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EFFECT OF GREYWATER (SOAP WATER) IRRIGATION ON GROWTH AND ROOT NODULES OF MEDICINAL PLANT (*SESBANIA GRANDIFLORA*) L.

RAFAT SAEED[1]*, AMEER AHMED MIRBAHAR[2], BUSHREEN JAHAN[1] AND AFSHEEN ZEHRA[1]

[1*]*Department of Botany, Federal Urdu University of Arts, Science and Technology, Karachi, Pakistan.*
[2]*Biotechnolgy Wing, H.E.J. Research Institute of Chemistry, University of Karachi, Karachi, Pakistan*
**Corresponding author: rafat_saeed@yahoo.com*

Abstract

Present study was conducted to evaluate the effect of household greywater (soap water) on growth of *Sesbania grandiflora* L. The plants were grown in sandy loam soil irrigated with soap water solutions (C = 0g/L, T1 = 0.5g/L and T2 = 1.0g/L). Significant increase in growth parameters (root length, shoot length, fresh and dry weights of root, shoot and leaves) was observed with application of T1 followed by T2 over control. Root nodules were significant increased under T1 followed by T2. Larger size nodules were found more in T1 compared to T2 and the control. The results demonstrated that utilization of greywater is beneficial for the cultivation of *Sesbania grandiflora* L. under scarcity of fresh water irrigation.

Introduction

Shortage of fresh water and salinity in agricultural land are the major global problems to supply food for increasing population. Earth surface covers approximately 70% of water out of which 97% is saline and only 3% is fresh water. Unfortunately greater portion of this water is locked up in ice caps and glaciers and only 0.3% is surface-water sources like rivers and lakes etc (Gleick, 1993) which is used by human in agriculture. Around 70% of available fresh water is used for agriculture, when it comes to personal and domestic use, the UN estimates that each person needs about 50-100 litres per day for drinking, cooking and washing. In water-scarce countries, around 38% of domestic water is used to clean clothes. In many of these areas, people wash garments by hand and use more water (Naseer, 2013; Anon, 2012, 2013).

Pakistan is classified as semi-arid to arid country due to low rainfall. Higher temperatures, rising sea levels, melting of glaciers, flooding and higher frequency of droughts due to climate change resulting decreased crop yields as a result affecting food production and livelihood. The total cultivated area in Pakistan is 22 Mha, out of which 85% is irrigated land i.e., about 19.27 Mha and rest 3.0 Mha is rainfed land (GOP, 2008). The annual rainfall varies between 100 mm to 700 mm throughout the Pakistan. Unfortunately, Pakistan faces severe challenges in reduction of crop productivity due to drought which is more severe due to low rainfall (Ashraf and Foolad, 2006). According to Ashraf and Harris, (2005) 17% yield reduction occurs by drought. About 45% of the global agricultural lands are regularly facing the problem of drought (Bot *et al*., 2000) which constraint to meet the world food demands for aprox.8.0 billion people by 2025 and 8.9 billion by 2050 (FAO, 2014).

Various management practices have been undertaken to resolve water crises for crop production. Among these drip water irrigation (Badr and Taalab, 2007) deficit irrigation (Kazemeini *et al*., 2009) and other has been installed to obtain the crop yield under aridity. Organic amendments, organic mulching and use of sea water for irrigation are also in practice (Saeed and Ahmad, 2009; 2013 and Saeed *et al*., 2014).

