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GROWTH RESPONSE OF TAMARIX APHYLLA IN RELATION TO WATER USE EFFICIENCY

RIZWAN KHAN
Department of Forestry & Range Management, University of Agriculture, Faisalabad, Pakistan.

SIDRA YOUSAF*
Department of Chemistry, GPGC for Women, University of Haripur, Hattar Road, Haripur City, KP, Pakistan.
Corresponding Author Email: sidrayousaf74321@gmail.com

MUHAMMAD ASIF
Department of Forestry & Range Management, University of Agriculture, Faisalabad, Pakistan.

SULTAN MUHAMMAD
Institute of Agriculture Sciences and Forestry, University of Swat, Pakistan.

MUHAMMAD AAMAD KHATTAK
Department of Land, Environment, Agriculture and Forestry, University of Padova, Legnaro, Italy.

IQRA BASHIR
Department of Horticulture, Faculty of Crop and Food Sciences, Pir Mehr Ali Shah-Arid Agriculture University, Pakistan.

GHULAM MURTAZA
Pesticides Quality Control Laboratory, Regional Agricultural Research Institute, Bahawalpur, Pakistan.

Abstract

Presently, climate change is one of the major ecological problems worldwide. It has important effects on the growth of plants, water usage and movement methods. These effects showed the water use efficiency of plants, communities, and environments, and ultimately, in plants division method pattern, composition of species and environmental system. Water use efficiency of plants assists in the perception and predicting the reactions of plants to climate change globally and the adopting methods. Water use efficiency in vegetation is a manifestation regarding amount of carbon absorbed to the rate of water loss by plants leaves. This research focuses the advantageous effects of water use efficiency on the development behavior of chosen plant. The major aim of that research was to observe the growth response of *Tamarix aphylla* at normal, mean and excess amount of water consumption. The research was accomplished in the nursery area of the Department of Forestry and Range Management, University of Agriculture Faisalabad. The required plants of the *Tamarix aphylla* were obtained from the nursery. Four treatment levels together with control level were finalized. The data was tested statistically by utilizing the Randomized Complete Block Design (RCBD). The germinating ability of the plants was noticed against water use efficiency during initial growth periods. Plants were then shifted in containers by applying water at various treatment levels e.g. Daily (T_0), four days (T_1), eight days (T_2), twelve days (T_3), and sixteen days (T_4) in order to observe the germination ratio and morphologic attributes at various levels of water application. The data exhibited changes in the growth behavior of plans after analysis for the above discussed morphologic attributes. The reaction of each treatment level on the height of the plant was significant. It was almost obvious that the growth response of *T. aphylla* was quite better by enhancing the water use efficiency.

Keywords: Plant Growth, Tamarix Aphylla, Water Use Efficiency

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1. INTRODUCTION

Pakistan is an arid-semiarid country in the world. In Pakistan, approximately 7.8 million of hectare land is affected by drought that can only be reclaimed through the planting of drought resistant species (Dunne *et al*., 2019). Pakistan is a densely populated country in the world having 189 persons per square kilometer with a population of about 220 million due to rapidly increasing rate of urbanization (1.90% annually). It may be increased to 200 million of people by the end of that century. Due to an increasing rate of population day by day, our energy needs can be far beyond the level i.e. the total wood (firewood) demand can be increased to a maximum level in the next coming years that can be nearly about 90 million cubic meter for the population of about 200 millions of people's (Ketiem *et al*., 2017). Water use efficiency is the "amount of water utilized in the metabolism of the plant to the loss of water by the plant by the process of transpiration". It describes the photosynthetic productivity ratio of plants in comparison with the rate at which it transpires water to the atmosphere. Field *et al*., (2015) concluded that water use efficiency potential by the plants has long been the interest of foresters, ecologists, and agronomists. Abdulazeez *et al*., (2014) studied that water use efficiency shows a measure of maximizing crop yield in a cropping pattern in the shape of limited supply of water. Water use efficiency is an important way between management of water and production of wood in any forestry system. Globally, water use efficiency connects the water ways of terrestrial vegetation and carbon and is also supposed to an increase in the coming days (Kebede *et al*., 2015; Dasgupta *et al*., 2014; Asrat and Simane, 2018).

In many regions of the world, water has become an increasingly limited source, thus emphasizing on the improvement and also the development of a new water courses by any untraditional methods (Porter *et al*., 2014). In many countries around the world, the recycling of water in an agricultural system is now being practiced. In several other under-developed countries involving Saudi Arabia, the severe deficit of water emphasis not only on the improvement of existing water courses but also on the making of the new water courses. Land use of water is regarded an ultimate way for minimizing the deficiency of water. Saudi Arabia does not have enough trees in order to meet the needs regarding wood industry i.e. firewood, sawn wood, fuel wood, and industrial wood and wood related composition panels. The value of wood and wood-based materials being imported to Saudi Arabia annually was 120 million dollars in 2005 and 310 million dollars in 2008.

To fulfill the enhancing need of wood and wood-based materials, Saudi Arabia has also started to plant such species having rapid growth in various regions of the country (Abdul-Razak and Kruse, 2017). The recycling of water as a new source of water application has also been started in the world in the last twenty years in order to maximize the best use of water for forest trees and crops (Morton, 2017; Sallawu *et al*., 2020). The domesticated water used in Riyadh City was 420,000 m^3 day^{-1} in 1993 and increased to 540,500 m^3 day^{-1} in 2008 as well as the recycled water also increased from 398,400 m^3 day^{-1} to 536330 m^3 day^{-1} during the same time (Limantol *et al*., 2016; Yaro *et al*., 2015).

