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Impact of different urea fertilizer dosages on the growth performance, biomass yield, and physiological traits of *Terminalia arjuna*

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Abstract

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Terminalia arjuna is an evergreen tree commonly known as Arjun. It is native to the Indo-Pak sub-continent. It has great importance as a medicinal tree and is considered a miracle tree for curing cardiac diseases. The only problem with this precious tree is that it is slow-growing. So, an experiment was designed to investigate the effect of urea fertilizer on the growth behaviour of *Terminalia arjuna* at the nursery level. Urea is a common nitrogenous fertilizer used by the agriculture sector on a large scale. Keeping this in view, this experiment was designed to study the impact of various doses of urea fertilizer on the growth of this highly important tree species at the seedling level. This was a pot experiment. The experiment was carried out in the nursery and experimental area of the Department of Forestry and Range Management, University of Agriculture, Faisalabad, Pakistan, in 2023. There were five treatments viz. T₀, control (no fertilizer), T₁(one gram urea, foliar spray), T₂ (two gram urea, foliar spray), T₃(one gram urea, root application), T₄(two gram urea, root application) per plant. The experiment was laid down under a completely randomized design. The treatments were applied after fifteen-day intervals. After 45 days, the plants were harvested and data on various growth parameters were recorded. The best results were obtained under treatment T₂. This treatment significantly improved all growth parameters viz. plant height, collar diameter, root and shoot length, root and shoot fresh and dry weights, root-shoot ratio, root mass allocation and shoot mass allocation. So, it is recommended that *T. arjuna* seedlings should be applied two grams of urea by foliar spray to get the most healthy and vigorous plants.

1 Introduction

Terminalia Arjuna is a large tree with evergreen nature. It is native to the subcontinent. It grows up to a height of twenty to twenty eight meters. Its stem grows up to a diameter of 1 to 2.5 meters. It has simple leaves. It produces flowers in April to May. The colour of flowers is yellowish white. Fruit is like a big capsule. The trunk has buttresses. In our country, it is grown in cultivated plains, including roadside plantations. It is shade tolerant and likes well drained soils. It is also cultivated in urban areas due to its attractive foliage, flowers and shade (Jain *et. al.*, 2009).

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For natural growth, it needs 800 to 3500 mm rainfall. It can tolerate temperatures up to 48 centigrade. It has no well known diseases and insect/pests. It is usually propagated through seed. However, it may also be propagated through vegetative means. It is a relatively fast growing tree. It is also a good agro forestry tree (Somasekhkar and Sharma, 2002). It successfully grows in saline and waterlogged soils. It is very suitable for growing in saline environments. Soil salinity is a major threat to food security in the present era. It shows resilience to salinity making it a good candidate for the reclamation of salt-affected soils in irrigated as well as in coastal areas. Its resistance to salt affected soils is definitely a function of its biochemical and physiological adaptations. These adaptations include osmotic adjustments, efficient salt extraction and antioxidant properties that protect it from physiological damage (Dagar and Singh, 2007). It has great medicinal value. The leaves and bark of *Terminalia* are used for the treatment of various diseases. Its bark is widely used by the cardiac patients. It opens up the closed valves of human heart and regulates blood supply in body. Its bark is expectorant and helps in healing respiratory diseases. The bark has laxative, purgative and antidiarrhoeal properties. Its bark is also used for the treatment of excessive sweating, anemia, tumors, asthma and cardiovascular problems. Bark also has antiviral, antimicrobial and anti-cancer properties. The bark is used as tea by the cardiac patients. It is also anti-hypertrophic and anti-hypertensive. It has antioxidant characteristics which have been studied by various scientists in detail. The bark has a wide range of valuable characteristics for human beings. Powdered bark has shown its effectiveness against obesity and hyperglycemia. It lowers down high cholesterol levels in the body. It also has antibacterial and antifungal properties. Its bark also has anti-inflammatory properties. The bio-chemicals derived from this miracle tree have been found very effective as cardiovascular/heart tonics (Kaur *et. al.*, 2001).

T. arjuna is also resistant to water stress due to various physiological and morphological traits. It can grow successfully in drought due to its extensive and deep root system. It promotes its roots deep in the soil and takes water from lower soil horizons especially in water stressed conditions or drought spell (Morton, 2002). It is also a religious tree in Hinduism and worshipped in religious events/ceremonies. Its flowers, bark and leaves are distributed as symbols of heavenly blessings (Mankodi, 2013). This tree plays a significant role in increasing the biodiversity of its natural and cultivated habitats. It provides nesting sites, shelter and food to various mammals, birds and insects. Thus increasing the overall biodiversity level of the ecosystem making it more stable and adherent to the nature (Sharma and Arya, 2018). Keeping in view all above mentioned characteristics/benefits of this miracle tree, it was necessary to carry out study on increasing the growth rate of *T. arjuna*. So, present study was designed to know effectiveness of urea fertilizer in increasing growth rate of *T. arjuna* seedlings. Urea fertilizer was selected for this trial as it is among the most commonly used fertilizers in Pakistan and is easily available. It is rich in nitrogen and promotes plant growth.

