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Effects of lateral depth and water applied on transport of *E. coli* in soil and residuals within plants and asparagus lettuce production for drip irrigation applying secondary sewage effluent

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***E. Coli* / asparagus lettuce / lateral depth / pan coefficient / subsurface drip irrigation**

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3. Results and discussion
4. Conclusions
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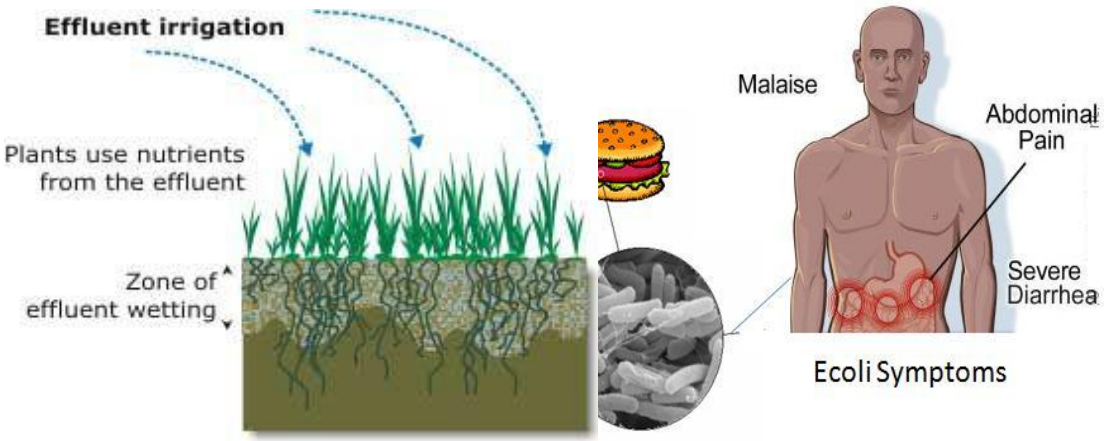
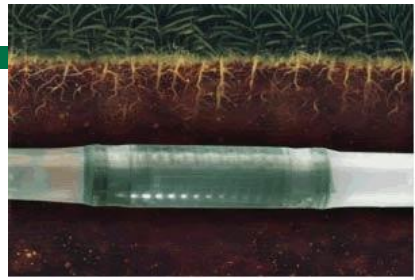
1. Introduction

Water scarcity and the potential risk of wastewater reuse

- **Water scarcity** and droughts are emerging as major issues worldwide.
- **Reuse of wastewater** is practiced not only in dry and water deficient areas, but in water abundant regions as well.
- Reuse of wastewater involves both **health and environmental risks.**



1. Introduction



Irrigation regime influences bacterial transportation and crop yield

- **Subsurface drip can avoid direct contact between wastewater and plants, thus reducing health and environmental risks (Campos et al., 2000).**
- **Ayars et al. (1999) demonstrated significant increases in yield and water use efficiency for all their research crops when applying subsurface drip irrigation.**

Objectives

- **To study the effects of lateral depth and irrigation water applied on *E. coli* distribution in soil and asparagus lettuce when applying secondary effluent**
- **To compare the production of asparagus lettuce and give recommendations for management of drip irrigation systems**

2. Materials and methods

Experimental design

➢**Experimental field**

- **Field experiments were conducted in a solar heated greenhouse of 50 m in length and 8 m wide.**
- **The soil was sandy loam with a bulk density of 1.44 g/cm^3, a field capacity of 0.33 cm^3/cm^3 and a permanent wilting point of 0.15 cm^3/cm^3.**

➢**Experiment design**

- **Lateral depth: 0 cm (D0), 10 cm (D1), and 20 cm (D2)**
- **Irrigation level: Pan coefficient of 0.6 (I1), 0.8 (I2) and 1.0 (I3)**
- **Water quality : Secondary sewage effluent and Groundwater**
- **Three replicates were used for each treatment**
- **A total of 36 plots**