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Drought stress is a major source of changes in the plants physiological functions and reduces the growth of plants, which significantly influence the performance of tree seedlings instantly during their formation period and after their planting time, also inducing acute damages and influencing their viability and ultimately yield. Acute drought stress situations efficiently reduce the growth of tall trees. So many plants manifest some alterations in their physiological and morphological features to reduce the effect of water stress. Some of these changes are very easy to evaluate and are visible which in turn show morphological adaptations (Nilsen, 2019; Delonge *et al*., 2016). The major objectives of the study were to check growth responses of *Tamarix aphylla* at various irrigation levels, to determine the minimum irrigation level to sustain normal growth, to determine the optimum irrigation level for maximum growth and development.

2. MATERIALS AND METHODS

The experimental trials to collect the required data were conducted in the nursery area of the Forestry Department. A pot experiment was planned for whole treatments. Soil was collected from nursery area. An important forest species was selected for this research, i.e. *Tamarix aphylla* (Farash). In this study, the 1st bed was a control bed, 2nd bed had 4 irrigation levels, 3rd bed was with 8 irrigation levels, 4th bed was with 12 irrigation levels, and 5th bed was with 16 irrigation levels.

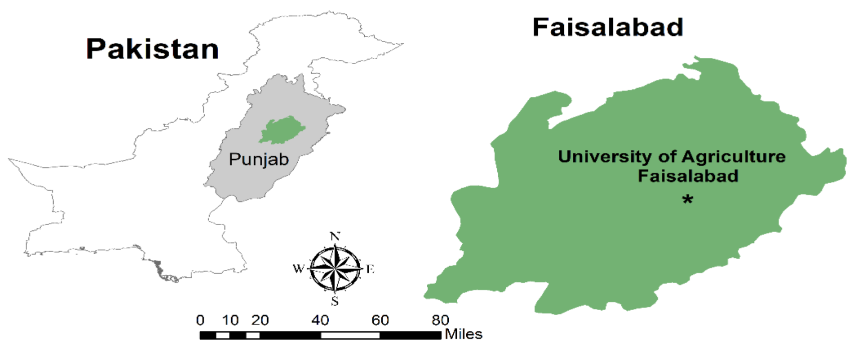

Fig 1: Site map of research area (University of Agriculture, Faisalabad)

Seedlings of *Tamarix aphylla* were gathered from the nursery of the above given department and were transferred in pots. Data was collected on regular basis. Planting rod was used for the transplanting of *Tamarix aphylla* cuttings. Watering was carried out on day-to-day basis and weeding was done on the routine basis. Following treatments were designed in the said experiment:

W_0 = Daily irrigation

W_1 = Four days

W_2 = Eight days

W_3 = Twelve days

W_4 = Sixteen days

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The required data was collected regularly.

2.1 Parameters

Following morphological parameters were analyzed:

- Sprouting % age
- Shoot length (cm)
- Shoot fresh weight (g)
- Shoot dry weight (g)
- Root-shoot ratio (%)
- Root fresh weight (g)
- Root length (cm)
- Root dry weight (g)
- Plant height (cm)

3. RESULTS AND DISCUSSION

The research was planned to check the impact of water use efficiency on the growth response of *Tamarix aphylla* at normal, mean, and excess levels of water application. A pot experiment was carried out for this purpose. Several treatments comprising of different irrigation intervals was applied to the *Tamarix aphylla* at different times. Data regarding several morphological parameters was collected at the end of the experiment and tested statistically using Randomized Complete Block Design. The reaction of each treatment level on the plant's height was significant but there was a great difference in the performance of each plant after applying treatments. Due to this, the mean values of the studied experiment varied significantly. Data for different morphologic attributes after analysis exhibited changes in their performances. The overall plant height was maximum in the treatment W_0 where plants were irrigated on regular basis. There was a moderate reduction in the height of plant when irrigation time period was reduced. Likewise, the plant height was maximum (70 cm) in treatment W_1 (4 days interval). It was quite clear that the plant height was maximum in all treatments. However, the root length changed extremely by the impact of the drought that showed a maximum 30 cm root length was obtained for the species where the plants were irrigated after 4 days' time period. Likewise, the performance was extremely affected in the treatments W_2 and W_3 yielding only 35 cm and 45 cm for the said species when irrigation was applied after 8 and 12 days interval. With the increase in irrigation interval, there was a drastic change in the fresh weight of shoot referring to the little fresh weight of shoot for the treatment W_4 (Irrigation after 16 days interval).

It was obvious that between each treatment level, the treatment W_0 produced higher (65 g) shoot fresh weight. It was clear from the correlation of means that the specie responded

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variedly for the root fresh weight. The highest (17 g) root fresh weight was observed in treatment W_0 where plants were irrigated on regular basis. Likewise, W_1 treatment exhibited 8 g of root fresh weight. The treatments W_2 and W_3 also performed well as they produced 12 and 27 g of root fresh weight where irrigation was applied after 8 and 12 days). After all, root dry weight in each treatment was better. It was quite obvious that the treatment W_1 yielded maximum root-shoot ratio where irrigation was applied after 4 days interval. Likewise, there was a clear change in the performance of treatment W_2 and W_3 where water was applied after 8 and 12 days interval. From the results, it was almost obvious that the growth behavior of *Tamarix aphylla* was quite better by comparing all treatments.

