Effect of biofertilizers and inorganic fertilizers on green and dry foliage, oil content and oil yield of patchouli (*Pogostemon cablin* Benth)

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ABSTRACT

Effect of biofertilizers and inorganic fertilizers on the yield parameters of patchouli (*Pogostemon cablin* Benth) was studied at the medicinal and aromatic crops section of the Department of Forest Product and Utilization, College of Forestry, Dr Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra during 2021-2022 in RBD with ten treatments and three replications comprising a combination of gross recommended dose of fertilizers (GRDF), Konkan Annapurna briquettes (KAB), phosphate solubilising bacteria (PSB), vesicular arbusculuar mycorrhiza (VAM) and *Azotobacter* and the observations on the dry foliage, green foliage, oil content and oil yield were recorded. In the first harvest (120 DAP), the maximum green foliage was recorded in T_{10} (100% GRDF + PSB 10 g/plant + VAM 20 g/plant + *Azotobacter* 10 g/plant) (8.52 tonnes/ha), T_9 (100% GRDF + *Azotobacter* 10 g/plant) (8.03 tonnes/ha), T_8 (100% GRDF + VAM 20 g/plant) (7.88 tonnes/ha) and T_6 [6 KAB per plant (NPK 204:84:36 kg/ha)] (7.72 tonnes/ha) and in the second harvest (210 DAP) in T_{10} (5.42 tonnes/ha), T_9 (5.16 tonnes/ha) and T_8 (5.00 tonnes/ha). In the first harvest, dry foliage per plant was maximum in T_{10} (68.81 g), T_9 (68.27 g), T_8 (66.01 g) and T_7 (100% GRDF + PSB 10 g/plant) (65.04 g) and in the second harvest, in T_{10} (38.55 g) and T_9 (38.21 g). The maximum oil content in the first harvest (2.63%) and (2.53%) was obtained in T_{10} and T_6 respectively and in the second harvest, in T_{10} (2.47%), T_6 (2.37%), T_9 (2.13%), T_5 [4 KAB per plant (NPK 136:56:24 kg/ha)] (2.00%) and T_8 (2.00%). Maximum oil yield (50.23, 26.43 and 76.66 kg/ha) was obtained in T_{10} in the first and second harvest and cumulative for two harvests respectively.

Keywords: Patchouli; biofertilizers; inorganic fertilizers; foliage; oil content

INTORDUCTION

Patchouli (*Pogostemon cablin* Benth) is one of the important aromatic crops belonging to the family Lamiaceae and is native to the Philippines. The patchouli plant was first described by botanist Pelletier-Sautelet in the Philippines in 1845 and was named *Pogostemon patchouli*. It grows wild in several parts of the world. In India, it is cultivated in coastal areas of south India, West Bengal, Assam, Karnataka, Madhya Pradesh and the coastal regions of Gujarat (Ramya et al 2013). Patchouli oil is a key constituent in exotic perfumes to which it gives a rich and spicy fragrance. It can also be used as a perfume in its own right. It has also good fixative properties, especially in soap perfumes (Farooqui and Sreeramu 2001). Global demand is very high for patchouli oil as compared to its production. Patchouli oil extraction is still new but has large market demand due to therapeutic and healing properties of oil (Parganiha et al 2018). Singh and Rao (2009) stated that patchouli oil is one of the most important essential oils used in modern perfumery and cosmetic industries. There is hardly any preparation of oriental nature where patchouli oil is not used. It is used mainly because of fixative property as it gives tenacity to other perfumes.

Saha et al (2014) carried out a field experiment at Nagicherra (Tripura West) to study the effect of nitrogen levels and plant geometry on growth, herbage and oil yield of patchouli under humid sub-tropical northeastern Himalayan region of India. Results

revealed that application of 140 kg N/ha under square planting (50 cm × 50 cm spacing) produced highest fresh herbage, dry herbage, oil yield and essential oil content as compared to all other nitrogen levels and planting geometry. Saha et al (2017) revealed that application of 140 kg nitrogen/ha under square planting (50 cm × 50 cm spacing) recorded maximum plant height, number of leaves, number of primary branches, plant spread, dry matter accumulation and fresh herbage yield of patchouli as compared to all other nitrogen levels and planting geometry at Nagicherra, Tripura (West). Singh (1999), in a field experiment at Bangalore, studied the effect of irrigation (0.50, 0.75 and 1.0 IW:CPE ratios) and N rate (0, 25, 50 and 75 kg N/ha/harvest) on herbage and oil yield of patchouli and found that irrigation at an IW:CPE ratio of 1.0 produced significantly higher yields compared with an IW:CPE ratio of 0.5.

