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Effect of drought stress on morphological characters of four tree species at seedling stage

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Abstract
The effect of drought stress on morphological characters in seedling of four forest tree species namely Neem (*Azodiracta indica*), Tamarind (*Tamarindus indica*), Milla (*Vitex pinnata*) and Teak (*Tectona grandis*) were studied. Three levels of drought stress (30, 50 and 70 % of field capacity) were imposed on four months old seedlings for 60, 90 and 120 days. Seedling height, leaf number, root length, root volume and dry matter declined with increasing levels of drought stress. The lowest rate of reduction in seedling height, leaf number, root length and total dry matter content was observed in tamarind, which indicates its relatively greater drought tolerance.

Keywords: drought stress, forest trees, morphological characters, tamarind

Introduction

In recent years afforestation has become important regionally as well as globally, due to the rapid decline of natural forest cover in all tropical and subtropical regions. In 1956, Sri Lanka had a forest area of 2,899,558 ha, representing 44 % of the country's total land area. This area had come down to 24.9 % in 1981 and to 20.3 % in 1992 (Hewage, 1994). In year 2004 the total area covered by forests was 17.9 % (Forest Department, 2005). Other than the natural wood forests the non wood forest resources include the areas under plantation crops, home gardens, sparsely planted crop lands and ravines and they presently supply over 50 % of the timber and 80 % of the fuel wood requirements of the nation. Therefore, afforestation and social forestry is important to supply future fuel wood and timber requirements (Gunasena, 1994). The national Multipurpose Species Research Network recognized the importance of promoting agro forestry by growing multipurpose tree species. Several tree species such as Jackfruit (*Artocarpus heterophyllus*), Neem (*Azodiracta indica*), Gliricidia (*Gliricidia sepium*), Leucaena (*Leucaena leucocephala*), Caliandra (*Calliandra callothyrus*) and Casuarina were being promoted through this network (Gunasena, 1994). One of the main problems of establishing forests or forest trees in agro forestry systems is drought. Drought or water stress is a recurrent factor in agriculture as well as in natural ecosystems. The problem is widespread and serious in tropical countries where periodic droughts due to Irregular distribution of rainfall causes a high rate of seedling mortality and retards growth of plants. The situation demands drought tolerant and drought resistant tree species for afforestation programmes. However research on growth of seedlings of tree species under drought conditions are limited. Most research has been conducted on physiological and biochemical changes of trees under stress conditions. On the other hand most of the reforestation and agro forestry programmes are introduced to dry zone areas. Therefore, it is important to determine the growth of tree species under drought stress, particularly at seedling stages, which is more vulnerable to the stress conditions. Therefore, the objective of this experiment was to analyse the effects of drought stress on morphological characters of four forestry tree species commonly used in afforestation programmes in Sri Lanka.

Materials and Methods

A pot experiment was conducted at the Faculty of Agriculture, University of Ruhuna. Sub soil was used to fill poly bags as new afforestation programmes are conducted in low fertile, eroded lands in the dry zone. Therefore due to the difficulty of having soils from those lands, sub soil was used for this experiment to represent the similar characters. (40 cm height and 30 cm diameter), kept in a protected house. From establishment, the seedlings were allowed to grow normally two weeks. Then the drought treatments were imposed until the harvest, by maintaining the field capacity of soil at 100 % (T_1), 70 % (T_2), 50 % (T_3) and 30% (T_4). The field capacity was determined by gravimetric method.

Seedling height (cm) and Leaf number, Root volume (cm^3/plant), Root length (cm/plant) and dry matter (g/plant) production were measured at 60, 90 and 120 days under water stress. The volume of roots was measured by the water replacement method using a measuring cylinder.

The statistical design was Completely Randomized Design with 9 replications. Three seedlings were taken from each treatment for data analysis. For mean comparison DMRT was used.

Result and Discussion

Seedling height

There is evidence of decreasing plant height with increasing drought stress in many crop species (Roberts and Cannon, 1992). In this study increasing the level of drought stress gradually reduced the seedling height of the four tree species. The lowest rate of reduction in seedling height was observed in Tamarind and it indicates the highest tolerance to drought. Cell expansion is one of the most sensitive processes to water stress and consequently the expansion of leaves, roots and other growing regions would be affected even by a small water deficit (Taize and Zeiger, 1991). They further described that in comparison to cell expansion, cell division is less sensitive to water stress. However this would be true only when water stress is not prolonged and does not reach high intensities. During prolonged and severe water stress cell division is also reduced and cell expansion is also reduced because of the lower cell number.

