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Studies on Integrated Nutrient Management in *Swietenia macrophylla* King. under Nursery Conditions

Shaiwal Shekhar Mishra, Naresh Kumar, Sangram B. Chavan, Asha Ram, Inder Dev, Ashok Shukla, Vishnu R, Pankaj Lavania, Shayma Parveen

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ABSTRACT

An experiment was conducted to study the effect of integrated nutrient management on quality seedling production of *Swietenia macrophylla* King. The study comprised of 12 treatments viz., T1- control (red soil: black soil: FYM (2:1:1))/pot/seedling, T2: T1 + 50 g vermicompost/pot/seedling, T3: T1 + 1 g NPK/pot/seedling, T4: T1 + 2 g NPK/pot/seedling, T5: T1 + 1 g NPK + 50 g vermicompost/pot/seedling, T6: T1 + 2 g NPK + 50 g vermicompost/pot/seedling, T7: T1 + 5 ml Azophos/pot/seedling, T8: T1 + 5 ml Azophos + 50 g vermicompost/pot/seedling, T9: T1 + 1 g NPK + 5 ml Azophos/pot/seedling, T10: T1 + 2 g NPK + 5 ml Azophos/pot/seedling, T11: T1 + 1 g NPK + 50 g vermicompost + 5 ml Azophos/pot/seedling and T12: T1 + 2 g NPK + 50 g vermicompost + 5 ml Azophos/pot/seedling and each treatment was replicated three times in completely Randomized Design. Two months old seedlings of *S. macrophylla*, raised in nursery beds, were transplanted in pots containing potting substrate as per different treatments, and kept under nursery conditions for three months. Observations on seedling growth and bio-chemical parameters were taken at harvest (after 3 months of transplanting). Results revealed that maximum increment in growth parameters was recorded when 2 g NPK was applied along with 50 g vermicompost (T6). Highest seedling quality index was also recorded in the same treatment. From the present study, it may be concluded that application of 2 g NPK + 50 g vermicompost per seedling can improve the seedling quality of *S. macrophylla.* However, the dose of NPK can be reduced to 1 g, as the treatment consisting of 1 g NPK + 50 g vermicompost has also resulted in higher value of seedling quality index which was at par with the treatment comprising of 2 g NPK + 50 g vermicompost.

Keywords Chlorophyll, Collar diameter, Mahogany, Seedling quality index.

Shaiwal Shekhar Mishra[1], Naresh Kumar[2], Sangram B. Chavan[3], Asha Ram[4], Inder Dev[5], Ashok Shukla[6], Vishnu R.[7]

[1]Research Scholar, [2]Principal Scientist, [3,4,7] Scientist, [5]Principal Scientist, [6]Research Associate
ICAR-Central Agroforestry Research Institute, Jhansi (UP) 284003, India

Pankaj Lavania* ,Teaching Associate
Rani Lakshmi Bai Central Agricultural University, Jhansi (UP), India

Shayma Parveen, Assistant Professor
Bundelkhand University, Jhansi (UP), India

Email: drkumarpankaj2010@gmail.com
*Corresponding author

INTRODUCTION

Swietenia macrophylla King. (Family: Meliaceae), commonly known as "Mahogany', is an evergreen, multipurpose tree species. It is found in moist humid tropics at 50-1500 m above mean sea level and its best growth has been observed in areas receiving 1000-1500 mm rainfall. It can grow up to 30 m height and is deciduous in nature where the dry season is very predominant. Its wood has great demand in national and international markets because of its easy carpentry work and exceptionally smooth, shiny and resistant surface. The fast growth behavior of mahogany, high utility and rising demand of its wood, motivate farmers to grow this species (Santos *et al.* 2013). In order to meet the demand, it is being cultivated in plantations especially in many parts of the tropics including India. It can be grown with agricultural crops in different agroforestry systems (Dolácio *et al.* 2019, Karthikeyan 2021). For any plantation, quality planting material is prerequisite for successful establishment. Production of quality planting material depends upon many factors such as genetically superior source, type of planting material, site conditions, climatic factors, fertilizer application, irrigation and so on. Nursery practices, such as sowing, seedbed density, pruning and fertilization are usually standardized for individual plant species, in order to produce high-quality seedlings. Application of inorganic fertilizers has shown positive effects in terms of improved growth of many tree species. It improves plant growth by either increasing soil resources or by enhancing the ability of seedlings to garner resources by modifying soil pH (Razaq *et al.* 2017).

