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COMPARATIVE STUDY ON WATER USE EFFICIENCY BETWEEN INTRODUCED SPECIES (*Eucalyptus camaldulensis*) AND INDIGENOUS SPECIES (*Tamarix aphylla*) ON MARGINAL SANDY LANDS OF NOORPUR THAL

Shazia Afzal[1], Muhammad Farrakh Nawaz[1,2,*], Muhammad Tahir Siddiqui[1] and Zubair Aslam[3]

[1]Department of Forestry and Range Management, University of Agriculture Faisalabad, Pakistan; [2]School of Ecosystem and Forest Sciences, The University of Melbourne, 3121 Richmond, Victoria, Australia; [3]Department of Agronomy, University of Agriculture Faisalabad, Pakistan.
[*]Corresponding author's e-mail: kf_uaf@yahoo.com

Future climate change predictive models are anticipating the warmer temperatures and altered rainfall patterns that can result in water stress for terrestrial vegetation. Water stress is a limiting factor for plant growth and wood production. Water use efficiency (WUE) is considered as the important parameter to examine the success of plants' adaptation in drought conditions. Objective of this study was to observe the comparative WUE between introduced species (*Eucalyptus camaldulensis*) and native species (*Tamarix aphylla*) in two different soil media. Four months old uniform sized seedlings of *Eucalyptus camaldulensis* and *Tamarix aphylla* were transplanted in pots with two different soil media for one year experiment. During the experiment, the leaf litter was collected and meteorological data was obtained. At the end of experiment all the morphological parameters of saplings were measured and WUE was determined. It was found that plant height was higher for *Eucalyptus camaldulensis* (251 cm) as compared to *Tamarix aphylla* (232.17 cm) irrespective of soil media. Higher total dry biomass (936.82 g) was recorded in *Eucalyptus camaldulensis* as compare to *Tamarix aphylla* (670.40 g) showing an increase of 28.43%. Comparison of WUE between introduced species (*Eucalyptus camaldulensis*) and native species (*Tamarix aphylla*) showed the higher WUE of *Eucalyptus camaldulensis* (1.3783 g/L) as compared to *Tamarix aphylla* (0.9858 g/L) showing an increase of 23.92%. Eucalyptus plantations on marginal lands can adapt themselves to drought conditions and can produce even more biomass than slow growing native drought resistant species.
Keywords: Climate change, drought, water stress, forest, agroforestry, water use efficiency.

INTRODUCTION

Anthropogenic activities are considered as the major cause for climate change and global warming (Nawaz *et al*., 2017a). Harsh weather conditions and high temperatures due to global warming are accelerating the problems of drought, glacier melting and floods (Davidson *et al*., 2012; Nawaz *et al*., 2017b). Predicted scenario as the result of climate change will negatively affect the global environment and may result in the agriculture crises (Valipour *et al*., 2017). Furthermore, anticipated warmer and drier Earth with high demands for water and natural resources will reinforce the issue of fresh water shortage (Chiang *et al.*, 2017). Although with less extreme in woody vegetation but similarly to crops, a decrease in water supply will result an increase in vapour pressure and hence more transpiration and evaporation (Zhai *et al.*, 2012; Zhou *et al.*, 2011). Being a global issue, it will affect the sustainable productivity of agriculture and forest crops (Lin *et al*., 2002; Shao *et al*., 2005). So, the existing scenario of prolonged water shortage will adversely affect the agricultural yield and economic stability of Asian countries (being agriculture country), especially, with arid climates like Pakistan and it will threat as well to forest /agroforest communities (Vinke *et al.*, 2017).

Under arid to semi-arid conditions coupled with high temperatures, plant growth is reduced as the process of photosynthesis slowed down (Schauberger *et al.*, 2017). So, it results in reduced wood production in trees planted in forestry and agroforestry (Sheik, 1989). In arid and irrigated areas, as the water use efficiency is the important component in these regions for sustainable wood production and the maximum profit earning; it is necessary to select the species which use water efficiently. Stape *et al*. (2004) concluded that increased water use efficiency was as a result of increased water supply under water-limited environment. In arid and semi- arid regions of the world, water stress is the most important factor for reduction in forest production (Helman *et al.*, 2017). The most important tool of adaptation to drought is thought as enhanced water use efficiency. Ponton *et al.* (2002) concluded that during dry years the increased water use efficiency of a tree contribute to its endurance and low water use efficiency declines in drought. Water use efficiency