3.1 Morphological Parameters

3.1.1 Sprouting percentage % age

Sprouting % age performs a key role in the better propagation of plants. It is one of the most important parameters in assessing the growth of seedlings. Sprouting % age was impacted significantly by each treatment as shown in analysis of variance table 3.1.1a of sprouting % age. The specie *Tamarix* also displayed significant fluctuations in its performance against all treatments. Least Significance Difference (LSD) test was used for comparing the mean values of each treatment of the plant. The impact of treatment (T_0) was highly significant among other treatments whereas the treatment (T_4) showed minimum significant effect. While the significant impact of (T_1), (T_2) and (T_3) treatments were slightly different among each other. The maximum 65.67% sprouting % age was recorded in the treatment T_0 while in the treatment T_4, the minimum 50.23% sprouting % age was noted. Likewise other treatments, the maximum sprouting % age noticed in the treatment T_1 was 62.75% whereas in the treatment T_2 was 60.23%. Similarly, in the treatment T_3, 56.35% sprouting % age was recorded. All these are in line with the results of present study. Similarly, several studies were reported on sprouting % age (Calo, 2017; Mateo-Sagasta *et al*., 2018) in which 10 cm seedlings revealed good results.

Table 3.1.1 a: ANOVA for sprouting % age

Means of variation	Degrees of freedom	Total squares	Mean squares	F value
Replication	3	152.749	50.916	
Treatment	4	151.334	37.833	41.52**
Error	12	10.934	0.911	
Total	19	315.017		

NS = Non-significant (P>0.05), * = Significant (P<0.05), ** = Highly-significant (P<0.01)

Table 3.1.1 b: Correlation of means

Treatments	Mean ± SE
T0	60.47 ± 2.20 A
T1	58.36 ± 1.60 B
T2	57.17 ± 1.31 B
T3	53.52 ± 1.19 C
T4	53.45 ± 1.77 C

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Means having same letters are non-significant statistically (P>0.05).

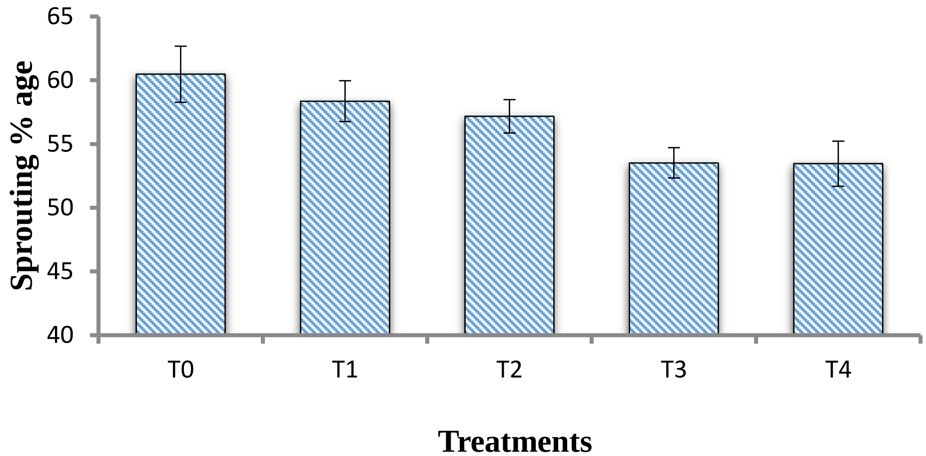

Fig 3.1.1.a: Sprouting % age as influenced by various watering levels

3.1.2 Effect of water use efficiency on the Root length

Root length was affected significantly by each treatment as shown in analysis of variance table 3.1.2a. The specie *Tamarix* also displayed significant fluctuations in its performance against all treatments. Least Significance Difference (LSD) test was used for comparing the mean values of each treatment of the plant. The impact of treatment (T_0) was highly significant among other treatments whereas the treatment (T_1) showed minimum significant effect. While the significant impact of (T_2), (T_3) and (T_4) treatments were slightly different among each other. The maximum 76.2 cm root length was recorded in the treatment T_0 while in the treatment T_1, the minimum 12.7 cm root length was noted. Likewise other treatments, the maximum root length noticed in the treatment T_2 was 58.42 cm whereas in the treatment T_3 was 68.58 cm. Similarly, in the treatment T_4, 40.64 cm root lengths were recorded. Similarly, that findings are quite similar with the results of (Dudley and Alexander, 2017) who explained that prolong water deficit is the main reason in the declining of fibrous roots of *Avocado* species and reduces roots growth in populous plants.

Table 3.1.2a: ANOVA for Root Length (cm).

Mean of variation	Degrees of freedom	Total squares	Mean squares	F value
Replication	3	103.82	34.61	0.75
Treatment	4	1580.64	395.16	8.57**
Error	12	553.47	46.12	
Total	19	2237.93		

NS = Non-significant (P>0.05); * = Significant (P<0.05); ** = Highly-significant (P<0.01)

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3.1.2 b: Correlation of means

Treatments	Mean ± SE
T0	49.53 ± 5.027 A
T1	29.21 ± 1.603 B
T2	31.75 ± 3.048 B
T3	46.99 ± 2.736 A
T4	29.85 ± 3.186 B

Means having same letters are non-significant statistically (P>0.05).