Waste water from laundry, baths, showers, kitchens, hand wash basins and household other than toilet is known as greywater. It is a source of compounds like, surfactants, soaps, oils, boron and other salts which can alter the soil and plant characters (Travis *et al*., 2008; Wiel-Shafran *et al*., 2006). Developing countries, like in Pakistan laundry water is commonly used in urban areas to irrigate plants while scarcity of water occurs, especially in posh areas of Karachi, like, Gulshan-E-Iqbal, Defence Housing Authority (DHA), Gulistan-E-Johar and North-Karachi etc. there is a little information available about the effective use of greywater. It is a popular medicinal plant and widely used in folk remedy for bruises, catarrh, dysentery, eyes, fevers, headaches, smallpox, sores and sore throat. It is also used for the treatment of anemia, bronchitis, opthalmia, inflammation, leprosy, gout, cancer or tumor and rheumatism (Joshi, 2000; Kasture *et al*., 2002; Sreelatha *et al*., 2011 and Patil *et al*., 2011). The objective of the present study was to evaluate the effects of soap water on growth of *Sesbania grandiflora* L.

Materials and Methods

The experiment was conducted in the field of Botany department, Federal Urdu University of Arts, Science and Technology, Karachi.

Seeds were surface sterilized with 0.2% hypochlorite followed by proper washing with distilled water. Clay pots (10 inch diameter) with basal hole for leaching excess water filled with one Kg sandy loam (3:1 soil and farm yard manure) were used for this experiment. Ten seeds were sown in each pot and initially irrigated with tap water till first compound leaf appeared.

Physico-chemical properties of experimental soil

Texture: Sandy loam (Sand = 65.1%, Silt = 24.6%, Clay = 10.3%)
ECe: 0.4 dS/m
pH: 6.8
LF (Leaching factor): 38.79%

Irrigation water (Greywater) was prepared by dissolving the amount of commercial beauty soap in tap water (0.5 and 1.0 g/L) referred as T1 and T2, whereas tap water was used as Control. Chemical analysis of irrigation water and soil leachate was monitored during experiment by using EC/ TDS meter Adwa 32, pH-meter HANNA. Each treatment had three replicates. Soil leachate was collected at the time of harvesting in plastic bowls placed under pots after 2-3 hours of irrigation. Plants were irrigated on one day interval. Harvesting was done after 60 days to the treatment. Shoot height, root length, number of leaves, fresh and dry biomass of root, shoot and leaves were recorded. For nodular root morphological studies, nodules were detached from the roots and then counted. The size of small (size <5mm) and large nodules (size >5 mm) were measured by using magnifying glass (10x). Total weight of nodules was also recorded. Statistical analysis of the data for standard errors of means and analysis of variance (ANOVA) was performed on SPSS Inc. 20 (for windows).

Table 1. Chemical analysis of greywater and soil leachate after irrigation.

	Irrigation water (IW)			Soil leachates (SL)		
Treatment	**EC dS/m**	**pH**	**TDS (ppt)**	**EC dS/m**	**pH**	**TDS (ppt)**
C (Tap water)	0.453 ± 0.029	7.033 ± 0.033	0.313 ± 0.003	0.527 ± 0.018	7.067 ± 0.033	0.357 ± 0.009
T1 (0.5 g/L)	0.697 ± 0.009	7.40 ± 0.058	0.380 ± 0.006	0.570 ± 0.015	6.967 ± 0.067	0.46 ± 0.012
T2 (1.0 g/L)	0.773 ± 0.003	7.60 ± 0.058	0.427 ± 0.015	0.813 ± 0.020	6.833 ± 0.033	0.643 ± 0.018
F – values	89.726	31.857	38.087	74.965	6.167	121.085
P – Values	0.000	0.001	0.000	0.000	0.035	0.000

Results

Chemical analysis of irrigation water and soil leachate presented in Table 1. Increased electrical conductivity (EC) was found with increasing concentration of soaps in greywater. Higher concentration of soap in water increased EC of the soil leachate due to raising salinity of the medium. Slightly increased pH was recorded in irrigation water (pH range 7.0 – 7.6). Whereas, pH of leachate showed slight decrease, however it lies within the neutral range (6.8-7.0). Total dissolved solids (TDS) increased in irrigation water as well as soil leachate with increasing concentration of soap in greywater.

