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Performance of *Melia dubia* under Different Moisture Regimes

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Abstract

This study is an attempt to assess the growth performance under rainfed and irrigated conditions of *Melia dubia* under field conditions. The primary growth indicators such as tree height, girth, trunk volume varied significantly and all of which cumulatively reflected in the total biomass production of 6.90 kg tree^{-1} and 20.00 kg tree^{-1} under rainfed and irrigated conditions respectively. Growth observed under rainfed condition compared to other tree species such as *Gravelia robusta* (4.49 kg tree^{-1}) and *Tectona grandis* (3.81 kg tree^{-1}) suggests that *M. dubia* is more suitable for rainfed conditions and 2.89 times increase in biomass with irrigation indicate the prospect of obtaining maximum returns per unit amount of water used. Large variation in the number of individuals in different girth classes of the same age trees of a species indicate the growth variability among the population and could be largely attributed to heterogeneity of the planting material of seed origin.

Keywords: *Melia dubia,* growth performance, rainfed, irrigated, seed origin, variability

Area under forest plantation has globally increased from 124 m ha to 187 m ha between 1995 and 2005. Out of this 62 per cent increase is seen in Asia (largely in China) and currently it is increasing by 4.5 m ha of which 89 per cent is contributed by Asia and South American countries. India has about 7,01,673 km^2 of forest area (21.34%) with a tree cover of 92,572 km^2 (FSI, 2015). Plantation forestry is making significant contribution in increasing the forest cover through various tree planting programmes such as Green India Mission, Compensatory Afforestation fund Management and Planning Authority (CAMPA) and other programmes in India. Given the concerns related to climate change and considering the role of trees in carbon sequestration, increasing tree cover in agriculture landscapes through Agroforestry systems has drawn considerable attention, which is evident from recent introduction of new Agroforestry policy in India (Annon, 2014). Increasing tree cover is considered to be one of the most economically viable approaches to mitigate climate change (IPCC, 2013). However to get maximum economic and environmental benefits from increased tree cover, identifying tree species suitable for the specific climatic conditions is very important.

In most tropical conditions moisture availability is one of the most important constraints and in semiarid tropical regions the source of moisture is highly unpredictable because of dependency on monsoonal rains. Rainfall in this region is mostly restricted to few months and is highly variable both in terms of intensity and distribution and therefore moisture availability plays a crucial role in crop productivity (Toledo *et al*., 2011; Grogan and Schulze, 2012). Under such circumstances trees being perennial are more resilient to environmental variations compared to annual plants. Considering the tangible benefits (such as timber, fuel, fodder, green manure) and non-tangible benefits (such as Oxygen in the air and sequestration atmospheric carbon), incorporating tree components in agriculture is considered to be most viable proposition. However, the benefits derived from tree components depends on the choice of appropriate tree species and the quality of planting material used for raising plantations.

In most of forestry programmes planting stock is obtained from seedlings of seed origin. Incidentally most tree species are cross pollinated and thus seedlings raised from seeds are heterozygous in nature. Thus there will be genetic variability among the individuals which leads to variability in growth (Le bec *et al*., 2015). Although trees have higher drought tolerance in general, identifying tree species with higher growth that can utilize water with higher efficiency is essential to maximize the water use efficiency under the changing climatic scenario.

Melia dubia is one such fast growing, indigenous and economically important multipurpose tree species that grows naturally in certain parts of the Western Ghats of South India, Eastern Himalayas, Sikkim, North Bengal, upper Assam, Khasi hills and Hills of Orissa (Kumar *et al.,* 2013). It is also distributed in most parts of Asia (Sri Lanka, Malaysia, Java and China) and Australia, suggesting that it has a wide range of climatic adaptability. It is found to have the potential to yield (biomass) in excess of 40 t acre^{-1} over 10-year rotation period that makes it a potential tree species suitable for drought situations. The timber of this species is widely used in plywood industry and is also found suitable for pulp industry. Further, large lush green canopy is a good source of nutrient rich fodder especially during summer months in semiarid regions of south India. All these multiple uses of this species have attracted the farmers in the recent years especially in the dry regions. However, there is not much scientific information available on its performance under field conditions. Therefore this study is an attempt to analyze the growth of *M. dubia* under rainfed and irrigated conditions and also to analyze the influence of seed origin planting material on productivity.

Materials and Methods

In order to get field grown plantation of *M. dubia* under irrigated and rainfed conditions a recognizance survey was conducted. From this data two plantations were identified which were of four years of age, grown at similar spacing (4x5 m), the planting material used was of seed origin. However, among these two plantations one was raised under rainfed conditions (located at GKVK, Bangalore) and another under irrigated condition (located at Periya patna, in Mysore district). Another reason for selecting these two sites is that both these sites were similar in their climatic conditions as these two locations received similar amount of rainfall (895 and 907mm, respectively) and were located at similar elevation (Table I).