According to Jha *et al.* (2017), quality of the seedlings can be manipulated using fertilizers and biofertilizers. During initial stage of the growth, seedlings require nutrients at which can be provided through application of inorganic or organic or biofertilizers or combination of any of these. Supply of the optimum quantity of nutrients can determine the quality of the seedlings. The indiscriminate application of chemical fertilizers alone tends to hamper crop productivity and quality, deteriorating the soil health and make plant more susceptible to pests and diseases (Shukla *et al.* 2018). Biofertilizers are renewable energy source and cost effective supplement to chemical fertilizers and can help to economize high investment needed for chemical fertilizer (Kumar *et al*. 2018). It is crucial to develop plant nutritional strategies to improve the seedling quality for better establishment and growth in the field. However, very little information is available on effect of use of inorganic, organic and biofertilizers on seedling growth of mahogany. Keeping in view the importance of mahogany and scarcity of information on effect of nutrient management on seedling growth of mahogany, the present study was carried out.

MATERIALS AND METHODS

The present study was undertaken in the nursery (24° 11' N latitude and 78° 17' E longitude, at an elevation of 271 m above mean sea level) and laboratory of ICAR-Central Agroforestry Research Institute, Jhansi, Uttar Pradesh during the year 2019-20. Mean annual rainfall of the region is 960 mm and mean maximum temperature ranges from 47.4 ºC (June) to 23.5 ºC (January) and mean minimum temperature from 27.2 ºC (June) to 4.1 ºC (December). Seeds of *S. macrophylla* were procured from Seed Center of Kerala Forest Research Institute, Peechi, Thrissur, Kerala. Prior to sowing, seeds were treated with a fungicide, namely Captan @ 0.1% for one minute. Seedlings after emergence at 60 days were pricked out, graded based on seedlings height in order to maintain uniformity within treatment and used for the experiments. Thereafter, homogenous seedlings were transplanted to the pots, containing potting substrate as per different treatments viz., T1- control (red soil: black soil: FYM (2:1:1))/pot/seedling, T2: T1 + 50 g vermicompost/pot/seedling, T3: T1 + 1 g NPK/pot/seedling, T4: T1 + 2 g NPK/pot/seedling, T5: T1 + 1 g NPK + 50 g vermicompost/pot/seedling, T6: T1 + 2 g NPK + 50 g vermicompost/pot/seedling, T7: T1 + 5 ml Azophos/pot/seedling, T8: T1 + 5 ml Azophos + 50 g vermicompost/pot/seedling, T9: T1 + 1 g NPK + 5 ml Azophos/pot/seedling, T10: T1 + 2 g NPK + 5 ml Azophos/pot/seedling, T11: T1 + 1 g NPK + 50 g vermicompost + 5 ml Azophos/pot/seedling and T12: T1 + 2 g NPK + 50 g vermicompost + 5 ml Azophos/pot/seedling and each treatment was replicated three times in Completely Randomized Design. For application of 50 g vermicompost, proportion of the potting substrate was compromised and for application of 1 and 2 g NPK, 5 and 10 g powder of NPK 20:20:20 was added to growing media, respectively. The biometric observations were recorded at the time of harvesting of seedlings i.e. 90 days after transplanting in the pots by following standard procedure. After recording all the biometric observations, seedlings were separated in root and shoot portion from collar region and observation on fresh weights were taken. Thereafter, these samples (root and shoot) were kept in an oven at 60ºC for 48 hours and observations on dry weights were recorded. Fresh and dry weights of shoot as well as root were expressed in g/plant. Recorded growth data were utilized for computing seedling quality index (Dickson *et.al.* 1960):

$$\text{Seedling quality index} = \frac{\text{Total dry weight of plant (g)}}{\dfrac{\text{Plant height (cm)}}{\text{Collar diameter (mm)}} + \dfrac{\text{Shoot weight (g)}}{\text{Rool dry weight (g)}}}$$

Leaf relative water content (RWC) was estimated as per the procedure given by Weatherley (1950). The relative water content was calculated by using formula given below:

RWC = [(Fresh weight – Dry weight)/(Turgid weight – Dry weight)] × 100

Leaf chlorophyll and total carotenoids content were estimated as per the method described by Arnon (1949). The total carotenoid content was determined by following the formula given by Lichtenthaler and Welburn (1983).

All the collected data were analyzed statistically using a general linear model for analysis of variance in a Completely Randomized Design. Least significant difference (LSD0.05) was used to compare treatment differences. The ANOVA was performed by using statistical package SYSTAT version 12.

