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# Effect of NPK and Bio-inoculants on Growth Pattern and Nodulation Behaviour of *Flemingia semialata* under Nursery Condition

**R.K. Kar[1]*, K. Upadhyaya[1] and P.C. Panda[2]**

*[1]Department of Forestry, School of Earth Science sand Natural Resources Management, Mizoram University, Tanhril – 796004, Aizawl, Mizoram*
*[2]Regional Plant Resources Centre, Bhubaneswar - 751003, Odisha*

**Corresponding author*

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**A B S T R A C T**

A field experiment was laid with *Flemingia semialata* Roxb. in the nursery of Department of Forestry, Mizoram University consisting of 17 treatments in CRD having 3 replications to study the effect of *Rhizobium*, endomycorrhizae and inorganic fertilizers under various combinations on plant growth, root development and nodulation. $T_{15}$ recorded the highest values for parameters rooting length (17.8 cm), angle between primary and secondary roots ($68^0$), length of primary roots (15.7 cm) and leaf length (17.5 cm), $T_{14}$ recorded the highest values for plant height (15.8 cm), collar diameter (3.8 mm), number of root nodules per plant (18), nodule biomass (0.15 gm), root spread (7.5 cm), shoot spread (18.8 cm), angle of branch emergence ($83^0$), number of branches (8) and branch length (6.9 cm), $T_{11}$ recorded highest for number of leaves per plant (21), $T_6$ recorded highest angle between secondary and tertiary roots ($69^0$) and length of tertiary roots (4.1 cm), $T_{10}$ recorded highest number of rootlets (82) and $T_{17}$ for maximum length of secondary roots (6.8 cm). *Rhizobium* contributes for good length of tertiary roots whereas endomycorrhizae for maximum number of rootlets which may be considered while introducing and managing *Flemingia sermialata* in various land use systems.

## Introduction

*Flemingia semialata* Roxb. synonym *Moghania semialata* and *Flemingia congesta* var. *Semialata* commonly called winged-stalk flemingia, Hindi bara solpan, a shrub of family Fabaceae and native of Uttaranchal, North East and Andaman and Nicobar in India, Pakisthan, Myanmar and China (Lewis *et al.*, 2005). It has gained popularity in view of its medicinal, nutritive, browsable, deep rooting, soil binding, nitrogen fixing, drought and waterlog bearing, fertilizer, mycorrhizae and rhizobial inoculation responding and of late exploited lac producing tendency. The species is known to be the best lac shrub host and commercially exploited by farmers due to its less gestation age, high coppicing and ease to access for employment, income generation and value addition (ICAR, 2008). It has tendency of soil and water conservation and used as hedge in improved fallow in Jhum and

Alley Cropping. Because of its multifarious uses *F. semialata* has been used as plantation species in degraded lands and in agroforestry systems. Being exploited for socio-economic and environmental benefits it becomes necessary to standardise techniques for producing quality planting materials. The application of less expensive bioinoculants increases the productivity without harming the environment. The species being a atmospheric nitrogen fixer it needs favourable environment and sufficient inoculum for its roots to be infected with *Rhizobium*. In this regard artificial inoculation of *Rhizobium* can boost nodulation potential at the initial growth at the seedling stage as well as after planting out.

Mycorrhizal inoculation nowadays became vital for hosts as it provides highly extension of the host root system and absorbs minerals like N, P, K, Ca, S, Zn, Cu and Sr from soils which are translocated to the host plant, it produces enzymes, vitamins, cytokinins, and other compounds that increase rootlet size and longevity, help in absorbing and translocating water to host (Bakshi, 1974) and play a vital role in nutrient cycling. About 90% of tropical plants are prevalent with endomycorrhizae also called Vescicular Arbuscular Mycorrhizal (VAM) fungi, there is urgency to inoculate these which through astrometrical mycelium originating from initial infection spread rapidly to infect other roots (Dwibedi, 1995). The sound management of fertilization must attempt to ensure both an enhanced and safeguarded environment. The advantages of chemical, organic and biofertilizers need to be integrated in order to make optimum use of each type of fertilizer and achieve balanced nutrient management for plant growth (Chen, 2006). There is dearth of literature regarding this aspect.

Keeping these in view, under the present investigations efforts have been made to study the effect of *Rhizobium*, *endomycorrhizae* and inorganic fertilizers under various combinations on plant growth, root development and nodulation of *Flemingia semialata* in Mizoram University Campus, Aizawl at nursery stage.

## Materials and Methods

The investigations were carried out in nursery of Department of Forestry, Mizoram University, Tanhril, Aizawl, Mizoram The study site has latitude $23^0$43’37" N and longitude $92^0$40’23" E with an elevation ranges of 795 m above mean sea level (msl.), maximum temperature ranges from $13^0$C to $36^0$C, and annual rainfall 2422 mm.

The treatment combinations were $T_1$ = Control, $T_2$ = Potting mixture, $T_3$ = Potting mixture + $N_1P_1K_1$, $T_4$ = Potting mixture + $N_2P_2K_2$, $T_5$ = Potting mixture + $N_3P_3K_3$, $T_6$ = Potting mixture + *Rhizobium*, $T_7$ = Potting mixture + $N_1P_1K_1$+ *Rhizobium*, $T_8$ = Potting mixture + $N_2P_2K_2$ + *Rhizobium*, $T_9$ = Potting mixture + $N_3P_3K_3$ + *Rhizobium*, $T_{10}$ = Potting mixture + Mycorrhizae, $T_{11}$ = potting mixture + $N_1P_1K_1$+ Mycorrhizae, $T_{12}$ = Potting mixture + $N_2P_2K_2$ + Mycorrhizae, $T_{13}$ = Potting mixture + $N_3P_3K_3$ + Mycorrhizae, $T_{14}$ = Potting mixture + Mycorrhizae + *Rhizobium*, $T_{15}$ = Potting mixture + $N_1P_1K_1$ + Mycorrhizae + *Rhizobium*, $T_{16}$ = Potting mixture + $N_2P_2K_2$ + Mycorrhizae + *Rhizobium*, $T_{17}$ = Potting mixture + $N_3P_3K_3$ + Mycorrhizae + *Rhizobium*, where $N_1P_1K_1$ means 125 mg $N_2$, 125 mg $P_2O_5$ and 125 mg $K_2O$, $N_2P_2K_2$ means 250 mg $N_2$, 250 mg $P_2O_5$ and 125 mg $K_2O$ and $N_3P_3K_3$ means 375 mg $N_2$, 250 mg $P_2O_5$ and 250 mg $K_2O$ and design was CRD with 3 replications.