2 Materials and Methods

The study was carried out at nursery and experimental area of Forestry department, UAF. Two months old potted plants of *Terminalia arjuna* were collected from forest nursery, UAF. All the pots had five kilograms soil. Only healthy/vigorous plants were taken for present study. All the plants were homogeneous in age, vigor and stature/size. The diameter of the pots was twelve inches and height was 18 inches. The experiment was carried out under completely randomized design (CRD). There were five treatments including control. There were three replications. In each replication, there were thirty plants. Thus, total number of plants in the experiment was ninety. The treatments were following:

- T_0 (no fertilizer) Control
- T_1 (foliar spray) 1 gram urea
- T_2 (foliar spray) 2 gram urea
- T_3 (root application) 1 gram urea
- T_4 (root application) 2 gram urea

For foliar spray (T_1), one gram urea was dissolved in 100 ml water. Similarly, for T_2 , two gram urea was dissolved in 100 ml water. The treatments were repeated after every 15 days. After completing 45 days interval, the plants were harvested and various parameters including fresh weight of shoot and root were determined with the help of a weighing balance. The samples were oven dried and data regarding dry weight of leaves, shoot and roots was recorded. Data on following parameters was recorded.

- i. Plant height (cm)

- ii. Root length (cm)
- iii. Stem diameter (mm)
- iv. Number of leaves
- v. Leaves fresh weight (g)
- vi. Leaves dry weight (g)
- vii. Shoot fresh weight (g)
- viii. shoot dry weight (g)
- ix. Root fresh weight (g)
- x. Root dry weight (g)
- xi. Root shoot ratio (%)
- xii. Root mass allocation (%)
- xiii. Shoot mass allocation (%)

2.3 Statistical analysis

The collected data was statistically analyzed by two-way analysis of variance for species, treatment. The means differences were tested by using Tukey HSD test. All the means are presented in the tables and all tests were taken significant at $P < 0.005$.

3 Results

3.1 Plant height (cm)

The results show that plant height significantly increased by the application of urea in all the treatments (table-1). In T_2 , plant height was maximum (60.9 cm). In T_0 , plant height was minimum (34 cm). The results indicate that foliar spray @ 2g urea per plant is the best for plant growth.

3.2 Root length (cm)

The results show that root length significantly increased by the application of urea in all the treatments (table-2). In T_2 , root length was maximum (5.9 cm). In T_0 , plant height was minimum (5.17 cm). The results indicate that foliar spray @ 2g urea per plant is the best for plant growth.

3.3 Stem diameter (mm)

The results show that stem diameter significantly increased by the application of urea in all the treatments (table-3). In T_2 , stem diameter was maximum (6.36 mm). In T_0 , stem diameter was minimum (5.09 mm). The results indicate that foliar spray @ 2g urea per plant is the best for plant growth.

3.4 Number of leaves

The results show that number of leaves significantly increased by the application of urea fertilizer in all the treatments (table-4). In T_2 , number of leaves was maximum (18.1). In T_0 , number of leaves was minimum (10.65). The results indicate that foliar spray @ 2g urea per plant is best for plant growth.

3.5 Fresh weight of leaves (g)

The results show that fresh weight of leaves significantly increased by the application of urea fertilizer in all the treatments (table-5). In T_2 , leaves fresh weight was maximum (2.59). In T_0 , leaves fresh weight was minimum (2.33). The results indicate that foliar spray @ 2g urea per plant is best for plant growth.

3.6 Dry weight of leaves (g)

The results show that dry weight of leaves significantly increased by the application of urea fertilizer in all the treatments (table-6). In T₂, leaves dry weight was maximum (1.75 g). In T₀, leaves dry weight was minimum (0.83). The results indicate that foliar spray @ 2g urea per plant is best for plant growth.

3.7 Shoot fresh weight (g)

The results show that shoot fresh weight significantly increased by the application of urea fertilizer in all the treatments (table-7). In T₂, shoot fresh weight was maximum (9.99 g). In T₀, shoot fresh weight was minimum (8.07). The results indicate that foliar spray @ 2g urea per plant is best for plant growth.

