Journal of Spices and Aromatic Crops
Vol. 23 (1) : 80–85 (2014)
www.indianspicesociety.in/josac/index.php/josac

Indian Society for Spices


# Influence of age of rooted cutting, nitrogen and stage of harvest on growth, yield and quality of patchouli [*Pogostemon cablin* (Blanco) Benth.]

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Received 02 December 2011; Revised 13 February 2013; Accepted 09 December 2013

**Abstract**

Field experiments were conducted to study the influence of age of rooted cuttings at the time of planting (30, 40, 50, 60, 70, 80 and 90 days), N levels (0, 50 and 100 kg $ha^{-1}$) and stage of harvest (once in 4, 5 and 6 months) on yield and oil quality of patchouli [*Pogostemon cablin* (Blanco) Benth.] under semi-arid tropical climate. The results indicated that planting 30 day old rooted cuttings produced higher plant height, plant canopy and oil yield compared with other treatments. Similarly, application of 100 kg N $ha^{-1}$ and stage of harvest after six months of planting produced maximum herbage yield, oil yield and oil content compared to other treatments. The highest net return (Rs. 59,550 $ha^{-1}$) and B:C ratio (1.168) were recorded with the application of 100 kg N $ha^{-1}$ and stage of harvest once in six months. Oil quality was not influenced by age of the rooted cuttings and N level.

**Keywords:** harvesting schedule, oil content, patchouli, *Pogostemon cablin*, quality, yield

## Introduction

Patchouli [*Pogostemon cablin* (Blanco) Benth.] belonging to family *Lamiaceae* is a branched, erect, perennial aromatic herb with quadrangular stem. It is one of the most important natural essential oil used to give a base and lasting character to a fragrance in perfumery industry. Indonesia is the major producer of patchouli oil in the world (1100 t $year^{-1}$), sharing more than 91.7% of the total world production (Lawrence 2009). Currently, India is producing a meager quantity of patchouli oil (20 t $year^{-1}$) and most of its domestic requirement is met by importing patchouli oil worth of 9 million rupees annually. Patchouli oil is known to possess antifungal properties and is being used in skin infections and eczema. Dry patchouli leaves have also been found to possess moth repellent properties and therefore, are used to scent ward robes and protecting clothes especially woolens from insect damage (Khanuja *et al.* 2004). Patchouli oil is effective for fungal and bacterial infection and is of great help for insect bites. It could also used as an insect repellent. It has water retention and can help with stress related problems and addictions. Studies on the performance of patchouli in a semi-arid tropical climate are limited (Singh *et al.* 2002; Singh & Rao 2009; Puttanna *et al*. 2005). It has been reported that application of N fertilizers

increased the productivity of patchouli (Bhaskar 1995; Singh 1999). No information is available on age of rooted cuttings at the time of planting, effect of N and harvesting schedule. There is also paucity of information on the influence of age of rooted cuttings and harvesting schedule of patchouli. Therefore, the present experiments were conducted to investigate the effect of age of rooted cuttings at the time of planting, effect of N and harvesting schedule on yields and quality of patchouli in a semi-arid tropical climate.

**Materials and methods**

Two field experiments were conducted during 2008–2010 at Central Institute of Medicinal and Aromatic Plants, Research Centre, Bengaluru, India. This area receives a mean annual rainfall of 870 mm, mostly between June to October. Minimum and maximum temperatures fluctuate between 11°C (January) to 37°C (May). Bengaluru is situated at 13°05'N and 77°55'E and is 930 m above MSL. The soil of the experimental field was a red sandy loam with a pH of 6.3. The organic carbon content of the soil was 0.37%. The soil had 185.5 kg N $ha^{-1}$, estimated using the alkaline $KMnO_4$ – method (Subbaiah & Asija 1956), 22.5 kg $P_2O_5$ $ha^{-1}$ (0.5 M NaH $CO_3$ – extractable P; John 1970) and 100.5 kg $K_2O$ $ha^{-1}$ (1 M $NH_4OAc$ extractable; Jackson 1958). The water holding capacity of the soil was 15.6% at -0.3 Mpa and 6.5% at -1.5 Mpa and its bulk density was 1.5 mg $m^{-3}$. The essential oil samples were analyzed for oil quality by GC on a Varian CP-3800 Gas Chromatograph fitted with two flame ionization detectors and split/splitless capillary injectors and Star work station software. 100% dimethylpolysiloxane column CP-Sil 5 CB 50 m × 0.32 mm ID., film thickness 0.25 μM from Varian was used with $N_2$ carrier gas with a constant flow rate of 0.4 mL $min^{-1}$. A 0.2 μL sample was injected in the split mode with split ratio 1:100. The column was initially held at 120°C for 2 min, then heated to 240°C at a rate of 8°C per min, held for 5 min. Injector and detector temperatures were kept at 250°C and 300°C, respectively.

