Impact of NPK on the Ecophysiological attributes of *Thespesia populnea*

ABSTRACT

A field experiment was conducted to investigate the effect of different levels of NPK on the performance of *Thespesia populnea*. A total of 17 treatments consisted of four levels of Nitrogen (50, 75, 100 and 125 g N plant^{-1}), two levels each of Phosphorus (50 and 75 g P plant^{-1}), and Potassium (25 and 50 g K plant^{-1}) were tried in RBD replicated three times, to standardize the fertilizer schedule for the tree crop taken for investigation. The experimental soil was red sandy loam, non-calcareous, neutral in reaction, low in available nitrogen, phosphorus and medium in available potassium with low organic carbon content.Ecophysiological parameters *viz.*,photosynthestic rate (A), transpiration rate (E), stomatal conductance (g_s) and Intercellular CO_2 concentration (CINT). Growth attributes were influenced by N, P and K at different levels. Among the various treatments application of 100 : 75 : 50 g NPK plant^{-1} (T_{12}) significantly influenced the growthattributes followed by 100 : 75 : 25 g NPK plant^{-1} (T_{11}).

Introduction

Forests are not just trees, but part of an ecosystem that interlinks life, economics and societies. Forest provides a multiplicity of environmental services. As per Indian State of Forest Report (ISFR) 2013, the forest cover of the country is 6,97,898 sq.km. (69.79 million ha) which is 21.23 per cent of the geographical area of the country while the tree cover of the country is estimated to be 91,266 sq.km. (9.13 million ha) which is 2.78 per cent of the geographical area. The total forest and tree cover of the country as per 2013 assessment is 7,89,164 sq.km. (78.92 million ha) which is 24.01 per cent of the geographical area of the country. There is an increase of 5,871 sq. km. in the forest and tree cover of the country in comparison to 2011 assessment. The total growing stock of India's forest and trees outside forest is estimated as 5,658.046 million m^3 which comprises 4,173.362 million m^3 inside the

forests and 1,484.68 million m^3 outside the forests. India is home to 17 per cent of world human population and 18 per cent of livestock population which causes severe pressure to the Indian forests. Nearly 40 per cent of domestic fuel needs of people and 30 per cent of fodder needs for cattle population in the country are met from forests. The demand and supply gap of timber, fuelwood and fodder is widening whereas the raw material requirement of wood based industries is on the raise. The National Forest Policy (1988) suggested that the wood based industries will have to make their own arrangements for the supply of raw materials. Besides this, most of the Government policies and acts stress mostly on the conservation of existing natural vegetation. Hence, the importance of industrial plantations has gained momentum across the country to meet out the industrial raw material needs. In order to fulfill the domestic and industrial demands of wood, the only viable option is to increase the area under agroforestry and industrial plantations. The role of indigenous species and fast growing species in this regard need not be overemphasized as selection of suitable tree species plays a major role in the success of agroforestry. *Thespesia populnea*is one such indigenous tree species which has multiple uses.

*Thespesia populnea*is a fast growing evergreen tree belonging to the family Malvaceae which is commonly known as Tulip tree or Portia tree and it is called as Puvarasu in Tamil. *Thespesia populnea*is a small to medium-sized evergreen tree of the coastal tracts of India and Myanmar which grows upto 20 m with a dense crown. It is widely planted as a roadside tree in tropical regions and recognized by its large yellow flowers with purple centres. The flowers open and close on the same day, and the yellow flowers turn dark red, purple or pink as the day progresses. Bark is dark brown, rough, deeply cracked, fissured and slash yellow coloured. It prefers neutral soils with pH 6.0-7.4 and thrives well on sandy coastal soils, but also grows on

volcanic soils, soils derived from limestone and rocky headlands. It does not do well on upland, acidic clays. It is very tolerant to salt spray, steady coastal winds and highly resistant to dry wood termites. It tolerates heavier soils, soil salinity and occasional inundation, but does not grow on permanently inundated soils. In order to obtain robust and healthy plantations, proper fertilizer management is essential under field conditions. Lack of studies in this aspect necessitated the present investigation to study the Impact of NPK on the Ecophysiological attributes of the species

