EFFECTS OF SEWAGE WASTE WATER ON MORPHOPHYSIOLOGY AND YIELD OF *SPINACIA* AND *TRIGONELLA*

N.A. KHAN, L. GUPTA, S. JAVID, S. SINGH, M. KHAN, A. INAM AND SAMIULLAH

Department of Botany, Aligarh Muslim University, Aligarh–202002, India

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SUMMARY

An experiment was conducted to evaluate the use of sewage waste water on morphophysiology and yield of two leafy vegetables, spinach (*Spinacia oleracea*) and methi (*Trigonella foenum-graecum*). Sewage waste water application increased chlorophyll a, b and total chlorophyll content, photosynthetic rate, photosynthetic water use efficiency, growth and yield. Physico-chemical characteristics of sewage waste water met the irrigation quality requirements and were within the permissible limits.

***Key words*: Morphophysiology, photosynthetic water use efficiency, sewage waste water, *Spinacia*, *Trigonella*.**

INTRODUCTION

There has been a strong global awakening during the last few decades regarding the proper management of existing natural resources. Among them, irrigation water is one which is becoming costlier due to increasing demand of human population. Simultaneously the demand for food is also increasing, which has brought more and more land under cultivation and focused our attention on fertilizers and irrigation water. With these certain limitations, one has to turn to non-conventional resources to meet the irrigation water demand. Among others, one of the most important irrigation as well as nutrient resource is municipal waste water, which consists of about 99% water and the rest as organic and inorganic nutrients. Since, its disposal is a big problem in urban areas, applying sewage waste water to agricultural fields instead of disposing off in lakes and rivers can make crops grow better due to presence of various nutrients like N, P, Ca, Mg etc. There can be both beneficial and damaging effects of irrigation with waste water on various crops including vegetables. The need is to assess waste water quality and plant species requirements before using treated waste water for crop production (Yoshida and Islam 1996).

MATERIALS AND METHODS

An experiment was conducted in 1999-2000 at the Department of Botany, Aligarh Muslim University, Aligarh, India to evaluate the impact of sewage waste water on morphophysiology and yield of two leafy vegetables, spinach (*Spinacia oleracea* L.) and methi (*Trigonella foenum-graecum* L.). Seeds of both the crops were sown in pots in two sets, one receiving waste water and other ground water. The sewage waste water was collected from the municipal waste water drain going along the Mathura road, Aligarh. This drain is the main irrigation source for cultivation of vegetables in the area. The water and soil were analysed for various physico-chemical characteristics following the method described elsewhere (Ghosh *et al.* 1983). Plant sampling was done at 50 and 80 days after sowing to assess the effect in terms of growth (Shoot length, leaf number, leaf area, fresh weight and plant dry weight) expressed on per plant basis. Chlorophyll a, b, total chlorophyll, net photosynthesis rate, stomatal conductance and photosynthetic water use efficiency were also determined at these stages. Chlorophyll content was estimated by the method of Mac Kinney (1941). Leaf area was calculated gravimetrically. Leaf area of about 10% of the total leaves from each pot was determined by outlining the leaves on graph paper and dry weight of these leaves was recorded. The leaf area per plant was computed using the leaf dry weight per plant and dry weight of those leaves for which the area was estimated (Watson 1958). Total plant dry weight was recorded by drying the plants at 80°C till constant weight. Net photosynthesis rate and stomatal conductance of leaves were measured by LI-COR 6200 portable photosynthesis system. The leaves of same age were selected and photosynthesis measurement was done at saturating photosynthetic active radiation (1100 µmol/ m^2/s) between 1100-1200 h. The photosynthetic water use efficiency was calculated by using the data on photosynthetic rate and stomatal conductance (Das *et al.* 1999). Yield components were determined at maturity. Data were analysed and standard deviation (SD) was calculated (Gomez and Gomez 1984).

RESULTS

The irrigation water analysis showed that the pH of sewage waste water and ground water was near to neutral. Sewage waste water showed low dissolved oxygen, higher chloride content and contained more essential plant nutrients like N, P, K and Ca etc. as compared to ground water (Table 1). The soil analysis showed minor difference in pH of the soil taken before sowing and after harvest. There was only marginal decrease in nitrogen and phosphorus content while potassium was almost unchanged in soil applied with sewage waste water. In case of ground water N, P and K were decreased more after harvest. Similarly, application of sewage waste water resulted in the increase in CEC and organic carbon as compared to ground water (Table 2).