The inoculum (broth) of *Rhizobium* was prepared following Somasegaran and Hoben, (1985) and.used to inoculate seeds. VAM culture developed using charcoal in Division of Microbiology, Indian Agricultural Rresearch Institute, New Delhi was used in

polybag soil before seed sowing. The inoculums used per polybag were 1ml *Rhizobium* and 2g of VAM. The seedlings were grown in polybags (21 x 30 cm) filled with well sieved soil potting mixture (ratio 1:1:1 of sand, soil and FYM) with usual liming dose 2.84mg/ kg of soil as per recommended dose of Forest Productivity Institute. 5 samples per replication were drawn for observation. The root growth and nodulation behaviour were studied and presented in table 1. The shoot growth behaviour were studied and presented in table 2. For variance ratio comparison in ANOVA F test followed and treatment means t test (Gomez and Gomez, 1983) and Duncan's Multiple Range Test ($P < 0.05$) (Duncan, 1955) were followed.

## Results and Discussion

It is revealed from table 1 that the root growth and nodulation behaviour were influenced significantly by the various treatments. The effects on various parameters are detailed below.

## Root length

Maximum root length was observed (Table 1) in $T_{15}$ (17.8 cm) which was significantly followed by $T_{14}$ (16.7 cm), $T_2$ (16.4 cm), $T_6$ (16.9 cm), $T_{16}$ (16.2 cm), $T_{11}$ (16.0 cm), $T_{17}$ (15.7 cm), $T_8$ and $T_{10}$ (15.2 cm), $T_9$ (14.8 cm) and least with $T_1$ (14.4 cm). All the treatment means were significantly different among each other except the following combinations. The treatments $T_7$, $T_4$, $T_3$, $T_5$, $T_{12}$ and $T_{14}$ were at par. Among $T_4$, $T_3$, $T_5$, $T_{12}$, $T_{14}$, $T_2$, $T_6$, $T_3$ were at par; Among $T_5$, $T_{12}$, $T_{14}$, $T_2$, $T_6$, $T_{16}$, $T_{11}$ and $T_{14}$ remained at par; similarly among $T_2$, $T_6$, $T_{16}$, $T_{11}$ and $T_{17}$. $T_{11}$ remained at par; among $T_{17}$, $T_8$, $T_{10}$ and $T_{17}$ remained at par with $T_8$, $T_{10}$, $T_9$ and $T_8$ remained at par with $T_{10}$, $T_9$ and $T_1$.

## Maximum root spread

Maximum root spread was observed (Table 1) in $T_{14}$ (7.5 cm) (Potting mixture + Mycorrhizae + *Rhizobium*) which was significantly followed by $T_{15}$ (6.2 cm), $T_9$ (6.1 cm), $T_8$ and $T_{16}$ (5.8 cm), $T_{17}$ (5.6 cm), $T_5$ (5.5 cm), $T_3$ (5.0 cm), $T_4$ (4.6 cm), $T_2$ (4.2 cm) and $T_1$ (4.0). All the treatment means were significant among each other except the following combinations. The treatments $T_{12}$, $T_6$, $T_{15}$ and $T_9$ remained at par with each other. Similarly, the relation among the treatments $T_6$ and remained at par with $T_{15}$, $T_9$, $T_8$, $T_{16}$ and $T_{17}$. $T_{15}$ remained at par with $T_9$, $T_8$, $T_{16}$, $T_{17}$ and $T_5$. $T_{17}$, $T_5$ and $T_3$ remained at par with each other. $T_5$ remained at par with $T_3$ and $T_4$. $T_3$ remained at par with $T_4$ and $T_2$ and $T_2$ remained at par with $T_1$.

## Angle between primary and secondary roots

Angle between primary and secondary roots observed (Table 1) highest in $T_5$ ($69^0$) which was followed by $T_{10}$ and $T_{15}$ ($68^0$), $T_6$ and $T_7$ ($66^0$), $T_3$, $T_8$, $T_{11}$, $T_{13}$ and $T_{16}$ ($65^0$), $T_2$, $T_4$ and $T_{14}$ ($64^0$), $T_1$ and $T_{17}$ ($63^0$), $T_9$ ($62^0$) and least with $T_{12}$ ($61^0$). However among the treatments most of relations were significant. The at par relations observed among the treatments namely $T_{10}$, $T_{15}$ $T_6$, $T_7$, $T_3$, $T_8$, $T_{11}$ and $T_{13}$ among $T_6$, $T_7$, $T_3$, $T_8$, $T_{11}$, $T_{13}$, $T_{16}$, $T_2$, $T_4$, $T_{14}$, $T_1$ and $T_1$ and among$T_{16}$, $T_2$, $T_4$, $T_{14}$, $T_1$, $T_{17}$, $T_9$ and $T_{12}$.

## Angle between secondary and tertiary roots

$T_6$ ($69^0$) was having maximum secondary to tertiary angle (Table 1) which was followed by $T_7$, $T_{11}$, $T_{14}$ and $T_{16}$ ($68^0$), $T_5$, $T_8$ and $T_{17}$ ($67^0$), $T_4$ and $T_{15}$ ($66^0$), $T_{13}$ ($65^0$), $T_1$, $T_9$ and $T_{10}$ ($63^0$), $T_3$ ($62^0$), $T_2$ and $T_{12}$ ($61^0$). Most of the relations was significant except at par relations observed among the combinations namely, $T_6$, $T_7$, $T_{11}$, $T_{14}$, $T_{16}$, $T_5$, $T_8$, $T_{17}$, $T_4$,

$T_{15}$ and $T_{13;}$ among $T_5$, $T_8$, $T_{17}$, $T_4$, $T_{15}$, $T_{13}$, $T_1$, $T_9$ and $T_{10;}$ among $T_{13}$, $T_1$, $T_9$, $T_{10}$ and $T_3$ and among $T_1$, $T_9$, $T_{10}$, $T_3$, $T_2$ and $T_{12.}$

## Number of rootlets

It is evident from Table 1 that maximum number of roots found in $T_{10}$ (82) which was significantly followed by $T_{11}$ (77), $T_{15}$ (69), $T_1$ (67), $T_{16}$ and $T_2$ (66), $T_{17}$ and $T_{12}$ (63), $T_7$ (62), $T_{13}$ (61), $T_8$ (60), $T_4$ (54), $T_5$ (53), $T_{14}$ (51) and minimum in $T_6$ (50). Significant relations were observed among all the treatments except at par relations among $T_9$, $T_3$ and $T_{11}$; among $T_{15}$, $T_1$, $T_{16}$ and $T_2$; among $T_1$, $T_{16}$, $T_2$, $T_{17}$ and $T_{12}$, among $T_{17}$, $T_{12}$, $T_7$, $T_{13}$ among $T_8$; among $T_4$, $T_5$ and $T_{14}$ and among $T_5$, $T_{14}$ and $T_6$.

