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Effect of integrated nutrient management on early growth performance of agarwood (*Aquilaria agallocha* L) and related changes in soil nutrient status

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Abstract

The experiment was conducted at farmers field in Uttara Kannada district to study the effect of integrated nutrient management on early growth performance of agarwood. Ten treatments consist of organic, inorganic and biofertilizers combination were imposed on agarwood. The data on growth parameters revealed that, the maximum tree height and diameter was recorded in T_6 (4.11m & 4.52 cm) respectively. Whereas crown diameter and number of branches were found highest in T_{10} (138.9 cm & 10.3) respectively, on the other hand maximum tree volume was noticed in T_6 (6227.9cm^3). The higher organic carbon percent was recorded in T_8 (0.73%), and maximum available nitrogen was also found in T_8 (383.00kg/ha), while available phosphorous and potassium were recorded highest in T_9 (44.44kg/ha) and T_5 (242.00kg/ha) respectively. The results clearly indicated that the treatment (T_6) FYM (2 Kg/ tree) + VAM (100 g/ tree)+ PSB (50 g/tree) + *Azospirillum* (50 g/tree) was found best in terms of tree height, diameter and total volume of tree.

Keywords: Agarwood, tree height, diameter, organic carbon, soil pH

Introduction

Agarwood (*Aquilaria agallocha*), is a fragrant dark resinous wood used in incense, perfume, and small carvings. It is formed in the heartwood of aquilaria trees when they become infected with a type of mold (*Phialophora parasitica*). Prior to infection, the heartwood is odourless, relatively light and pale coloured; however, as the infection progresses, the tree produces a dark aromatic resin, called aloeswood. The resinous inner stem of agarwood is valued at Rs. 10,000 per kg while agarwood oil costs Rs. 10 lakh/kg in the international market. The oil is used as stimulant, cardiac tonic, carminative and sedative (Okugawa *et al.*, 1993) [10]. Due to higher market value of agarwood, now farmers are introducing this crop as an alternative to arecanut in Uttara Kannada district of Karnataka. It takes hardly 8-15 years to mature and fetch good returns. Even though plantations of agarwood were reported to exist in many countries but no written reports on propagation, silviculture characteristics, nutrient application, and other management practices. Therefore, scientific approach for management of agarwood is of utmost important. Keeping these points in view Effect of integrated nutrient management on early growth performance of agarwood (*Aquilaria agallocha* L) and related changes in soil nutrient status was undertaken.

Materials and Methods

A field experiment was carried out in three year old agarwood plantation raised by farmer at Koppa village, of Sirsi taluk, Uttara Kannada District, which comes under Central Western Ghats of India. The area located at 14^0 32.318' N latitude and 074^0 54.056' E longitudes with an elevation of 649 m above mean sea level (MSL). The average annual rainfall of the study area is 2375.7mm while mean maximum and minimum temperature ranged between 26.5- 33.7 °C and 12.7- 21.5 °C respectively. Hence, prevailing climatic conditions are suitable for cultivation of agarwood as supported by Quang and Huu (2011) [12] who reported that similar optimum climatic conditions suitable for agarwood cultivation.

The treatments were imposed during the month of July and treatments consisted of ten different combinations of organic, inorganic and bio-fertilizers.

The details of the treatments were namely T_1 - Control, T_2- FYM (2 Kg/tree), T_3- N (20 g/ tree), P (20 g/ tree), K (8 g/ tree), T_4- VAM (100 g/tree) + PSB (50 g/tree) + *Azospirillum*(50 g/tree), T_5- FYM (2 Kg/ tree) + N (20 g/ tree) P (20 g/ tree) K (8 g/ tree), T_6- FYM (2 Kg/ tree) + VAM