Table 1. Physico-chemical properties of irrigation water. (All determinations in mg l^{-1} except pH) (Mean ± SD)

Parameters	Analysis of irrigation water Ground water	Waste water
PH	7.00±1.24	6.70±1.02
Dissolved oxygen	7.40±1.10	2.30±1.01
Chloride	66.00±3.46	136.00±2.92
Hardness	110.00±5.20	330.00±6.02
Nitrate	0.60±0.12	9.01±1.24
Phosphate	0.13±0.01	2.01±0.12
Potassium	10.00±1.02	17.00±1.62
Calcium	14.90±1.82	156.12±1.14
Magnesium	55.90±1.42	132.00±1.02
Bicarbonate	68.90±2.84	694.00±3.26
Total dissolved solids	551.00±10.56	2426.00±12.42

In general, all the growth and yield characteristics of both the crops were increased with sewage waste water application, as is evident from increased leaf number, leaf area, shoot length and dry matter accumulation (Table 3). Sewage waste water application resulted into increase in plant dry weight by 12.5% and 40.5% in *Spinacia* and 29.2% and 30% in *Trigonella* at 50 and 80 days respectively. Greening of plants was enhanced by sewage

Table 2. Physico-chemical properties of experimental soil (Mean ±SD)

Parameters	Analysis of experimental soil: Ground water Before sowing	Ground water After harvest	Waste water Before sowing	Waste water After harvest
pH	7.01±0.11	7.03±0.10	7.02±0.21	7.08±0.14
Phosphorus (kg ha^{-1})	12.30±2.21	10.25±2.61	12.18±2.11	11.95±2.40
Nitrogen (kg ha^{-1})	136.2±3.46	112.5±2.85	137.3±3.46	134.4±2.88
Potassium (kg ha^{-1})	61.06±2.18	54.4±1.86	60.26±1.28	60.13±1.60
Organic matter (%)	0.36±0.01	0.20±0.02	0.35±0.01	1.29±0.10
CEC (meq100g^{-1} soil)	2.76±0.02	2.40±0.10	2.78±0.14	3.42±0.20

waste water application and thus chlorophyll content of *Spinacia* was increased by 21.6% 52.2% and that of *Trigonella* by 17.9% and 18.3% at 50 and 80 days respectively (Table 4). The chlorophyll a/b ratio was 2.0 and 1.3 under sewage waste water treatment in *Spinacia* and *Trigonella* respectively at 50 days, while at 80 days stage, the chlorophyll a/b ratio was 4.5 in *Spinacia* and 1.2 in *Trigonella*. The sewage waste water application increased net photosynthetic rate and photosynthetic water use efficiency compared to ground water application (Fig. 1). The increase recorded at 50 days was 71.6% and 54.9% in *Spinacia* and *Trigonella*, while at 80 days stage, the increment was 51.8% and 62.6% respectively for net photosynthesis. The photosynthetic water use efficiency

Table 3. Effect of sewage waste water on growth parameters of spinach (*Spinacia oleracea* L.) and methi (*Trigonella foenum-graecum* L.) (Mean±SD)

Parameters	Spinach Ground water	Spinach Waste water	Methi Ground water	Methi Waste water
		50 d after sowing		
Leaf number plant^{-1}	7.36±0.27	7.60±0.27	5.05±0.47	6.08±0.47
Leaf area (cm^2 plant^{-1})	15.75±0.18	17.86±0.22	15.15±0.10	16.93±0.12
Shoot length (cm)	8.40±0.24	8.50±0.19	7.13±0.01	7.37±0.14
Fresh weight (mg plant^{-1})	776.60±2.47	853.32±2.94	165.0±0.47	206.6±0.27
Dry weight (mg plant^{-1})	120.26±10.2	165.51±5.48	18.6±0.27	26.3±0.54
		80 d after sowing		
Leaf number plant^{-1}	25.00±0.47	31.36±0.72	7.65±0.27	9.59±0.72
Leaf area (cm^2 plant^{-1})	63.50±1.24	116.03±2.4	23.56±2.1	35.20±0.18
Shoot length (cm)	40.08±0.09	44.67±0.27	26.34±0.72	30.00±0.94
Fresh weight (mg plant^{-1})	5280.02±0.47	7510.02±0.94	1330.0±0.15	1930.0±0.08
Dry weight (mg plant^{-1})	800.0±0.47	1190.06±0.47	306.63±0.72	420.05±0.47

Table 4. Effect of sewage waste water irrigation on chlorophyll contents (mg g^{-1} leaf fresh weight) of spinach (*Spinacia oleracea* L.) and methi (*Trigonella foenum-graecum* L.) (Mean ± SD)

Parameters	Spinach Ground water	Spinach Waste water	Methi Ground water	Methi Waste water
		50 d after sowing		
Chlorophyll a	0.48±0.01	0.52±0.02	0.64±0.005	0.75±0.003
Chlorophyll b	0.19±0.008	0.26±0.01	0.50±0.003	0.62±0.005
Chlorophyll a + b	0.67±0.009	0.78±0.008	1.14±0.004	1.37±0.005
		80 d after sowing		
Chlorophyll a	0.52±0.02	0.63±0.003	0.70±0.001	0.84±0.004
Chlorophyll b	0.26±0.001	0.49±0.002	0.53±0.005	0.68±0.004
Chlorophyll a + b	0.78±0.001	1.12±0.009	1.23±0.007	1.52±0.02