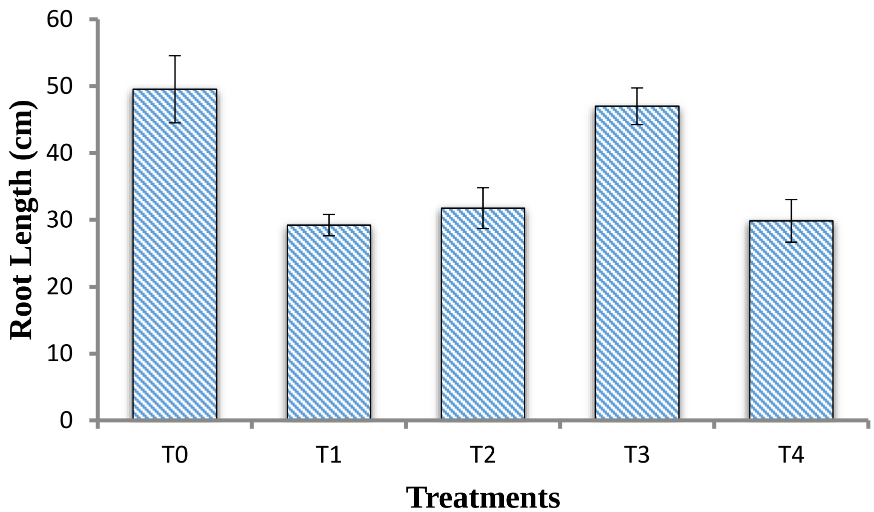

Fig 3.1.2. a: Root length as influenced by various watering levels

3.1.3 Shoot Length (cm)

Shoot length was affected significantly by each treatment as shown in analysis of variance table 4.1.3a of shoot length. The tree species *Tamarix* also displayed significant fluctuations in its performance against all treatments. Least Significance Difference (LSD) test was used for comparing the mean values of each treatment of the plant. The impact of treatment (T_0) was significant among other treatments whereas the treatment (T_4) showed minimum significant effect. While the significant impact of (T_1), (T_2) and (T_3) treatment was almost same and there was a little difference in their significant effect. The maximum 86.36 cm shoot length was recorded in the treatment T_0 while in the treatment $T_{4;}$ the minimum 27.94 cm shoot length was noted. Likewise other treatments, the maximum shoot length noticed in the treatment T_1 was 48.26 cm whereas in the treatment T_2 was 53.34 cm. Similarly, in the treatment $T_{3,}$ 78.74 cm shoot lengths were recorded. These findings are similar with the conclusion of (Medina *et al*., 2020) who explained that compaction of soil enhances soil bulk density and decreases yield, root length, saturated hydraulic conductivity and finally shoot length.

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Table 3.1.3a: ANOVA for Shoot Length (cm)

Mean of variation	Degrees of freedom	Total squares	Mean squares	F value
Replication	3	101.75	33.92	0.63
Treatment	4	1117.42	279.35	5.20*
Error	12	645.22	53.77	
Total	19	1864.39		

NS = Non-significant (P>0.05); * = Significant (P<0.05); ** = Highly-significant (P<0.01)

3.1.3b: Correlation of means

Treatments	Mean ± SE
T0	56.52 ± 4.867 A
T1	40.01 ± 1.105 BC
T2	40.01 ± 4.794 BC
T3	46.99 ± 3.274 AB
T4	34.93 ± 1.906 C

Means having same letters are non-significant statistically (P>0.05).

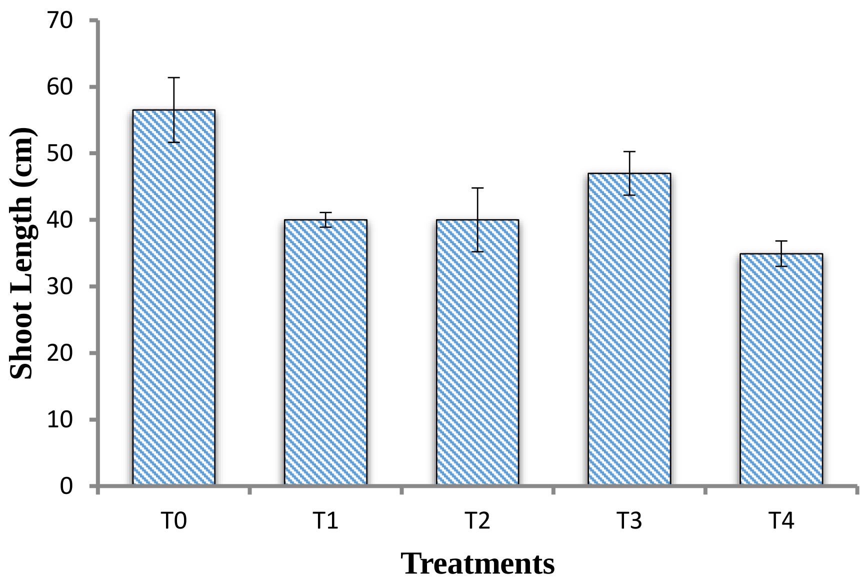

Fig 3.1.3. a: Shoot length as influenced by various watering levels

3.1.4 Root Fresh Weight (g)

Root fresh weight was found statistically significant by each treatment as shown in analysis of variance table 4.1.4a of root fresh weight. The specie *Tamarix* also displayed significant fluctuations in its performance against all treatments. Least Significance Difference (LSD) test was used for comparing the mean values of each treatment of the plant. The impact of treatment (T_3) was highly significant among other treatments whereas the treatment (T_1) showed minimum significant effect. While the significant impact of (T_0), (T_2) and (T_4) treatment was slightly changed with each other. The maximum 55 g root

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fresh weight was recorded in the treatment T_3 while in the treatment T_1, the minimum 5 g root fresh weight was noted. Likewise other treatments, the maximum root fresh weight noticed in the treatment T_0 was 26 g whereas in the treatment T_2 was 18 g. Similarly, in the treatment T_4, 16 g root fresh weights were recorded. That findings are similar to the results of (Paudel and Crago, 2021; Gilbert, 2015) who reported that prolong water deficiency is the main factor in the declining of fibrous roots of *Avocado* species and explained considerable losses in root length, leaf area and shoot length (Gosnell *et al*., 2020).