(100 g/ tree)+ PSB (50 g/tree) + *Azospirillum* (50 g/tree), T_7- FYM (2 Kg/ tree) + N (20 g/tree) P (20 g/tree) K (8 g/tree) + VAM (100 g/ tree) + PSB (50 g/ tree) + *Azospirillum* (50g / tree), T_8-FYM (1 Kg/tree) + N (10 g/ tree), P (10 g/ tree) K (4g/ tree)+ VAM (100 g/ tree), T_9- FYM (1 Kg/tree) + N (10 g/ tree), P (10 g/ tree), K (4g/ tree)+ PSB (50 g/ tree), T_{10}-FYM (1 Kg/tree) + N (10 g/ tree), P (10 g/ tree), K (4 g/ tree)+ *Azospirillum* (50 g/ tree).

Weeding was carried out twice during the experimental period, one at the beginning (June) and other during November. Artificial irrigation was provided from December to March through drip. Data recorded on total tree height (m), diameter at breast height (cm), number of branches per tree, tree volume (cm^3).

Composite soil samples were collected from the experiment site with a depth of 0-45 cm, before the initiation of the experiment and also after the completion of the experiment as per the treatment to study the soil nutrient status. The soil properties analyzed were Soil pH (1:2.5), EC (1:2.5) dSm^{-1}, Organic Carbon (%), Available Nitrogen (kg/ha), Available P_2O_5 (kg/ha) and Available K_2O (kg/ha) as per standard procedure. Randomized complete block design (RCBD) was followed with three replications. The data was analyzed statistically using MSTAT-C programme.

Results and Discussion

The study on influence of integrated nutrient management on growth of agarwood recorded significantly in all the parameters (Table 1).

The influence of integrated nutrient management on total tree height of agarwood 9 months after treatment (MAT) noticed significantly highest in T_6 (4.11 m). The treatment T_8, T_{10} and T_3 where at par with T_6, whereas, lowest tree height was recorded in T_1 (3.18 m). The data on diameter at breast height (DBH) was noticed significantly maximum in T_6 (4.52 cm). The treatment T_8, T_{10}, T_7 and T_4 were at par with T_6, while lowest DBH was reported in control- T_1 (3.31 cm). Influence of integrated nutrient management on crown diameter was recorded significantly highest in T_{10} (138.9 cm). The treatment T_6, T_9, T_3, T_7, T_8 and T_4 were noticed at par with T_{10}. The lowest crown diameter was noticed in T_1 (111.9 cm). The maximum number of branches was recorded same as that of highest crown diameter in T_{10} (10.3), while lowest number of branches was in control- T_1 (7.3). The influence of integrated nutrient management on total volume of agarwood trees were noticed maximum in T_6 (6227.9 cm^3). The volume is dependent on total tree height and DBH, the data also showed highest tree height and diameter in T_6. The increased tree height, diameter, crown diameter, number of branches and volume might be due to increase in vigorous vegetative growth and photosynthetic activity there by influencing chlorophyll formation in plants due to optimum application of nutrients through integrated approach. These results are in agreement with Prakash, (2014) [11] in *Santulum album* who reported that the highest growth parameters were found in NPK (37.5:15:15 g/tree) with VAM (100g/tree) followed by NPK (37.5:15:15 g/tree) with PSB (50g/tree). Similar results were also noticed by Kundu *et al.* (2011) [7] in mango: Deswal *et al.*, (2001) [2] in *Acacia nilotica*; Hulikatti and Madiwalar (2011) [5] in *Acacia auriculiformis*.

Table 1: Influence of integrated nutrient management on growth parameters of agarwood at 9 months after treatment

Treatments	Tree height (m)	DBH (cm)	Crown diameter (cm)	No. of branches	Tree volume (cm^3)
T_1	3.18	3.31	111.93	7.3	2564.3
T_2	3.69	3.44	120.23	8.5	3207.0
T_3	3.88	3.80	131.02	8.2	4129.8
T_4	3.60	3.94	128.91	9.7	4092.4
T_5	3.46	3.44	117.81	6.9	2996.0
T_6	4.11	4.52	133.64	9.2	6227.9
T_7	3.77	4.03	130.56	9.0	4536.3
T_8	4.04	4.25	129.30	9.0	5348.2
T_9	3.78	3.88	133.04	9.8	4271.7
T_{10}	3.97	4.25	138.92	10.3	5259.0
Mean	3.74	3.88	127.50	8.8	4263.3
SEm±	0.09	0.20	6.19	0.66	510.39
CD at 5%	0.26	0.60	18.57	1.98	1530.24