(WUE) is measured as main factor for adaptation of plants in drought conditions. The low water use efficiency may report for the continuously noticed declines in adult trees following drought while high water use efficiency of a plant is considered significant for its survival in dry period (Ponton *et al*., 2002). In the vegetation of arid and semi arid regions, *Calotropis procera* is considered as a dominant species because of high WUE (Kumar, 2004). In a comparative study of water uptake by *Eucalyptus camaldulensis*, *Acacia nilotca*, *Azadirachta indica* and *Albizia procera*, the WUE was found to be 0.32, 0.48, 0.16 and 0.77 g/L for *Acacia nilotica*, *Albizia lebbeck*, *Azadirachta indica* and Eucalyptus respectively (Zahid *et al*., 2010).

Pakistan is the fifth most populous country in the world and 4th in Asia with 2.1% population growth rate (Shahbaz *et al.*, 2017). So, current and predicted population pressure for wood and its products on its poor forest resources (4.2 million hectares) is enormous (Anonymous, 2006). Pakistan forest area per capita is 0.265 hectare as compared to world average of 1 hectare (Pakistan Economic Survey, 2004-05). Moreover, forest area is declining day by day due to deforestation and other managerial factors (Khan *et al*., 2001). So, the only hope for the survival of existing forests, by reducing the demand pressure as well as for fulfilling the local demands of wood rely on agroforestry (FAO, 2001: Nawaz *et al*., 2016a). There are numerous types of traditional agroforestry systems in Pakistan such as compact plantation, Eucalyptus and Chickpea crop, silvo-pasture, alley cropping, wind breaks and shelter belts etc. (Abbas *et al.*, 2017). These agroforestry systems play an important role to enhance ecosystem services by improving soil quality and mitigating climate change (Paul *et al.*, 2017).

Most parts of the Pakistan lies under arid and semi arid conditions with summer temperatures more than 45°C and annual rainfall 250-300 mm with evaporation losses of 75% round the year (Qadir *et al.*, 2003; Nimbkar *et al.*, 1986; Johnson *et al.*, 2005). In early 20th century, Eucalyptus species were introduced in Pakistan and had planted in all parts of the country on a large scale. Throughout the world the amount of water require to Eucalyptus plantation is an applicable question (Stape *et al*., 2004). *Eucalyptus camaldulensis* is a plant of Australia where arid climate is dominant and it has various mechanism for drought resistance like osmatic manipulation, deep roots and dynamic variation in leaf area index etc. (Whitehead and Beadle, 2004; Nawaz *et al*., 2016b). Being evergreen species, it has more access to water at greater depth as compared to the deciduous trees (Baker *et al*., 2002). *Eucalyptus camaldulensis* is one of the species which have potential to grow well in marginal lands as it has been demonstrated in previous studies carried out in Noorpur Thal region, Pakistan (Nawaz *et al*., 2017a; Afzal *et al*., 2017).

Noorpur Thal desert is located in Khushab district. It has extreme variations of seasonal temperature, winter season is extremely cold and summer season is very hot like any other desert. Noorpur Thal is facing the major problem of water shortage resulting in rain-fed marginal agricultural lands. Farmers of this area are rapidly adopting *Eucalyptus camaldulensis* based agroforestry system on their rain fed marginal farmlands (Qureshi, 2010). *Tamarix aphylla* is native species of Noorpur Thal. *Tamarix aphylla* is a tall tree and shares many physiological changes like it's a drought tolerant plant (Abd El-Ghani, 2000). *Tamarix aphylla* is famous due to its adjustment to arid condition (Misak and Draz, 1997) but farmers of Khushab (Noorpur Thal) are replacing *Tamarix aphylla* with *Eucalyptus camaldulensis* due to its fast growth and early income generation. Until now, no comparative research study is present in Pakistan to evaluate the WUE of exotic and native woody vegetation when planted in marginal sandy lands. Literature related to water use efficiency of *Tamarix aphylla* is scarce, whereas sufficient studies are available for water use efficiency of *Eucalyptus camaldulensis.* There was a dire need to compare water use efficiency of the introduced and native species. Keeping in view the scenario, the study was design with the objective to observe comparative water use efficiency between introduced species (*Eucalyptus camaldulensis*) and native species (*Tamarix aphylla*) on two different soil media.