3.8 Shoot dry weight (g)

The results show that shoot dry weight significantly increased by the application of urea fertilizer in all the treatments (table-8). In T₂, shoot dry weight was maximum (4.73 g). In T₀, shoot dry weight was minimum (2.81 g). The results indicate that foliar spray @ 2g urea per plant is best for plant growth.

3.9 Root fresh weight (g)

The results show that root fresh weight significantly increased by the application of urea fertilizer in all the treatments (table-9). In T₂, root fresh weight was maximum (4.01 g). In T₀, root fresh weight was minimum (2.34 g). The results indicate that foliar spray @ 2g urea per plant is best for plant growth.

3.10 Root dry weight (g)

The results show that root dry weight significantly increased by the application of urea fertilizer in all the treatments (table-10). In T₂, root dry weight was maximum (2.21 g). In T₀, root dry weight was minimum (1.57 g). The results indicate that foliar spray @ 2g urea per plant is best for plant growth.

3.11 Root shoot ratio

The results show that root shoot ratio significantly increased by the application of urea fertilizer in all the treatments (table-11). In T₂, root shoot ratio was maximum (0.39 g). In T₀, root shoot ratio was minimum (0.28 g). The results indicate that foliar spray @ 2g urea per plant is best for plant growth.

3.12 Root mass allocation (%)

The results show that root mass allocation significantly increased by the application of urea fertilizer in all the treatments (table-12). In T₂, root mass allocation was maximum (23.65 %). In T₀, root mass allocation was minimum (17.85 %). The results indicate that foliar spray @ 2g urea per plant is best for plant growth.

3.13 Shoot mass allocation (%)

The results show that shoot mass allocation significantly increased by the application of urea fertilizer in all the treatments (table-13). In T₂, shoot mass allocation was maximum (57.85 %). In T₀, shoot mass allocation was minimum (30.2 %). The results indicate that foliar spray @ 2g urea per plant is best for plant growth.

Table:1: Plant height (cm) of *Terminalia arjuna* as effected by various doses of urea fertilizer

Treatment	Plant height (cm)
T ₀	34 b
T ₁	44.8 ab
T ₂	60.9 a
T ₃	40 ab
T ₄	44.7 ab

T₀ = Control (no fertilizer), T₁ = 1g urea (foliar application), T₂ = 2g urea (foliar application), T₃=1g urea (root application), T₄ = 2g urea (root application).

Table: 2: Root length (cm) of *Terminalia arjuna* as effected by various doses of urea fertilizer

Treatment	Root length (cm)
T ₀	5.17 b
T ₁	5.7 a
T ₂	5.9 a
T ₃	5.25 a
T ₄	5.62 a

Table: 3: stem diameter (mm) of *Terminalia arjuna* as effected by various doses of urea fertilizer

Treatment	Stem diameter (mm)
T ₀	5.09 b
T ₁	6.05 a
T ₂	6.36 ab
T ₃	5.36 ab
T ₄	5.90 ab

Table: 4: Number of leaves of *Terminalia arjuna* as effected by various doses of urea fertilizer

Treatment	Number of leaves
T ₀	10.65 a
T ₁	13.12 ab
T ₂	18.1 a
T ₃	15 ab
T ₄	12.7 ab

Table: 5: Fresh weight of leaves (g) of *Terminalia arjuna* as effected by various doses of urea fertilizer

Treatment	Fresh weight of leaves (g)
T ₀	2.33b
T ₁	2.38 ab
T ₂	2.59 a
T ₃	2.24 b
T ₄	2.27 ab

Table: 6: Dry weight of leaves (g) of *Terminalia arjuna* as effected by various doses of urea fertilizer

Treatment	Dry weight of leaves (g)
T ₀	0.83 b
T ₁	1.14 ab
T ₂	1.75 ab
T ₃	0.98 ab
T ₄	1.08 ab

Table: 7: Shoot fresh weight (g) of *Terminalia arjuna* as effected by various doses of urea fertilizer

Treatment	Shoot fresh weight (g)
T ₀	8.07 b
T ₁	9.18 ab
T ₂	9.99 ab
T ₃	8.34 ab
T ₄	8.93 ab

Table: 8: Shoot dry weight (g) of *Terminalia arjuna* as effected by various doses of urea fertilizer

Treatment	Shoot dry weight (g)
T ₀	2.81 b
T ₁	3.32 ab
T ₂	4.73 a
T ₃	3.91 ab
T ₄	3.94 ab

Table: 9: Root fresh weight (g) of *Terminalia arjuna* as effected by various doses of urea fertilizer

