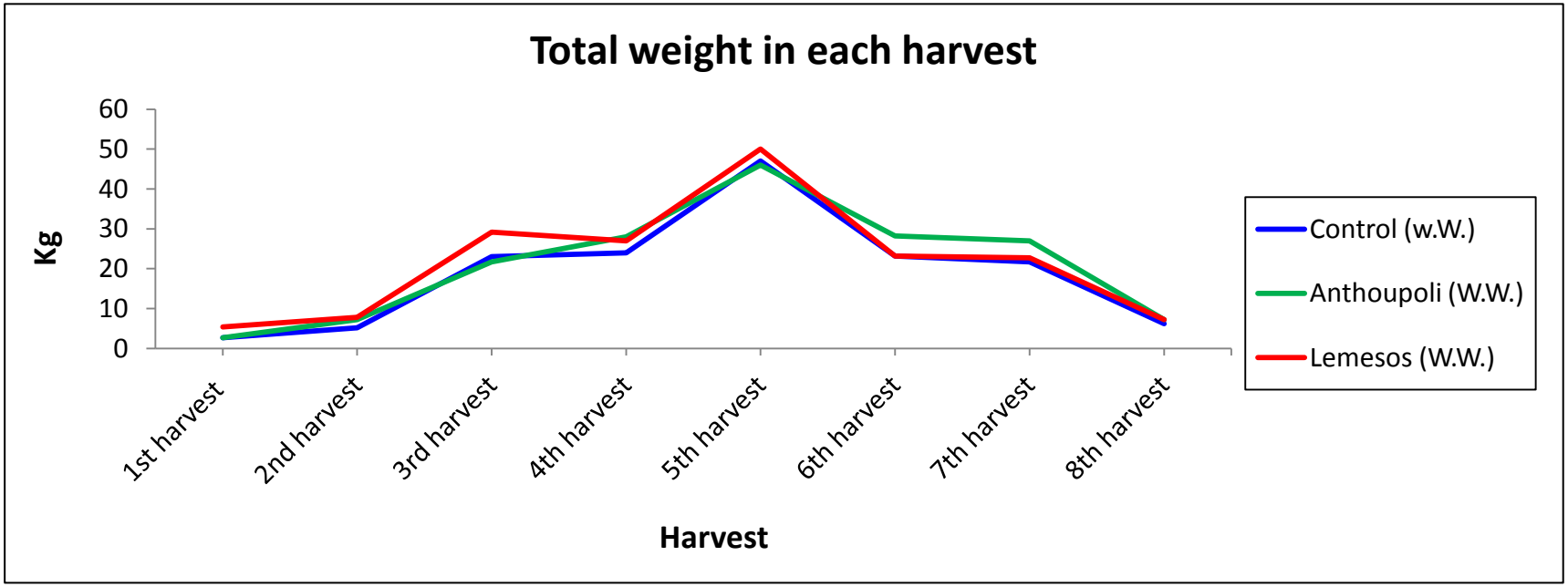


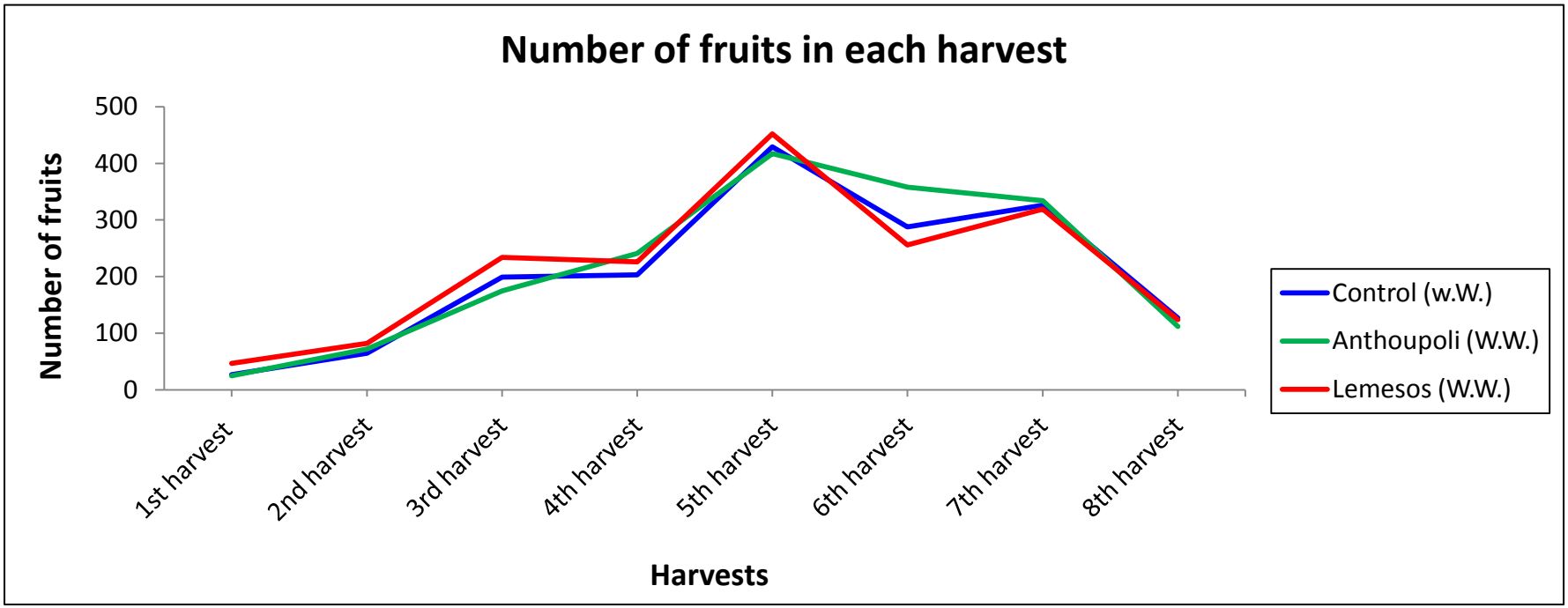


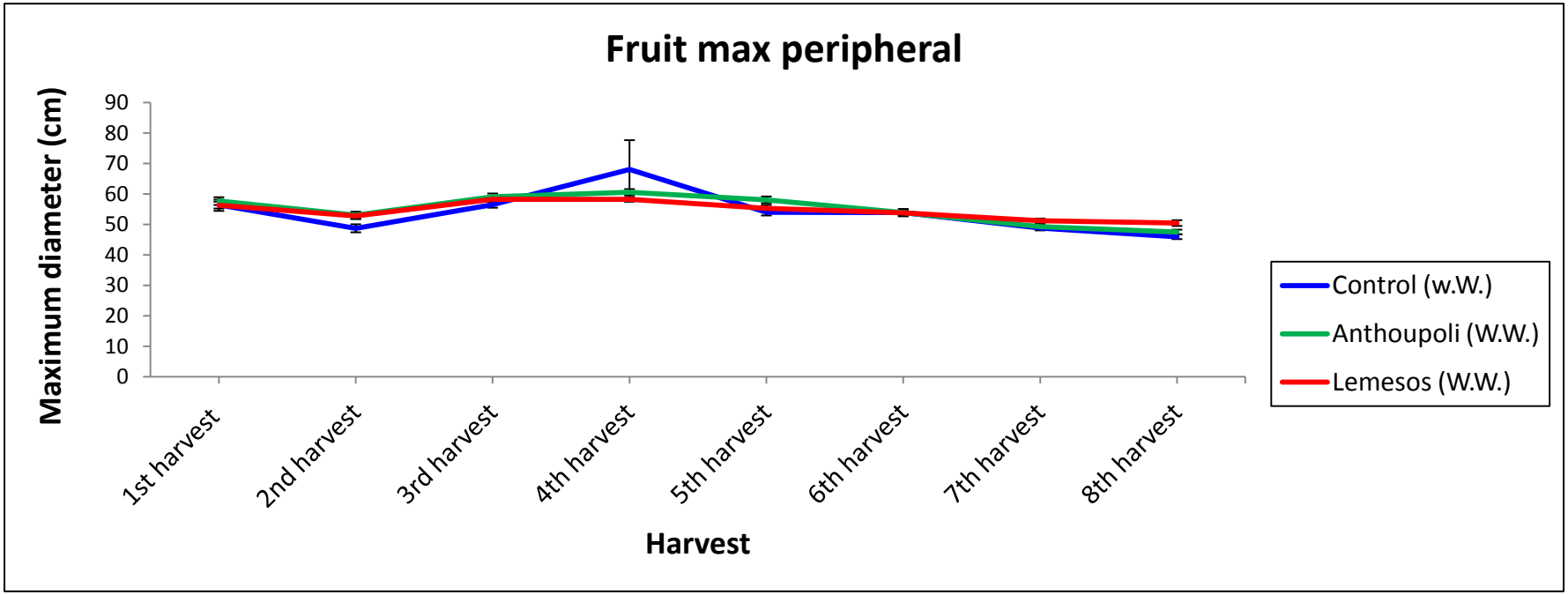





Mean fruit weight
Fruit mean weight (gr)
180
160
140
120
100
80
60
40
20
0
1st harvest
2nd harvest
3rd harvest
4th harvest
5th harvest
6th harvest
7th harvest
8th harvest
Harvest
Control (w.W.)
Anthoupoli (W.W.)
Lemesos (W.W.)


Total weight in each harvest
Kg
60
50
40
30
20
10
0
1st harvest
2nd harvest
3rd harvest
4th harvest
5th harvest
6th harvest
7th harvest
8th harvest
Harvest
Control (w.W.)
Anthoupoli (W.W.)
Lemesos (W.W.)


Number of fruits in each harvest
Number of fruits
500
400
300
200
100
0
1st harvest
2nd harvest
3rd harvest
4th harvest
5th harvest
6th harvest
7th harvest
8th harvest
Harvests
Control (w.W.)
Anthoupoli (W.W.)
Lemesos (W.W.)


Fruit max peripheral
Maximum diameter (cm)
90
80
70
60
50
40
30
20
10
0
1st harvest
2nd harvest
3rd harvest
4th harvest
5th harvest
6th harvest
7th harvest
8th harvest
Harvest
Control (w.W.)
Anthoupoli (W.W.)
Lemesos (W.W.)

	Tomato fruit Peel			Tomato fruit flesh		
	Control (w.W.)	Anthoupoli (W.W.)	Lemesos (W.W.)	Control (w.W.)	Anthoupoli (W.W.)	Lemesos (W.W.)
Aerobic Plate Count cfu/g	278	530	810	20	20	20
Total Coliforms cfu/g	NON DETECTED	NON DETECTED	NON DETECTED	NON DETECTED	NON DETECTED	NON DETECTED
Fecal coliforms cfu/g	NON DETECTED	NON DETECTED	NON DETECTED	NON DETECTED	NON DETECTED	NON DETECTED

Microbial in total fruit			
	Control (w.W.)	Anthoupoli (W.W.)	Lemesos (W.W.)
Salmonella spp. +ve/-ve in 25 g	negative	negative	negative
Listeria spp. +ve/-ve in 25 g	negative	negative	negative
E.coli 0157:H7 +ve/-ve in 25 g	negative	negative	negative