Sesbania grandiflora L. (Fig.1) showed improved growth parameters under lower concentration of soap in irrigation water (T1 = 0.5g/L) followed by higher concentration (T2 = 1.0g/L) over tap water control (C = tap water). Significant ($P < 0.01$) increase in root length was recorded under T1 and T2 compared to control (Fig. 2). Highest root length was recorded in T1, and least was found in T2 treatment. Similarly, significant ($P < 0.01$) shoot height was found maximum in T1 followed by T2 and least was found in Control (C) (table 1). Fig. 2 showed non-significant increase in total plant length (root + shoot lengths) recorded in T1 followed by T2 over control. Total number of leaves significantly ($P < 0.001$) increased in T1 followed by T2 over control. Fresh weights of root, shoot and leaves significantly increased with application of grey water ($P < 0.01$; $P < 0.01$ and $P < 0.001$ respectively) (Fig. 2). While, dry weights of root, shoot and leaves were increased under soap water irrigation ($P < 0.001$; $P=0.218^{ns}$ and $P< 0.001$ respectively). Effect of soap water (T1 and T2) on total fresh biomass (root + shoot + leaves) was non-sgnificant ($P = 0.193^{ns}$), and total dry biomass (root + shoot + leaves) was increased significantly ($P < 0.01$).

Fig. 1. Effect of grey water (soap water) on plant growth of *Sesbania grandiflora* L.

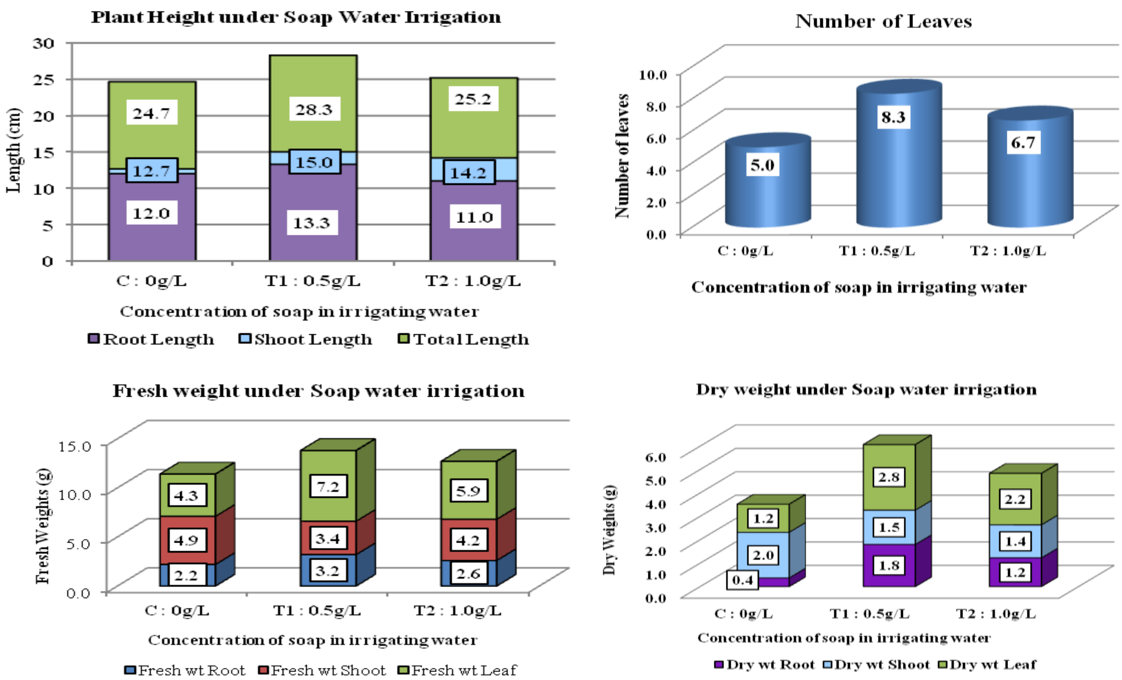

Fig. 2. Effect of grey water (soap water) on root length, shoot length, number of leaves, fresh weight and dry weights of root, shoot and leaves of *Sesbania grandiflora* L.