MATERIALS AND METHODS

***Experiment*:** A one year study was initiated in the nursery of Forestry and Range Management, University of Agriculture, Faisalabad in March 2014 to Feb 2015. Prior to start the experiment, uniform sized seeds of two selected species: *Eucalyptus Camaldulensis* and *Tamarix aphylla* were collected from the nursery of Forestry department (UAF). These were sown in the month of November in polythene bags under the polythene tunnel. After four months, these plants were transplanted for pot experiment in two different soil media: sandy soil and clay loam soil. Each pot (12″ x 12″) contained 7 kg of soil. Selecting the representative of study area, sandy soil was collected in bulk quantity and transported from fields of Noorpur Thal, Khushab and clay loam soil was collected from nursery of Forestry and Range Management. There were three numbers of repeats each for soil and plant species. Seedlings, thus, transplanted were 6 to 9 inches in height. Plastic sheets were spread beneath the potted plants to collect litter falling from time to time. The irrigation started from very first day and measured quantity of water was supplied to each pot. The details of irrigated water are given in Table 1.

***Data collection*:** Daily metrological data were collected from the Metrological Station of Department of Agronomy, University of Agriculture, Faisalabad that was permanently installed just few meters away from experimental site. The summary of climatic conditions during experimental period (2014-2015) is given in Table 2. At the end of the experiment, recorded morphological parameters were height (cm), diameter (mm), shoot length (cm), fresh shoot weight (g), fresh root weight (g), fresh leaves and twigs weight (g), total fresh biomass (g), dry shoot weight (g), dry root weight (g), dry leaves and twigs weight (g), total dry biomass (g), and total amount of water applied (L). Water-use efficiency was considered as total amount of dry matter produced by a plant divided by the total amount of water applied.

Table 1. Amount of water apply to *Eucalyptus camaldulensis* and *Tamarix aphylla*.

Month (Year)	Quantity of irrigated water (liters)
March (2014)	40
April (2014)	56
May (2014)	56
June (2014)	60
July (2014)	56
August (2014)	62
September (2014)	48
October (2014)	62
November (2014)	60
December (2014)	62
January (2015)	62
Feb (2015)	56
Total amount of water	680

Table 2. Average monthly temperature and rainfall range during year 2014 and 2015.

Month (Year)	Average Min temp	Average Max	Average temperature (^{0}C)	Average rainfall (mm)
March (2014)	13.6	24.7	19.2	41.7
April (2014)	18.6	32.2	25.4	28.2
May (2014)	23.7	36.6	30.1	41.2
June (2014)	28.1	40.9	34.5	7.1
July (2014)	28.0	37.0	32.5	57.5
Aug. (2014)	27.3	37.1	32.2	4.8
Sep. (2014)	24.5	33.9	29.2	140.2
October (2014)	19.1	31.3	25.2	3.6
Nov. (2014)	11.5	26.3	18.9	10.0
Dec. (2014)	5.9	18.5	12.2	0.0
Jan. (2015)	6.9	16.6	11.7	12.2
Feb. (2015)	11.1	22.0	16.5	20.5

***Soil analysis*:** Three soil samples were taken at a depth of 0-15 cm from both types of soils: Nursery soil and soil of Noorpur Thal to determine the physico-chemical properties. Saturated soil paste was made by adding distilled water in 250 g soil sample, then pressure was applied with a filter paper and extract was obtained from saturated soil. To prevent salts's precipitation, one drop per 25 mL sodium hexametaphosphate (1%) solution was added. The soil pH was determined from saturated soil paste, electrical conductivity (EC) from soil extract, total nitrogen by Ginning and Hibbard's method, available phosphorus and potassium by a model PFP.7 Jenway flame spectro photometer, and soil organic matter and soil carbon was determined by Walkley and Black method. Sodium and calcium were found under detection limit in soil samples. Average and standard deviations were calculated for all the analysed parameters (Table 3).

Table 3. Physico-chemical properties of nursery and Noorpur Thal soils.