To ensure maximum productivity in any crop, proper nutrient supply is an important factor. Among the various nutrients, nitrogen, phosphorus and potassium are the three important nutrients that are frequently in short supply in the soil and their application plays a very important role in altering various growth, yield and quality attributes of the plants. However, modern and intensive agriculture calls for a heavy dependence on fertilizers and chemicals which are not only costly but also cause soil and water pollution. Thus by considering the recent concept of eco-friendly technology, the application of biofertilizers in combination with inorganic fertilizers substitutes the above need in many crops.

However, information of use of different levels of nitrogen under various planting geometry for enhancing the biofertilizers and inorganic fertilizers use efficiency in patchouli is very little. There is scarcity of information on the optimization of fertilizers requirement of the crop planted under different planting geometry. Therefore, a field experiment was conducted to study the effect of biofertilizers and inorganic fertilizers foliage and oil yield of patchouli.

MATERIAL and METHODS

Experimental site: The present investigations were carried out at the medicinal and aromatic crops section of the Department of Forest Products and Utilization, College of Forestry, Dr Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra during 2021-2022. The experimental site was situated at an elevation of 243.84 m amsl and latitude of 12° 58' North and longitude 77° 55' East. The climate of Dapoli is warm and humid with an annual rainfall ranging from 3,000 to 3,500 mm. The climate is typically tropical with hot and humid summers having heavy rainfall during monsoon and warm winters. The experimental area comprised red sandy loam soil with uniform fertility and available nitrogen 288.512 kg/ha, available phosphorus 7.8 kg/ha, available potassium 202.944 kg/ha, pH 5.16, EC 0.17ds/m and organic carbon 1.51 per cent.

Experimental design and treatments: Gross recommended dose of fertilizers (GRDF), Konkan Annapurna briquettes (KAB), phosphate solubilising bacteria (PSB), vesicular arbusculuar mycorrhiza (VAM) and *Azotobacter* were included in ten treatments viz T_1 (Control), T_2 (100% GRDF), T_3 (125% GRDF), T_4 [2 KAB per plant (NPK 68:28:12 kg/ha)], T_5 [4 KAB per plant (NPK 136:56:24 kg/ha)], T_6 [6 KAB per plant (NPK 204:84:36 kg/ha)], T_7 (100% GRDF + PSB 10 g/plant), T_8 (100% GRDF + VAM 20 g/plant), T_9 (100% GRDF + *Azotobacter* 10 g/plant) and T_{10} (100% GRDF + PSB 10 g/plant + VAM 20 g/plant + *Azotobacter* 10 g/plant) with three replications under RBD.

The recommended dose of phosphorus and potash was applied in the form of single super phosphate (16% P_2O_5) and muriate of potash (60% K_2O). Nitrogen was applied in the form of urea as per the treatments. The fertilizers mixture was applied in rows at a depth of 2.5 cm below the soil surface. Full dose of phosphorus and potassium was applied at the time of planting. Nitrogen was applied in two equal split doses. The first dose of 50 per cent nitrogen was given as basal application. The second dose of another 50 per cent was applied 120 days after planting. Patchouli cv Kelker was planted on 1 august 2021 in plots at a spacing of 60 cm x 60 cm accommodating 27,777 plants/ha. Two harvests were taken up during 1 August 2021 to 31 March 2022. The plants were harvested 20 cm above ground level. Whole plant samples of above ground level were collected. The fresh herbage was shade-dried and the dry herbage yield was computed and expressed in tonnes per hectare on dry weight basis.

The oil content in air-dried herbage was estimated using Clevenger's apparatus (Clevenger 1928). Total essential oil yield was calculated by multiplying the percentage of oil content by air-dried

herbage and expressed in kg/ha. Data were subjected to analysis of variance and estimation of the significance of difference between means was at 5 per cent level of significance.

Cultural operations: The various cultural operations carried out during the course of the investigations comprised ploughing of the experimental field with a tractor-operated plough followed by harrowing with spring tooth harrow. Layout of the experimental plot was done in RBD after harrowing of the field. There were total 30 plots in the experimental field and 10 plots in each replication. The plots of 3 m × 3 m were prepared and demarked manually. The recommended dose of 200 kg nitrogen, 50 kg phosphorus and 50 kg potassium per hectare was applied in the form of urea, single super phosphate and muriate of potash, respectively as per the treatments. Periodic hand weeding was carried out to keep the plots free of weeds. Irrigation was given at an interval of 5-6 days depending on the soil moisture condition. There was no serious pest or disease incidence observed throughout the experiment. However, stray incidences of leaf eating caterpillars and *Rhizoctonia* wilt were noticed. For controlling leaf eating caterpillars, foliar spray of methyl parathion @ 0.1 per cent and for *Rhizoctonia* wilt, soil drenching with carbendiezn (2.5 g/l of water) were given at fortnightly intervals.