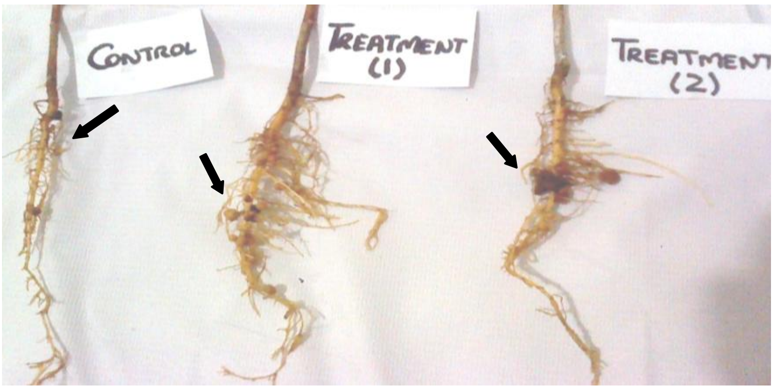

Fig. 3. Effect of grey water (soap water) on number of nodules of *Sesbania grandiflora* L.

Sesbania grandiflora L. is leguminous plant, so its root nodules showed differential behavior under soap water irrigation (C, T1 and T2). Root morphology was presented in Fig 3. It was clearly visible that highest number of nodules developed in plants treated with T1 and least were found in control. Additionally, nodules are categorized as larger size (i.e., greater than 5mm, or >5mm) and smaller size (i.e., smaller than 5mm, or <5mm). Data presented in Table 2 showed significant ($P < 0.001$) increased in total number of nodules under T1 followed by T2 and control. Larger size of nodules also significantly increased in T1 ($F= 10.720$, $P < 0.01$). Number of smaller nodules and their size showed significant interaction between groups ($P < 0.01$ and $P < 0.01$). Smaller size nodules were found more in number in control compared to larger size nodules.

Table 2. Soap water effects on nodular morphology of *Sesbania grandiflora* L.

Treatment	Total Number of Nodule	Total Nodule Wt (g)	Number of Large Nodule	Large Nodule Size (≥ 5mm)	Number of Small Nodule	Small Nodule Size (≤5mm)
C	6.333 ± 0.882	0.439 ± 0.104	2.000 ± 1.000	5.300 ± 0.208	4.333 ± 0.333	2.567 ± 0.657
T1	21.667 ± 2.963	1.561 ± 0.176	14.667 ± 2.848	6.033 ± 0.176	7.000 ± 0.577	2.500 ± 0.361
T2	11.000 ± 2.082	0.725 ± 0.204	5.667 ± 1.667	5.533 ± 0.219	5.333 ± 0.667	0.133 ± 0.020
F-value	**13.344****	**12.255*****	**10.720***	**3.445ns**	**6.125***	**10.264***
P-values	**0.006**	**0.008**	**0.010**	**0.101**	**0.036**	**0.012**

Table. 3. ANOVA of growth parameters of *Sesbania grandiflora* under greywater irrigation.

S. No.	Growth parameters	df	F	P	Sign.
1	Root Length	2	6.076	0.0361	P < 0.05
2	Shoot Length	2	3.492	0.0102	P < 0.01
3	Total Length	2	3.330	0.1062	Ns
4	Number of Leaves	2	15.000	0.0051	P < 0.01
5	Root Fresh wt	2	4.957	0.0415	P < 0.05
6	Shoot Fresh wt	2	4.829	0.0506	P < 0.1
7	Leaf Fresh wt	2	26.014	0.0011	P < 0.01
8	Total Fresh Biomass	2	2.191	0.1933	Ns
9	Root Dry wt	2	25.862	0.0012	P < 0.01
10	Shoot Dry wt	2	1.981	0.2184	Ns
11	Leaf Dry wt	2	26.862	0.0010	P < 0.01
12	Total Dry Biomass	2	8.897	0.0100	P = 0.01
	** P < 0.05	*** P < 0.01	* P < 0.1	ns P > 0.1	

Discussion

Soap is the first man-made detergent (Kirk, 1983) and has been used as an insecticide to control soft-bodied insects for many years in agriculture (Puritch, 1975). Vavrina *et al*., (1995) reported tomato yield reduction with higher detergent concentrations; whereas lower concentrations control white fly infection and yield reduction was insignificant. The effect of greywater (detergents and soap) on plants varies due to the type of plants species and methodology of application of the greywater.