In the present experiment, the duration of drought might not effect on the turgor pressure of the cells. Therefore, we could not observe significant reduction in plant height in relavant to drought imporzing in all four forest species (Figure 1).

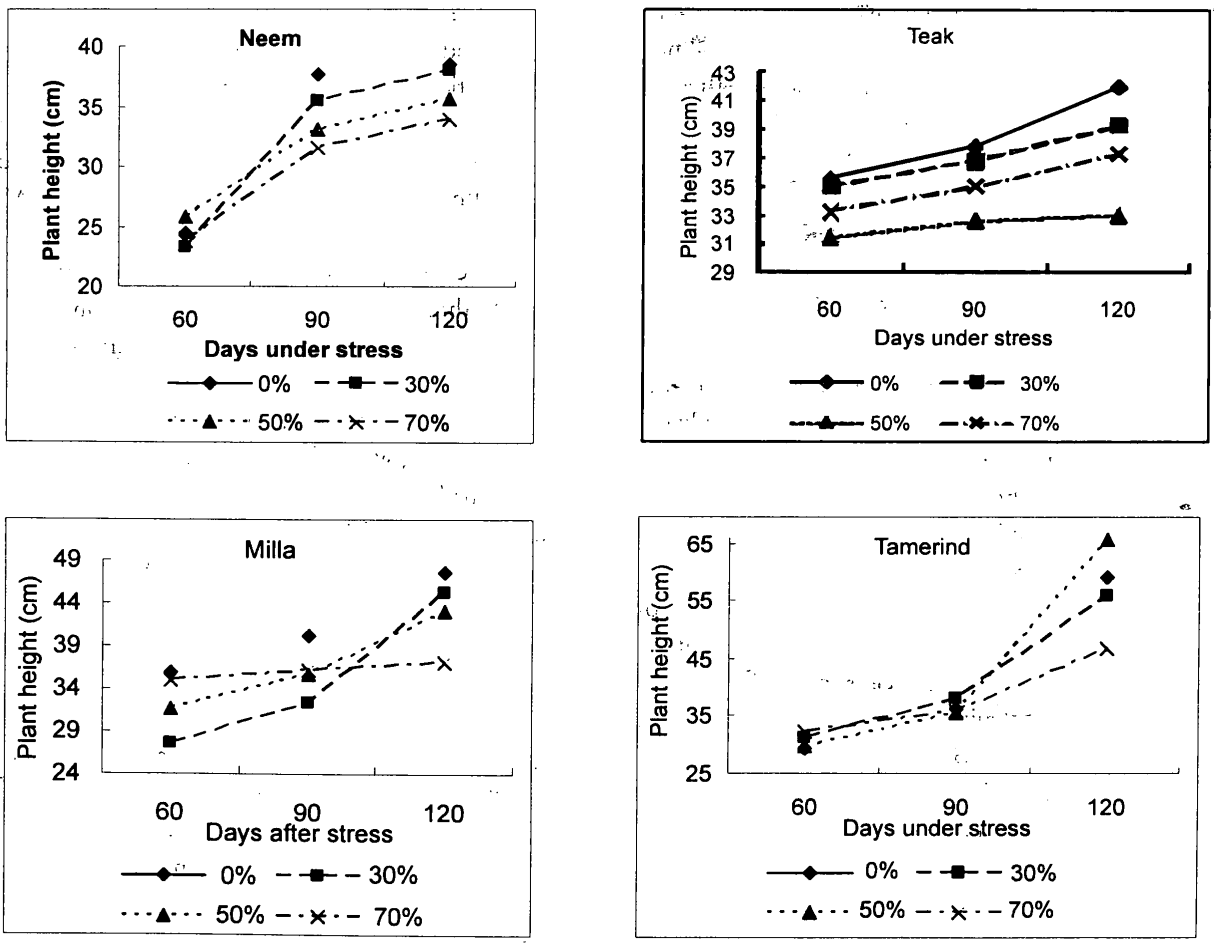

Figure 1. Effect of water stress on seedling height of four different forest tree species

Leaf number

Neem plants reduced leaf numbers per plant with increasing levels of stress (Figure 2). However in teak seedlings of 70 % water stress also showed a comparatively higher leaf number than 50% and 30% water stress levels, whereas in tamarind the highest number of leaves were observed when subjected is a 30% water stress level.