Parameters	Sandy soil	Clay loam soil
pH	8.2 ± 0.1	8.0 ± 0.06
EC (dSm^{-1})	1.00 ± 0.04	1.68 ± 0.02
TSS (ppm)	700 ± 35	1176 ± 48
Nitrogen (%)	0.010 ± 0.003	0.077 ± 0.005
Phosphorous (ppm)	1.0 ± 0.08	3.9 ± 0.2
Potassium(ppm)	60 ± 2	280 ± 12
Organic matter (%)	0.42 ± 0.3	1.54 ± 0.2
Sand (%)	59 ± 1	40 ± 0.8
Silt (%)	22 ± 0.5	45 ± 0.7
Clay (%)	19 ± 0.5	15 ± 0.4

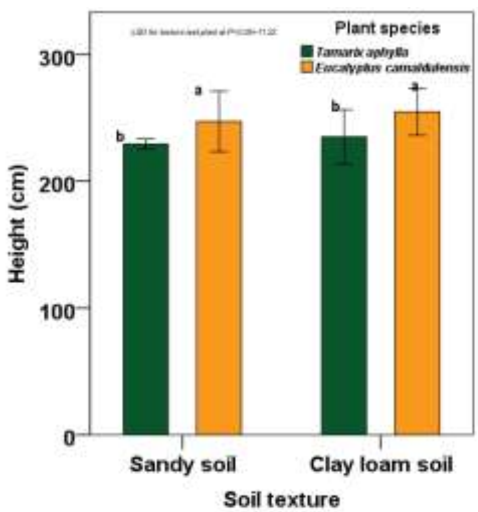
***Statistical analysis*:** Pot experiment was conducted with two factor factorial under completely randomized design (CRD). Data were analyzed using the statistical package SPSS version 11.0. ANOVA was performed as described by Steel and Torrie (1981). A *P*-value of <0.05 was considered significantly different. All data presented were expressed as mean ± standard error.

RESULTS

***Growth parameters*:** A significant difference (LSD at $P<0.05=7.9363$) existed for plant height between two plant species as was evident from Fig. 1a. Higher plant height (251 cm) was recorded in *Eucalyptus camaldulensis* as compared to *Tamarix aphylla* (232.17 cm) showing an increase of 7.50%. Effect of soil texture on plant height remained non-significant as on sandy soil it was 244.92 cm while on clay loam soil it was 238.25 cm. Interaction of plant height and texture too remained non-significant. Similar to plant height substantial variance (LSD at $P<0.05=0.9276$) ensued for plant diameter between two plant types as was obvious from Figure1b. Greater plant diameter (14.10 mm) was noted in *Eucalyptus camaldulensis* as compared to *Tamarix aphylla* (12.06 mm) presenting a rise of 7.50%. Effect of soil texture on plant diameter remained non-significant as on sandy soil it was 13.27 mm while on clay loam soil it was 12.89 mm. Interaction of plant height and texture was found non-significant.

In *Eucalyptus camaldulensis* higher shoot length (243.83 cm) was noted on both soils as compared to *Tamarix aphylla* (228.75 cm) illustrating an advance of 6.18% which was significant at P<0.05=0.9276 as given in Figure 2a. Impact of texture as in above mentioned parameters remained at par. Same was the case with interaction of shoot length and texture. Higher fresh shoot weight (1332.8 g) in *Eucalyptus camaldulensis* is evident (Fig. 2b) as compared to *Tamarix aphylla* (1158.0 g) clarifying an improvement of 13.11% significant at P<0.05=0.9276. Impact of texture on fresh shoot weight remained at par. Same was the case with interaction of shoot length and texture.

a.



b.

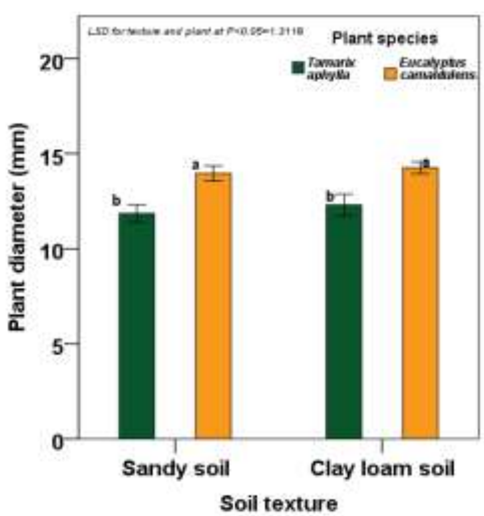


Figure 1. Comparative effect of soil texture on (a) plant height (b) and plant diameter of *Eucalyptus camaldulensis* and *Tamarix aphylla*.