A first field experiment was conducted during 2008–09 to study the influence of age of rooted cuttings at the time of planting on growth and yield of patchouli (cv. CIM-shreshtha). The treatments consisted of planting of different ages of rooted cuttings (30, 40, 50, 60, 70, 80 and 90 days) in a randomized block design with three replications. Rooted cuttings were planted with the spacing of 50 cm × 50 cm with a bed size of 3 m × 3 m. Phosphorus and potassium were applied as basal dose @ 50 kg $ha^{-1}$ each and N @ 100 kg $ha^{-1}$ was applied in three equal splits. 1/3$^{rd}$ N was applied after one week of planting and remaining 2/3$^{rd}$ was applied in two split @ 50 days interval. N, P and K were

**Table 1.** Influence of age of rooted cuttings at the time of planting on growth, herbage, oil yield and oil content of patchouli

| Age of cutting (days) | Plant height (cm) | Plant canopy ($m^2$ $plant^{-1}$) | Herbage yield (t $ha^{-1}$) | Oil yield (kg $ha^{-1}$) | Oil content (%) |
|---|---|---|---|---|---|
| 30 | 69.3 | 0.463 | 9.50 | 45.29 | 1.88 |
| 40 | 64.9 | 0.380 | 8.17 | 35.75 | 1.87 |
| 50 | 60.7 | 0.368 | 7.06 | 30.49 | 1.87 |
| 60 | 56.9 | 0.345 | 7.20 | 33.50 | 2.00 |
| 70 | 55.8 | 0.280 | 6.56 | 25.54 | 1.95 |
| 80 | 54.7 | 0.254 | 6.17 | 24.92 | 1.85 |
| 90 | 53.9 | 0.255 | 5.94 | 24.31 | 1.97 |
| SEm± | 5.0 | 0.055 | 0.97 | 4.48 | 0.07 |
| LSD (P<0.05) | 10.9 | 0.120 | 2.13 | 9.75 | N.S. |

SE=standard error; LSD=least significant difference

applied in the form of urea, superphosphate and muriate of potash, respectively. Field was irrigated immediately after planting for better establishment of crop. Weeds were removed manually whenever necessary. Plant height and plant canopy (plant spread) were measured in five plants before harvest. Crop was harvested on 180 days after planting (DAP) and herbage yield was recorded and air dried for 48 h for oil distillation. Oil was distilled in Clevenger's apparatus (Clevenger 1928) for 6 h. Total essential oil yield was calculated by multiplying the percentage of oil content by air dried herbage and expressed in kg. The experimental data were statistically analysed by the analysis of variance technique. Estimation of the significance of differences between means was based on a probability of $P < 0.05$ (Cochran & Cox 1957).

A second field experiment was conducted during 2009–10 to study the influence of N levels (0, 50 and 100 kg $ha^{-1}$) and three stage of harvest (once in 4, 5 and 6 months after planting) in a randomized block design with three replications. Patchouli cv. CIM-shreshtha was planted with a spacing of 50 cm × 50 cm and bed size of 3.5 M × 3.5 M. P and K @ 50 kg $ha^{-1}$ each was applied as basal and N was applied in three equal splits. (1/3$^{rd}$ N was applied after one week of planting and remaining 2/3$^{rd}$ was applied in two splits @ 50 days interval). N, P and K were applied in the form of urea, single super phosphate and muriate of potash, respectively. Field was irrigated immediately after planting for better establishment of crop. Weeding was done by manually whenever necessary. Crop was harvested as per schedule and fresh herbage yield was recorded in net plot of 6.25 $m^2$. Fresh herbage was air dried for 48 h before oil distillation. Oil was distilled in Clevenger's apparatus (Clevenger 1928) for 6 h.

**Results and discussion**

*Effect of age of rooted cuttings*

Plant height and canopy were significantly influenced by the age of rooted cuttings at the time of planting (Table 1). Plant attained maximum height of 69.3 cm in 30 days old rooted cuttings compared with other treatments. Similar pattern was obtained in case of plant canopy. Patchouli produced maximum herbage and oil yields when 30-day old rooted cuttings were planted in the main field compared with 40 or 50-day old rooted cuttings. Higher yield may be due to better plant height and spread at 30 days and more growing period which ultimately increased the biomass yield (Table 1). Oil content and quality were not influenced by age of rooted cuttings at the time of planting, except α–Bulnesene and Seychellene (%) in oil (Table 2).