Reduction in leaf number is an adaptive mechanism of plants under drought conditions. In many crop plants older leaves get senescence quickly under water stress conditions, thereby helping reduce water loss and enabling the remaining leaves to maintain their water balance. Neem and milla showed a clear reduction of leaf production with increasing level of water stress. On the other hand the size of the leaves should also be considered when screening drought tolerant species.

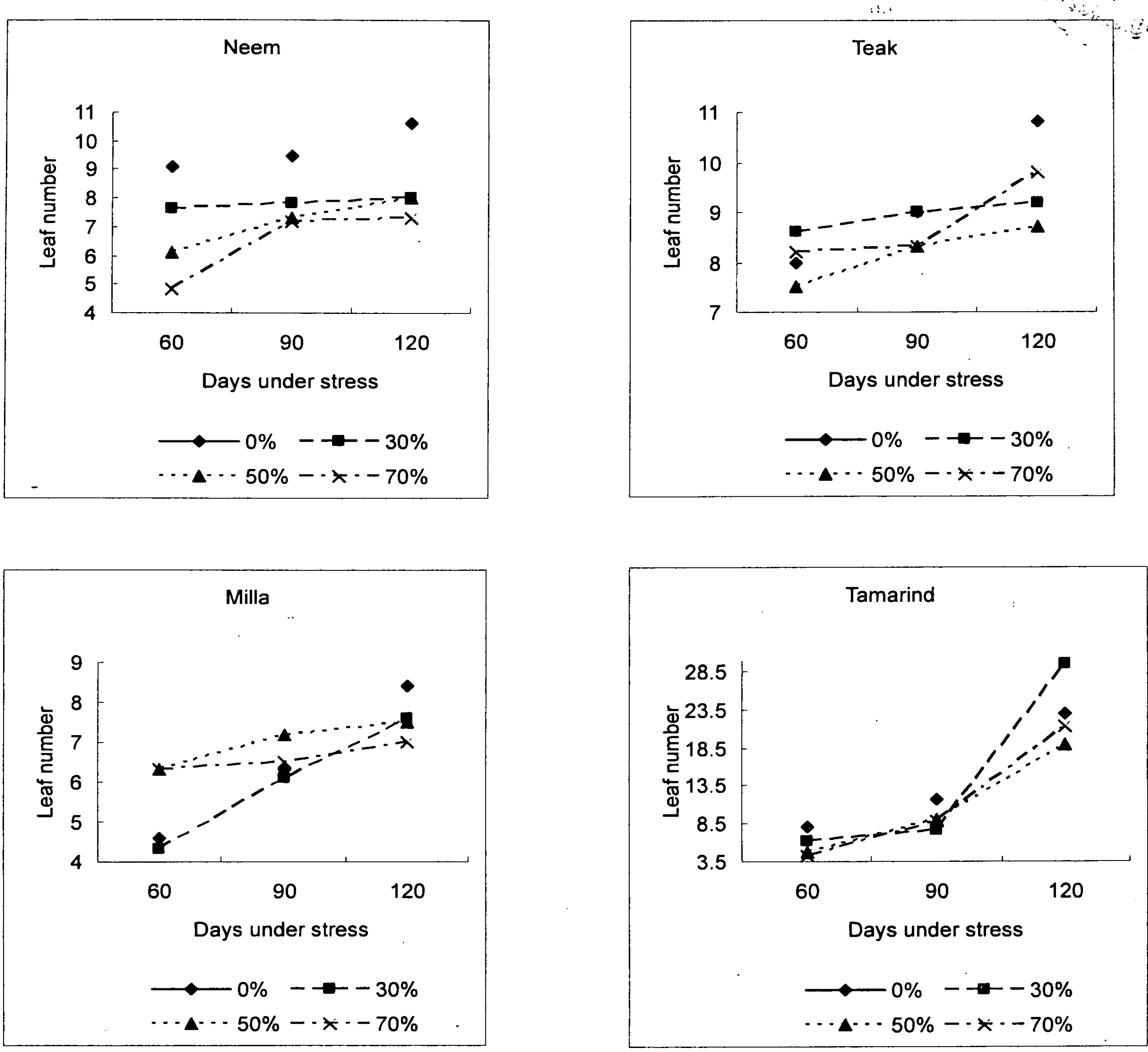

Figure 2. Effect of water stress on leaf number of four different forest tree species

Root length

Under mild water stress conditions milla seedlings produced the highest root length (Figure 3). The results of previous experiments showed that the root length increased at mild water stress but decreased at acute stress. Squire *et al* (1987) also observed that drought stressed *Pinus radiata* seedlings had significantly larger total root length than irrigated seedlings. In this study tamarind was an exception by showing highest root length under 70 % water stress at the final harvest.