## Number of root nodules

Maximum number of root nodules (Table 1) were observed in $T_5$ (23) which was significantly followed by $T_{10}$ (18), $T_{14}$ (17), $T_{11}$ (16), $T_9$ (15), $T_8$ and $T_{16}$ (14), $T_{15}$ (13), $T_2$, $T_4$, $T_{12}$ and $T_{17}$ (12), $T_7$ (11), $T_3$ and $T_6$ and $T_{13}$ (10) and lowest with $T_1$ (8). The relations among the treatments were significant except following at par relations among $T_{14}$, $T_{11}$, $T_9$, $T_8$ and $T_{16}$; among $T_{11}$, $T_9$, $T_8$, $T_{16}$ and $T_{15}$; among $T_9$, $T_8$, $T_{16}$ and $T_{15}$; among $T_9$, $T_8$, $T_{16}$, $T_{15}$, $T_2$, $T_4$, $T_{12}$, and $T_{17}$; among $T_8$, $T_{16}$, $T_{15}$, $T_2$, $T_4$, $T_{12}$, $T_{17}$ and $T_7$; among $T_5$, $T_2$, $T_4$, $T_{12}$, $T_{17}$ and $T_7$ and among $T_3$, $T_6$, $T_{13}$ and $T_{1.}$

## Length of primary root

Maximum length of primary root was observed (Table 1) with the treatment $T_{15}$ (15.7 cm) which was followed by $T_{11}$ (15.6 cm), then $T_{10}$ (15.1 cm), $T_2$ (14.8 cm), $T_{14}$ (14.8 cm), $T_3$ and $T_{16}$ (14.2 cm), $T_5$ (14.1cm), $T_4$ and $T_{17}$ (13.8 cm), $T_{1,}$ $T_7$ and $T_{12}$ (13.7 cm), $T_6$ (13.3 cm), $T_8$ (12.8 cm), $T_{13}$ (12.1cm) and minimum in $T_9$ (11.6 cm). The at par relations were observed among the treatments namely, $T_{15,}$ $T_{11}$ and $T_{10}$; among treatments $T_{11}$, $T_{10}$, $T_2$ and $T1_4$; among $T_2$, $T_{14}$, $T_3$, $T_{16}$, $T_{5;}$ among $T_3$ and $T_{16,}$ $T_5$, $T_4$, $T_{17,}$ $T_{1,}$ $T_7$ and $T_{12;}$ among $T_5$, $T_4$, $T_{17,}$ $T_1$, $T_7$, $T_{12}$ and $T_6$; between, $T_6$ and $T_8$, between $T_8$ and $T_{13}$ and between $T_{13}$ with $T_9$.

## Length of secondary roots

Maximum length of secondary root observed (Table 1) in $T_{17}$ (6.8 cm) which was followed by $T_{11}$ (6.5 cm), $T_{14}$ and $T_{15}$ (6.1 cm), $T_{13}$ (6.0 cm), $T_{11}$ and $T_{12}$ (5.8 cm), $T_{10}$ (5.4 cm), $T_9$ (5.1 cm), $T_7$ and $T_8$ (4.8 cm), $T_6$ (4.7 cm), $T_4$ and $T_5$ (3.4 cm), $T_3$ (3.2 cm), $T_2$ (3.0 cm), and $T_1$ (2.8 cm). Among the treatments relations were significant except few at par relations between $T_{17}$ and $T_{16}$; among $T_{16}$, $T_{14}$ and $T_{15}$; among $T_{14}$, $T_{15}$ and $T_{13}$, $T_{11}$ and $T_{12}$; among $T_{11}$, $T_{12}$ and $T_{10}$; among $T_{10}$ and $T_9$; among $T_9$, $T_7$, $T_8$ and $T_6$; among $T_7$, $T_8$ and $T_6$; among $T_4$, $T_8$, $T_3$ and $T_2$ and between $T_2$ and $T_1$.

## Length of tertiary roots

Maximum length of tertiary root was observed (Table 1) with $T_6$ (4.1 cm) which was followed by $T_7$ (3.6 cm), then $T_8$ (2.8 cm), $T_5$ (2.6 cm), $T_{15}$ (2.2 cm), $T_{12}$ (2.1 cm), $T_4$ (2.0 cm), $T_{13}$ 2.0 cm), $T_{2,}$ $T_{10,}$ $T_{14}$ and $T_{16}$ (1.8 cm), $T_3$ and $T_{11}$ (1.7 cm), $T_1$ and $T_{17}$ (1.6 cm) and minimum with $T_9$ (1.4 cm). Among the treatments relations remained significant except the at par relations were observed among $T_{15}$, $T_{12}$, $T_4$ and $T_{13}$, $T_2$, $T_{10}$, $T_{14}$ and $T_{16}$; among $T_2$, $T_{10}$, $T_{14}$, $T_{16}$, $T_3$, $T_{11}$, $T_1$ and $T_7$ and among $T_3$, $T_{11}$, $T_1$, $T_{17}$, $T_9$ and between $T_1$ and $T_{17}$.

## Root nodule biomass

Maximum root nodule biomass (Table 1) was with $T_{14}$ (0.15 g) which was followed by $T_{13}$ (0.13 g), $T_{10}$ (0.08 g), $T_6$, $T_8$, $T_{12}$ and $T_{15}$ (0.05 g), $T_2$, $T_{4,}$ $T_{5,}$ $T_{7,}$ $T_{11,}$ $T_{16}$ and $T_{17}$ (0.04 g), $T_3$ and $T_9$ (0.03 g) and $T_1$ (0.002 g). Significant relationship was observed among the treatments except the at par relation observed

among the treatments namely, $T_4$, $T_5$, $T_6$ and $T_7$; among $T_8$, $T_9$, $T_{10}$, $T_{11}$, $T_{12}$, $T_{13}$, $T_{14}$, $T_{15}$ and $T_{16}$ and among $T_{15}$, T16 and $T_{17}$.

