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RESPONSE OF EUCALYPTUS CAMALDULENSIS PLANTATION TO EXPERIMENTAL DROUGHT

Waqar Zafar*[1], Dr. Aamir Saleem[2], Hanza Ahmad Khan[3]

[*1,2]*Department of Forestry, Range Management, Pir Mehr Ali Shah Arid Agriculture University Rawalpindi, Pakistan.*
[3]*Department of Botany, Lahore College for Women University, Lahore, 54000, Pakistan*

[*1]w.hunjra@gmail.com

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Corresponding Author: * Waqar Zafar

Abstract
Background: *Both climate change and the lack of water are serious hazards for plant health and production in both forestry and agroforestry. Because Eucalyptus camaldulensis can resist many climate conditions, it is cultivated in many parts of the world. But not much research has been done on how Eucalyptus responds to drought stress with controlled conditions in Pakistan.* ***Introduction:*** *Since drought intensity is increasing, it is necessary to check a plant's drought tolerance for sustainable farming. An experimental drought was carried out with Eucalyptus camaldulensis at Kolo Tarar in Hafizabad during 2015-16. The data indicates that growing drought-resistant genotypes is useful in plantations in dry or rainfed regions. What I have found is useful for making better decisions about afforestation when faced with climate changes.* ***Objective:*** *The purpose of the study is to examine how the plant and soil moisture change in Eucalyptus camaldulensis when drought and irrigation treatments are applied.* ***Materials and Methods:*** *In 2015 and 2016, the study was carried out in Kolo Tarar, Hafizabad, using 40 Eucalyptus camaldulensis trees that were separated into two groups. Twenty trees received normal rainfall (the control group) and twenty were kept under plastic to withhold water (drought treatment). The plastic sheets were placed 2 feet off the ground to stop rainwater from touching the trees, to protect them. The researcher took regular measurements of height, trunk diameter and health* ***Results:*** *Results from the data revealed that Eucalyptus camaldulensis is able to handle drought conditions well. Although drought-treated trees grew less, they did not face major stress while they survived. It means the species is capable of surviving dry conditions. As a result, this tree can successfully be planted in both desert and rainy climate regions.* ***Conclusion:*** *The research found that Eucalyptus camaldulensis is well adapted to dryness. Despite having smaller leaves, the trees experienced little stress as they went through the drought. It lets us know that the species can tolerate times without water. For this reason, this tree can be grown in areas with harsh deserts or lots of rain.*

INTRODUCTION

Insufficient irrigation and limited rainfall lead to drought stress, causing a depletion of available soil moisture, which in turn hampers plant growth and development. During drought conditions, the balance between water uptake by roots and water loss through transpiration is disrupted, ultimately affecting various physiological processes in plants. (keith.hansen, 2011).Due to increasing trend in temperature drought is the biggest threat for agriculture in future (IPCC 2007 An increasing temperature trend makes drought the greatest danger for farming in the years to come (IPCC 2007). More irregular rain, warming temperatures and melting snowpacks are reasons why droughts often occur (Stewart et al. 2005). An increase in drier periods and snow free zones is being caused by snow melting ahead of schedule because of water cycles controlling melting and high temperatures (Westerlinget *al.* 2006). During periods of drought, trees are more susceptible to death, so this should be a major area of focus for future scientists (Allen et al. 2010). The ways plants react to drought differ greatly and have been defined properly. (McDowell *et al.* 2008).

In different areas of Pakistan and during several times throughout the year, drought is an issue and if it worsens, it could cause big problems because the country relies on agriculture for much of its economy. Increased desertification from drought will reduce the main places we grow crops, damaging the economy of the country since the international community has identified it as an important economic, social and environmental problem (Irshad *et al.*, 2007).

Physiological Adaptations of Plants to Drought Stress:

Drought-adaptive strategy for plants involves changes in leaf area index and in the relationship between roots and shoots for every plant species (Larcher, 2003). Plants that can function with less soil moisture from above have had their performance in drought-stressed conditions measured (Canadell *et al.*, 1996; Nepstad *et al.*, 1994). The speed at which Carbon dioxide is taken in is linked to how wide stomata are and how well mesophyll functions (Lawlor, 1995;Keenan *et al.*, 2010;Chaves *et al.*, 2009) also affecting source to sink relationship (Palacio *et al.,* 2014). Plant photosynthesis is more strongly influenced by drought than is their respiration or the environment around them (Shi *et al.*, 2014; Schwalm *et al.*, 2012; Atkin and Macherel, 2009).