Treatment	Root fresh weight (g)
T ₀	2.34 b
T ₁	3.56 ab
T ₂	4.01 a
T ₃	3.44 b
T ₄	3.72 ab

Table: 10: Root dry weight (g) of *Terminalia arjuna* as effected by various doses of urea fertilizer

Treatment	Root dry weight (g)
T ₀	1.57 c
T ₁	1.99 ab
T ₂	2.21 a
T ₃	1.79 bc
T ₄	1.82 abc

Table: 11: Root shoot ratio of *Terminalia arjuna* as effected by various doses of urea fertilizer

Treatment	Root shoot ratio
T ₀	0.31 b
T ₁	0.35 ab
T ₂	0.36 b
T ₃	0.33 b
T ₄	0.34 ab

Table: 12: Root mass allocation (%) of *Terminalia arjuna* as effected by various doses of urea fertilizer

Treatment	Root mass allocation (%)
T ₀	17.85 a
T ₁	21.15 a
T ₂	23.65 b
T ₃	18.6 a
T ₄	20.57 a

Table: 13: Stem mass allocation (%) of *Terminalia arjuna* as effected by various doses of urea fertilizer

Treatment	Stem mass allocation (%)
T ₀	30.2 a
T ₁	46.42 ab
T ₂	57.85 ab
T ₃	47.68 b
T ₄	52.07 b

4 Discussion

In agriculture, urea is a well known fertilizer which promotes the growth of various crop plants. It's a nitrogenous fertilizer. It has high nitrogen content (46.6%). Its effect on the growth of various slow growing tree species has not been studied widely (Khan, 2012). *T. aphylla* is one of slow growing plants/trees of Pakistan whose growth has not been studied as affected by various artificial fertilizers. So it was need of the time to analyze the effect of urea fertilizer on the growth behaviour of this important tree. Nitrogen is an essential nutrient required by the plants in large quantities because it promotes the synthesis of chlorophyll. More chlorophyll means more photosynthesis and more photosynthesis means more growth (Manivannan, 2015).

T. anjuna, a semi-evergreen plant, is native to the Indian sub-continent. It is well known and widely used for its medicinal properties. The bark of this miracle tree is widely used for cure of various heart/cardiac diseases. This study was designed to investigate the effect of urea fertilizer on the growth of *T. anjuna* seedlings because it is a slow growing tree. In the present experiment, urea fertilizer was applied at the rate of 1% and 2% as foliar spray per plant as well by root application. The results of this study have been discussed/compared to previous research on various crop plants as a little literature is available on this topic.

The results of present study show that maximum growth of *T. aphylla* was shown by T₂ i.e. 2 gram urea per plant by foliar spray. The results of present study are in agreement with the findings of (Smith *et al.*, 2017) who reported that growth of maize crop was significantly increased by the application of urea fertilizer. The results of present study are also in line with the findings of (Jones *et al.*, 2019) who reported increased growth of wheat plants as a result of application of urea fertilizer. In our study, all growth parameters including plant height, root length, fresh shoot and root weight, dry shoot and root weight, all were significantly increased by the application of urea. These results are similar to the findings of (Li *et al.*, 2018) who reported that chlorophyll contents of rice crop were increased by the application of urea. (Wang *et al.*, 2020) also reported that application of urea to soyabean seedlings increased the chlorophyll contents and photosynthetic rate in the plans. Ultimately, growth of soyabean plants was increased. Our results are also in line with the findings of (Zaman *et al.*, 2016) who evaluated the impact of urea on the growth behaviour of *Acacia nilotica* seedlings. He reported that plant height, leaf area, stem diameter and other growth parameters were significantly improved when urea fertilizer was applied to the *A. nilotica* plants. Similarly (Devkota *et al.*, 2018) reported significant improvement in the growth of all parameters of *Dalbergia sissoo* seedlings with the application of urea fertilizer. Our results are also similar to the results of (Chaudhary and Panda, 2015) who reported that urea significantly increased the growth of tomato plants. Conclusively, it is stated that application of 2 gram urea as foliar spray is the best option/treatment for promoting the growth of *T. anjuna* plants at nursery level.

Conclusion

The study concludes that applying two grams of urea as a foliar spray (T₂) significantly enhances the growth of *Terminalia arjuna* seedlings at the nursery level. This treatment yielded the best results across all measured growth parameters, including plant height, collar diameter, root and shoot lengths, and biomass. Therefore, it is recommended to use a foliar spray of two grams of urea per plant to promote vigorous and healthy growth in *T. arjuna* seedlings.

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