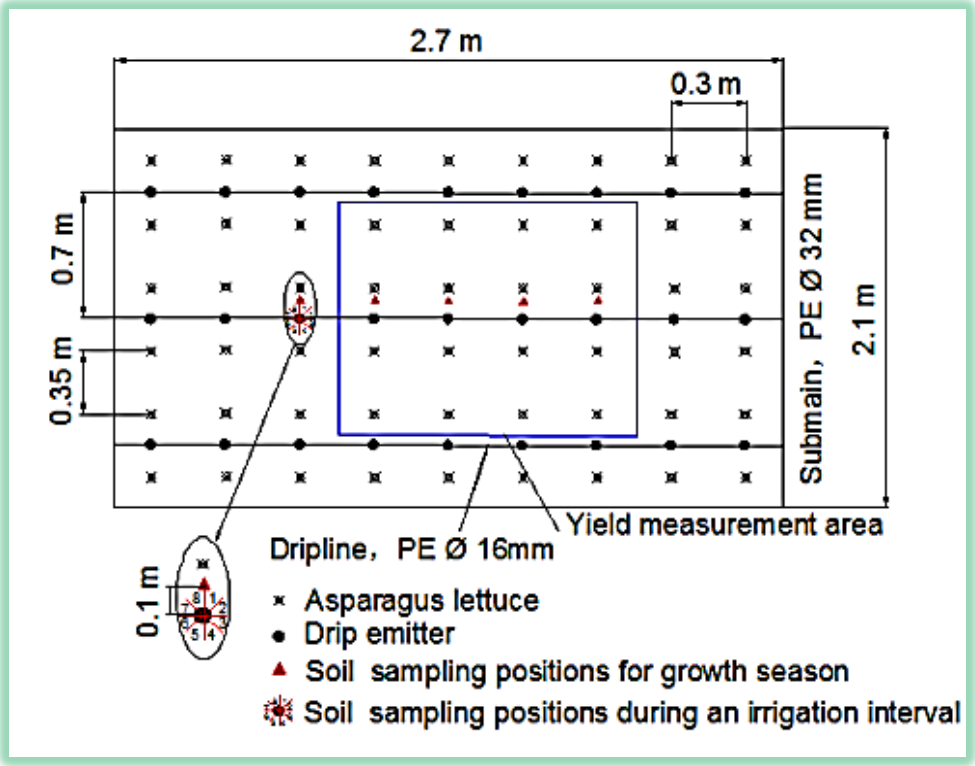
2. Materials and methods

Asparagus lettuce

- A row spacing **35 cm** and a plant spacing of **30** cm
- **16** Asparagus lettuces in each plot were weighed for production analysis.

Sample collection

- The growth season: **28 August – 31 October**
- **36 points** one time
- **Four depths** for each point: 0 to 10 cm, 10 to 20 cm, 20 to 30 cm, and 30 to 40 cm
- **Aseptic sampling**