MATERIALS AND METHODS:

STUDY AREA:

The study was carried out in Village Kolo Tarar, just 14Km from the city of Hafizabad, Pakistan. The location of the site is at 800 feet (240 m) above sea-level, right in central Punjab inside the space bounded by 32°-20° north latitudes and 73°-12°east longitude, as represented in figure 1. Along field side borders and canals, eucalyptus camaldulensis plantations were widespread. Young trees of Eucalyptus camaldulensis are used in this study. Shelterbelts and firewood are the chief reasons farmers grow Eucalyptus in communities. Most of this type is cultivated along canals, highways and motorways. A small group also lives there who once made profits by farming and selling Eucalyptus. More and more people from Hafizabad are taking up agro forestry, growing many types of useful plants. Some farmers plant willows along field edges for shelter, some take them for firewood, but the new thing is that more people are starting to grow them to profit from their fast growth.

The major species of the area are:

Sufaida (*Eucalyptuscamaldulensis*), Shisham(*Dalbergiasissoo*), Kikar (*Acacia nilotica*), Beri(*Zizyphusmauritiana),* Mulberry(*Morusalba*), Dharek(*Meliaazedarach),* Neem(*Azadirachtaindica*), Pipal(*Ficusreligiosa*).

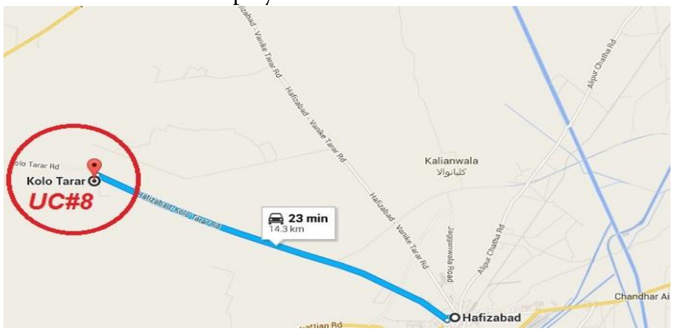

Figure 1: Study Area Map

SOIL SAMPLING:

We collected soil from 8 areas in the field, 4 from located under the protective mesh and 4 from those that remained uncovered. In each months of the research time, samples of 50 grams of soil were collected twice. Samples were dug from a depth of 0-12cm at several sites 2 meters apart. We sealed these samples in individual polythene zippers. Following sampling, they were brought to the laboratory and passed through a 2mm-sieve made from stainless steel. Those samples that remain after sieving were weighed again and later placed in a drier oven for 24 hours at 105 degrees Celsius. The samples were left in desiccators for 30 minutes once cooled and then weighed again. Soil moisture calculated by the following formula:

Soil moisture = (Wt. of fresh soil – Wt. of dry soil)/ Wt of dry soil × 100

DIAMETER:

Diameter of trees was measured with diameter tape at breast height. By measuring tape girth of trees was determined and then by using the following formula diameter was calculated.

Diameter = G/π

Where G = Girth of tree π= 3.1428

RESEARCH DESIGN:

To ensure we make a fair comparison, this study applies two treatments to Eucalyptus camaldulensis trees. In the first treatment, we left 20 Eucalyptus camaldulensis trees open to rainfall. Eucalyptus camaldulensis trees were also given experimental drought treatment on 20 trees. For this reason, the shelters were constructed so that water didn't reach the floor beneath the trees. Trees were covered below their trunks with plastic sheets placed about 2 feet from the ground to cause no unwanted damage.

We found 40 Eucalyptus camaldulensis growing at two sites, arranged into 4 rows where each row has 10 trees spaced 5×4 feet apart. Along the northern edge, the first two rows had uncovered trees, but the next two rows which were to the south, were undercover. Now we cut up 4 pieces of plastic. Back in that row, two sheets of plastic were arranged so each sheet protected 5 trees. Sheets were fastened with rope. We needed to be sure that water did not get through.