Review of Literature

Ecophysiological parameters

1. Photosynthetic rate

Estimates of the canopy photosynthetic capacity of forests provide information about their role in global carbon cycles, involving biomass production (Bassow and Bazzaz, 1997). Comparison of 51 clones of *Casuarina equisetifolia* in terms of growth and eco physiological characters revealed that five fast growing clones recorded high photosynthetic rate and thus showed a higher productivity (Balasubramanian and Gurumurthi, 2001). Chen *et al*. (2001) stated that the photosynthetic characters of *Phyllostachys heterocycla* cv. *pubescens* provenances recorded increase in Net Photosynthetic Rate (NPR) with increasing latitude and all provenances had two peaks of NPR in one year.

Rao (2005) studiedthe effect of shade on net photosynthetic rate of five important tree species *viz*., *Albizia lebbeck*, *Dalbergia sissoo*, *Leucaena leucocephala*, *Shorea robusta* and *Tectona grandis*. Net photosynthetic rate (P, μ mol m^{-2} s^{-1}) decreased with increasing shade in all the species during all the three

seasons. The photosynthetic rate of *Dalbergia sissoo* was reported to be maximum as compared to *Acacia auriculiformis*and *Albizia lebbeck*(Srivastava and Ram, 2009).

Saraswathi and Paliwal (2008) investigated the net photosynthesisrate (P_n) in six month old seedlings of *Albizia lebbek* and *Cassia siamea* under different levels of drought stress. *Cassiasiamea*had a transpiration rate of 2.56 m mol m^{-2} s^{-1} and increased photosynthesisrate was observed in *A. lebbek* of 4.35 µ mol m^{-2} s^{-1} at 9.00 hrs.

Highest net photosynthetic rate of 6.61 and 6.76 µ mol m^{-2} s^{-1} was recorded in the treatment which received 25 per cent more fertilizer than the soil test recommendation value of 93.75: 225: 100 of NPK kg ha^{-1} in *Casuarina* species (Baranidharan*et al.*, 2013).

Photosynthesis, photorespiration and CO_2 compensation point comparison of two year old seedlings of *Thuja orientalis* from six seed sources showed significant variation in net photosynthetic rate among different sources (Wu and Ma, 1988).

Highly significant variation was reported by Kundu and Tigerstedt (1999) among ten provenances of *Azadirachta indica* in net photosynthesis rate ranged from 8.14 to 15.13 µ mol m^{-2} s^{-1}. They concluded that whole plant phytomass production in neem seedlings was associated with photosynthesis and stomatal characteristics during the early stages of growth.

2. Transpiration rate

In an afforested plantation, *Gmelina arborea* @ 21 MAP recorded significantly higher transpiration rate of 4.81 m mol m^{-2} s^{-1} followed by *Dalbergia sissoo* (4.32 m mol m^{-2} s^{-1}),*Tectona grandis* (4.01 m mol m^{-2} s^{-1})and*Bambusavulgaris*

var. *vulgaris* (2.47 m mol m^{-2} s^{-1}). The lowest transpiration rate of 1.67 m mol m^{-2} s^{-1} was registered by *Swietenia macrophylla* (Narendra Babu, 2012). Transpiration rate from several Australian semiarid zone species was studied in the field by Kreeb (1966) using the torsion balance technique and he concluded that among the different species studied, the maximum transpiration rate was observed in *Eucalyptus camaldulensis* (5.0 and 7.9 m mol m^{-2} s^{-1}).

Dolley and Grieve (1966) studied *E. marginata* forest over a period of four months to evaluate the transpiration rate which ranged from 0.34 to 1.10 m mol m^{-2} s^{-1} respectively per day. It was found that transpiration rate had a positive correlation with air temperature. A field study done by Ujala Singh (2005) studied the transpiration rates of different *Eucalyptus* species and concluded that *E. urophylla* and *E. grandis* had the highest transpiration rate with 180 and 165 g day^{-1} $plant^{-1}$ respectively. On the other hand, *E. ochrophloia* recorded the lowest value of 65 g day^{-1} $plant^{-1}$.