A significant difference (LSD at P<0.05) existed for fresh root weight between two plant species as was evident from Figure 2c. Higher fresh root weight (439.75 g) was recorded in *Eucalyptus camaldulensis* as compared to *Tamarix aphylla* (401.92 g) showing an increase of 8.60%. Fresh root weight in case of *Eucalyptus camaldulensis* (427.83 g) on clay loam soil was found non-significant as compared to *Tamarix aphylla* (416.17 g) on sandy soil. Interaction of fresh root weight and texture remained non-significant. Similar to fresh root weight, considerable change (LSD at P<0.05) stemmed in fresh leaves+twigs between two plant types as was obvious from Figure 2d. Larger fresh leaves+twigs weight (41.178 g) was noted in *Eucalyptus camaldulensis* as compared to *Tamarix aphylla* (34.307) bestowing a rise of 16.68%. Fresh leaves+twigs weight in case of *Eucalyptus camaldulensis* (40.22 g) on clay loam soil was found non-significant as compared to *Tamarix aphylla* (35.38 g) on sandy soil. Interaction of fresh leaves+twigs weight and texture remained non-significant

A noteworthy dissimilarity (LSD at P<0.05) occurred for fresh total biomass between two plant species as was evident from Figure 2e. Higher fresh total biomass (1813.60 g) was recorded in *Eucalyptus camaldulensis* as compared to *Tamarix aphylla* (1594.20 g) showing an increase of 12.09%. Fresh total biomass in case of *Eucalyptus camaldulensis* (1764.50 g) on clay loam soil was found non-significant as compared to *Tamarix aphylla* (1632.11 g) on sandy soil. Interaction of fresh total biomass and texture remained non-significant.

***Growth parameters (Dry)*:** A significant difference (LSD at P<0.05=41.403) existed for dry shoot weight between two plant species as was evident from Figure 3a. Higher shoot weight (251.00 g) was recorded in *Eucalyptus camaldulensis* as compared to *Tamarix aphylla* (232.17 g) showing an increase of 7.51%. Effect of soil texture on shoot weight remained non-significant as on sandy soil it was 576.58 g while on clay loamy soil it was 548.25 g. Interaction of shoot weight and texture too remained non-significant.

Similar to dry shoot weight substantial variance (LSD at P<0.05=11.713) ensued for dry root weight between two plant types as was obvious from Figure 3b. Greater dry root weight (14.10 g) was noted in *Eucalyptus camaldulensis* as compared to *Tamarix aphylla* (12.06 g) presenting a rise of 14.46%. Dry root weight in case of *Eucalyptus camaldulensis* (227.52 g) on clay loamy soil was found non-significant as compared to *Tamarix aphylla* (215.61 g) on sandy soil. Interaction of fresh total biomass and texture remained non-significant.

A significant difference (LSD at P<0.05=2.0997) existed for dry weight of leaves+twigs between two plant species as was evident from Figure 3c. Higher dry weight of leaves+twigs (23.263 g) was recorded in *Eucalyptus camaldulensis* as compared to *Tamarix aphylla* (17.080 g) showing an increase of 26.57%. Effect of soil texture on dry weight of leaves+twigs remained non-significant as on sandy soil it was 20.756 g while on clay loamy soil it was 19.5875 g. Interaction of dry weight of leaves+twigs and texture remained non-significant.