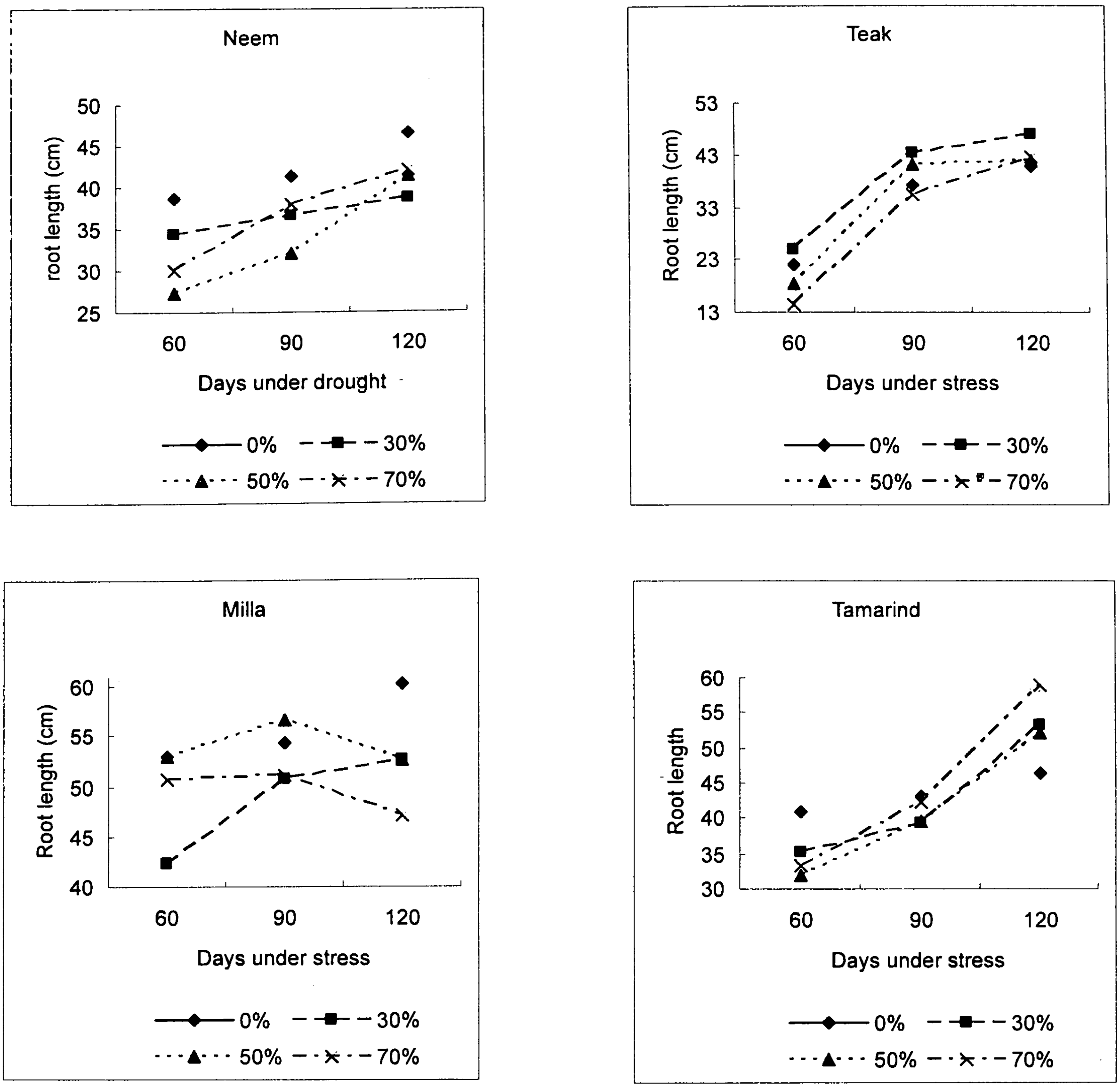

Figure 3. Effect of water stress on root length (cm) of four different forest tree species

Root volume

Root volumes of all four tree species were reduced with increasing the levels of stress (Figure 4). Root volume is proportional to the product of root length, root branching and root diameter. Under mild water stress conditions roots grew into deeper layers of the soil to prevent water potential of the plant. In this study plants were grown in poly bags and it restricts the growth of roots. Teak seedlings showed a significant reduction of root volume even under mild water stress conditions, showing it's susceptibility to drought conditions. At 70% water stress level Neem and Milla had the highest volume of roots.