Highly significant differences in transpiration rate and stomatal conductance of leaves were reported and strongly correlated among seed sources of *Ginkgo biloba* (Chiang *et al*., 1996). Suman Chandra (2003) observed leaf to air temperature difference (dT) of 0.72 m mol m^{-2} s^{-1} and transpiration rate *(Tr)* of 2.64 m mol m^{-2} s^{-1} in *Aesculus indica*and lowest in *Toona cilliata*of0.41 m mol m^{-2} $s^{-1}$and 1.54 m mol m^{-2} s^{-1} respectively. He concluded a positive correlation between leaf to air temperature difference (dT) and rate of transpiration *(Tr).*

Baranidharan*et al.* (2013) observed that a fertilizer dose of 25 per cent more than the soil test recommendation value of 93.75: 225: 100 of NPK kg ha^{-1} recorded

the highest transpiration rate value of 2.20 and 2.38 m mol m^{-2} s^{-1} and was significantly superior when compared with other nutrient levels in *Casuarina* species.

3. Stomatal conductance

Stomata are the points of exit for the water vapour from leaves. Under conditions of adequate supply of water, stomata opening in the morning with increasing radiant flux and maintain a relatively constant aperture until radiant flux declines in the late afternoon. So, there was a correlation exists between stomatal opening and radiant flux (Gikloo*et al.*, 2012).

Stomatal conductance did not show any variation in three provenances of rosewood studied and appeared to be more influenced by the photon flux density during the morning. However, in afternoon, the stomatal behavior appeared to be controlled by specific humidity deficit (Rosa *et al*., 1998). Ladjal*et al.* (2007) studied greenhouse grown Cedar seedlings subjected to two different watering regimes and observed that the dry set showed lower net photosynthesis and stomatal conductance than the plants in the well watered set.

De Costa et al. (2000) investigated stomatal conductance in nine tree species *viz*., *Alstonia macrophylla, Filiciumdecipiens, Macaranga peltata, Tectona grandis, Acronychia pedunculata, Semicarpusnigro-viridis, Swietenia macrophylla, Mesua ferrea* and *Terminalia catappa*growing under different levels of natural shade, i.e. open, medium shade and full shade. According to them, the total leaf stomatal conductance varied significantly with tree species and shade levels and the highest stomatal conductance was observed in *S. nigroviridisand T. catappa*, with 92.03 and 78.18 m mol m^{-1} s^{-1} respectively. The rest of the species had recorded lower stomatal conductance values which ranged from 34 to 44 m mol m^{-2} s^{-1}.

The stomatal conductance and transpiration were studied for tropical rain forest species and desert species in biosphere. The results showed that the stomatal conductance and transpiration of rain forest species decreased from 127.4 ± 65.6 m mol m^{-2} s^{-1} and 2.04 ± 0.61 m mol m^{-2} s^{-1} to 61.3 ± 30.5 m mol m^{-2} s^{-1} and 1.54 ± 0.65 m mol m^{-2} s^{-1} respectively (Jiang Gaoming*et al*., 1997).

Okuto and Ouma (2010) reported variation in stomatal conductance among provenances of *Syzygiumcuminii*seedlings from three districts of Kenya *viz*., Vihiga, Kisumu and Siaya. Among them, stomatal conductance was similar for Kisumu and Siaya but higher than Vihiga.

4. Inter cellular CO_2 concentration (CINT)

Esser (2004) correlated Inter cellular CO_2 concentration with the photosynthetic efficiency of three species.

Suresh kumar (2011) and Narendra Babu (2012) have also confirmed that Inter cellular CO_2concentration in *Tectona grandis* and *Gmelina arborea* was lower than that of *Dalbergia sisooand Bambusavulgaries*var .*vulgaris*during 9 MAP respectively.

Materials and Methods

The present study was conducted in order to standardize the fertilizer requirement for *Thespesia populnea*(L.) Selex Correa**.** With the view of fulfilling the objectives envisaged, experiments were carried out at Forest College and Research Institute, Mettupalayam, Tamil Nadu during 2014-2015.