RESULTS AND DISCUSSION

Effect of integrated nutrient management on shoot length, root length and collar diameter

The maximum shoot length (37.7 cm) was recorded in treatments T6 and T12 i.e. 2 g NPK + 50 g vermicompost and 2 g NPK + 50 g vermicompost + 50 ml Azophos (37.7 cm). However, the shoot length recorded in these treatments was found statistically at par with T5 and T11. The maximum root length (39.0 cm) was recorded in treatment T12 which was statistically at par with the root length recorded in treatment T6. Almost similar trend was recorded for collar diameter and the maximum collar diameter

Table 1. Effect of integrated nutrient management on shoot length (cm), root length (cm) and collar diameter (mm). *T1- control (red soil: black soil: FYM (2:1:1)), T2: T1 + 50 g vermicompost, T3: T1 + 1 g NPK, T4: T1 + 2 g NPK, T5: T1 + 1 g NPK + 50 g vermicompost, T6: T1 + 2 g NPK + 50 g vermicompost, T7: T1 + 5 ml Azophos, T8: T1 + 5 ml Azophos + 50 g vermicompost, T9: T1 + 1 g NPK + 5 ml Azophos, T10: T1 + 2 g NPK + 5 ml Azophos, T11: T1 + 1 g NPK + 50 g vermicompost + 5 ml Azophos, and T12: T1 + 2 g NPK + 50 g vermicompost + 5 ml Azophos.

Treatments	Shoot length (cm)	Root length (cm)	Collar diameter (mm)
T1*	32.7	24.1	4.30
T2	33.0	28.2	5.85
T3	33.2	28.2	5.95
T4	33.9	29.2	6.45
T5	35.7	36.5	8.55
T6	37.7	38.1	8.75
T7	33.3	28.0	5.38
T8	34.2	29.9	5.98
T9	34.3	29.9	6.25
T10	34.4	30.0	6.28
T11	35.7	36.2	8.53
T12	37.7	39.0	8.75
F-ratio	3.517	33.200	78.642
P-value	0.005	<0.001	<0.001
LSD 0.05	2.7	2.4	0.49

(8.75 mm) was recorded in T12 and T6, which were statistically at par with the values recorded in T5 and T11 (Table 1). These findings are in line with the results of many researchers who have reported the positive effects of blend of different inorganic, organic and biofertilizers on seedling growth (Sujatha and Manjappa 2015, Dharmveer *et al.* 2016).

Effect of integrated nutrient management on seedling biomass

Data on effect of integrated nutrient management on fresh and dry biomass are presented in Table 2. Maximum fresh weight of shoot (23.50 g/plant) and root (8.38 g/plant) were recorded in treatment consisting of T6 (2 g NPK + 50 g vermicompost). Total fresh (31.88 g/plant) and dry weights (7.76 g/plant) were also recorded maximum in the same treatment. Addition of organic matter in potting media is important because it supplies essential nutrients required by the seedlings and promote the growth and biomass. Our results are corroborated with the findings of earlier researchers (Verma *et al.* 2015). Kumar *et al.* (2018) Rani *et al.* (2019) also reported improved growth and biomass of *Alibizia lebbeck* and *Leucaena*

Table 2. Effect of integrated nutrient management on fresh and dry weight (g/plant) of *S. macrophylla*. T1- control (red soil: black soil: FYM (2:1:1)), T2: T1 + 50 g vermicompost, T3: T1 + 1 g NPK, T4: T1 + 2 g NPK, T5: T1 + 1 g NPK + 50 g vermicompost, T6: T1 + 2 g NPK + 50 g vermicompost, T7: T1 + 5 ml Azophos, T8: T1 + 5 ml Azophos + 50 g vermicompost, T9: T1 + 1 g NPK + 5 ml Azophos, T10: T1 + 2 g NPK + 5 ml Azophos, T11: T1 + 1 g NPK + 50 g vermicompost + 5 ml Azophos and T12: T1 + 2 g NPK + 50 g vermicompost + 5 ml Azophos.

Treatments	Fresh weight (g/plant)			Dry weight (g/plant)		
	Shoot	Root	Total	Shoot	Root	Total
T1*	17.11	5.89	23.00	5.67	2.44	8.11
T2	18.35	6.12	24.47	5.95	2.98	8.93
T3	18.85	6.75	25.60	6.25	3.21	9.46
T4	18.99	7.32	26.31	6.31	3.42	9.73
T5	22.89	8.18	31.07	7.54	3.98	11.52
T6	23.50	8.38	31.88	7.76	4.10	11.86
T7	17.10	6.01	23.11	5.64	2.92	8.56
T8	18.36	6.25	24.61	5.97	2.95	8.92
T9	18.41	6.72	25.13	6.01	3.16	9.17
T10	18.43	7.12	25.55	6.02	3.39	9.41
T11	22.35	8.14	30.49	7.38	3.92	11.3
T12	22.83	8.32	31.15	7.48	4.02	11.5
F-ratio	21.069	25.590	21.876	30.081	50.992	35.700
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
LSD 0.05	1.52	0.55	2.07	0.42	0.22	0.64

leucocephala seedlings raised in the potting mixture containing vermicompost.