The growth performance under rainfed and irrigated conditions was assessed using two primary growth parameters *viz.,* tree height and girth of the trees, from which biomass was derived. Tree height was measured using Altimeter and girth was measured using girth tape. The above ground sanding biomass of *Melia dubia* was derived using the trunk volume and wood density (Vashum and Jayakumar 2012; Nuthan *et al*., 2009). To assess the variability of growth within a population of rainfed and irrigated plantations, entire population was segregated into different girth class intervals. From these girth classes, number of individuals in each girth class as well as biomass was segregated. Since the climatic conditions of the two study sites were similar and plantations were similar in their age, spacing and planting material (from seed), the variation among the individuals is assumed to arise out of genetic differences among the individual trees, because of their cross pollinated nature. Thus the variability in growth is quantified based on the biomass of the individuals. The variability in biomass production is quantified as follows. The biomass produced by the trees of highest girth class was presumed to be the optimum growth possible when the superior uniform planting material is used. Therefore the average biomass produced by trees of highest girth class was subtracted from the biomass produced by the trees in lower girth classes and the difference is considered as the loss of growth and hence the productivity of the plantation because of the genetic variability of the planting material arising out of cross pollination. However, under rainfed condition there was only one tree in the highest girth

Table I

The location and climatic variables of the study site

Study sites	Rainfall (mm)	Temperature (°C)		Elevation (m)	Location (LAT/Long)
		Min	Max		
Bangalore (rainfed)	907	19.58	30.50	890	13°07'N/77°58'E
Periyapatna (irrigated)	895	16.00	29.42	844	12°33'N/76°09'E

Note : Source of Rainfall and temperature is Department of Agro-meteorology, UAS, GKVK, Bengaluru class (>60 cm) which was thought could be an exception and hence the mean biomass of its immediate higher girth class was used which had reasonably higher number of trees (45-60 cm).

The growth of silver oak (*Gravelia robusta*) and teak (*Tectona grandis*) were also assessed under rainfed conditions grown along with *M. dubia* for comparison of growth among these three species. Silver oak and teak trees used for comparison were of same age and grown under similar conditions that of *M. dubia*. The data was subjected to one way analysis of variance to assess the statistical significance of the differences.

Results and Discussion

Girth of the trees varied from 0.45 m under rainfed condition to 0.60 m under irrigated condition, while tree height varied significantly from 3.27 m to 7.82 m, which is more than two times the increase under irrigated conditions (Fig. 1). Trunk volume and the biomass of the tree derived from girth and height of the tree also varied significantly (Fig. 1). Higher volume and biomass seen under irrigated conditions is contributed from tree height to a large extent compared to girth of the trees. It is a well established fact that, the tree growth occurs in different phases, wherein tree height is largely attained to its maximum extent in the initial years which is referred to as pole stage of growth, while diameter increase occurs mostly after the completion of pole stage. Therefore from the results it is evident that growth in the initial stage in terms of height increment seems to be influenced more by moisture availability and this would have a cumulative effect on growth in the subsequent years. Further, about 34.5 per cent increase in biomass under irrigated conditions (20 kg/tree of biomass against 6.9 kg/tree under rainfed condition) clearly suggests that biomass production which is a cumulative reflection of growth is constrained to a large extent under rainfed conditions due to suppression of growth in the initial stages and was carried through. Such a strong influence of moisture on growth is because it has a strong bearing on all other environmental factors such as temperature, relative humidity and other micro climatic conditions (Le bec *et al*., 2015) to which plant biological response is regulated which will reflect in growth.