The materials used and the methods followed during the course of investigation are furnished in this chapter.

MATERIALS

Species under study- *Thespesia populnea*

i) Species description

Species	:	*Thespesia populnea*
Family	:	Malvaceae
Tamil name	:	Poovarasu
Common name	:	Indian Tulip Tree, Portia tree, Pacific Rosewood
Trade name	:	Seychelles Rose wood

ii) Botanical features

It is a small to medium sized, fast-growing, evergreen tree with a dense spreading crown attaining a height of 20 m with a clear bole height of 0.6 - 2 m, grey to brown bark, fissured, often knobby and fibrous. Leaves are broad 8-15 cm x 6.10 cm, heart-shaped like pipal or poplars, entire, petiole 2.5-10 cm long, stipules subulate, deciduous. Flowers axillary, solitary, bisexual, bell-shaped, 5-7.5 cm across, pedicels 5 -7.5 cm long. Petals 5, yellow with deep maroon in the centre, fading to purplish-pink before falling. Fruit a globose capsule, 2.5 - 4 cm in diameter, flattened covered with disk like persistent calyx at the base, black when ripe, containing 1-3 egg-shaped seeds about 1 cm long.

*Thespesia populnea*anchors sandy coastal soils and protect them from erosion .The tree is used to stabilize bunds for ponds in prawn production (Hanum and van der Maesen, 1997). The wood may produce a yellow dye used to dye wool in East and South-East Asia, and the leaves are used to make a black dye (Clark and Thaman, 1993). Large tulip trees are made into small canoes in ancient times in

Hawaii (Abbott, 1992).The wood is also used for boat building in South Asia and elsewhere in the Pacific.

Location

The experiment was conducted in J block, of Forest College and Research Institute, Mettupalayam (Coimbatore district). The geographical location is 11°19' N latitude and 77°56' E longitude at an altitude of 320 m above mean sea level

Climate and Weather

The mean annual rainfall of the experimental site is 913.9 mm. The maximum temperature ranges from 30.5 to 36.6°C and the minimum temperature ranges from 17.1 to 23.5°C. The mean maximum and minimum temperature are 34.5°C and 20.63°C respectively.

Assessment of eco-physiological behavior

Ecophysiological characters were assessed by using a Portable Photosynthesis System (PPS, model LCpro + Photosynthesis System CO_2 gas analyzer, UK) to assess the eco-physiological behaviour of selected tree species. The measurements were made on fully matured leaves (5-6 leaves from the bud). The ecophysiological parameters *viz*., transpiration rate, stomatal conductance, Intercellular CO_2 Concentration (CINT) and photosynthetic rate were measured on a sunny day between 10.00 AM and 11.00 AM as per the procedure described below.

Photosynthetic rate (A)

The photosynthetic rate of trees was measured using the Portable Photosynthesis System (PPS, model LCpro + Photosynthesis System CO_2 gas analyzer, UK). The PPS measures the uptake of CO_2 and estimates the photosynthetic productivity using Infra-Red Gas analyzer (IRGA) and expressed in µ mol m^{-2} s^{-1}.

Transpiration rate (E)

The transpiration rate was measured using Portable Photosynthesis System (PPS, model LCpro^{+} Photosynthesis System Co_2 gas analyzer, UK) and expressed as m mol m^{-2} s^{-1}.

Stomatal conductance (gs)

Stomatal conductance was measured using the Portable Photosynthesis System (PPS, model LCpro + Photosynthesis System CO_2 gas analyzer, UK) and expressed in m mol m^{-2} s^{-1}.

Intercellular Co_2 Concentration (CINT)

Intercellular Co_2 concentration measures the photosynthetic efficiency of plant. It was measured using Portable Photosynthesis System (PPS, model LCpro + Photosynthesis System CO_2 gas analyzer, UK) and expressed in ppm.