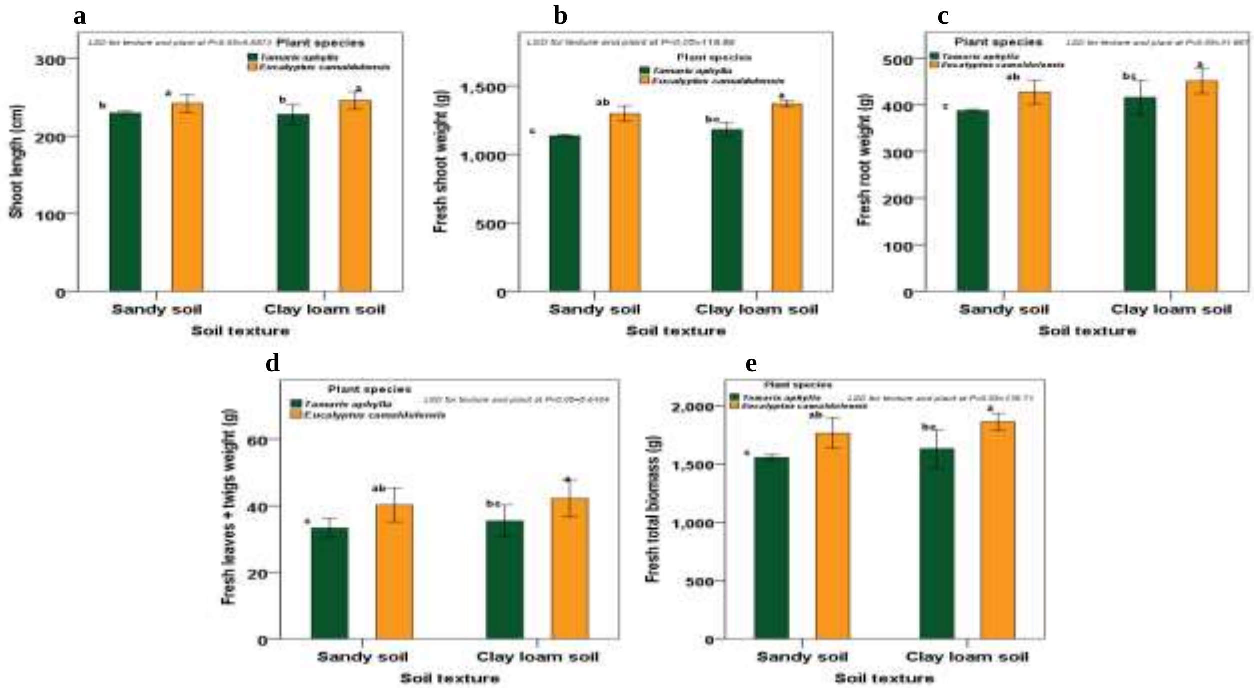


Figure 2. Comparative effect of soil texture on (a) shoot length (b) fresh shoot weight (c) fresh root weight (d) fresh leaves+ twig weight and (e) fresh total biomass of *Eucalyptus camaldulensis* and *Tamarix aphylla*.

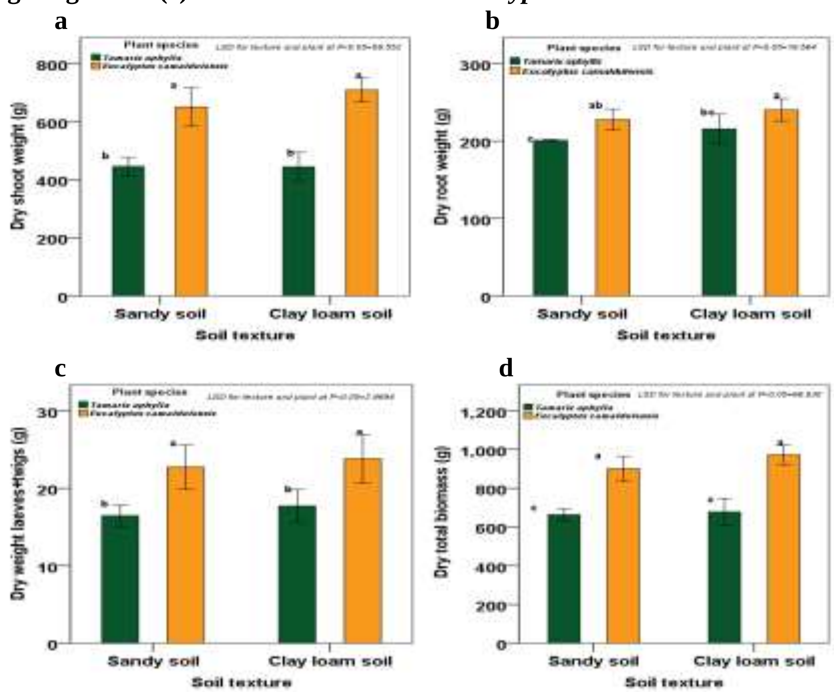


Figure 3. Comparative effect of soil texture on (a) dry shoot weight (b) dry root weight (c) dry leaves+ twig weight and (d) dry total biomass of *Eucalyptus camaldulensis* and *Tamarix aphylla*.