## Plant height

Maximum plant height was observed (Table 2) in $T_{14}$ and $T_{16}$ (15.8 cm) which was followed by then $T_4$ (15.6 cm), $T_{17}$ (15.5 cm), $T_6$ (14.8 cm), $T_{12}$ (14.5 cm), $T_{13}$ and $T_{15}$ (14.3 cm), $T_2$ (14.1 cm), $T_7$ (13.9 cm), $T_3$ (13.8 cm), $T_1$ (13.2 cm), $T_8$ (12.9 cm), $T_{11}$ (12.4 cm), $T_{10}$ (12 cm), $T_5$ (11.9 cm) and minimum with $T_9$ (11.2 cm). Among the treatments significant difference was observed except at par relations marked among $T_{14}$, $T_{16}$ and $T_4$; between $T_{17}$ and $T_{17}$; between $T_6$ and $T_{12}$; among $T_{12}$, $T_{13}$, $T_{15}$ and $T_2$; among $T_{13}$, $T_{15}$, $T_2$ and $T_7$; among $T_2$, $T_7$ and $T_3$; between $T_1$ and $T_8$; between $T_{11}$ and $T_{10}$, between $T_{10}$ and $T_5$.

## Shoot spread

Maximum shoot spread was observed (Table 2) under $T_{10}$ (22.6 cm) which was followed by $T_{14}$ (18.8 cm) and then $T_6$ (17.0 cm), $T_{12}$ (16.3 cm), $T_{11}$ (13.7 cm), $T_2$ (13.6 cm), $T_9$ (13.2 cm), $T_{13}$ and $T_{16}$ (12.9 cm), $T_4$ and $T_8$ (12.8 cm) $T_7$ (12.7 cm), $T_{17}$ (12.6 cm), $T_{15}$ (12.3 cm), $T_3$ (11.8 cm), $T_1$ (11.2 cm) and least spread was with $T_5$ (10.5 cm). Significant relationships were observed among the treatments except the at par relations observed among the treatments $T_1$, $T_2$ and $T_9$; among $T_9$, $T_{13}$, $T_{16}$, $T_4$, $T_8$, $T_7$ and $T_{17}$; among $T_{13}$, $T_{16}$, $T_4$, $T_8$, $T_7$, $T_{17}$ and $T_{15}$; between $T_{15}$ and $T_3$ and between $T_3$ and $T_1$.

## Angle of branch spread

Branching angle was maximum (Table 2) with $T_{14}$ ($83^0$) which was followed by $T_3$ ($81^0$) then $T_{15}$ ($78^0$), $T_2$ and $T_4$ ($75^0$), $T_6$ ($74^0$), $T_1$ and $T_5$ ($73^0$), $T_7$ ($71^0$), $T_8$ and $T_{12}$ ($69^0$), $T_{11}$ and $T_{16}$ ($65^0$), $T_{17}$ ($63^0$), $T_9$ ($62^0$), $T_{10}$ ($61^0$) and the minimum angle observed with the treatment $T_{13}$ ($58^0$). Significant difference was observed among the treatments except the at par difference was observed between $T_{14}$ and $T_3$; between $T_3$ and $T_{15}$; among $T_{15}$, $T_2$ and $T_4$; among $T_4$, $T_6$, $T_1$ and $T_5$; among $T_6$, $T_1$, $T_5$ and $T_7$; among $T_7$, $T_8$ and $T_{12}$; among $T_{11}$, $T_{16}$, $T_{17}$ and $T_9$; between $T_9$ and $T_{10}$ and between $T_{10}$ and $T_{13}$.

## Number of branches

Maximum number of branches (Table 2) was observed with $T_6$ and $T_4$ (8) which was followed by $T_4$, $T_7$, $T_{10}$, $T_{17}$ and $T_{15}$ (6), $T_1$, $T_3$, $T_5$, $T_9$, $T_{11}$, $T_{13}$ and $T_{16}$ (5) and minimum with $T_2$ and $T_{17}$ (4). Significant difference was observed among the treatments except at par relation was existing among the treatments $T_6$, $T_{14}$, $T_4$, $T_7$, $T_{10}$, $T_{12}$ and $T_{15}$; among $T_4$, $T_7$, $T_{10}$, $T_{12}$, $T_{15}$, $T_1$, $T_3$, $T_5$, $T_8$, $T_9$, $T_{11}$, $T_{13}$, $T_{16}$, $T_2$ and $T_{17}$.

## Branch length

Highest branch length was recorded (Table 2) with treatment at $T_{14}$ (6.9 cm) which was followed by $T_{12}$ (6.2 cm) and then $T_{13}$ (6.0 cm), $T_6$ and $T_7$ (5.8 cm), $T_2$ and $T_{15}$ (6.7 cm), $T_3$ (5.3 cm), $T_{16}$ (5.1 cm), $T_{12}$ (4.9 cm), $T_{17}$ (4.6 cm), $T_1$ (4.5 cm), $T_4$ (4.3 cm), $T_{11}$ and $T_5$ (4.2 cm), $T_8$ (4.1 cm) and lowest with $T_9$ (3.8 cm). Significant relation was observed among the treatments except the at par relationship between the treatments $T_{14}$ and $T_{10}$; among the treatments $T_{10}$, $T_{13}$, $T_6$, $T_7$, $T_2$ and $T_{15}$; among $T_7$, $T_2$, $T_{15}$, and $T_3$, among $T_{15}$, $T_3$, $T_{16}$ and $T_{12}$; among $T_3$, $T_{16}$, $T_{12}$ and $T_{17}$; among $T_{16,}$ $T_{12}$, $T_{17}$ and $T_1$; among $T_{12}$, $T_{17}$, $T_1$, $T_4$, $T_{11}$ and $T_5$ and among $T_{17}$, $T_1$, $T_4$, $T_{11}$, $T_5$ and $T_8$.

## Number of leaves

Number of leaves was highest (Table 2) with $T_{11}$ (21) which was followed by $T_6$ (19), $T_{10}$ and $T_{14}$ (19), $T_3$ (18), $T_2$, $T_7$, $T_{12}$ and $T_{15}$ (15), $T_8$ and $T_9$ (16), $T_5$ and $T_{16}$ (15), $T_{13}$ (14), $T_{17}$ (13), $T_4$ (12) and $T_1$ (11). Significant relations were observed among the treatments except

the at par relations among $T_6$, $T_{10}$, $T_{14}$, and $T_3$; among $T_3$, $T_2$, $T_7$, $T_{12}$ and $T_{15}$; among $T_2$, $T_7$, $T_{12}$, $T_{15}$, $T_8$, $T_9$, $T_5$ and $T_{16}$, among $T_5$, $T_{16}$ and $T_{13}$; between $T_{13}$ and $T_{17}$ and between $T_{17}$ and $T_{14}$.