Table 3.1.4a: ANOVA for Root Fresh Weight (g).

Mean of variation	Degrees of freedom	Total squares	Mean squares	F value
Replication	3	5.20	1.73	0.14
Treatment	4	992.80	248.20	19.75**
Error	12	150.80	12.57	
Total	19	1148.80		

NS = Non-significant (P>0.05); * = Significant (P<0.05); ** = Highly-significant (P<0.01)

3.1.4b: Correlation of means

Treatments	Mean ± SE
T0	16.75 ± 1.436 B
T1	8.75 ± 0.629 C
T2	11.25 ± 1.887 C
T3	28.50 ± 2.327 A
T4	11.75 ± 1.250 BC

Means having same letters are non-significant statistically (P>0.05).

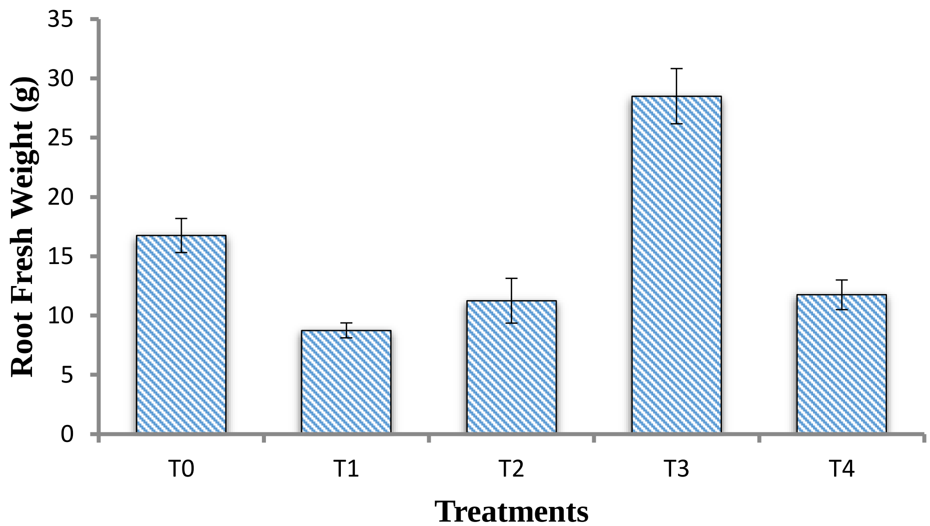

Fig. 3.1.4.a: Root fresh weight as influenced against various watering levels

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3.1.5 Soot Fresh Weight (g)

Shoot fresh weight was found statistically significant by each treatment as shown in analysis of variance table 4.1.5a of shoot fresh weight. The tree species *Tamarix* displayed some fluctuations in its performance against all treatments. Least Significance Difference (LSD) test was used for comparing the mean values of each treatment of the plant. The impact of treatment (T_0) was highly significant among other treatments whereas the treatment (T_4) showed minimum significant effect. While the significant impact of (T_1) and (T_2) and (T_3) treatment was totally different from each other. The maximum 153 g shoot fresh weight was recorded in the treatment T_0 while in the treatment T_4; the minimum 4 g shoot fresh weight was noted. Likewise other treatments, the maximum shoot fresh weight noticed in the treatment T_1 was 59 g whereas in the treatment T_2 was 58 g. Similarly, in the treatment T_3, 126 g shoot fresh weights were recorded. The results are similar to the findings of (Clapp *et al*., 2018) who designed their research on the two varieties of maize underwater stress at several growth stages of maize plants. They explained the poor growth behavior of maize plants including a decrease in root and shoot fresh weight. All these findings are accordance to present study.

Table 3.1.5a: ANOVA for Shoot Fresh Weight (g)

Mean of variation	Degrees of freedom	Total squares	Mean squares	F value
Replication	3	144.55	48.18	0.77
Treatment	4	5640.20	1410.05	22.55**
Error	12	750.20	62.52	
Total	19	6534.95		

NS = Non-significant (P>0.05); * = Significant (P<0.05); ** = Highly-significant (P<0.01)

3.1.5b: Correlation of means

Treatments	Mean ± SE
T0	65.50 ± 2.598 A
T1	35.50 ± 5.454 BC
T2	32.75 ± 4.270 C
T3	46.50 ± 3.571 B
T4	14.50 ± 2.661 D

Means having same letters are non-significant statistically (P>0.05).

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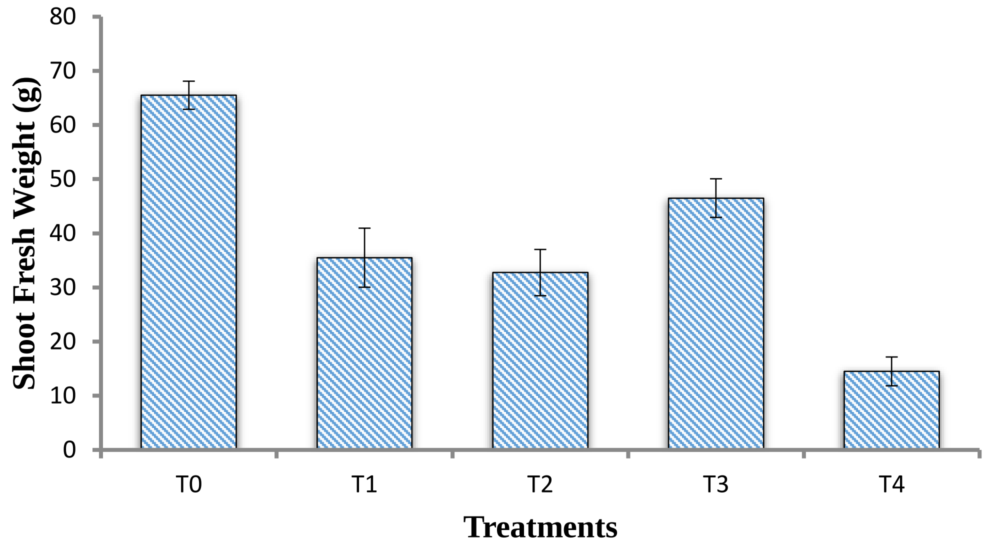

