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Integrated Nutrient Management on *Aquilaria malaccensis* Lamk. Seedlings

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The present study was undertaken to study the effect of integrated nutrient management on the growth of *Aquilaria malaccensis* and soil properties. The results revealed that the integration of 200mg: 300mg : 200mg of NPK + Vermicompost (5g) + *Azophos* (5g) enhanced the various growth parameters like shoot length and dry matter production at all stages of seedling growth *viz*., 30, 60, 90 and 120 days after transplanting. In addition, the INM treatment also enhanced the quality index and volume index used for the evaluation of seedling quality characteristics. The analysis of soil samples for the physico-chemical characters *viz*., pH and EC and the nutrient status of the soil through available N, P and K and organic carbon both initially and at 120 days after transplanting (DAT) revealed that there was no profound influence of INM on soil pH and EC but, the organic carbon (2.98 g kg $^{-1}$), available nitrogen (190 kg ha $^{-1}$), phosphorus (7.90 kg ha^{-1}) and potash (192 kg ha^{-1}) status in the soil was found to be appreciably increased with the application of 200mg: 300mg : 200mg of NPK + Vermicompost (5g) + *Azophos* (5g)bag^{-1}. Compared to all the treatments, control registered the lowest growth attributes.

Key words: *Aquilaria malaccensis*, Agarwood, INM, Growth parameters, Organic carbon and Soil properties

Agarwood is a resinous substance occurring in trees of the genus *Aquilaria* (a member of the Thymelaeccae family), a fast-growing tree which can be found growing from the foothills of the Himalayas to the rain forests of Papua New Guinea. *Aquilaria malaccensis* is one of the 15 tree species in the Indo-Malaysian genus *Aquilaria*. It is a large evergreen tree, growing over 15-40 m tall and 0.6-2.5 m in diameter and has white flowers (Chakrabarty *et al.,* 1994). *A. malaccensis* and other species in the genus *Aquilaria* sometimes produce resin-impregnated heartwood. There are many names for this resinous wood, depending on the oleoresin content of the wood. There are many names for this resinous wood, including agar, agarwood, aloeswood, eaglewood, gaharu and kalamabak, this wood being in high demand for medicine, incense and perfumes across Asia, Middle East and Europe. First-grade agarwood is one of the most expensive natural raw materials in the world, with prices in consumer countries ranging from a few dollars per kg for low quality material to more than US$30,000 per kg for top quality wood. Agarwood oil fetches similarly high prices (Agarwood "Wood of Gods" International Conference, 2003).

The Agarwood in general has three principal uses *viz.,* medicine, perfume and incense. Smaller quantities are used for carving purposes. Agarwood has been a traditional source for Ayurvedic, Tibetan and East Asian Medicine. It is used for the treatment of Pleurisy. Maheshwari *et al.,* (1963) isolated three new sesquiterpenic furanoids of the selinane group from Agarwood oil, obtained from the fungus infected plant and their structures and absolute configurations determined by degradative studies and physical measurements. Varma *et al.,* (1965) examined that degradative studies and physical measurements supported by an unambiguous synthesis of the derived ketone have led to the assignment of a novel spiroskeleton to agarospirol, a sesquiterpene alcohol isolated from the essential oil of infected Agarwood.

Most of the nursery seedling are raised in a potting mixture consisting of soil, sand and composted manure without assessment of nutritional requirement of the species. Nursery planting medium with sufficient nutrients induces resistance in the seedling and enable the seedling to be adaptable in adverse situation on out -planting (Neeta Srivastava and Behl, 2002). Therefore, raising of good quality seedlings of *A. malaccensis* through proper nutrition is an essential pre-requisite for large scale plantation. Keeping this in view, a study was carried out to find the effect of INM under nursery condition for quality seedlings production.

Materials and Methods

The experiment was carried out at Forest College and Research Institute, TNAU, Mettupalayam during the year 2011-12. The aim of the study was to find the effect of manures and fertilizers on growth and development of *A. malaccensis* seedlings. For this study, well decomposed vermicompost was used

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as organic manure. Urea, diammonium phosphate and muriate of potash were used as inorganic sources of N, P_2O_5 and K_2O, respectively. Inorganic fertilizers were applied to each seedling in the form of aqueous solution at seven days after the application of biofertilizers. The microbial inoculants *viz*., *Azosp*hos was used as biofertilizer and vermicompost as organic manure. The polythene bags of size 15 x 25 cm were filled with two kg of soil mixture (2:1:1). The pre treated seeds (3 days leaching in 24 h interval) were sown in mother bed. At 30th day healthy and uniform height seedlings were pricked out and transplanted @ one seedling bag^{-1}.