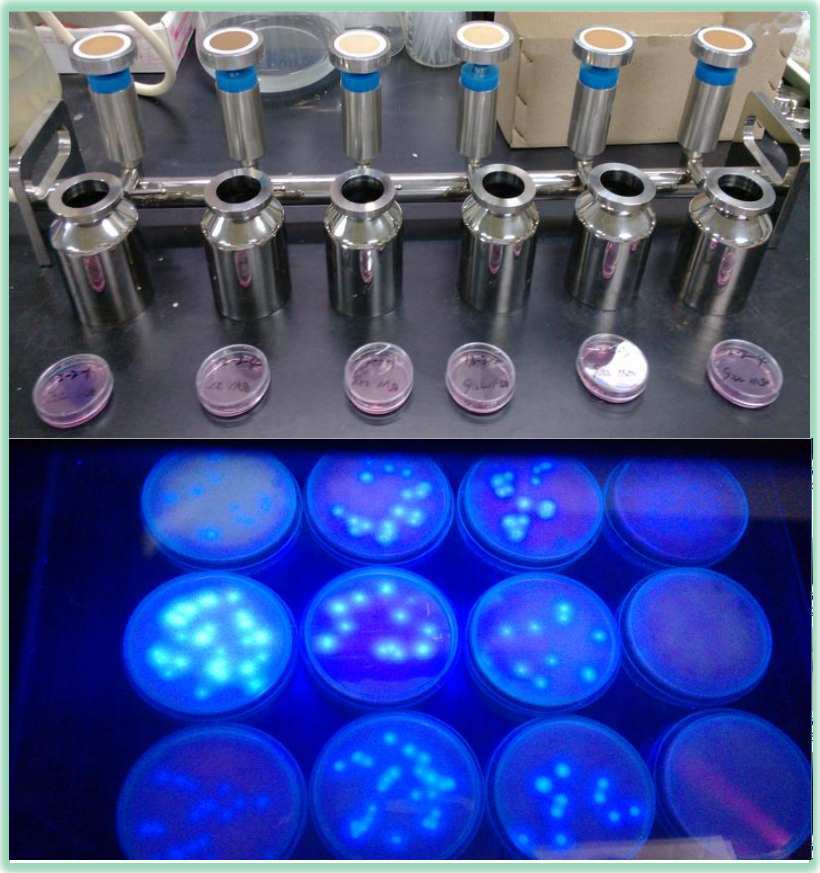


Layout of driplines and sampling positions

2. Materials and methods

Enumeration of *E. coli*

- **1 g soil was transferred into 10 mL PBS (**sterile phosphate-buffered solution**) and mixed uniformly**
- **5 g asparagus lettuce was transferred into 50 mL PBS and mixed uniformly**
- **Membrane filter method**
- **Cultivation and enumeration**



Filtration and enumeration

2. Materials and methods

Environmental conditions and irrigations

- The temperature decreased with time.
- The evaporation also showed a slightly decreasing trend.
- In total, six irrigations were applied during the entire growth season.

Date	Water applied (mm)		
	I 1	I 2	I 3
13-Sep	17.4	24.0	30.0
20-Sep	12.0	16.1	20.2
27-Sep	9.0	12.1	15.1
10-Oct	12.1	16.8	21.0
18-Oct	12.5	17.0	21.4
28-Oct	12.0	16.0	20.0
Sum	75.0	102.0	127.7

2. Materials and methods

Water source	Date	Water quality (mg/L)					
		COD_{Cr}	BOD_5	TN	TP	TSS	Cl^-
Secondary effluent	27-Sep	4.7	2.1	10.6	3.57	29	158
	10-Oct	5.1	2.5	10.4	3.50	45	162
	19-Oct	4.6	1.9	10.2	3.16	13	168
Groundwater	27-Sep	2.6	1	0.12	0.056	16	23.7

Date	*E. coli* (CFU/100 mL)					
	13-Sep	20-Sep	27-Sep	10-Oct	18-Oct	28-Oct
E. coli in effluent	700	0	1100	600	900	500
E. coli in groundwater	0	0	0	0	0	0

3. Results and discussion

- Few *E. coli* were detected in soil prior to transplanting (26-Aug) and after harvest (1-Nov).
- Relatively more *E. coli* in soil were detected just after the irrigation ceased (18-Oct).
- Few *E. coli* detected in lettuce leaves and no *E. coli* in stems on harvest.