Influence of integrated nutrient management on increment per cent of agarwood 9 MAT was calculated (Table 2). The highest increment per cent with respect to tree height (48.91%) and dbh (67.40%) was noticed in T_6. While lowest increment per cent of 15.63 in tree height and diameter of 21.24% was noticed in control-T_1. The maximum crown diameter and number of branches increment percent was recorded in T_8 (28.68 & 83.67% respectively). Whereas, maximum tree volume increment percent was recorded in T_6 (316.87%). The lowest crown diameter, number of branches and tree volume was noticed in T_1 (8.40, 46.00 & 71.39% respectively). These results indicated beneficial effect of biofertilizers with respect to its effect on increasing nitrogen fixation, production of growth promoting substance or organic acids which enhanced nutrient uptake as reported by Samah, (2002) [13]. Similarly use of PSB and Azospirillum also reported maximum plant height increment and diameter increment in teak by Verma *et al.*, 2008 [16]. In crown diameter and number of branches increment also showed similar results by Harshavardhan *et al.*, (2007) [4] in *Melissa officinalis* and Dar *et al.*, (2009) [1] in *Cedrus deodar*.

Table 2: Influence of integrated nutrient management on Increment per cent of agarwood at 9 months after treatment over the initial.

Treatments	Tree height (%)	Diameter at breast height (%)	Crown diameter (%)	Number of branches (%)	Tree volume (%)
T_1	15.63	21.24	8.40	46.00	71.39
T_2	30.85	33.33	13.51	37.10	133.40
T_3	33.33	37.18	15.5	51.85	152.29
T_4	30.90	40.71	18.26	70.18	159.48
T_5	33.07	40.40	19.30	50.00	162.12
T_6	48.91	67.40	27.71	70.37	316.87
T_7	37.09	46.54	19.06	47.54	193.59
T_8	43.26	49.12	28.68	83.67	217.76
T_9	40.00	44.77	20.09	78.18	192.00
T_{10}	45.42	51.78	27.84	68.85	237.11
Mean	35.85	43.24	19.84	60.37	183.60

Chemical properties of soil

The application of organic manure, inorganic fertilizers and biofertilizers showed statistically significant effect on soil pH, EC and OC over control. The data on soil pH showed from 6.04 to 6.23. The maximum soil pH was noticed in T_1 (6.23), while minimum soil pH was noticed in T_4 (5.99), whereas initial soil pH was recorded (6.26). This clearly indicated that soil pH was higher before imposition of treatment. The soil treated with organic manure (T_2) and biofertilizers (T_4) showed decline in soil pH (6.11 & 5.99) respectively. The soil treated with inorganic fertilizers T_3 showed comparatively higher soil pH (6.19) than T_2 & T_4. The electrical conductivity (EC) results revealed that, the maximum EC was reported in T_6 (0.048dSm^{-1}), while minimum EC was noticed in T_1 (0.021 dSm^{-1}), on the other hand initial EC was found (0.01 dSm^{-1}), which was lowest in comparison to all the treatment. The data on organic carbon % was (OC) found maximum in T_8 (0.73%), while minimum OC was noticed in T_1 (0.42%), whereas, initial OC reported was o.41%. Results indicated that, there was increase in OC % after imposition of treatment in comparison to initial reading.The reduction in soil pH is may be due to biofertilizers comprise of micro-organisms which secreted organic acids such as formic, acetic propionic and succinic acids which lower the soil pH these results are in line with These results in line with Usha *et al.* (2004) [15] in kinnow mandarin who concluded that, application of VAM and Azotobacter, decreases the soil pH. Organic treatment also ensures the release of micronutrients increases the soil organic carbon, these results are in line with studies conducted by Khan *et al.* (2015) [6] in *Andrographis paniculata*.