The seedlings were arranged in a Completely Randomized Bock Design with three replications @ 20 seedlings per replication. Intercultural operation *viz*., watering, weeding and plant protection were given as per general recommendation. A shade panthal was erected to protect the transplanted seedlings from the sunshine. The calculated quantities of biofertilizers were added in the pot mixture while the inorganic fertilizers were added as aqueous solution to each poly bag (Based on the treatment). The treatment details of the experiment are furnished in Table 1.

Table 1. Treatment details

Treatment	Details
T1.	Control
T2.	N, P and K @ 100:200:100 mg
T3.	100 : 200 : 100 mg NPK + Vermicompost (5g)
T4.	100 : 200 :100 mg NPK + *Azophos* (5g)
T5.	100 : 200 :100 mg NPK + Vermicompost (5g) + *Azophos* (5g))
T6.	N, P and K @ 200:300:200 mg
T7.	200 : 300 : 200 mg NPK + Vermicompost (5g)
T8.	200 : 300 : 200 mg NPK + *Azophos* (5g)
T9.	200 : 300 : 200 mg NPK + Vermicompost (5g) + *Azophos* (5g)

Analysis of soil samples

The initial soil sample (pot mixture prior to imposing treatments) as well as soil samples collected at the end of the experiment (120 days after transplanting) were processed and analyzed for physico-chemical properties following Jackson (1973), organic carbon Walkley and Black (1934), NPK status following the standard procedures Subbiah and Asija, (1956), Olsen *et al.* (1954) and Stanford and English, (1949).

Results and Discussion

All the INM treatments had a profound influence in enhancing the growth and quality parameters of the seedling. However, integration of 200: 300: 200 mg NPK + Vermicompost (5g) + *Azophos* (5g) (T9) recorded the highest shoot length (52.59 cm) and shoot dry matter (9.45 g) (Table 2) at 120 days after transplanting. Nitrogen is the key element for increasing the dry matter production and obviously the N availability in the soil has unique importance. Pankaj Tiwari and Saxena (2003) recommended that application of 100 mg of urea and 25 mg of SSP seedling^{-1} for one year old *Dalbergia sissoo* had produced vigorous seedlings with high survival and maximum dry matter production. Vogel *et al*. (2001) has also reported that the dry weight of the above ground root and total biomasses of *Hovenia dulcis* seedlings was positively influenced by the application of vermicompost.

In addition to the accepted growth parameters, these indices were also utilized to assess the quality of *Aquilaria malaccensis* seedlings on application of various INM treatments. The highest volume index (2755.00) and quality index (1.91) (Table 2) was noticed in the seedling grown in 200: 300: 200 mg NPK + Vermicompost (5g) + *Azophos* (5g) kg^{-1} of soil. It is supported with Hidalgo and Harkess (2002), who reported that growth index (Volume index and Quality index), foliar and bract area and dry weight were greater in Poinsettia (*Euphorbia pulcherrima*) grown in substrates with vermicast.

Soil physico - chemical properties

The soil used for the analysis of physico - chemical properties was red non-calcareous (*Typic ustropept*) and sandy loam in texture. Before imposing INM treatment, the soil had a pH of 8.45 and the electrical conductivity (EC) of 0.15 dS m^{-1}. After imposing the INM treatment, the pH of the soil was not altered much by the treatments. It was observed that there was a decline in soil pH as compared to the initial pH (7.41) (Table 3). The probable reason would be the release of organic acids from the potting media and also from the organic sources of nutrients during the growing period. The decrease in soil pH upon organic manure addition was also reported by Sukhmal Chand *et al*. (2002). The EC also varied within narrow limits among the treatments. When compared to initial EC value (0.27), control and biofertilizers alone treatments recorded relatively lower values, which might be due to the presence of relatively lesser concentration of soluble salts.