Dry matter content

Significant ($P \leq 0.05$) differences of dry matter production were observed among the treatments (Figure 5). The seedlings in the control treatment produce the highest dry matter in all four tree species at the first harvest, whereas in the final harvest 30% of water stress produced highest dry matter in milla and tamarind. Bradbury (1990) also observed reduced dry matter production in Acacia and Sesbania seedlings under water deficit conditions. Under water deficit conditions the rate of photosynthesis is reduced due to low rate of CO_2 exchange under low stomatal conductance as well as the low amount of water, resulting in the reduction in total dry matter content. However tamarind had the highest dry matter contents at 30% and 50 % water stress levels when compared to the control treatment. This indicates that Tamarind was able to maintain a high rate of photosynthesis even under low moisture conditions and it indicates high tolerance to drought conditions.

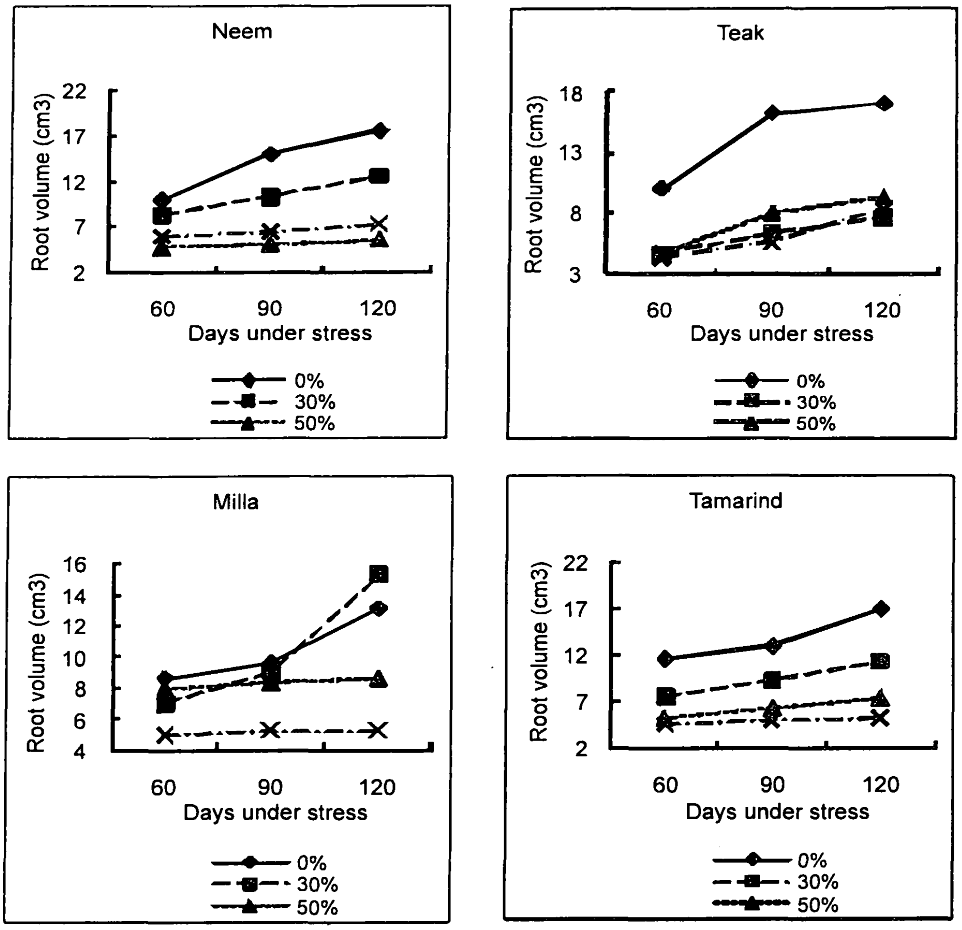

Figure 4. Effect of water stress on root volume (cm^3) of four different forest tree species.