## Leaf length

Maximum leaf length was observed (Table 2) with $T_{15}$ (17.5 cm) which was followed by $T_6$ (17 cm) and then $T_5$ (16.3 cm), $T_{11}$ (15.2 cm), $T_3$ (15.0 cm), $T_{14}$ (14.3 cm), $T_7$ (14.2 cm), $T_2$ (14.1 cm), $T_{16}$ (14 cm), $T_4$ (13.9 cm), $T_1$ (13.9 cm), $T_{17}$ (13.6 cm), $T_8$ (13.1 cm), $T_{10}$ (12.1 cm), $T_{13}$ (11.6 cm), $T_9$ (11.1 cm) and minimum with $T_{12}$ (10.8 cm). Among the treatments significant difference was observed except few at par relation existed among the treatments namely, $T_{15}$, $T_6$ and $T_5$; $T_{11}$, $T_3$ and $T_{14}$; among $T_3$, $T_{14}$ and $T_1$; among $T_{14}$, $T_7$, $T_2$, $T_{16}$, $T_4$, $T_1$ and $T_{17}$; among $T_4$, $T_{17}$ and $T_8$; among $T_{10}$, $T_{13}$ and $T_9$ and between $T_{10}$ and $T_{13}$ and among $T_{13}$, $T_9$ and $T_{12}$.

## Collar diameter

Maximum collar diameter was observed (Table 2) in $T_{14}$ (Potting mixture + Mycorrhizae + *Rhizobium*) which was significantly followed by $T_{12}$, $T_9$, $T_3$, $T_7$, $T_2$, $T_4$, $T_{16}$, $T_8$, $T_5$, $T_{17}$, $T_1$ and least with $T_{15}$. The relationship among $T_{10}$, $T_6$, $T_{13}$ and $T_{12}$ are at par with $T_{11}$, $T_6$ was at par with $T_{13}$, $T_{12}$ and $T_9$, $T_{12}$ with $T_9$, $T_3$, $T_7$, $T_2$, $T_4$, $T_{16}$ and $T_8$ at par. Similarly, $T_9$ was at par with $T_3$, $T_7$, $T_2$, $T_4$, $T1_6$, $T_8$, $T_5$, $T_{17}$, $T_1$ and $T_{15}$.

## Root length and spread and length of primary, secondary and tertiary roots

Ecologically, plant roots constitute a major source of organic material for soil and thus affect structure, aeration and biological activities. Fitter (1991) reported that the diversity of root systems are dependent on these functions to a greater extent. Their distribution through space and time is influenced by genetic characters of the plant and localized soil conditions (Huck, 1983). Application of potting mixture, Mycorrhizae, *Rhizobium* and $N_1P_1K_1$ produced the highest root length. Further application of fertilisers in this combination reduced the root length Maximum root length was observed in $T_{15}$. It shows that length increases with bioinoculants and fertilisers, further dose beyond $N_1P_1K_1$ was harmful.

The root length is proportional to the forging ability and higher doses of fertilisers reduce this ability. It confirms the observation of Costa *et al.,* 2002. On the other hand, root spread was maximum with $T_{14}$ and minimum with $T_{16}$. This indicates spread is positive to bioinoculants but sensitive to fertilisation. This is in line with the report of Taylor, 1972 who reported that the rate of expansion of root systems has often been ascribed to be increasing due to insufficient water and nutrients flow to them. Maximum length of primary root was with $T_{15}$ increasing further fertiliser doses became more harmful in length of primary root compared to that of root spread.

*Rhizobium* effect suffers more with high fertilisation than that of Mycorrhizae in primary root length. Length of secondary root was highest with $T_{17}$ minimum with $T_1$. It shows that high fertilisation favoured secondary root development; further these roots more respond to fertilisers than bioinoculants thus changing formers dose makes abrupt fall in its length despite bioinoculants presence. Peculiar was with tertiary root length; its maximum length was with $T_6$ and least with $T_9$. It shows that tertiary root length was more encouraged by *Rhizobium* than Mycorrhizae and much suffered by fertilisation. Effect of fertilisers on root development have been reported by Song *et al.,* 2010 who found the combined application of N and P to have increased root surface area, root length, and root-shoot mass.

## Angle of primary and angle of secondary root emergence

The root branch angles are key components of root system architecture in which lateral roots diverge from parent root at wider angles which increase the chances of their entry to unexploited horizons (Henderson *et al.,* 1983; Fitter, 1991). In general the primary roots tend to be positively geotropic, secondary diageotropics and further branches to be ageotropic (Fitter, 1987). Angle of secondary root emergence from primary and tertiary root emergence from secondary roots have shown different behaviour. Potting mixture with $N_3P_3K_3$ give maximum secondary root angle while potting mixture with *Rhizobium* gives maximum tertiary root angle while least angle of secondary and tertiary roots with treatment potting mixture, mycorrhizae and $N_2P_2K_2$. It seems that high inorganic fertilisation led lateral roots to emerge horizontal while *Rhizobium* led tertiary roots to emerge vertical. Usually, angle between secondary and tertiary roots were greater than that of primary and secondary roots. Similar trend was observed with *Acacia mangium, Leucaena leucocephala* and *Leucaena diversifolia* and reverse trend with *Gliricidia sepium, Albizia lebbek* (Kar *et al*, 2007), *Albizia chinensis* and *Alnus nitida* (Kar, 1999).

## Number of rootlets and number and biomass of root nodules

Number of rootlets after counting all primary, secondary and tertiary rootlets it was maximum with potting mixture and mycorrhizae, maximum number of root nodules and maximum nodule biomass were observed with potting mixture with *Rhizobium* and mycorrhizae. Least nodulation was with control soil. It was indicated that mcorrhizae contributed phosphorus encouraged nitrogen fixation gave better nodulation at combination however mycorrhizal encouraged better number of rooting. Jamaluddin *et al*, 1992 observed more number of nodules in *Dalbergia sissdules.oo, Leucaena leucocephala, Pongamia pinnata* and *Albizia lebbeck Afte*r inoculation of *Rhizobium in Acacia catechu gave more number and biomass of nodules* (Banyal and Bhardwaj 2003). Role of phosphorus in root branching has been described by Lopez *et al.,* 2003.They also revealed N availability has significant effects on root elongation (Lopez *et al.,* 2003) and root branching.

## Collar diameter, plant height, shoot spread and branch length

Maximum collar diameter, plant height, shoot spread and branch length were observed with the combination of potting mixture, mycorrhizae and *Rhizobium* application. Bioinoculation has positive effect over horizontal and vertical development of aerial parts to which fertilisation has no adequate response. Prasad and Meghvani (2005) observed that the combination AM fungi and *Rhizobium* gave maximum number of nodules and maximum plant height than their counterparts in *Acacia nilotica*, they too claimed maximum shoot growth and height in this combination might be due to maximum nodulation. Singh and Puri (2006) also reported the enhanced plant height due to AM fungi and *Rhizobium* inoculation singly and in combination in *Dalbergia sissoo* (Lopez *et al.,* 2003).