Effect of INM on the available nutrient status

Before imposing INM treatments, the soil was low in available N (168 kg ha^{-1}), medium in available P (6.1 kg ha^{-1}), low in available K (158 kg ha^{-1}) and also low in organic carbon (0.36 %). The application of 150 mg of N, 200 mg of P_2O_5 and 100 mg of K_2O kg^{-1} soil along with vermicompost (T9) was associated with relatively higher organic carbon (2.98 g kg^{-1}) content (Table 2). This might be due to the integrated effect of various sources of nutrients with vermicompost. The present finding is in corroboration with the findings of Saravanapandian (1990).The same treatment (T9) had recorded the highest soil available N status (190 kg ha^{-1}). This clearly indicated the beneficial effect of integration of vermicompost with inorganic fertilizers by virtue

Table 2. Effect of INM on shoot length, shoot dry matter, quality index and volume index of *A. malaccensis* seedlings at 120 days after planting

Treatment	Shoot length (cm)	Shoot dry matter (g)	Quality index (QI)	Volume index (VI)
T1 (Control)	25.16	5.88	1.30	597.00
T2 (N, P and K @ 100:200:100 mg)	31.58	6.46	1.45	1046.00
T3 (T2 + Vermicompost (5g))	40.56	6.65	1.35	1461.00
T4 (T2+ *Azophos* (5g))	44.43	6.32	1.33	1718.00
T5 (T2 + Vermicompost (5g) + *Azophos* (5g))	45.83	7.27	1.58	1954.00
T6 (N, P and K @ 200:300:200 mg)	40.42	6.45	1.32	1436.00
T7 (T6 + Vermicompost (5g))	43.59	6.90	1.49	1715.00
T8 (T6 + *Azophos* (5g))	48.13	8.22	1.79	2335.00
T9 (T6 + Vermicompost (5g) + *Azophos* (5g))	52.59	9.45	1.91	2755.00
SEd	0.92	0.12	0.06	131.07
CD (P = 0.05)	1.86	0.24	0.13	267.00

of more favorable environment to the crop. Increase in available N and P was obtained by fertilization with FYM and was also reported by Singh e*t al*. (1968). The beneficial effect of inorganic fertilizers on soil available N status was also reported by Thiyagarajan *et al*. (1986) and Muthuswamy *et al.* (1990). The soil available Phosphorus also had a higher amount (7.90 kg ha $^{-1}$) rated to be the best among all other treatments. This paved the way for better nutrition to the soil by the contribution of P from applied source of inorganic fertilizer and P supplemented with the effect of vermicompost, which mineralizes the unavailable soil P into available form. The positive influence of integrated supply of nutrients was also reported by Santhy (1995) and Karikalan (2005). Similarly, potassium also recorded higher value (192 kg ha^{1}) by recording the highest available K at 120 DAT. It was further observed in the present study that, addition of inorganic K had appreciably increased the available K status of the soil, the beneficial effects of INM in increasing the available K status. This finding is in accordance with the observation of Aravind (1987) and Santhy (1995).

Table 3. Effect of INM on physico-chemical properties and available nutrient status of soil at 120 days after planting of *A. malaccensis* seedlings

Treatment	pH	Electrical conductivity (dS m^{-1})	Organic Carbon g kg^{-1}	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})
T1 (Control)	7.45	0.19	0.48	180.00	6.90	175.00
T2 (N, P and K @ 100:200:100 mg)	7.44	0.22	0.57	183.00	7.20	182.00
T3 (T2 + Vermicompost (5g))	7.43	0.23	0.59	184.00	7.30	183.00
T4 (T2+ *Azophos* (5g))	7.44	0.23	0.62	184.00	7.4	183.00
T5 (T2 + Vermicompost (5g) + *Azophos* (5g))	7.42	0.25	0.65	185.00	7.50	184.00
T6 (N, P and K @ 200:300:200 mg)	7.43	0.25	0.59	188.00	7.73	188.00
T7 (T6 + Vermicompost (5g))	7.42	0.26	0.62	189.00	7.80	189.00
T8 (T6 + *Azophos* (5g))	7.43	0.26	0.69	189.00	7.80	189.00
T9 (T6 + Vermicompost (5g) + *Azophos* (5g))	7.41	0.27	0.75	190.00	7.90	190.00
SEd	0.03	0.26	0.01	1.74	0.02	1.40
CD (P = 0.05)	NS	NS	0.02	3.55	0.05	2.87

Conclusion

The Integrated nutrient management indicated that the integration of 200mg: 300mg : 200mg of NPK + Vermicompost (5g) + *Azophos* (5g)) enhanced the various growth parameters like shoot length, root length, collar diameter, dry matter production and the quality index values**.** The above scored treatment also recorded higher amount of organic carbon, available nitrogen, phosphorus, and potash status of the potting mixture evaluated at 120 days after transplanting.

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