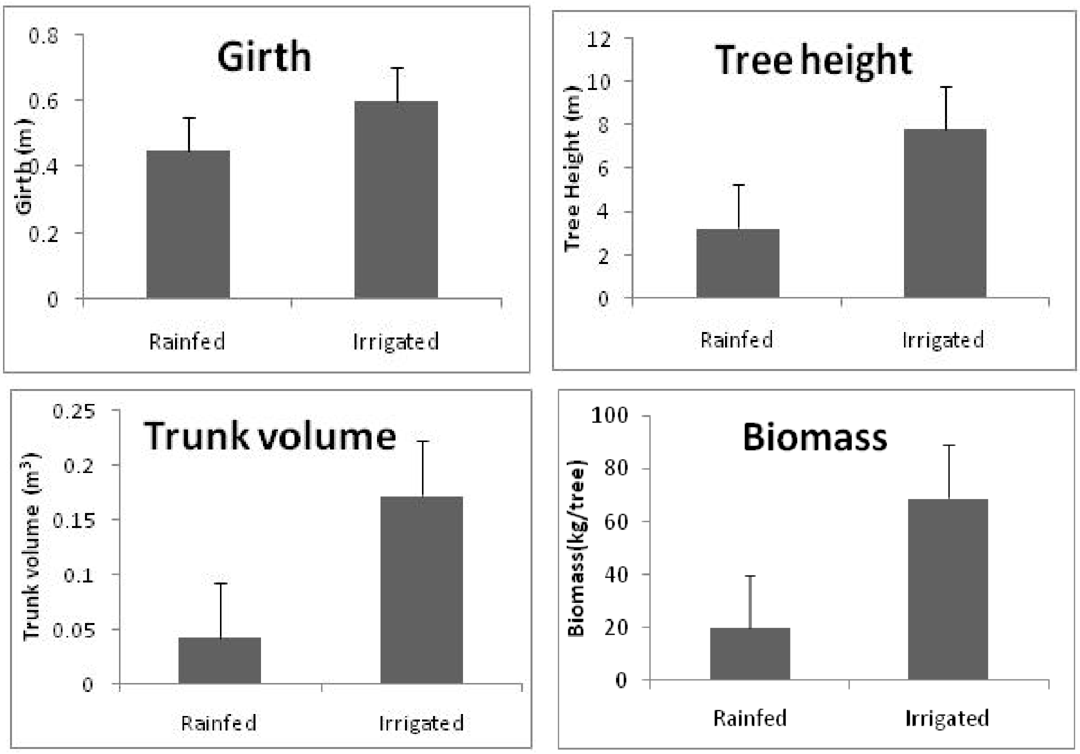

Fig. 1. Tree growth under rainfed and irrigated conditions

However, when the growth of *Melia* was compared with other tree species grown in this region such as *Grevelia robusta* and *Tectona grandis,* performance of *M. dubia* is found to be much better (Table II) indicating, *M. dubia* has higher drought adaptation capability that help in sustaining growth under moisture stress situations. Such a capability in *Melia* is possible because of its higher photosynthetic rate under stress (Neha *et al.,* 2018). *Melia* maintain higher phosynthetic rates because of its isohydric nature of stomata, where stomatal conductance tends to remain high even at mid day that enable in extending carbon assimilation for longer duration (Franks *et al.,* 2007). In order to maintain higher stomatal conductance it is necessary to maintain higher water status and is perhaps possible by exploiting higher soil volume by diverting more biomass towards root growth.

TABLE II

Growth of Melia dubia *in comparison with other tree species under rainfed conditions*

Tree species	Girth (m)	Hieght (m)	Volume (m^3)	Biomass (kg tree^{-1})
Melia dubia	0.50	4.36	0.073	25.06
Grevillea robusta	0.27	2.34	0.011	4.49
Tectona grandis	0.25	2.46	0.009	3.81
CD@5%	0.17	0.94	0.03	14.34

To further elucidate the reasons for growth tree distribution in different girth class was assessed. It is interesting to note that there was a wide variation in both girth class distribution and the number of trees in different girth classes under two moisture regimes. About 64 per cent of the population was found in 30-45 cm girth class under rainfed conditions while 61 per cent of the population was seen in >60 cm girth class under irrigated condition (Table III). Distribution of trees in different girth class to some extent can be attributed to variation in the genetic constitution of trees from seed source. However, biomass produced by trees was found to be about four times higher than under rainfed condition. In other words, the productivity can be enhanced four times at optimum growing conditions in *Melia*. This further reiterate that growth of initial years where height of the trees is constrained due to moisture stress had cascading effect on growth of majority of the population.

The present study it is found that *Melia dubia* has higher drought tolerance which is seen from its performance under rainfed conditions. The performance is found to be better compared to *G. robusta* and *T. grandis* which are commonly grown tree species of the dry region. From the biomass production seen under irrigated condition it is clear that productivity can be substantially increased with irrigation. Higher growth rates seen with irrigation can help to reduce the duration to achieve the harvestable size and also to enhance the productivity per unit time.

TABLE III

Differences in the number of trees in different girth classes and biomass under rainfed and irrigated conditions

Girth Class (cm)	Rainfed			Irrigated		
	No. of trees	Biomass (kg/tree)	Biomass (kg)	No. of trees	Biomass (kg/tree)	Biomass (kg)
15 – 30	13 (4.30)	4.68	61.00	6 (1.44)	05.80	35
30 – 45	193 (64.00)	19.90	3841.00	55 (13.28)	20.24	1113
45 – 60	94 (31.22)	38.04	3576.00	100 (24.15)	49.14	49154
>60	1	64.58	65.00	253 (61.11)	88.89	22486
Total	301	127.20	7542	414	164.07	28549
CD@5%	-	5.32		-	12.82	

Note : Values in the parenthesis is the percentile of total population.

Large variation seen in the girth class as well as number of trees in different girth class under two moisture regimes suggests that the influence of moisture under rainfed condition that reduced the tree height in the initial years of growth at pole stage had a cumulative influence on growth to reduce productivity four times that of its optimum growth under favorable growing conditions.

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