RESULTS

PLANT HEIGHT:

These plants are among the tallest you will find anywhere in the world. When conditions favour it, palms can grow as high as 180 feet, again, depending on which variety is used. More plant biomass and aerial growth are good reasons to use higher plants. Elevated plants are able to send light and much more propagules to distant plants (Harper, 1982). I used an Abney's level to measure plant height in the experimental plants. The records reveal that rainfall is significantly higher for covered than for uncovered plants. Treatment without covering showed a highest plant of 44.7 feet. for the 19th sample, next highest was seen on the 12th sample with 41.7 feet. and the 6th sample with only 6.73 feet. was the shortest plant height in treatment with covering as seen in table 1. Moreover, a remarkable variation by height (85%) was found between the tallest and shortest plants.

The same results for maximum height in plant height (37.82, 37.11 feet.) were seen in the 12th and 19th crops. In addition, the mean minimum plant height was observed in the 6th plant (at 14.2 feet.) and the 3rd at 15 feet. A mean difference of 62 % was discovered when we compared the high and low heights in both treatments. The more soil moisture available may be why uncovered plants appear higher. For mean plant height, the variation between treatments with and without plants was 39 %. The depth of your plants will depend mostly on how much water there is in the soil. Because of the monsoon rain in June and July, water became more available and eucalyptus which grow very quickly when soil moisture is high, had suitable growth conditions as reported previously. The varied plant heights come from the ready availability of high soil moisture during the experiments. We found that greater plant height was present among uncovered plants, since there was enough moisture for them to develop as they should. The fact that our eucalyptus showed differences in height was an expression of their genetic makeup ($p = 0.000$), regardless of the treatment. Singh et al., (2014) reported findings that agreed with ours. Greater soil moisture was found to increase plant height and was important for the action of stomata in opening and shutting by Givnishet al., (2014).

Table 1: The Table represent the plant height readings for Eucalyptus camaldulensis are shown in the table under various treatment conditions. Trees receiving usual amounts of water (approximately 29.835 cm on average) were markedly taller than those that suffered drought (their mean height was 18.113 cm). It proves that water availability affects the rate at which the species develops.

1	20.1mno	29.8ghi	**24.9E**
2	11.2rs	24.5kl	**17.9IJ**
3	9.1stu	20.8mn	**15KL**
4	26.9ijk	17.5op	**22.2FG**
5	32fg	35.6de	**33.8B**
6	8.2stu	20.2mno	**14.2L**
7	17.2op	34ef	**25.6E**
8	10.2rs	38.3cd	**24.3EF**
9	29.5ghij	33.2ef	**31.4C**
10	6.9tu	31.3fgh	**19.1HI**
11	24.4kl	16.4p	**20.4GH**
12	34ef	41.7ab	**37.8A**
13	13qr	22.4lmn	**17.7IJ**
14	28.9ghij	29ghij	**28.9D**
15	10rst	39.2bc	**24.6E**
16	8.7stu	23.2lm	**16JKL**
17	19.6no	28.1hij	**23.9EF**
18	16.1pq	40.5bc	**28.3D**
19	29.5ghij	44.7a	**37.1A**
20	6.7u	26.5jk	**16.6JK**
Mean	**18.113 B**	**29.835 A**	

STEM DIAMETER:

It is considered beneficial for economic reasons if the stem is thick enough to avoid lodging and produce plenty of biomass. Reporting counts your stems precisely, so you can estimate the economic value of your firewood and timber. To understand the structure of a stand, stem diameter must be measured in silviculture. Stem width is normally checked at breast height in an unbiased way so that all data is accurate and the same for all surveyed trees. Stem becomes a basic measure in positioning plant bodies around and over other bits, so it can capture more light for photosynthesis and sturdiness from its thickness supports all these actions.

There were major differences in diameter for stems receiving the various treatments. Table 2 reveals that the thickest stem (5.2 inches) was found on the 12th plant and the thinnest, uncovered (1.4 inches), on the covering sheets. A large difference (73 %) between the largest and smallest stem diameter was observed. The maximum thickness for the stem occurred in the cover treatment (4.9 inches). The 4.5-inch diameter was the greatest thickness of stem in the 12th plant, followed by 4.4 inches in the 5th plant. The 20th plant had the smallest diameter of 2.0 inches.