Fig. 3.1.5.a: Shoot fresh weight as influenced against various watering levels

3.1.6 Root Dry Weight (g)

Root dry weight was found significant statistically by each treatment as shown in analysis of variance table 4.1.6a of root dry weight. The tree species *Tamarix* displayed significant fluctuations in its performance against all treatments. Least Significance Difference (LSD) test was used for comparing the mean values of each treatment of the plant. The impact of treatment (T_3) was highly significant among other treatments whereas the treatment (T_1) showed minimum significant effect. While the significant impact of (T_0) and (T_2) and (T_4) treatment was totally different from each other. The maximum 31 g root dry weight was found in T_3 treatment while the minimum 3 g root dry weight was noted in the treatment T_1. Likewise other treatments, the maximum root dry weight noticed in the treatment T_0 was 15 g whereas in the treatment T_2 was 12 g. Similarly, in the treatment T_4, 11 g root dry weights were recorded. Plants productivity and their growth under water stress is relevant to the action of the spectral and temporal root distribution, dry matter partitioning, length and quality of functional roots and allocation of biomass (Rose and Chilvers, 2018; Newell and Taylor, 2017). All those are similar with the findings of current study.

Table 3.1.6a: ANOVA for Root Dry Weight (g)

Mean of variation	Degrees of freedom	Total squares	Mean squares	F value
Replication	3	12.150	4.050	0.84
Treatment	4	352.000	88.000	18.33**
Error	12	57.600	4.800	
Total	19	421.750		

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3.1.6b: Correlation of means

Treatments	Mean ± SE
T0	9.00 ± 0.408 B
T1	4.00 ± 0.408 C
T2	7.00 ± 0.913 BC
T3	16.50 ± 1.555 A
T4	7.25 ± 1.493 BC

Means having same letters are non-significant statistically (P>0.05).

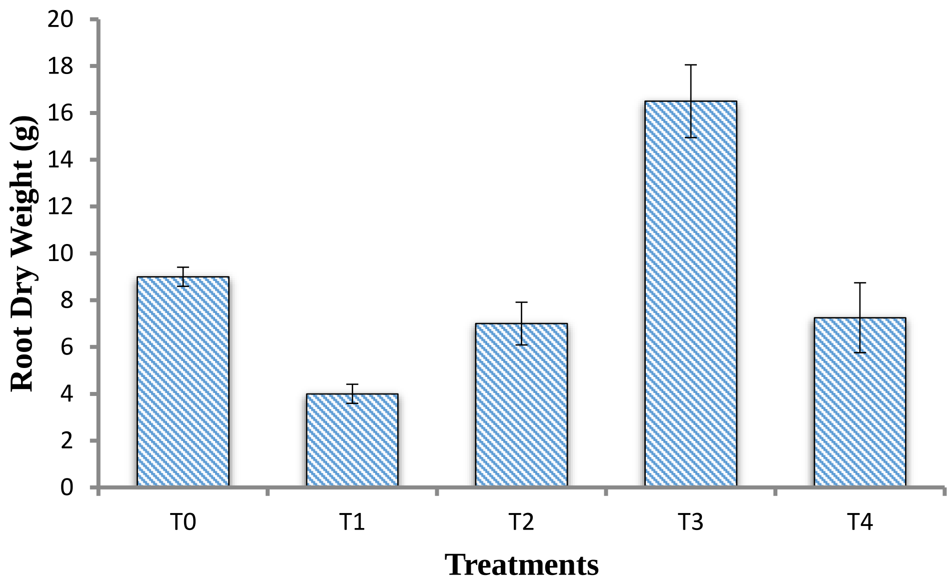

Fig. 3.1.6.a: Root dry weight as influenced against various watering levels

3.1.7 Shoot Dry Weight (g)

Shoot dry weight was found statistically significant by each treatment as shown in analysis of variance table 4.1.7a of shoot dry weight. The specie *Tamarix* also displayed significant fluctuations in its performance against all treatments. Least Significance Difference (LSD) test was used for comparing the mean values of each treatment of the plant. The impact of treatment (T_0) was highly significant among other treatments whereas the treatment (T_4) showed minimum significant effect. While the significant impact of (T_1) and (T_2) was little different from each other and (T_3) treatment was totally different. The maximum 63 g shoot dry weight was recorded in the treatment T_0 while in the treatment $T_{4;}$ the minimum 2 g shoot dry weight was noted. Likewise other treatments, the maximum shoot dry weight noticed in the treatment T_1 was 30 g whereas in the treatment T_2 was 25 g. Similarly, in the treatment $T_{3,}$ 53 g shoot dry weights were recorded. Similarly, those findings are quite similar to the results of (Bassett and Fogelman, 2013) who reported that drought stress is much destructive at flowering stage. The shortage and excess of soil moisture to plants reduces their roots and shoots fresh and dry weights.