## Angle of branch emergence, number of branches and number of leaves and leaf length

Maximum angle of branch emergence from the stem with was observed with $T_3$ i.e., potting mixture with 125 mg N, 125 $P_2O_5$ and 125 mg $K_2O$ and minimum with potting mixture, Mycorrhizae and 375 mg N, 250 $P_2O_5$ and 250 mg $K_2O$. However, more nutrition (bio-inoculants and fertilisation) decreased angle in both shoot and secondary root. This may be proved by future researches.

**Table.1** Effect of NPK and bio-inoculants on root distribution and nodulation behaviour of *Flemingia semialata*

| Treatment Name | Root Length (cm) | Lateral Root Spread (cm) | Angle between Primary secondary roots (deg) | Angle between secondary tertiary roots (deg) | No of rootlets | Length of Primary root (cm) | Length of secondary Roots (cm) | Length of Tertiary Roots (cm) | No of nodules | Nodule Biomass (gm) |
|---|---|---|---|---|---|---|---|---|---|---|
| $T_1$ | 14.4 (±0.79)$^{h}$ | 4.0 (±0.68)$^{h}$ | 63 (±1.99)$^{cde}$ | 63 (±1.99)$^{cde}$ | 67 (±1.24)$^{cd}$ | 13.7 (±0.69)$^{de}$ | 2.8 (±0.71)$^{g}$ | 1.6 (±0.67)$^{fg}$ | 8 (±1.06)$^{g}$ | 0.02 (±0.003)$^{f}$ |
| $T_2$ | 16.4 (±0.80)$^{cde}$ | 4.2 (±0.68)$^{gh}$ | 64 (±2.48)$^{cde}$ | 61 (±2.46)$^{e}$ | 66 (±1.34)$^{cd}$ | 14.8 (±0.70)$^{bc}$ | 3 (±0.69)$^{gh}$ | 1.8 (±0.67)$^{ef}$ | 12 (±1.60)$^{def}$ | 0.04 (±0.009)$^{de}$ |
| $T_3$ | 16.9 (±0.79)$^{abcd}$ | 5 (±0.71) $^{efg}$ | 65 (±2.09)$^{bcd}$ | 62 (±1.47)$^{de}$ | 78 (±2.01)$^{ab}$ | 14.2 (±0.75)$^{cd}$ | 3.2 (±0.70)$^{hg}$ | 1.7 (±0.67)$^{fg}$ | 10 (±1.62)$^{fg}$ | 0.03 (±0.002)$^{ef}$ |
| $T_4$ | 17.3 (±0.71)$^{abc}$ | 4.6 (±0.66)$^{fgh}$ | 64 (±1.33)$^{cde}$ | 66 (±1.81)$^{abc}$ | 54 (±1.22)$^{f}$ | 13.8 (±0.62)$^{de}$ | 3.4 (±0.60)$^{h}$ | 2 (±0.63)$^{def}$ | 12 (±1.57)$^{def}$ | 0.04 (±0.012)$^{de}$ |
| $T_5$ | 16.8 (±0.51)$^{abcd}$ | 5.5 (±0.25)$^{def}$ | 69 (±2.22)$^{a}$ | 67 (±2.19)$^{abc}$ | 53 (±1.62)$^{fg}$ | 14.1 (±0.47)$^{cde}$ | 3.4 (±0.18$^{)}$h | 2.6 (±0.16)$^{c}$ | 23 (±2.28) | 0.04 (±0.004)$^{de}$ |
| $T_6$ | 16.3 (±1.06)$^{cde}$ | 6.7 (±0.94)$^{abc}$ | 66 (±1.91)$^{bc}$ | 69 (±2.11)$^{b}$ | 50 (±1.39)$^{g}$ | 13.3 (±0.93)$^{ef}$ | 4.7 (±0.93)$^{fg}$ | 4.1 (±0.92)$^{a}$ | 10 (±1.72)$^{fg}$ | 0.05 (±0.004)$^{d}$ |
| $T_7$ | 17.6 (±0.67)$^{ab}$ | 7.2 (±0.62)$^{a}$ | 66 (±1.98)$^{bc}$ | 68 (±1.99)$^{ab}$ | 62 (±1.75)$^{e}$ | 13.7 (±0.59)$^{de}$ | 4.8 (±0.57)$^{fg}$ | 3.6 (±0.54)$^{b}$ | 11 (±1.56)$^{ef}$ | 0.04 (±0.003)$^{de}$ |