A 56 percent variation occurred in stem diameter, from largest to smallest. The work showed that uncovered plants reached a better stem diameter than their covered counterparts. Statistically mean values report 3.3 Inches stem thickness for plants without covers and 3.0 inches stem diameter for plants with covers. The overall variation in stem diameter between the treatments was only 9 % ($p = 0.0846$). That information is shown in table 2. When there's no cover, plants' stems grow wider because they are less likely to grow dry from lack of soil moisture. Changing levels of moisture and tension in the stem wall are important causes of stem thickness changes. If the diameter of the stem is observed, we can accurately measure water condition inside the stem or transpiration pull.

Table 2: The table shows that size of the stem is shown under both drought conditions and with irrigation for Eucalyptus camaldulensis. Higher mean stem diameter was found among uncovered trees than among covered trees, proving better yield with more water. It appears that drought causes the species' stems to develop slightly smaller diameters.

Plants #	Covered	Uncovered	Mean
1	3.4hij	3.5hij	**3.4D**
2	3mn	3no	**3EF**
3	2.3rs	2.3rs	**2.3I**
4	3.4hijk	2.2st	**2.8GH**
5	4.9b	3.9ef	**4.4A**
6	3.1klmn	3.1lmn	**3.1E**
7	2t	3.4hijk	**2.7H**
8	2.6pq	4.3cd	**3.5CD**
9	3.6gh	3.1lmn	**3.3D**
10	2.3rs	3.6ghi	**2.9EF**
11	3.1lmn	2.7op	**2.9FG**
12	3.8fg	5.2a	**4.5A**
13	3.3jklm	2.7op	**3EF**
14	3.1klmn	3.5hij	**3.3D**
15	2.5qr	4.1de	**3.3D**
16	2.3rs	2.5qr	**2.4I**
17	3.3ijkl	3.9ef	**3.6C**
18	2.3rs	4.5c	**3.4D**
19	3.8fg	4.2d	**4B**
20	1.4u	2.6pqr	**2J**
Mean	**3.0 B**	**3.3A**	

SOIL MOISTURE:

Effective plant growth and development are closely related to soil moisture. How plants work is controlled by the moisture they absorb. If soil moisture dries out, plants wilt and the products that dry can no longer be rescued and they support various chemical reactions underground. Experimental plots were sampled for soil moisture over different times. 17.0 percent of the soil was found to be most moist at the 19th plant, with 18.0 percent at the 18th plant in uncovered treatment as shown in the table 3. Distilled water measured in the soil for plants numbered 6, 10, 16 and 20 each showed the lowest development, at 2.5, 2.9, 2.8 and 2.6 units. Higher moisture in open treatment might be because polythene covering blocked rainfall underneath this canopy. Soil moisture contents were 85 percent different between their highest and lowest level.

Typically, moisture content in soil was highest under the 12th and 19th plants (13.5% and 12.9% respectively), while it dropped to 4.1% under the 6th crop, resulting in a 70% difference between the highest and lowest values. Covered plants contained 32% less water in the soil than uncovered ones ($p = 0.000$). They were mostly shaped by the quality of the soil and the local environment instead of by rainfall. According to Srivastava et al. (2007), soil moisture in eucalyptus plantations is more influenced by various reaons and during times of drought, eucalyptus plantations still absorb and retain more water than other surrounding lands (Srivastava, 1993). Kumar (1984) noted that eucalyptus conserves water by transpiring less and that their stomatal activity depends on the surrounding moisture, without limiting how well they grow. As Figure 2 indicates, rainfall is relatively low from October to December, increases a little in February and shoots up in July, indicating the beginning of the monsoon season; therefore, soil moisture varies noticeably between the dry and wet periods within the plantation.