Data collection: For dry foliage, green foliage, oil content and oil yield per hectare at 1st and 2nd harvesting, the observations were recorded from five randomly selected plants from all replications. Dry matter production and its accumulation in different parts were estimated at harvest stage. Five plants were uprooted randomly, leaf and stem were separated and oven dried at 60±°C separately until a constant dry weight was recorded for two consecutive days. Dry matter accumulation in different parts of the plants was recorded. Total dry matter production was calculated by adding dry weight of leaves and stem and expressed in g per plant.

Statistical analysis: The data pertaining to all the parameters were tabulated and subjected to statistical analysis using randomised block design (RBD). Fischer and Yates (1963) method of analysis of variance was adopted. Wherever the F-test was significant for comparison of treatment means, CD values were worked out at a probability level of 5 per cent.

RESULTS and DISCUSSION

The data on green and dry foliage and oil content and yield obtained are given in Table 1.

Green foliage: In the first harvest (120 DAP), the maximum green foliage was recorded in T_{10} (100% GRDF + PSB 10 g/plant + VAM 20 g/plant + *Azotobacter* 10 g/plant) (8.52 tonnes/ha), T_9 (100% GRDF + *Azotobacter* 10 g/plant) (8.03 tonnes/ha), T_8 (100% GRDF + VAM 20 g/plant) (7.88 tonnes/ha) and T_6 [6 KAB per plant (NPK 204:84:36 kg/ha)] (7.72 tonnes/ha) which were at par and the lowest in T_1 (Control) (5.07 tonnes/ha) and T_2 (100% GRDF) (5.37 tonnes/ha), the latter two being at par. Similarly, the maximum green foliage in the second harvest (210 DAP) was recorded in T_{10} (5.42 tonnes/ha), T_9 (5.16 tonnes/ha) and T_8 (5.00 tonnes/ha) which were at par while the least in T_1 and T_2 (2.66 tonnes/ha each).

Dry Foliage: In the first harvest, dry foliage per plant was maximum in T_{10} (68.81 g), T_9 (68.27 g), T_8 (66.01 g) and T_7 (100% GRDF + PSB 10 g/plant) (65.04 g) which were at par and lowest in T_1 (45.44 g). In the second harvest, maximum dry foliage per plant was recorded in T_{10} (38.55 g) and T_9 (38.21 g) which were at par and the lowest in T_1 (31.36 g), T_2 (31.77 g) and T_3 (125% GRDF) (32.28 g), the three being at par.

Oil content: The maximum oil content in the first harvest (2.63%) and (2.53%) was obtained in T_{10} and T_6 respectively, which were at par and lowest in T_1 (1.24%), T_2 (1.30%) and T_7 (1.33%), the latter three being at par. In the second harvest, maximum oil content was recorded in T_{10} (2.47%), T_6 (2.37%), T_9 (2.13%), T_5 [4 KAB per plant (NPK 136:56:24 kg/ha)] (2.00%) and T_8 (2.00%), all being at par and lowest in T_1 (1.10%), T_2 (1.13%), T_3 (1.13%), T_7 (1.33%) and T_4 [2 KAB per plant (NPK 68:28:12 kg/ha)] (1.43%), the five treatments being at par.

Oil yield per hectare: In the first harvest, maximum oil yield (50.23 kg/ha was obtained in T_{10} which was significantly superior to the rest of the treatments and the lowest in control (15.65 kg/ha). In the second harvest, again the treatment T_{10} recorded the highest oil yield (26.43 kg/ha) while the lowest was recorded in treatments of T_1 (9.59 kg/ha), T_2 (9.61 kg/ha) and T_3 (10.17 kg/ha), which were at par. Under cumulative data, the maximum oil yield was obtained in treatment T_{10} (76.66 kg/ha) which was significantly superior to

Table 1. Influence of biofertilizers and inorganic fertilizers on the yield parameters of patchouli