Effect of integrated nutrient management on chlorophyll content, carotenoids and relative water content in leaves

The treatment having 2 g NPK + 50 g vermicompost + 5 ml Azophos recorded maximum chlorophyll A (2.90 mg/g of fresh weight of leaves) and chlorophyll B content (1.47 mg/g of fresh weight of leaves) which were statistically at par the with value recorded in 2 g NPK + 50 g vermicompost. Minimum chlorophyll A and B contents were recorded in control (Table 3).

More or less similar results were obtained in terms of total chlorophyll content in leaves of *S. macrophylla.* Maximum total chlorophyll content was found in 2 g NPK + 50 g vermicompost (4.52 mg/g of fresh weight of leaves), followed by 2 g NPK + 50 g vermicompost + 5 ml Azophos (4.42 mg/g of fresh weight of leaves) and 1 g NPK + 50 g vermicompost (4.32 mg/g of fresh weight of leaves). These values were statistically at par with each other. The minimum

Table 3. Effect of integrated nutrient management on chlorophyll, carotenoids and relative water content. *T1- control (red soil: black soil: FYM (2:1:1)), T2: T1 + 50 g vermicompost, T3: T1 + 1 g NPK, T4: T1 + 2 g NPK, T5: T1 + 1 g NPK + 50 g vermicompost, T6: T1 + 2 g NPK + 50 g vermicompost, T7: T1 + 5 ml Azophos, T8: T1 + 5 ml Azophos + 50 g vermicompost, T9: T1 + 1 g NPK + 5 ml Azophos, T10: T1 + 2 g NPK + 5 ml Azophos, T11: T1 + 1 g NPK + 50 g vermicompost + 5 ml Azophos and T12: T1 + 2 g NPK + 50 g vermicompost + 5 ml Azophos

Treat-ments	Chlorophyll A (mg/g FW)	Chlorophyll B (mg/g FW)	Total Chloro-phyll (mg/g FW)	Total Caroten-ids (mg/g FW)	Relative water content (%)
T1*	1.58	0.60	2.25	0.50	52.23
T2	1.72	0.72	2.54	0.51	53.24
T3	1.76	0.74	2.62	0.51	54.55
T4	1.78	0.92	2.90	0.52	55.12
T5	2.81	1.35	4.32	0.53	68.65
T6	2.85	1.46	4.52	0.53	69.33
T7	1.65	0.75	2.43	0.52	55.12
T8	1.73	0.79	2.62	0.52	55.17
T9	1.75	0.82	2.69	0.51	55.86
T10	1.76	0.85	2.47	0.52	55.94
T11	2.82	1.36	4.28	0.53	68.62
T12	2.90	1.47	4.42	0.53	69.48
F-ratio	104.933	153.799	120.540	0.696	29.155
p-value	<0.001	<0.001	<0.001	0.730	<0.001
LSD 0.05	0.16	0.08	0.24	NS	3.87

total chlorophyll content was recorded in control (2.25 mg/g of fresh weight of leaves).

In the present study, different treatment combinations having NPK fertilizer resulted in more chlorophyll contents in the leaves. NPK fertilizer application has important influence on plant chlorophyll content, because N is an important component of chlorophyll. Similarly, P can promote chlorophyll synthesis by maintaining the ATP and NADPH contents in leaves. K+ can also increase plant photosynthetic efficiency by promoting chlorophyll synthesis and strengthening chloroplast structure (Liu 2012). Grzesik *et al.* (2017) also found that biofertilizers can improve the chlorophyll content in *Salix viminalis*. Therefore, the application of NPK fertilizers could promote chlorophyll synthesis.