Available nutrient status in soil

Data on available nitrogen, phosphorous and potash in soil 9 MAT as influence by integrated nutrient management (Table 3) revealed, significantly higher available nitrogen was in T_8 (383.00 kg/ha), while lowest available nitrogen was noticed in control- T_1 (225.00 kg/ha). In all the treatments available nitrogen found higher over the initial available soil nitrogen (212.00 ka/ha). Available phosphorous 9 MAT was found highest in T_9 (44.44 kg/ha), on the other hand lowest phosphorous was recorded in T_{10} (36.32 kg/ha). However, initial phosphorous was found (34.59 kg/ha), which was lesser as compared to all the treatment. Data on available potassium was found maximum in T_5 (242.00 kg/ha), whereas, minimum available potassium was reported in T_4 (144.33 kg/ha). However available potassium before imposition of treatment was 144.77 kg/ha. Increase in available nitrogen might be due gradual decomposition and subsequent release of mineral nutrients by organic manures resulting in increase of nitrogen content (Muthuvel *et al.*, 1977) [8] and beneficial effect of biofertilizer in fixing gaseous atmospheric N releasing into the soil and thereby increasing N soil content. Maximum available phosphorus in the soil was attributed to the activity of micro-organisms and also due to the influence of organic manure in increasing the available phosphorous through complexing of cations like Ca^{2+}, Mg^{2+}, Fe^{3+} and Al^{3+} which are mainly responsible for fixation of phosphorous (Shashi bala *et al.*, 2011) [14]. Higher available potassium might be due to increase in potassium content of the soil which might be due to the added fertilizers and further, slower mineralization rate of this nutrient which are responsible for higher accumulation of nutrients in the soil. These results are in conformity with the findings of Narahari (1999) [9] and Devegowda (1997) [3].

Table 3: Soil pH, electrical conductivity, organic carbon, available nitrogen, phosphorous and potassium as influenced by integrated nutrient management

Treatments	pH	EC (dSm^{-1})	OC (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)
Initial	**6.26**	**0.01**	**0.41**	**212.00**	**34.59**	**144.77**
T_1	6.23	0.021	0.42	225.00	37.16	155.33
T_2	6.11	0.030	0.67	353.00	38.39	165.00
T_3	6.19	0.032	0.64	332.00	40.42	194.66
T_4	5.99	0.041	0.61	315.00	39.09	144.33
T_5	6.18	0.047	0.66	344.00	42.78	242.00
T_6	6.11	0.048	0.68	348.00	40.42	173.33
T_7	6.16	0.031	0.60	315.00	43.10	213.33
T_8	6.04	0.026	0.73	383.00	43.94	183.66
T_9	6.14	0.034	0.58	305.00	44.44	186.33
T_{10}	6.14	0.041	0.56	295.00	36.32	232.66
Mean	6.13	0.035	0.62	321.50	40.60	189.06
SEm±	0.025	0.0034	0.03	16.93	1.73	19.85
CD at 5%	0.076	0.0102	0.09	50.76	5.19	59.50

Conclusion

The study revealed that integrated nutrient treatment combination of organic manures and biofertilizers (T_6) which comprises FYM (2 Kg/ tree), VAM (100 g/ tree), PSB (50 g/tree) and *Azospirillum* (50 g/tree) proved to be the best among all the treatments in terms of higher total tree height, diameter at breast height, crown diameter, number of branches and total volume of tree. The use of organic manure and biofertilizers not only effective but also eco-friendly, thus minimizes the use of chemical fertilizers and its negative effect on forest ecosystem. These results could be adapted at farm level by farmers to get maximum biomass and higher returns.

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