Treatment	Green foliage (tonnes/ha)		Dry foliage (g/plant)		Oil content (%)		Oil yield (kg/ha)		
	120 DAP (I harvest)	210 DAP (II harvest)	120 DAP (I harvest)	210 DAP (II harvest)	120 DAP (I harvest)	210 DAP (II harvest)	120 DAP (I harvest)	210 DAP (II harvest)	Cumulative
T_1	5.07	2.66	45.44	31.36	1.24	1.10	15.65	9.59	25.24
T_2	5.37	2.66	56.10	31.77	1.30	1.13	20.28	9.61	29.89
T_3	6.22	3.57	62.16	32.28	1.67	1.13	28.89	10.17	39.06
T_4	6.27	3.54	58.24	32.73	2.17	1.43	35.15	13.01	48.16
T_5	7.59	3.68	60.49	33.67	2.27	2.00	38.14	18.80	56.94
T_6	7.72	4.10	62.71	34.35	2.53	2.37	44.35	22.85	67.20
T_7	6.10	4.37	65.04	34.89	1.33	1.33	24.40	12.90	37.30
T_8	7.88	5.00	66.01	36.70	2.03	2.00	37.15	20.40	57.55
T_9	8.03	5.16	68.27	38.21	2.23	2.13	42.37	22.58	64.95
T_{10}	8.52	5.42	68.81	38.55	2.63	2.47	50.23	26.43	76.66
Mean	6.88	4.02	61.33	34.45	1.94	1.71	33.66	16.60	50.29
SEm±	0.30	0.21	1.93	0.35	0.079	0.23	0.86	0.32	2.90
$CD_{0.05}$	0.88	0.63	5.75	1.06	0.23	0.68	2.55	0.94	9.27

T_1: Control, T_2: 100% GRDF, T_3: 125% GRDF, T_4: 2 KAB per plant (NPK 68:28:12 kg/ha), T_5: 4 KAB per plant (NPK 136:56:24 kg/ha), T_6: 6 KAB per plant (NPK 204:84:36 kg/ha), T_7: 100% GRDF + PSB 10 g/plant, T_8: 100% GRDF + VAM 20 g/plant, T_9: 100% GRDF + *Azotobacter* 10 g/plant, T_{10}: 100% GRDF + PSB 10 g/plant + VAM 20 g/plant + *Azotobacter* 10 g/plant

all other treatments and minimum in T_1 (25.24 kg/ha) and T_2 (29.89 kg/ha), the two being at par.

Earlier, Singh and Rao (2009) studied the influence of sources and doses of N and K on herbage, oil yield, nutrient uptake, nitrogen utilization efficiency and oil content of patchouli. The results revealed that application of 200 kg N/ha and 41.5 kg K/ha produced significantly higher patchouli herbage and oil yields compared with controls.

Singh et al (2002), in a field experiment at Bangalore, studied the influence of irrigation, organic mulch and nitrogen application on patchouli growth, herbage, oil yield and quality. Irrigation at 1.0 IW:CPE ratio (irrigation water:cumulative pan evaporation), 5 tonnes/ha distilled waste material of palmarosa or 200 kg N/ha produced maximum herbage and oil yields. The oil content varied from 0.61 to 0.73 per cent. The highest oil content was recorded with irrigation at 0.8 IW:CPE ratio, no mulch and 100 kg N/ha.

Sumathi et al (2012) carried out experiments to find out the effect of different levels of nitrogen and VAM levels on herbage and oil yield of patchouli. The study revealed that effect of nitrogen and VAM had significant effect on yield and yield attributing characters. The plant height was increased with the increased dose of nitrogen and VAM application. The highest dose of nitrogen and VAM had significant influence on leaf area and leaf area index. Essential oil content of the treatments did not vary significantly among the treatments. Essential oil yield in herbage was highest at 150 kg nitrogen and 50 kg VAM/ha (110.42 kg/ha). The application of nitrogen @ 150 kg/ha and VAM at 50 kg/ha enhanced the quantitative and qualitative traits and recorded maximum cost benefit ratio (1:3.67).

Singh et al (2015) recorded significantly higher oil yield in 75 per cent vermicompost + 25 per cent NPK (256%) followed by 100 per cent NPK (249%) as compared to control. The study indicated that 75 per cent chemical fertilizer could be saved by integrating 75 per cent vermicompost with 25 per cent chemical.

Syafruddin et al (2020) found that in Aceh's organic patchouli, Ultisol soil order and mycorrhizal biofertilizer genus of *Glomus mosseae* gave the best results for the average parameters viz plant height, stem diameter, number of leaves, number of primary branches, fresh weight, dry weight, root mycorrhizae colonization, P uptake, and oil content.

CONCLUSION

It can be concluded that the treatment 100 per cent gross recommended dose of fertilizers + phosphate solubilising bacteria 10 g/plant + vesicular arbusculuar mycorrhiza 20 g/plant + *Azotobacter* 10

g/plant was amongst the treatments which resulted in maximum green and dry foliage production and oil content percentage in patchouli. However, this treatment proved superior over all other treatments in case of oil yield per hectare resulting in 50.23, 26.43 and 76.66 kg/ha oil at first harvest (120 DAP), second harvest (210 DAP) and cumulative of the two harvests respectively. Therefore, this treatment could be used for growing patchouli for higher production of dry and green foliage and higher oil content in typically tropical with hot and humid summers having heavy rainfall areas of Dapoli, Maharashtra.

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