| $T_8$ | 15.2 (±0.71)$^{fgh}$ | 5.8 (±0.64)$^{cd}$ | 65 (±2.04)$^{bcd}$ | 67 (±1.88)$^{ab}$ | 60 (±1.85)$^{e}$ | 12.8 (±0.62)$^{fg}$ | 4.8 (±0.59)$^{fg}$ | 2.8 (±0.56)$^{c}$ | 14 (±1.79)$^{bcde}$ | 0.05 (±0.004)$^{d}$ |
| $T_9$ | 14.8 (±0.70)$^{gh}$ | 6.1 (±0.72)$^{bcd}$ | 62 (±1.80)$^{de}$ | 63 (±2.47)$^{cde}$ | 81 (±1.74)$^{ab}$ | 11.6 (±0.69) | 5.1 (±0.67)ef | 1.4 (±0.66)$^{g}$ | 15 (±1.07)$^{abcd}$ | 0.03 (±0.003)$^{ef}$ |
| $T_{10}$ | 15.2 (±0.90)$^{fgh}$ | 7.0 (±0.75)$^{a}$ | 68 (±2.04)$^{b}$ | 63 (±2.01)$^{cde}$ | 82 (±2.52)$^{a}$ | 15.1 (±1.39)$^{ab}$ | 5.4 (±0.75)$^{de}$ | 1.8 (±0.74)$^{ef}$ | 18 (±1.64)$^{a}$ | 0.08 (±0.007)$^{c}$ |
| $T_{11}$ | 16 (±0.97)$^{def}$ | 7.3 (±0.84)$^{a}$ | 65 (±2.59)$^{bcd}$ | 68 (±2.17)$^{a}$ | 77 (±2.11)$^{b}$ | 15.6 (±0.86)$^{ab}$ | 5.8 (±0.83)$^{cd}$ | 1.7 (±0.79)$^{fg}$ | 16 (±1.69)$^{abc}$ | 0.04 (±0.003)$^{de}$ |
| $T_{12}$ | 16.8 (±0.84)$^{abcd}$ | 6.9 (±0.58)$^{ab}$ | 61 (±2.43)$^{e}$ | 61 (±2.44)$^{e}$ | 63 (±1.34)$^{de}$ | 13.7 (±0.58)$^{de}$ | 5.8 (±0.55)$^{cd}$ | 2.1 (±0.57)$^{de}$ | 12 (±1.55)$^{def}$ | 0.05 (±0.005)$^{d}$ |
| $T_{13}$ | 17.5 (±1.01)$^{ab}$ | 7.1 (±0.94)$^{a}$ | 65 (±1.90)$^{bcd}$ | 65 (±1.91)$^{cd}$ | 61 (±2.18)$^{e}$ | 12.1 (±0.92)$^{gh}$ | 6.0 (±0.92)$^{c}$ | 2.0 (±0.92)$^{de}$ | 10 (±1.24)$^{fg}$ | 0.13 (±0.024)$^{b}$ |
| $T_{14}$ | 16.7 (±1.11)$^{bcde}$ | 7.5 (±0.97)$^{a}$ | 64 (±2.19)$^{cde}$ | 68 (±2.06)$^{a}$ | 51 (±2.34)$^{fg}$ | 14.8 (±0.99)$^{bc}$ | 6.1 (±0.96)$^{bc}$ | 1.8 (±0.93)$^{ef}$ | 17 (±1.77)$^{ab}$ | 0.15 (±0.020)$^{a}$ |
| $T_{15}$ | 17.8 (±1.06)$^{a}$ | 6.2 (±0.97)$^{bcd}$ | 68 (±2.06)$^{b}$ | 66 (±2.04)$^{abcd}$ | 69 (±2.30)$^{c}$ | 15.7 (±1.02)$^{a}$ | 6.1 (±0.94)$^{bc}$ | 2.2 (±0.93)$^{d}$ | 13 (±1.28)$^{cdef}$ | 0.05 (±0.005)$^{d}$ |
| $T_{16}$ | 16.2 (±1.06)$^{de}$ | 5.8 (±0.98)$^{cd}$ | 65 (±1.65)$^{bcd}$ | 68 (±2.66)$^{abc}$ | 66 (±2.21)$^{cd}$ | 14.2 (±1.00)$^{cd}$ | 6.5 (±0.96)$^{ab}$ | 1.8 (±0.93)$^{ef}$ | 14 (±1.28)$^{bcde}$ | 0.04 (±0.003)$^{de}$ |
| $T_{17}$ | 15.7 (±1.08)$^{efg}$ | 5.6 (±0.95) $^{cde}$ | 63 (±1.63)$^{cde}$ | 67 (±2.06)$^{abc}$ | 63 (±1.63)$^{de}$ | 13.8 (±1.00)$^{de}$ | 6.8 (±0.96)$^{a}$ | 1.6 (±0.93)$^{fg}$ | 12 (±1.28)$^{def}$ | 0.04 (±0.003)$^{de}$ |
| **$SE_d$** | **0.42** | **0.25** | **1.58** | **1.67** | **1.34** | **0.35** | **0.20** | **0.16** | **0.35** | **0.008** |
| **$CD_{0.05}$** | **0.20** | **2.04** | **4.23** | **3.41** | **2.74** | **0.72** | **0.41** | **0.31** | **0.72** | **0.016** |
| **$CD_{0.01}$** | **0.27** | **2.75** | **4.36** | **4.59** | **3.69** | **0.97** | **0.56** | **0.41** | **0.97** | **0.021** |