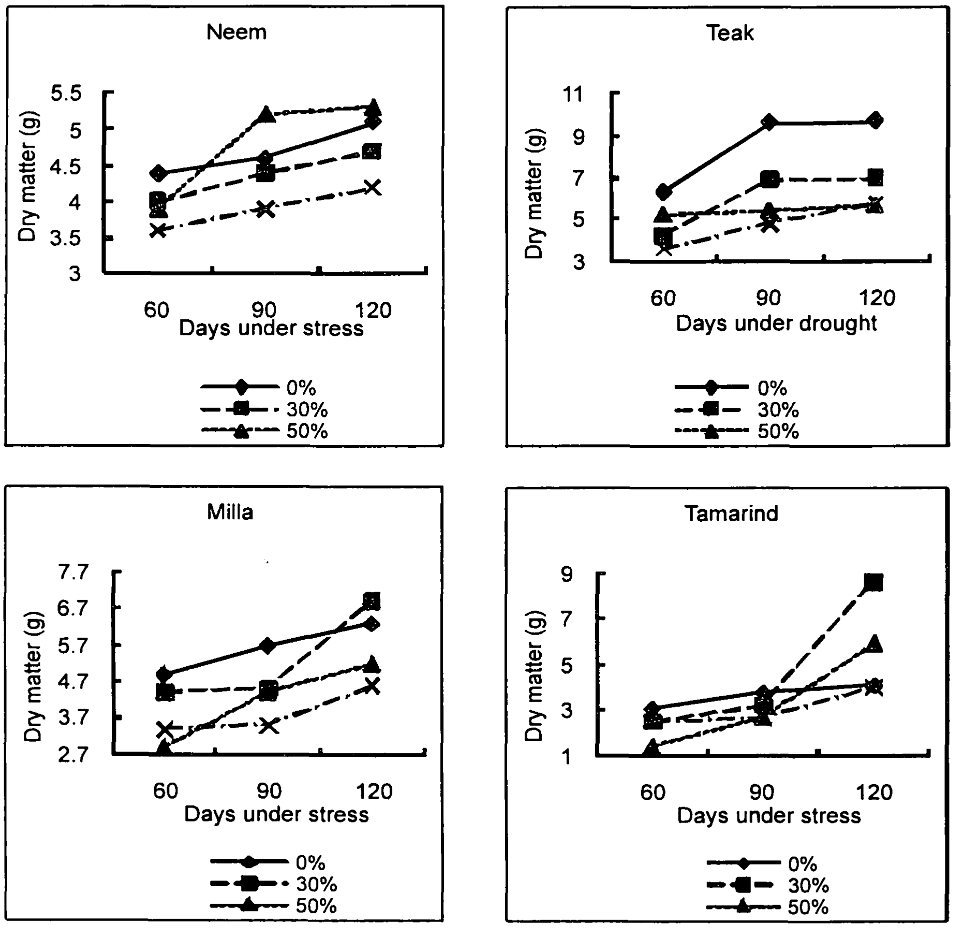

Figure 4. Effect of water stress on root volume (cm^3) of four different forest tree species.

Conclusion

From the above findings, it is concluded that tamarind seedlings are better adapted to drought conditions since the rate of reduction in seedling height, number of leaves, root volume and dry matter content under increasing drought stress was minimum. Hence Tamarind could be grown in drought prone areas more successfully than the other three species tested.

References

Bradbury, M. (1990). The effect of water stress on growth and dry matter distribution in juvenile sesbania sesban and *Acacia nilotica*. J. Arid Environ. 18(3): 325-333.

Gunasena, H.P.M. (1994). Multipurpose tree species in Sri Lanka. Proceedings, 4th regional workshop on multipurpose trees, Kandy, Sri Lanka.

Hewage, T., (1994) Sri Lanka's forestry sector and revision of the forestry master plan. In: Gunasena, H.P.M. (eds.). Multipurpose tree species in Sri Lanka. Proceedings, 4th regional workshop on multipurpose trees, Kandy, Sri Lanka.

Roberts, B,R. and Cannon, W.N. (1992). Growth and water relationship of red spruce seedlings exposed to atmospheric deposition and drought. Canadian J. forest Res. 22(2): 193-197.

Squire, R.O., Attiwall, P.M. and Neales, T.F. (1987). Effect of changes of available water and nutrients on growth and root development and water use in Pinus radiate seedlings. Aust. J. Forest Res. 17(2): 99-111.

Taize, L and Zeiger, E. (1991). Plant physiology. The Benjamin/Cummings publishing company, Inc. California.