Results and Discussion

Ecophysiological attributes

Portable Photosynthesis System (LC Pro $^{+}$) was used to observe changes in ecophysiologicalbehaviour of *Thespesia populnea* and four parameters *viz.*, photosynthetic rate (A), transpiration rate (E), stomatal conductance (g_s) and inter cellular Co_2 (CINT) were recorded and tabulated in Table 1.

Table 1. Influence of NPK on the ecophysiologicalbehaviour of *Thespesia populnea* at 6 MAP

Treatments	Photosynthetic rate (μ mol m^{-2} s^{-1})	Transpiration rate (m mol m^{-2} s^{-1})	Stomatal conductance (m mol m^{-2} s^{-1})	Inter Cellular CO_2 Concentration (ppm)
T_1 -50:50:25 g NPK plant^{-1}	9.94	3.82	0.11	175
T_2 -50:50:50 g NPK plant^{-1}	10.67	3.84	0.12	178
T_3-50:75:25 g NPK plant^{-1}	11.62	4.42	0.12	188
T_4 -50:75:50 g NPK plant^{-1}	11.86	4.83	0.13	190
T_5 -75:50:25 g NPK plant^{-1}	12.27	5.06	0.14	198
T_6 -75:50:50 g NPK plant^{-1}	12.63	5.35	0.14	205
T_7 -75:75:25 g NPK plant^{-1}	12.93	5.53	0.15	208
T_8 -75:75:50 g NPK plant^{-1}	12.95	5.61	0.15	214
T_9 -100:50:25 g NPK plant^{-1}	13.14	6.15	0.16	218
T_{10} -100:50:50 g NPK plant^{-1}	13.21	6.22	0.16	225
T_{11} -100:75:25 g NPK plant^{-1}	14.13	6.96	0.21	256
T_{12} -100:75:50 g NPK plant^{-1}	15.19	7.26	0.24	263
T_{13} -125:50:25 g NPK plant^{-1}	13.54	6.41	0.17	232
T_{14} -125:50:50 g NPK plant^{-1}	13.68	6.50	0.18	245
T_{15} -125:75:25 g NPK plant^{-1}	13.69	6.56	0.19	250
T_{16} -125:75:50g NPK plant^{-1}	15.10	7.04	0.22	259
T_{17}-Absolute control	9.45	3.62	0.10	167
SEd	**1.78**	**0.20**	**0.01**	**1.32**
CD(P=0.05)	**3.61**	**0.42**	**0.03**	**2.68**

Photosynthestic rate (A)

Photosynthetic rate which is a measure of productive potential of a tree was measured and the results are presented in the Table 1. During 6 MAP, the application of 100:75:50 g NPK plant^{-1} (T_{12}) recorded the highest photosynthetic rate of 15.19 μ mol m^{-2} s^{-1} followed by the application of 125:75:50 g NPK plant^{-1} (T_{16}) which

recorded 15.10 μ mol m^{-2} s^{-1} whereas the treatment T_{17} which did not receive any fertilizers registered the lowest photosynthetic rate of 9.45 μ mol m^{-2} s^{-1}.

Transpiration rate (E)

The transpiration rate exhibited significant variation among the different treatments imposed (Table 1). At 6 MAP, the highest transpiration rate of 7.26 m mol m^{-2} s^{-1} was observed due to application of 100:75:50 g NPK $plant^{-1}$ (T_{12})followed by the application of 125:75:50 g NPK $plant^{-1}$ (T_{16}) and 100:75:25 g NPK $plant^{-1}$(T_{11}) with the values of 7.04 and 6.96 m mol m^{-2} s^{-1} respectively. The lowest transpiration rate of 3.62 m mol m^{-2} s^{-1} was registered where no fertilizer were imposed.

Stomatal conductance (gs)

Stomatal conductance recorded significant variation among the various treatments and the results are presented in Table 1. During 6 MAP, the highest stomatal conductance of 0.24 m mol m^{-2} s^{-1} was reported due to application of 100:75:50 g NPK $plant^{-1}$ (T_{12}) followed by the application of 125:75:50 g NPK $plant^{-1}$ (T_{16}) and 100:75:25 g NPK $plant^{-1}$ (T_{11}) with the values of0.22 and 0.21 m mol m^{-2} s^{-1}respectively . The treatment T_{17}recorded the lowest stomatal conductance of 0.10 m mol m^{-2} s^{-1} where no nutrients were applied.