The figures in the parentheses are standard deviation from mean. Means with the same letter are not significantly different of Duncan test ($p \leq 0.05$).

**Table.2** Effect of NPK and bio-inoculants on shoot growth pattern of *Flemingia emialata*

| Treatment Name | Collar Diameter (mm) | Plant Height (cm) | Shoot Spread (cm) | Angle of Branch Spread (deg) | Number of Branches | Branch Length (cm) | No. of Leaves | Length of Leaf (cm) |
|---|---|---|---|---|---|---|---|---|
| $T_1$ | 1.8 (±0.13)$^{e}$ | 13.2 (±0.94)$^{g}$ | 11.2 (±0.81)i | 73 (±2.40)$^{de}$ | 5 (±0.33)$^{b}$ | 4.5 (±0.19)$^{fgh}$ | 11 (±0.82) | 13.7 (±0.52)$^{de}$ |
| $T_2$ | 2.1 (±0.15)$^{de}$ | 14.1 (±0.95)$^{def}$ | 13.6 (±0.96)$^{e}$ | 75 (±2.83)$^{ef}$ | 4 (±0.18)$^{a}$ | 5.7 (±0.14)$^{bc}$ | 17 (±0.82) $^{cd}$ | 14.1 (±0.44)$^{d}$ |
| $T_3$ | 2.3 (±0.23)$^{de}$ | 13.8 (±0.95)$^{f}$ | 11.8 (±0.83)$^{hi}$ | 81 (±2.33)$^{gh}$ | 5 (±0.26)$^{b}$ | 5.3 (±0.19)$^{cde}$ | 18 (±0.90)$^{bc}$ | 15.0 (±0.48)$^{bc}$ |
| $T_4$ | 2.1 (±0.17)$^{de}$ | 15.6 (±1.06)$^{a}$ | 12.8 (±0.93)$^{fg}$ | 75 (±2.21)$^{ef}$ | 6 (±0.24)$^{c}$ | 4.3 (±0.19)$^{gh}$ | 12 (±0.90)$^{h}$ | 13.9 (±0.40)$^{de}$ |
| $T_5$ | 2.01 (±0.78)$^{e}$ | 11.9 (±0.82)$^{i}$ | 10.5 (±0.74) | 73 (±219.52)$^{de}$ | 5 (±0.20)$^{b}$ | 4.2 (±0.19)$^{gh}$ | 15 (±0.98)$^{ef}$ | 16.3 (±0.49)$^{a}$ |
| $T_6$ | 3.1 (±0.34)$^{abc}$ | 14.8 (±1.04)$^{bc}$ | 17.0 (±1.23)$^{c}$ | 74 (±2.31)$^{de}$ | 8 (±0.27)$^{d}$ | 5.8 (±0.14)$^{b}$ | 19 (±0.90)$^{b}$ | 17.0 (±0.59)$^{a}$ |
| $T_7$ | 2.3 (±0.21)$^{de}$ | 13.9 (±0.96)$^{ef}$ | 12.7 (±0.93)$^{fg}$ | 71 (±2.46)$^{cd}$ | 6 (±0.23)$^{c}$ | 5.8 (±0.21)$^{bc}$ | 17 (±0.93)$^{cd}$ | 14.2 (±0.44)$^{cd}$ |
| $T_8$ | 2.1 (±0.14)$^{de}$ | 12.9 (±0.89)$^{g}$ | 12.8 (±0.91)$^{fg}$ | 69 (±2.44)$^{c}$ | 5 (±0.22)$^{b}$ | 4.1 (±0.23)$^{h}$ | 16 (±0.82)$^{de}$ | 13.1 (±0.92)$^{e}$ |
| $T_9$ | 2.4 (±0.17)$^{cde}$ | 11.2 (±0.78) | 13.2 (±0.91)$^{ef}$ | 62 (±2.22)$^{b}$ | 5 (±0.20)$^{b}$ | 3.8 (±0.15) | 16 (±0.82)$^{de}$ | 11.1 (±0.82)$^{h}$ |
| $T_{10}$ | 3.2 (±0.31)$^{ab}$ | 12.0 (±0.82)$^{ih}$ | 22.6 (±1.55)$^{a}$ | 61 (±2.50)$^{ab}$ | 6 (±0.23)$^{c}$ | 6.2 (±0.20)$^{ab}$ | 19 (±0.98)$^{b}$ | 12.1 (±0.51)$^{g}$ |
| $T_{11}$ | 3.5 (±0.32)$^{ab}$ | 12.4 (±0.86)$^{h}$ | 13.7 (±0.95)$^{e}$ | 65 (±2.92)$^{b}$ | 5 (±0.22)$^{b}$ | 4.2 (±0.12)$^{gh}$ | 21 (±0.90)$^{a}$ | 15.2 (±0.47)$^{b}$ |
| $T_{12}$ | 2.8 (±0.29)$^{bcd}$ | 14.5 (±0.98)$^{cd}$ | 16.3 (±1.10)$^{d}$ | 69 (±2.70)$^{c}$ | 6 (±0.21)$^{c}$ | 4.9 (±0.23)$^{defg}$ | 17 (±0.90)$^{cd}$ | 10.8 (±0.37)$^{h}$ |
| $T_{13}$ | 3.1 (±0.25)$^{abc}$ | 14.3 (±0.97)$^{de}$ | 12.9 (±0.89)$^{fg}$ | 58 (±2.26)$^{a}$ | 5 (±0.21)$^{b}$ | 6.0 (±0.29)$^{b}$ | 14 (±0.93)$^{fg}$ | 11.6 (±0.38)$^{gh}$ |
| $T_{14}$ | 3.8 (±0.29)$^{a}$ | 15.8 (±1.07)$^{a}$ | 18.8 (±1.30)$^{b}$ | 83 (±2.42)$^{h}$ | 8 (±0.27)$^{d}$ | 6.9 (±0.21)$^{a}$ | 19 (±0.93)$^{b}$ | 14.3 (±0.49)$^{bcd}$ |
| $T_{15}$ | 1.6 (±0.25)$^{e}$ | 14.3 (±0.96)$^{de}$ | 12.3 (±0.86)$^{gh}$ | 78 (±2.35)$^{fg}$ | 6 (±0.22)$^{c}$ | 5.7 (±0.17)$^{bcd}$ | 17 (±1.00)$^{cd}$ | 17.5 (±0.60)$^{a}$ |
| $T_{16}$ | 2.1 (±0.99)$^{de}$ | 15.8 (±1.07)$^{a}$ | 12.9 (±0.92)$^{fg}$ | 65 (±1.95)$^{b}$ | 5 (±0.22)$^{b}$ | 5.1 (±0.19)$^{def}$ | 15 (±1.41)$^{ef}$ | 14.0 (±0.44)$^{d}$ |
| $T_{17}$ | 2.0 (±0.20)$^{e}$ | 15.0 (±1.02)$^{b}$ | 12.6 (±0.87)$^{fg}$ | 63 (±1.71)$^{b}$ | 4 (±0.17)$^{a}$ | 4.6 (±0.15)$^{efgh}$ | 13 (±1.00)$^{gh}$ | 13.6 (±0.47)$^{de}$ |
| **$SE_d$** | **0.33** | **0.18** | **0.20** | **1.58** | **0.17** | **0.22** | **0.68** | **0.37** |
| **$CD_{0.05}$** | **0.67** | **0.38** | **0.41** | **3.23** | **0.35** | **0.44** | **1.38** | **0.75** |
| **$CD_{0.01}$** | **0.90** | **0.51** | **0.56** | **4.36** | **0.46** | **0.60** | **1.86** | **1.01** |

The figures in the parentheses are standard deviation from mean. Means with the same letter are not significantly different of Duncan test ($p \leq 0.05$).

Maximum number of branches, number of leaves and leaf length were observed with $T_{14}$ (combination of potting mixture, *Rhizobium* and Mycorrhizae), $T_{11}$(combination of potting mixture + Mycorrhizae + 125 mg N, 125 $P_2O_5$ and 125 mg $K_2O$) and $T_{15}$ (combination of potting mixture, *Rhizobium* and Mycorrhizae +125 mg N, 125 $P_2O_5$ and125 mg $K_2O$). Reena and Agyaraj (2009) worked on effect of with twelve different species of AM fungi on *Dalbergia sissoo* and obtained plant height and leaf number were increased than control. *Rhizobium* inoculation showed significantly higher number of branches in *Acacia catechu* and *Acacia mollissima* as observed by previous workers (Banyal and Bhardwaj, 2003).

In conclusion, *Flemingia semialata* has been potentially used in eco-restoration purpose or as lac host integrated with trees or crops in agroforestry systems. Bioinoculants and soil amendments have been long used to augmented biomass production. However, how individually or in combination these two respond to root developmental, nodulation and shoot developmental pattern need to be ascertained. The present study revealed under nursery conditions of *Flemingia semialata*, lateral shoot and root growing pattern, root nodulation, shoot branch angle and branching pattern well responsive of combination of *Rhizobium* and Mycorrhizae to which NPK has no effect; to this slight NPK dose positively affects leaf and root length, length of primary root and angle of secondary root emergence. However, number of rootlets is dependent of Mycorrhizae to which slight fertilisation gives maximum leaves number. On an average, *Rhizobium* provides better effect to tertiary root length whereas Mycorrizae has role for maximum number of rootlets. These findings may be further tried for other edapho-climatic conditions and under plantations.

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