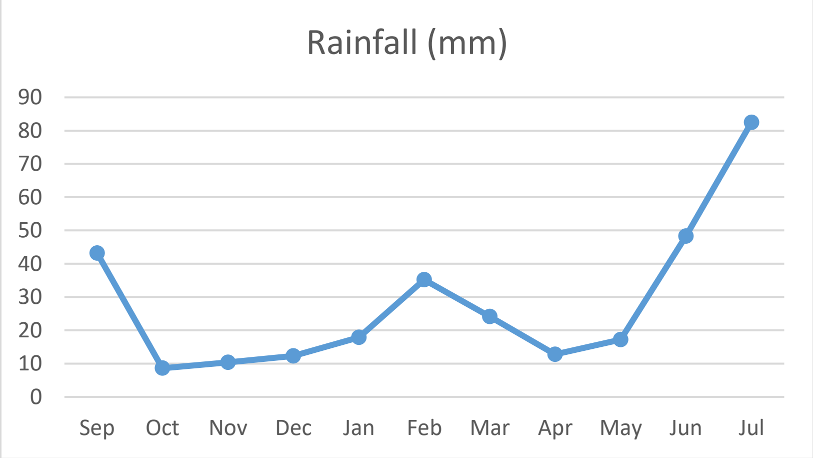

Figure 2: Average Rainfall (mm)

Table 3: The table illustrates soil moisture is shown for drought conditions with a cover over the soil and irrigated conditions without a cover. The moisture content of uncovered plans (10.28) was much higher than that of covered plans (7.0) which means the drought simulation produced good results. Changes in moisture levels are likely what account for the observed changes in plant growth.

Plants #	Covered	Uncovered	Mean
1	8.7jkl	10.3efghi	**9.5CD**
2	6nop	9hijkl	**7.5E**
3	4.9opq	6.9mn	**5.9FG**
4	9.7fghij	5.7nop	**7.7E**
5	11.1def	11.4de	**11.2B**
6	2.5r	5.7nop	**4.1H**
7	7.9klm	10.6defg	**9.3CD**
8	4.8pq	13.6c	**9.2D**
9	10.3efghi	10.4efgh	**10.4BC**
10	2.9r	11def	**6.9EF**
11	9.6fghij	5.4nop	**7.5E**
12	12d	15bc	**13.5A**
13	6.5mno	7.7lm	**7.1E**
14	8.9hijkl	9.9efghij	**9.4CD**
15	3.7qr	14.1bc	**8.9D**
16	2.8r	8klm	**5.4G**
17	9.4ghijk	9.2ghijkl	**9.3CD**
18	6.5mn	15.5ab	**11B**
19	8.8ijkl	17a	**12.9A**
20	2.6r	9.1ghijkl	**5.9FG**
Mean	**7.0 B**	**10.28 A**	

DISCUSSIONS:

Because at my site Eucalyptus trees were planted as shelter belts and for erosion control beside rivers. Important variations between the parameters of covered and uncovered plants were noted during the study. European Soil Moisture Database data recorded significant moisture differences under each Eucalyptus canopy. There was enough water for plants to support both their shape and put on more leaves. In many studies that show eucalyptus helps retain soil water, we faced no dryness problems under the eucalyptus while doing the study. A greater growing pattern was detected in plants that do not use climbers. Physiological function determines aerial biomass, since uncovered plants were seen to be more productive than others.

Genotypes react in different ways to challenges related to soil moisture, so finding those that tolerate those conditions will matter a lot for upcoming planting. Those stands receiving the same amount of rain each year were found to be more likely to suffer from drought than the stands whose precipitation varied over the year. The behavior of different genotypes during a drought helps us find and retain drought tolerant maize seeds for later use. Stress tolerant species are also chosen based on how much water they take up. Having said that, choose genotypes that are tolerant to drought for best results if your plantation is in a different environment. Long term drought effects on biomass from Eucalyptus plantation need to be checked by conducting further research. Looking back at the genotypes selected from our study can support decisions for future use of Eucalyptus in rain fed areas (Sevanto, 2003).

CONCLUSION:

The findings confirm that Eucalyptus camaldulensis is well adapted to withstand experimentally caused drought conditions. Water reduction did not seriously hinder the survival and some expansion of these trees. The plant height, stem size and amount of water in the soil were all much different for drought-treated trees than for those that received water. Trees which received rainfall grew better, making clear that proper hydration helps trees thrive. Even so, the trees that suffered drought experienced only a mild decline in their growth. Soil moisture changes reflected those during drought which supported the drought simulation process. Stem diameter and plant height showed effects from a lack of water during the trial. The results demonstrate that the species can support rainfed and drought-prone schemes for afforestation. Drought-resistant varieties should be used in future plantation planning. Extended studies should be done to assess how effects of BC biomass production affect sustainability.

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