A significant difference (LSD at P<0.05=47.256) existed for total dry biomass between two plant species as was evident from Figure 3d. Higher total dry biomass (936.82.00 g) was recorded in *Eucalyptus camaldulensi*s as compared to *Tamarix aphylla* (670.40 g) showing an increase of 28.43%. Effect of soil texture on total dry biomass remained non-significant as on sandy soil it was 825.19 g while on clay loamy soil it was 782.03 g. Interaction of total dry biomass and texture remained non-significant.

A significant difference (LSD at $P<0.05=0.0697$) existed for WUE between two plant species as was evident from Fig. 4. Higher WUE (1.3783 g/L) was recorded in *Eucalyptus camaldulensis* as compared to *Tamarix aphylla* (0.9858 g/L) showing an increase of 28.47%. Effect of soil texture on WUE remained non-significant as on sandy soil it was 1.2142 g/L while on clay loamy soil it was 1.1500 g/L. Interaction of WUE and texture remained non-significant.

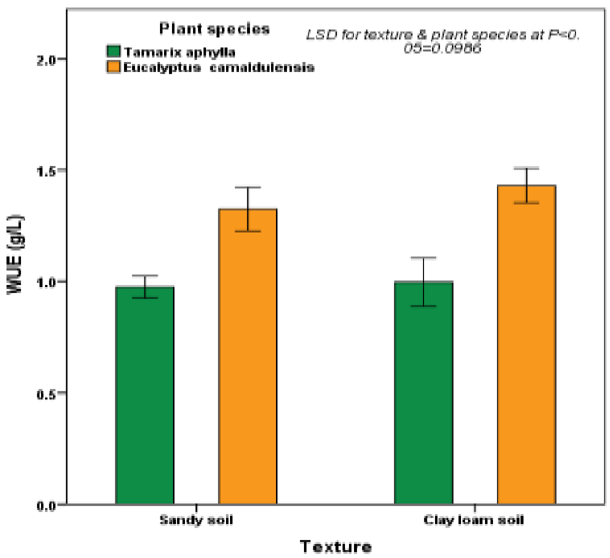


Figure 4. Comparative effect of soil texture on WUE of *Eucalyptus camaldulensis* and *tamarix aphylla*.

DISCUSSION

Eucalyptus is an evergreen tree which is native to Australia and its plantations are now growing on more than 20 M hectares (Carle *et al*., 2002; FAO, 2006). It plays a significant role in providing wood, renewable energy, slow water runoff and also helps in controlling pollution (Bauhus *et al*., 2009). It is a fast growing tree, grows in poor environment or wide ecological zones, no sowing treatment is required and shows resistance against environmental stress and diseases (Zerfu 2002; Mekonnen *et al*., 2007; Nduwamungu *et al*., 2007). On the other hand, Eucalyptus increases soil erosion, drain water resources and cause allelophathic effects (Nduwamungu, 2007). Drying of soil, soil moisture depletion and water shortage problems occur when Eucalyptus trees grow in regions which are susceptible to drought conditions because these trees have high water requirement (Jagger and Pender, 2000).

Tamarix trees are able to grow on variety of soil like silt loam, clay loam and silt clay loam. They have extensive deep root systems which stretch to the underground water reservoir (Kerpez and Smith, 1987). Even if ground water is not accessible, Tamarix can survive in such soil. Its root system helps in the survival under stress conditions. It sheds its leaves when drought is severe; this behavior helps in survival (Baker *et al*., 2002). Therefore, Tamarix can withstand lengthy drought period, although the growth rates are reduced (Ditomaso, 1998). *Tamarix aphylla* adjust itself to arid conditions successfully. That's why it is dominant from North America to the desert of Sindh. If artificial irrigation is not available it can survive and grow in area where average annual rainfall is 100-150 mm, during first few years. Its survival rate is upto 90% after five years of its plantation. It shed its twigs in a continuous pattern which make a litter layer quickly. It expands its deep root system rapidly (Misak and Draz, 1997). In water accessible sites, it is a fast growing plant having height upto 10 m. It is drought tolerant with saline leaf litter. Natively it grows on sandy soil along the river banks (Abd El-Ghani, 2000). Tamarix trees evapo-transpire more water as compared to many other tree species (Dahm *et al*., 2002). It depends on the technique and duration of measurement and climatic conditions (Shafroth *et al*., 2005). Study proved that, Tamarix has the ability to be grow in both low quantity of water and high quantity of water, growth of plants depend on the canopy development, availability of moisture, atmospheric demand, energy balance and evapotranspiration in arid land riparian zones like the Virgin river (Devitt *et al*., 1998).