The total carotenoid content in leaves varied in very narrow range i.e. 0.50 to 0.53 mg/g of fresh weight of leaves under different treatments. The statistical difference among treatments was found

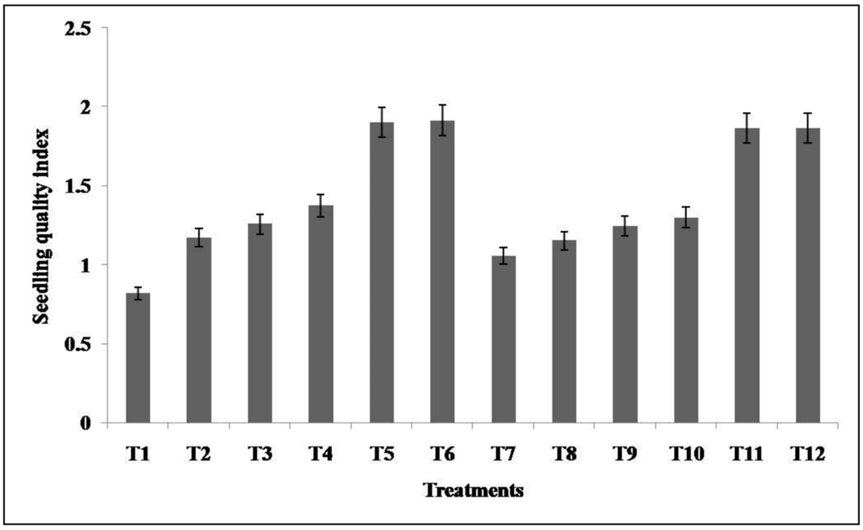

Fig. 1. Effect of integrated nutrient management on seedling quality index. *T1- control (red soil: black soil: FYM (2:1:1)), T2: T1 + 50 g vermicompost, T3: T1 + 1 g NPK, T4: T1 + 2 g NPK, T5: T1 + 1 g NPK + 50 g vermicompost, T6: T1 + 2 g NPK + 50 g vermicompost, T7: T1 + 5 ml Azophos, T8: T1 + 5 ml Azophos + 50 g vermicompost, T9: T1 + 1 g NPK + 5 ml Azophos, T10: T1 + 2 g NPK + 5 ml Azophos, T11: T1 + 1 g NPK + 50 g vermicompost + 5 ml Azophos and T12: T1 + 2 g NPK + 50 g vermicompost + 5 ml Azophos.

non-significant (p=0.730); hence, comparison could not be made. However, minimum carotenoid content was recorded in control (0.50 mg/g of fresh weight of leaves) and the maximum (0.53 mg/g of fresh weight of leaves) was recorded in four treatments, namely 2 g of NPK + 50 g vermicompost + 5 ml Azophos, 1 g of NPK + 50 g vermicompost + 5 ml Azophos, 2 g of NPK + 50 g vermicompost and 1 g of NPK + 50 g vermicompost.

Among treatments, the relative water content in leaves ranged between 52.23 and 69.48%. Its maximum value was recorded in 2 g NPK + 50 g vermicompost + 5 ml Azophos (69.48%) which was found statistically at par with the value recorded in 2 g NPK + 50 g vermicompost (69.33%), 1 g NPK + 50 g vermicompost (68.65%) and 1 g NPK + 50 g vermicompost + 5 ml Azophos (68.62%). The minimum relative leaf water content was recorded in control (52.23%) (Table 3).

Effect of integrated nutrient management on seedling quality

Data on effect of integrated nutrient management on seedling quality index of *S. macrophylla* are depicted in Fig. 1. The seedling quality index is a quantitative standard for evaluating seedlings through seedling height, root collar diameter and dry weight and can intuitively reflect the growth status of seedlings. In general, the higher the QI the better the seedling quality. In the present study, maximum index value was recorded in 2 g NPK + 50 g vermicompost, followed by 1 g NPK + 50 g vermicompost, 2 g NPK + 50 g vermicompost + 5 ml Azophos and 1 g NPK + 50 g vermicompost + 5 ml Azophos. These values were at par with each other. It shows that application of NPK along with vermicompost as well as Azophos improved the seedling quality of *S. macrophylla*. Rani *et al.* (2019) also reported that all growth parameters (shoot length, root length, fresh shoot weight, fresh root weight, dry shoot weight and dry root weight) were significantly higher in growing media containing soil and vermicompost. This could be due to the presence of vermicompost as it contains high organic matter which increases water and nutrient holding capacity of the medium for supply to the plants. According to Bachman and Metzger (2008), vermicompost is reported to have bioactive compounds considered to be beneficial for root growth, root initiation, germination and growth of the plants.

CONCLUSION

From the present study, it may be concluded that application of 2 g NPK + 50 g vermicompost per seedling has improved the seedling quality of *S. macrophylla*. However, the dose of NPK can be reduced to 1 g, as the treatment consisting of 1 g NPK + 50 g vermicompost has also resulted in higher value of seedling quality index which was at par with the treatment comprising of 2 g NPK + 50 g vermicompost. Moreover, the toxicity and environmental hazards, generally caused by extensive use of inorganic fertilizer may be reduced to some extent by judicious application of inorganic fertilizers along with organic fertilizers.

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