Inter Cellular CO_2 Concentration (CINT)

Among the different treatments, the maximum inter cellular CO_2 concentration (CINT) of 263 ppm was observed in T_{12} followed by T_{16} and T_{11} with the values of 259 and 256 ppm whereas the treatment T_{17} which did not receive any fertilizers registered lowest inter cellular CO_2 concentration (CINT) of 167 ppm.

Ecophysiological attributes

The ecophysiologicalbehaviour of plants plays a vital role in the growth of plants and are important factors for changing environmental conditions (Camposeo*et al.*, 2011).The influence of different levels of nutrients on the parameters *viz.*,photosynthestic rate (A), transpiration rate (E), stomatal conductance (g_s) and Intercellular CO_2 concentration (CINT) are discussed.

Photosynthetic rate (A)

At 6 MAP, significant difference in photosynthetic rate was observed due to the influence of various treatments imposed. Photosynthetic rate was highest in T_{12} (100: 75: 50 g NPK plant^{-1}) which recorded 15.19 µ mol m^{-2} s^{-1} followed by T_{16} (125:75:50 g NPK plant^{-1}) which recorded 15.10 µ mol m^{-2} s^{-1} and were *on par*.

Similar findings were also observed by Baranidharan*et al.* (2013) who observed the highest net photosynthetic rate of 6.61 and 6.76 µ mol. m^{-2} s^{-1} when *Casuarina* species was applied with 25 per cent more of fertilizer over the soil test recommendation value of 93.75: 225: 100 of NPK kg ha^{-1}.

Mohan Raj (2008) observed thehighest photosynthetic rate of 8.21 m mol. m^{-2} s^{-1} in Eucalyptus at 18 MAP in heavy fertilizer dose application (150:200:100 g NPK kg^{-1} of soil).

Increased fertilizer application increased the photosynthetic rate in trees (Kao and Tsai, 1999) who stated that an increase in nitrogen availability significantly increased the photosynthetic rate in *Kandeliacandel* grown under saline conditions. Sitka spruce (*Picea sitchensis*) seedlings supplied with high nitrogen dose recorded higher photosynthetic rate than seedlings supplied with low nitrogen dose (Murray *et al.*, 2000). The current finding also state that increased application of N, P and K enhanced the photosynthetic rate in *Thespesia populnea*.

Transpiration rate (E)

Significant difference in transpiration rate was observed at 6MAP due to the influence of various treatments imposed. The transpiration rate was highest in T_{12} (100: 75: 50 g NPK plant^{-1}) which recorded 7.26 m mol. m^{-2} s^{-1}. This result is in tune with Mohan Raj (2008) who recorded the highest transpiration rate in Eucalyptus (2.63 m mol. m^{-2}s^{-1}) at 18 MAP in heavy fertilizer dose application.

Baranidharan*et al.* (2013) observed that 25 per cent more of fertilizer application over the soil test recommendation value of 93.75: 225: 100 of kg NPK ha^{-1} in *Casuarina* species recorded the highest transpiration rate value of 2.20 and 2.38 m mol. m^{-2} s^{-1} and was significantly superior to all the other nutrient levels recorded.

In *Gmelina arborea*, significantly higher transpiration rate of 4.81 m mol. m^{-2} s^{-1} followed by *Dalbergia sissoo* (4.32 m mol. m^{-2} s^{-1}),*Tectona grandis* (4.01 m mol m^{-2} s^{-1})and*Bambusa vulgaris* var. *vulgaris* (2.47 m mol m^{-2} s^{-1}). The lowest transpiration rate of 1.67 m mol m^{-2} s^{-1} was registered by *Swietenia macrophylla* at 21 MAP (Narendra Babu, 2012). Transpiration rate from several Australian semiarid zone species was studied in the field by Kreeb (1966) using the torsion balance technique and he concluded that among the different species studied, the maximum transpiration rate was observed in *Eucalyptus camaldulensis* (5.0 and 7.9 m mol m^{-2} s^{-1}).