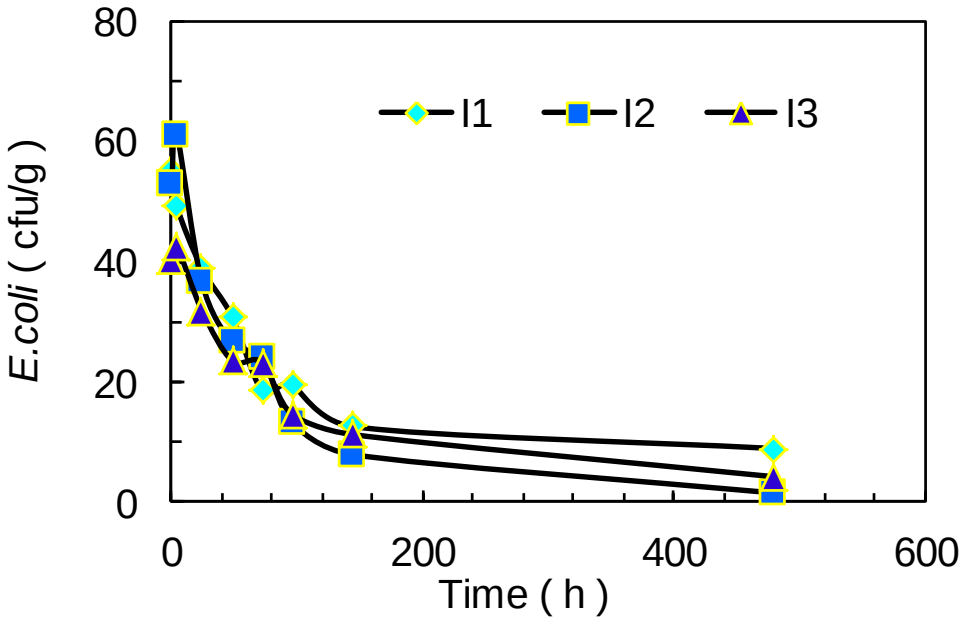
Source	Sampling date	Depth (cm)	No. of *E. coli* positive samples	Total no. of samples	Maximum of *E. coli* (cfu/g)	Treatment of the maximum *E. coli*
Soil	26-Aug	0-10	1	36	1	I3D0
		10-20	0	36	0	
		20-30	0	36	0	
		30-40	0	36	0	
	7-Oct	0-10	1	36	1	I2D0C
		10-20	0	36	0	
		20-30	0	36	0	
		30-40	0	36	0	
	18-Oct	0-10	9	36	35	I3D0
		10-20	8	36	34	I3D2
		20-30	2	36	10	I3D3
		30-40	1	36	1	I2D1C
	1-Nov	0-10	3	36	1	I2D0
		10-20	0	36	0	
		20-30	0	36	0	
		30-40	1	36	1	I2D1C
Asparagus lettuce	1-Nov	Leaves	6	108	1	I1D0
		Stems	0	108	0	

E. coli distribution in soil and asparagus lettuce samples

3. Results and discussion

Decay of E. coli in the soil following an irrigation

- The concentration of *E. coli* in effluent was 1100 CFU/100 mL.
- *E. coli* decreased from 50-60 CFU/g to less than 15 CFU/g within an irrigation interval about a week.
- The irrigation level has no statistically significant effect on *E. coli decay.*



E. coli decay in the 10 cm surface soil after an irrigation ceased

3. Results and discussion

Production

- The production for all treatments ranged from 42 to 51 t/ha.
- A general increasing tendency of yield with lateral depth.
- A slightly higher average yield (9%) for the treatments irrigated with effluent than that for the groundwater irrigation.
- Experimental factor has no statistically significant effect on production of asparagus lettuce.

Treatments	Single plant weight (g)	Yield (t/ha)
I1D0	492 a	43 a
I1D1	530 a	46 a
I1D2	496 a	50 a
I2D0	504 a	48 a
I2D1	539 a	51 a
I2D2	538 a	51 a
I3D0	538 a	47 a
I3D1	455 a	50 a
I3D2	479 a	47 a
I2D0C	436 a	42 a
I2D1C	496 a	47 a
I2D2C	506 a	48 a
Two-way analysis of variance		
Irrigation level	I	NS (P=0.97)
Lateral depth	D	NS (P=0.54)
Irrigation level	I	NS (P=0.99)
Water quality	C	NS (P=0.67)

Asparagus lettuce yield and variance analysis

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4. Conclusions

- **Subsurface drip irrigation is efficient in preventing *E. coli* contamination on soil surface.**

- ***E. coli* increased in the surface 10 cm soil layer after applying sewage effluent through surface drip irrigation, and the count was decreased to a low level within an irrigation interval of one week.**

- **There was no elevated risk of *E. coli* contamination of asparagus lettuce irrigated by either surface or subsurface drip irrigation with sewage effluent.**

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4. Conclusions

- The subsurface drip irrigation treatments at a pan coefficient of 0.8 produced a higher yield.

- Drip irrigation applying sewage effluent produced a higher yield than groundwater irrigation.

- The result obtained from this research suggests that subsurface drip irrigation with secondary sewage effluent is effective in reducing E. coli contamination in soil and within plants and improving asparagus lettuce production.

5. Acknowledgement

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Thank you for your attention !