It was observed that maximum plant height, shoot length, fresh root weight, fresh total biomass, dry shoot weight, dry weight of leaves and twigs, total dry biomass was expressed by *Eucalyptus camaldulensis* as compared to *Tamarix aphylla* while non-significant variation was observed among these two species on two different soil media.

Tree roots absorb higher quantities of water to reduce transpiration losses and losses due to metabolic actions. For both species, the change in tree root behavior for water absorption and transport in two different soil media has been supposed to mask the effects of two different soil media on plant morpho-physiological parameters. However, the water necessity per unit dry mass produced differs among different plant species and even clones of same species can show different growth patterns for same available quantity of waters (Fisher and Binkley, 2000). Estimation of monitoring of standing canopy structure and physiological processes are used as a tool for understanding the water use efficiency of a particular tree. It is a challenge to increase the productivity of forest plantation to meet the requirement of wood and water. Therefore, it is important to know the water use and growth related problems of trees (Stape *et al*., 2004). Contrary results were reported by different researchers regarding water use efficiency of Eucalyptus species. Water use efficiency (WUE) in various species varies dramatically during rotation and stand age (Almeida *et al*., 2007). Other works also suggest that increased water availability has no negative impact on water use efficiency in Eucalyptus plantations. Eucalyptus absorbs water through the roots and water loss i.e. transpiration occurs through leaves (Hubbard *et al*., 2004; Stape *et al.*, 2004; Benyon *et al*., 2006). Results of the present study are more or less related to the work stated by Davidson (1989). Eucalyptus consumed less water per unit of biomass produced than other trees species, especially, in countries like China and India. Outcomes of the study are also supported by the statement of Whitehead and Beadle (2004). *Eucalyptus camaldulensis* is a plant of Australia where arid climate is dominant and it has various mechanisms for drought resistance like osmatic manipulation, deep roots and dynamic variation in leaf area index etc. As compared to the deciduous trees it has more access to water at greater depth being evergreen species (Baker *et al*., 2002). In present study performance of Eucalyptus is better than Tamarix, it might be due to the reason that water is a limiting factor for Eucalyptus but not for Tamarix because water requirements for later are less and it is also a slow growing plant. Tamarix grows well in less quantity of water, especially, in dry regions but it produced less biomass in short time whereas in adequate quantity of water Eucalyptus performs better because it's a fast growing plant and adjust itself to the environment rapidly as compared to other species. However, research is required to study about the physiology of Tamarix because it's a native of the Khushab area where as growing of Eucalyptus is a controversial issue, many studies support it and many studies are discouraging this plant.

***Conclusion*:** Comparative water use efficiency between introduced species (*Eucalyptus camaldulensis*) and native species (*Tamarix aphylla*) showed higher water use effeciency of *Eucalyptus camaldulensis* as compared to *Tamarix aphylla*. Eucalyptus plantation on marginal lands can be serves as timber mines to fulfill the demand for timber for Punjab and Pakistan. Eucalyptus is recommended for marginal areas as this tree species is highly productive, fast growing and well adapted to dry, sandy and infertile sites. However, it is the need of time to screen the water use efficient pure clones of *E. camaldulensis* for the afforestation of marginal lands with water shortage. In villages of Noorpur Thal (Khushab) people are growing Eucalyptus on their farm. Level of ground water is at the depth of 10-15 ft. Eucalyptus is notorious for utilizing more water, so, research is required on long term basis to monitor the water budget and to access how much level of ground water has decreased due to growing Eucalyptus and at the end recommendation should be given on basis of water budget either to grow Eucalyptus trees or not. So, long term research is required on water budget.

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