Stomatal conductance rate (g_s)

Stomatal conductance rate exhibited significant difference at 6 MAP due to the influence of various treatments applied. The highest stomatal conductance rate was found to be associated with the application of 100: 75: 50 g NPK plant^{-1} (T_{12}) which recorded the value of 0.24 m mol. m^{-2} s^{-1} followed by 100:75:25 g NPK plant^{-}

[1](T_{11}) which recorded 0.21 m mol. m^{-2} s^{-1} and which were *on par* with each other. This is in line with findings of De Costa *et al.*(2000) who reported that the stomatal conductance in nine tree species *viz*., *Alstonia macrophylla, Filiciumdecipiens, Macaranga peltata, Tectona grandis, Acronychia pedunculata, Semicarpusnigro-viridis, Swietenia macrophylla, Mesua ferrea* and *Terminalia catappa*growing under different levels of natural shade, i.e. open, medium shade and full shade. According to them, the total leaf stomatal conductance (g_s) varied significantly with the tree species and shade levels and the highest (g_s) was observed in *S. nigroviridis* and *T. catappa*, with values of 92.03 and 78.18 m mol. m^{-1} s^{-1} respectively.

Stomata are the points of exit for the water vapour from leaves. Under conditions of adequate water supply, stomata open in the morning with increasing radiant flux and maintain a relatively constant aperture until radiant flux declines in the late afternoon. So, there was a correlation present among the stomatal opening and radiant flux (Giklooet *al.*, 2012). They also reported that the leaf stomatal conductance during January was consistently higher than during September (0.08 to 0.14 vs 0.02 to 0.08 mol m^{-2} s^{-1}).

Ladjal*et al.* (2007) studied greenhouse grown Cedar seedlings subjected to two different watering regimes and observed that dry set showed lower net photosynthesis and stomatal conductance than the plants in the well watered set. Measurements of diameter, growth, CO_2 uptake and stomatal conductance at the age of 4-5 years showed that Victorian provenances of *Eucalyptus camaldulensis* was better adapted to semi-arid conditions.

Inter cellular CO_2 concentration (CINT)

The inter cellular CO_2 concentration exhibited significant difference at 6 MAP due to the influence of various treatments applied. The highest inter cellular CO_2concentration was found to be associated with the application of 100 : 75 : 50 g NPK plant^{-1} (T_{12}) they recorded the value of 263 ppm followed by 125:75:50 g NPK plant^{-1}(T_{16}) which recorded 259 ppm and which were *on par*.

Inter cellular CO_2 is also an indicator of plant productivity in which it is highly related to plant photosynthetic rate. Esser (2004) correlated Inter cellular CO_2 concentration with the photosynthetic efficiency of three species. Similar result was observed by Suresh Kumar (2011) and Narendra Babu (2012) have also confirmed that Inter cellular CO_2concentration in *Tectona grandis* and *Gmelina arborea* was lower than that of *Dalbergia sisooand Bambusavulgaries*var .*vulgaris*during 9 MAP respectively.

Summary and Conclusion

Nutrient managementis one of the prime factors which plays a vital role in the growth, development and successful completion of life cycle in crop plants. Judicious integration of organic and inorganic fertilizers has been proved to be a viable and economically feasible technology for enhancing the initial growth and development of plants.

Growth components *viz.,* plant height, collar diameter, volume index and biomass yield were recorded. Growth analysis was done by estimating LAI and ecophysiological parameters *viz.*,photosynthestic rate (A), transpiration rate (E), stomatal conductance (g_s) and Intercellular CO_2 concentration (CINT) were also recorded. The growth attributes were influenced by N, P and K at different levels.

Among N, P and K levels,application of 100: 75: 50 g NPK plant^{-1} (T_{12}) significantly influenced the growthattributes followed by 100: 75: 25 g NPK plant^{-1} (T_{11}).

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