*Effect of N and stage of harvest*

Application of 100 kg N $ha^{-1}$ produced maximum herbage and oil yield of patchouli compared with 50 kg N $ha^{-1}$ and control. Herbage and oil yield increased by 87.1% and 88% respectively, compared to control. Similar results were reported earlier by Bhaskar (1995), Puttanna *et al.* (2005), Singh *et al*. (2002) and Singh & Rao (2009). Red sandy loam soils of semi-arid regions are deficient in available nutrients and they respond well to N application (Table 3). Patchouli crop harvested after 6 months produced maximum herbage and oil yield compared to 4 months. Herbage yield increased by 112.9% and 153% compared to 4 months. Similar trend was noticed in case of oil yield. Oil content was not influenced by N levels but stage of harvest i.e harvesting at 4 months gave significantly less oil content than harvesting once in 6 months. Interaction effects were significant when no N or 50 N were applied. Patchouli could be harvested after 5 months, while at 100 N the crop had to be harvested after 6 months. Response to N was highest at 6 months age (Table 4). Oil content and quality were not influenced by N levels (Table 3) but harvesting patchouli after 6 months of planting gave more oil content compared with harvesting once in 4 months. Similarly, oil composition i.e. α-bulnesene, α-guaiene and caryophyllene were higher in harvesting at once in 6 months after planting compared with harvesting at 4 months (Table 5). There was no effect on β–patchoulene, patchouli alcohol and α–δ-patchoulene in oil but seychellene was more during early harvest

**Table 2.** Oil composition of patchouli as influenced by age of rooted cuttings at the time of planting

| Age of cutting (days) | Patchouli alcohol (%) | α-Bulnesene (%) | α-Guaiene (%) | Seychellene (%) | α-δ-Patchoulene (%) | Caryophyllene | β-patchoulene (%) |
|---|---|---|---|---|---|---|---|
| 30 | 44.07 | 11.74 | 8.75 | 7.23 | 5.65 | 3.20 | 1.69 |
| 40 | 42.57 | 11.91 | 8.91 | 7.43 | 5.87 | 3.17 | 1.68 |
| 50 | 42.01 | 12.04 | 9.04 | 7.54 | 5.84 | 3.05 | 1.69 |
| 60 | 40.16 | 13.95 | 9.78 | 6.94 | 5.75 | 3.38 | 1.80 |
| 70 | 42.12 | 12.81 | 8.75 | 6.80 | 5.35 | 2.93 | 1.57 |
| 80 | 40.50 | 13.70 | 9.33 | 6.82 | 5.64 | 3.17 | 1.62 |
| 90 | 40.66 | 13.65 | 9.49 | 6.96 | 5.58 | 3.32 | 1.71 |
| SEm± | 1.56 | 0.45 | 0.56 | 0.16 | 0.23 | 0.22 | 0.11 |
| LSD (P<0.05) | N.S. | 0.99 | N.S. | 0.35 | N.S. | N.S. | N.S. |

SE=standard error; LSD=least significant difference

**Table 3.** Influence of nitrogen and stage of harvest on herbage, oil yield, oil content and oil quality of patchouli

| Treatment | Herbage (t $ha^{-1}$) | Oil yield (kg $ha^{-1}$) | Oil content (%) | Patchouli alcohol in oil (%) |
|---|---|---|---|---|
| *N level kg $ha^{-1}$* | | | | |
| 0 | 4.34 | 19.60 | 2.22 | 40.4 |
| 50 | 5.92 | 26.79 | 2.27 | 40.0 |
| 100 | 8.12 | 36.85 | 2.21 | 49.4 |
| SEm± | 0.70 | 2.75 | 0.09 | 1.0 |
| LSD (P<0.05) | 1.46 | 5.85 | N.S. | N.S. |
| *Stage of Harvest (month)* | | | | |
| 4 months | 3.72 | 15.10 | 2.09 | 40.7 |
| 5 months | 6.74 | 29.74 | 2.23 | 41.2 |
| 6 months | 7.92 | 38.20 | 2.39 | 38.8 |
| SEm± | 0.70 | 2.75 | 0.09 | 1.0 |
| LSD (P<0.05) | 1.46 | 5.85 | 0.19 | N.S. |