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Table 3.1.7a: ANOVA for Shoot Dry Weight (g)

Mean of variation	Degrees of freedom	Total squares	Mean squares	F value
Replication	3	36.20	12.07	0.81
Treatment	4	1020.20	255.05	17.02**
Error	12	179.80	14.98	
Total	19	1236.20		

NS = Non-significant (P>0.05); * = Significant (P<0.05); ** = Highly-significant (P<0.01)

3.1.7b: Correlation of means

Treatments	Mean ± SE
T0	27.75 ± 1.887 A
T1	15.75 ± 2.462 B
T2	14.50 ± 1.848 B
T3	23.25 ± 1.702 A
T4	7.25 ± 1.436 C

Means having same letters are non-significant statistically (P>0.05).

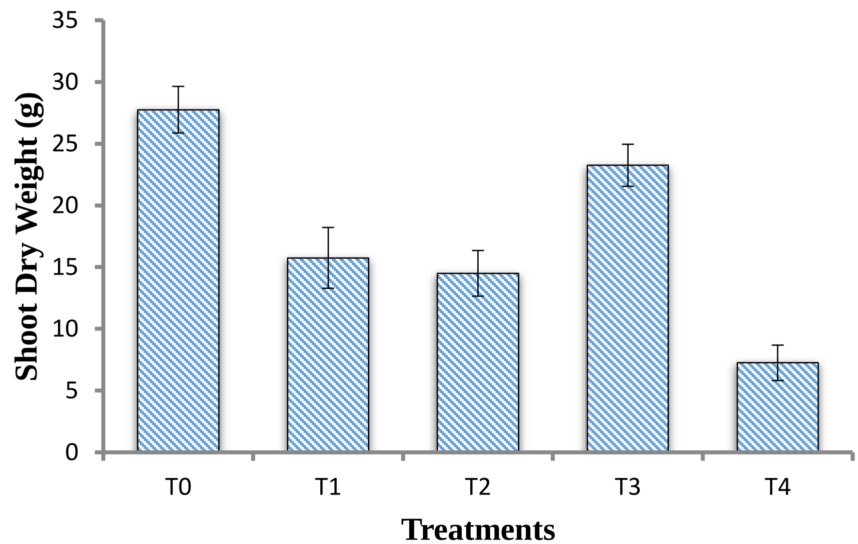

Fig. 3.1.7.a: Shoot dry weight as influenced by various watering levels

3.1.8 Plant height (cm)

Plant height was significantly impacted by each treatment as shown in analysis of variance table 4.1.8a of plant height. The specie *Tamarix* also displayed significant fluctuations in its performance against all treatments. Least Significance Difference (LSD) test was used for comparing the mean values of each treatment of the plant. The impact of treatment (T_0) was highly significant among other treatments whereas the treatment (T_4) showed minimum significant effect. While the significant impact of (T_1) and (T_2) and (T_3) was totally different from each other. The maximum 162.56 cm plant height was

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recorded in the treatment T_0 while in the treatment T_4, the minimum 53.34 cm plant height was noted. Likewise other treatments, the maximum plant height noticed in the treatment T_1 was 99.06 cm whereas in the treatment T_2 was 94.53 cm. Similarly, in the treatment T_3, 109.22 cm plant heights were recorded. Mateo-Sagasta *et al*., (2018) and Paudel and Crago, (2021) studied the causes of reduction in the trunk size of *Albizzia* seedlings under water stress. All these findings are accordance to present study.

Table 3.1.8a: ANOVA for Plant height

Mean of variation	Degrees of freedom	Total squares	Mean squares	F value
Replication	3	256.64	85.55	1.57
Treatment	4	5133.54	1283.38	23.59**
Error	12	652.94	54.41	
Total	19	6043.12		

NS = Non-significant (P>0.05); * = Significant (P<0.05); ** = Highly-significant (P<0.01)

3.1.8b: Correlation of means

Treatments	Mean ± SE
T0	106.05 ± 2.884 A
T1	69.22 ± 2.454 C
T2	71.76 ± 4.324 C
T3	93.98 ± 5.212 B
T4	64.77 ± 3.949 C

Means having same letters are non-significant statistically (P>0.05).

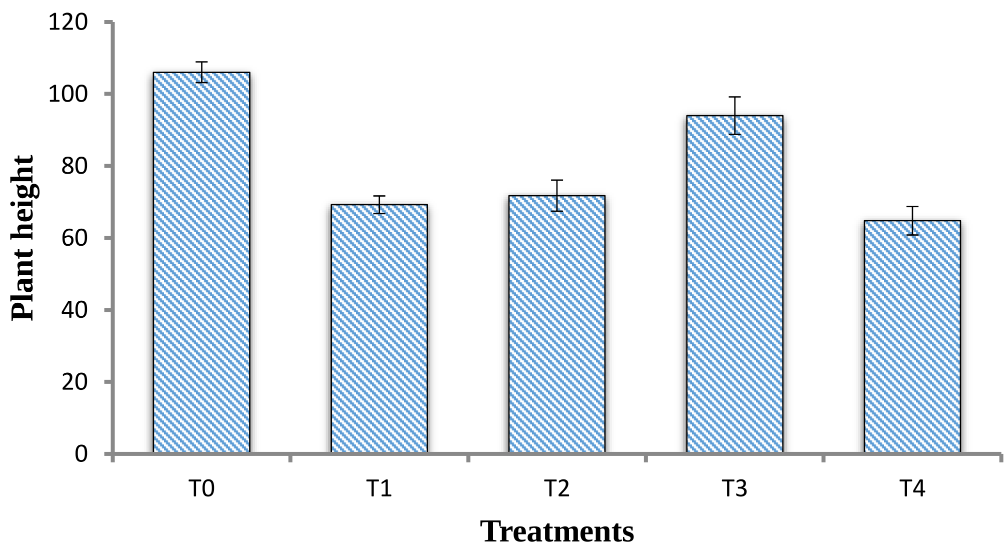

Fig 3.1.8.a: Plant height as influenced by various watering levels

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3.1.9 Root Shoot Ratio (%)