Electrical conductivity and pH of the greywater varies according to type of detergent or soap. Plants grow well in soil having slightly acidic pH (6.5-6.8). Higher pH values found in greywater contains powder detergent (9.3 – 10.0), whereas greywater contains liquid soap or soft beauty soap have lower or neutral pH (6.5 – 6.9). Present study revealed significant change in pH from neutral to slightly acidic after irrigation by greywater as it contains increasing concentration of beauty soap (0-1.0 g/L). Soaps and detergents contain salts which raises salinity of the greywater. Increasing EC and TDS (ppt) was proportionate to the concentration of soap in T1 and T2. Mzini and Winter (2015) reported increased TDS with increasing concentrations of soaps and detergent in greywater. Matos *et al*., (2012) reported more TDS in greywater containing washing machine detergent than wash basin. Laundry greywater directly affected the soil characters and plant growth by raising salinity (Anwar, 2011). Sawadogo, (2014) reported increased EC of greywater which cause death of the okra plant grown in pots. Higher EC was recorded with powder detergent while, comparatively lower EC found in liquid soap in greywater (Singh *et al*., 2013).

The results showed increased vegetative growth parameters under T1 (0.5 g/L beauty soap solution) whereas, decreased growth was observed under T2 (1.0 g/L beauty soap solution) over control (tap water). The results are in accordance with earlier studies (Pinto *et al.*, 2010). Heidari (2013) has found increased root and shoot lengths of sunflower seedling under 0.02-0.3g/L detergent as compared to control, while reduction in growth has been recorded under 2-20g/L detergent. Similar results were also reported by Sawadogo *et al.*, (2014) in okra plants under 0.1-5g/L commercial laundry detergent in distilled water respectively. Detergents in greywater directly affect the plant growth. Beauty soaps contain 70-80% fatty matter, floral fragrance, fruit extracts, milk and some essential natural oils. These contents become soluble in bathing water and reached to the garden for plants and worked as additive for soil.

Detergents contribute 11% of total phosphate input to European surface waters (Morse *et al*., 1994). Phosphates in detergents have different functions (buffering, physical properties, neutralizing hard water, preventing re-deposition). Higher phosphorus level in soil found to reduce absorption of the two essential mineral nutrients (Zinc and Managese) and limits the plants growth (Kidd *et al*., 2007). Reduction in plant growth may be due to the detergents found in grey water cause reduction of hydraulic conductivity of soil adversely affecting the soil properties and builds water repellent property and hence reduces agricultural productivity and environmental sustainability (Lado and Ben-Hur, 2009; Rodda, *et al*., 2011 and Wiel-Shafran, *et al*., 2005).

We found improved growth of *S. grandiflora* under grey water irrigation which can be due to availability of certain essential minerals through roots. Greater number of root nodules in *Sesbania* plants under T1 treatments could be due to availability of minerals to the plants. Additionally, higher concentration of detergents revealed toxic effects resulting in poor growth and development of root nodules which may be due to ionic toxicity or change of hydraulic properties of the soil. The results are in agreement with Sawadogo *et al*., 2014; Heidari, 2012; Poongodi and Sasikala, 2013 and Singh *et al*., 2013).

The results of the present study suggested that recycling of greywater can be helpful to grow plants under scarcity of water. However, regular use of greywater result increased EC and pH which limits the plant growth on long term basis. Nutritional values of the plants grown under such conditions would be explored in future.

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