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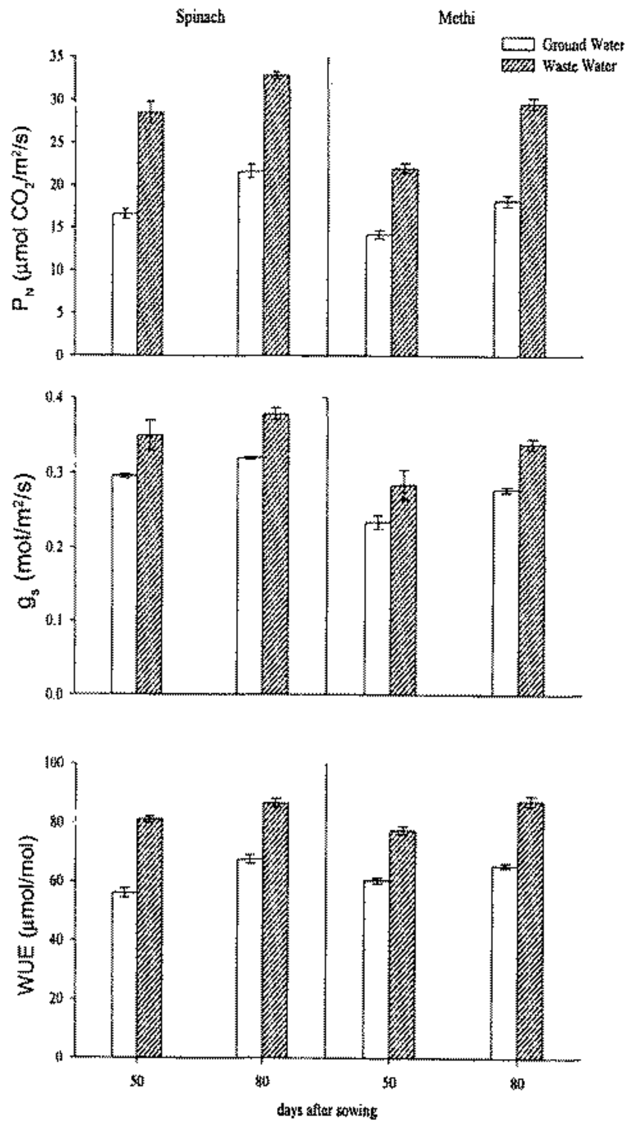

Fig.1. Effect of sewage waste water on net photosynthetic rate (P_N), stomatal conductance (gs) and photosynthetic water use efficiency (WUE) of spinach (*Spinacia oleracea* L.) and methi (*Trigonella foenum-graecum*) at 50 and 80 days after sowing

was increased by waste water application showing 53% and 24.2% more values in *Spinacia* and 28.2% and 33.3% in *Trigonella* at 50 and 80 days respectively (Fig. 1). Regarding the yield characteristics, sewage waste water proved beneficial and recorded an increase of 61% and 67% in seed yield per plant for *Spinacia* and *Trigonella* respectively (Table 5).

Table 5. Effect of sewage waste water on yield of spinach (*Spinacia oleracea* L.) and methi (*Trigonella foenum-graecum* L) (Mean ± SD)

Parameters	Ground water	Waste water
	Spinach	
Seed number plant^{-1}	113.3±0.48	146.6±0.62
100 seed weight (mg)	846.0±0.002	1050.0±0.47
Total biomass (mg plant^{-1})	1266.6±0.24	2963.3±0.46
Seed weight (mg plant^{-1})	955.98±66.8	1539.30±123.9
	Methi	
Pod number plant^{-1}	3.33±0.27	3.66±0.27
Seed number plant^{-1}	22.6±0.49	31.3±0.49
100 seed weight (mg)	470.13±0.35	570.27±0.36
Total biomass (mg plant^{-1})	425.0±0.47	516.6±0.71
Seed weight (mg plant^{-1})	106.22±12.8	178.42±15.3

DISCUSSION

A perusal of the data on both the vegetable crops showed that sewage waste water is beneficial for the growth and yield of the plants. This may be attributed to the presence of several essential plant nutrients like N, P, K, Ca and Mg present in the sewage waste water. In case of plants such as grasses and leafy vegetables, where mainly vegetative growth takes place, nitrogen plays an important role and stimulates the growth of stem and leaves. Thus increased nutrient concentration increased leaf number and leaf area by increasing cell size and number (Hewitt 1963, Gardner *et al.* 1985, Devlin and Witham 1986). Thus, the higher plant mineral nutrient status, larger leaf number and leaf area, higher concentrations of both chlorophyll a and b and enhanced net photosynthetic rate led to greater biomass production under sewage waste water treatment. The photosynthetic water use efficiency, a measure of carboxylation (Vanden Boogard *et al.* 1995) was also higher in waste water grown plants (Fig. 1). It may therefore, be suggested that sewage waste water acts as a supplement to the soil fertility, humus content, organic matter and mobile compounds of nutrients. These findings are in agreement with earlier reports of Iqbal *et al.* (1994), Nair and Hippalgaonkar

(1996), Veer and Lata (1997). Better growth finally resulted into higher seed yield.

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