SE=standard error; LSD=least significant difference

**Table 4.** Interaction effect of nitrogen and harvesting schedule on oil yield of patchouli

| Treatment | Oil yield (kg ha$^{-1}$) | | | |
|---|---|---|---|---|
| | Stage of harvest (months) | | | |
| | 4 | 5 | 6 | Mean |
| *N level (kg ha$^{-1}$)* | | | | |
| 0 | 10.65 | 21.14 | 27.01 | 19.60 |
| 50 | 18.65 | 30.55 | 31.16 | 26.79 |
| 100 | 16.00 | 38.12 | 56.42 | 36.85 |
| Mean | 15.10 | 29.94 | 38.20 | - |
| SEm± | 4.78 | | | |
| LSD (P<0.05) | 10.13 | | | |

SEm±=standard error; LSD=least significant difference

than that of late harvesting. Nitrogen and stage of harvest highly influenced the oil yield, net return and benefit cost (B:C) ratio in patchouli (Table 6). Net return and B:C ratio increased with increasing levels of N and stage of harvest. The highest net return (Rs. 59,550 ha$^{-1}$) and B:C ratio (1.168) were recorded with application of 100 kg N ha$^{-1}$.

It was concluded that 30 days old rooted cuttings should be used with application of 100 kg N ha$^{-1}$ and harvesting should be done after 6 months of planting to obtain maximum yield, net return and B:C ratio in patchouli. Oil content and quality were not influenced by age of rooted cuttings but it was influenced by stage of harvest.

**Acknowledgments**

The authors are grateful to the Director, Central Institute of Medicinal and Aromatic Plants (CIMAP), Lucknow and the Scientist-in-charge of the CIMAP Centre, Bengaluru for facilities and encouragement.

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**Table 5.** Influence of nitrogen and stage of harvest on oil composition of patchouli

| Treatment | Patchouli oil composition (%) | | | | | |
|---|---|---|---|---|---|---|
| | β-patchoulene | Patchouli alcohol | α-Bulnesene | α-Guaiene | Caryophyllene | Seychellene | α-Patchoulene |
| *N level (kg ha$^{-1}$)* | | | | | | | |
| 0 | 1.77 | 40.41 | 13.65 | 9.37 | 3.84 | 5.97 | 5.46 |
| 50 | 1.71 | 40.90 | 14.72 | 8.95 | 3.65 | 6.18 | 5.22 |
| 100 | 1.68 | 39.38 | 14.64 | 9.37 | 3.85 | 6.10 | 5.31 |
| SEm± | 0.10 | 1.02 | 0.95 | 0.48 | 0.20 | 0.15 | 0.18 |
| LSD (P<0.05) | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. |
| *Stage of harvest (months)* | | | | | | | |
| 4 | 1.65 | 40.68 | 14.03 | 8.52 | 3.36 | 6.32 | 5.22 |
| 5 | 1.70 | 41.19 | 13.71 | 9.08 | 3.78 | 5.97 | 5.24 |
| 6 | 1.81 | 38.84 | 15.78 | 10.09 | 4.19 | 5.96 | 5.53 |
| SEm± | 0.10 | 1.02 | 0.95 | 0.48 | 0.20 | 0.15 | 0.18 |
| LSD (P<0.05) | N.S. | N.S. | 2.01 | 1.02 | 0.40 | 0.32 | N.S. |

SEm±=standard error; LSD=least significant difference

**Table 6.** Influence of nitrogen and stage of harvest on oil yield and economics of patchouli production (pooled data of two years)

| Treatment | Oil yield (kg ha$^{-1}$) | Cost of cultivation (Rs ha$^{-1}$) | Gross return (Rs ha$^{-1}$) | Net return (Rs ha$^{-1}$) | B:C ratio |
|---|---|---|---|---|---|
| *N level (kg ha$^{-1}$)* | | | | | |
| 0 | 19.60 | 50 000 | 58 800 | 8 800 | 0.176 |
| 50 | 26.79 | 50 600 | 80 370 | 29 700 | 0.588 |
| 100 | 36.85 | 51 000 | 110 550 | 59 550 | 1.168 |
| SEm± | 2.75 | - | - | - | - |
| LSD (P<0.05) | 5.85 | - | - | - | - |
| *Stage of harvest (months)* | | | | | |
| 4 | 15.10 | 50 000 | 45 300 | 4 700 | 0.094 |
| 5 | 29.94 | 54 000 | 89 820 | 35 820 | 0.663 |
| 6 | 38.20 | 56 000 | 1 14 600 | 56 600 | 1.011 |
| SEm± | 2.75 | - | - | - | - |
| LSD (P<0.05) | 5.85 | - | - | - | - |

SEm±=standard error; LSD=least significant difference, patchouli oil price rupees 3,000 kg$^{-1}$

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