Root shoot ratio was significantly impacted by each treatment as shown in ANOVA table 4.1.9a of root-shoot ratio. The specie *Tamarix* also displayed significant fluctuations in its performance against all treatments. Least Significance Difference (LSD) test was used for comparing the mean values of each treatment of the plant. The impact of treatment (T_3) was highly significant among other treatments whereas the treatment (T_1) showed minimum significant effect. While the significant impact of (T_1) and (T_2) and (T_3) was totally different from each other. The maximum root shoot ratio was found in T_3 treatment while the minimum 65.55% root shoot ratio was noted in T_1 treatment. Similarly, that findings are similar to the results of (Hardiyanti *et al*., 2021) who explained that prolong water deficit is main reason in declining of fibrous roots of *Avocado* species and also minimizes roots growth in populous plants that are similar to the current study findings.

Table 3.1.9a: ANOVA for Root-Shoot ratio.

Mean of variation	Degrees of freedom	Total squares	Mean squares	F value
Replication	3	690.3	230.1	0.70
Treatment	4	7214.2	1803.5	5.50**
Error	12	3932.5	327.7	
Total	19	11837.0		

NS = Non-significant (P>0.05); * = Significant (P<0.05); ** = Highly-significant (P<0.01)

3.1.9b: Correlation of means

Treatments	Mean ± SE
T0	90.42 ± 8.690 B
T1	70.30 ± 6.233 B
T2	83.46 ± 7.514 B
T3	127.51 ± 10.536 A
T4	93.17 ± 10.169 B

Means having same letters are non-significant statistically (P>0.05).

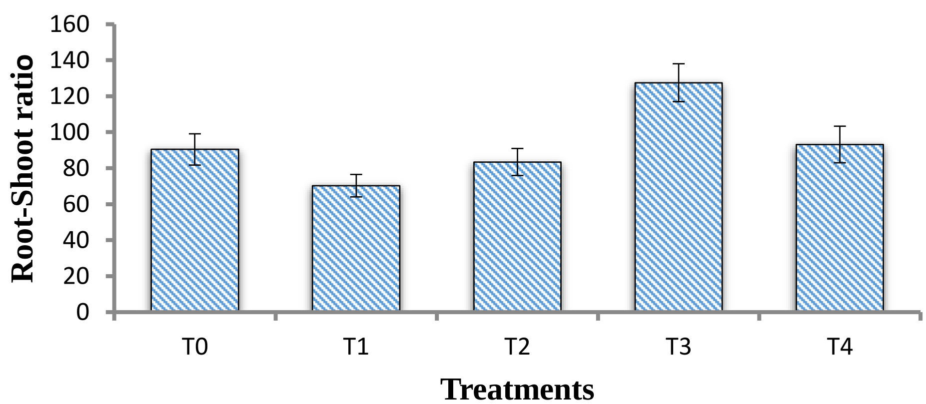

Fig. 3.1.9: Root Shoot ratio as influenced against various watering levels

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4. CONCLUSION

The research was planned in order to check the impact of water use efficiency on the growth response of *Tamarix aphylla* at normal, mean, and excess levels of water application. A pot experiment was carried out for this purpose. Several treatments comprising of different irrigation intervals was applied to the *Tamarix aphylla* at different times. Data regarding several morphological parameters was collected at the end of the experiment and tested statistically using Randomized Complete Block Design. The reaction of each treatment level on the plants height was significant but there was a great difference in the performance of each plant after applying treatments. Due to this, the mean values of the studied experiment varied significantly. Data for different morphologic attributes after analysis exhibited changes in their performances.

The overall plant height was maximum in the treatment W_0 where plants were irrigated on regular basis. There was a moderate reduction in the height of plant when irrigation time period was reduced. Likewise, the plant height was maximum (70 cm) in treatment W_1 (4 days interval). It was quite clear that the plant height was maximum in all treatments. However, the root length changed extremely by the impact of the drought that showed the maximum 30 cm root length was obtained for the specie where the plants were irrigated after 4 days' time period. Likewise, the performance was extremely affected in the treatments W_2 and W_3 yielding only 35 cm and 45 cm for the said species when irrigation was applied after 8 and 12 days interval. With the increase in irrigation interval, there was a drastic change in the fresh weight of shoot referring to the little fresh weight of shoot for the treatment W_4 (Irrigation after 16 days interval).

It was quite obvious from the results that the treatment W_1 yielded maximum root-shoot ratio where irrigation was applied after 4 days interval. Likewise, there was a clear change in the performance of treatment W_2 and W_3 where water was applied after 8 and 12 days interval. From the results, it was obvious that growth response of *T. aphylla* was much better by increasing the water use efficiency. All the findings were similar to those of (Dunne *et al*., 2019; Ketiem *et al*., 2017; Field *et al*., 2015; Abdulazeez *et al*., 2014). Besides limiting factors, the results of the current study can be utilized for UNFCCC REDD+ mechanism and scientific action plans for making Pakistan climate change free.

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