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EFFECT OF NITROGEN AND VAM LEVELS ON HERBAGE AND OIL YIELD OF PATCHOULI (*POGOSTEMON PATCHOULI* PETLLE.)

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ABSTRACT
Pogostemon patchouli Pellet. Is an important aromatic plant, which gains commercial importance in recent years. The increasing demand for the essential oil both for the perfumery industry and pharmaceutical industry stressed the need for systematic investigation for increasing the herbage and oil yield. An experiment was therefore carried out in Horticultural College and Research Institute in Periyakulam, to find the effect of different levels of Nitrogen and VAM levels on herbage and oil yield 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 maximum plant height was recorded with 200kg/ha nitrogen and 50kg/ha VAM (89.51 cm). Application of 150kg/ha nitrogen and 50kg/ha VAM recorded highest number of laterals (20.27). Number of leaves was increased with application of nitrogen up to 15kg/ha and the highest number of leaves (361) was recorded with application of 150kg N/ha along with 50kg VAM/ha. The highest dose of nitrogen and VAM had significant influence on leaf area and leaf area index. Application of 200kg nitrogen with 50kg VAM/ha recorded the maximum leaf area and leaf area index but it was on par with nitrogen at 150kg/ha and VAM at 50kg/ha. Highest herbage yield (13.60 t/ha) and dry weight of herbage (4.07 t/ha) was recorded at 150kg N/ha and 5kg VAM/ha. Essential oil content of the treatments did not varied significantly among the treatments. Essential oil yield in herbage was highest at 150kg nitrogen and 50kg VAM/ha(110.42 kg/ha). Highest mycorrhizal colonization percentage of 90.50% was recorded with the treatment receiving 150kg nitrogen/ha and 50 kg VAM/ha. In the nutshell of the research, application of Nitrogen @150kg/ha and VAM at 50kg/ha enhanced the quantitative and qualitative traits and recorded maximum cost benefit ratio (1: 3.67).

KEYWORDS: FYM – Farm Yard Manure, N – Nitrogen, P – Phosphorus, K – Potassium, VAM – Vesicular arbuscular mycohrrizae, ha – hectare, Gm- gram, Cm- Centimeter, Kg- kilogram, Rs- Rupees, Mm –Millimeter, NS- Non significant, RH – Relative humidity, SE(d)- Standard error of difference, CD – Critical difference, DAP – Days after planting.

INTRODUCTION

Patchouli (Pogostemon patchouli Pellet.) syn. (Pogostemon cablin Benth.) is one of the important aromatic crops which belongs to the family Lamiaceae and its native to Philippines. Shade dried leaves of Patchouli on steam distillation yield essential oil containing about 97 per cent of compounds which have no influence on aroma, out these 40 to 45 per cent belongs to sesquiterpene group and the balance seems to consist of patchouli alcohol. Patchouli oil is one of the most important essential oil of the perfumery industry, as the oil blends well woth other essential oils like vetiver, sandalwood, geranium, lavender, clove oil etc. Hence it is regarded as the best fixative for heavy perfumes imparting strength, character and alluring notes and lasting qualities. Besides the oil is also used as flavor ingredients in the major food products, including alcoholic and nonalcoholic beverages. In Indo – Malayan region, it has been used as insecticide and leach repellent and also to soothe menstrual cramps. There is no synthetic chemical to replace the oil of patchouli which further enhances its value (Ramachandra *et al*., 2002). Thus, it has a unique position in the market and the oil is in great demand in perfumery, soap, scent, after shave lotion, detergent, tobacco and incense manufacturing industries. It has been amply shown that patchouli being a tropical plant can be successfully grown under Indian conditions (Bhaskar *et al*., 1997.) Around 1962, systemic efforts on cultivation were started by Central Institute of Medicinal and Aromatic plants (CIMAP) at regional Centre, Bangalore. Production of Patchouli in India is very negligible (about 100 – 150kg/year), as against the total annual world production of 700 to 800 tones. Presently India is importing over 200 tonnes of oils from Indonesia, Malaysia and Singapore (Manjunatha *et al*., 2002).

To grow any crop, the point of paramount importance is to get maximum output with minimum of inputs. This can be achieved through evolution of scientifically sound and economically feasible methodologies in the management of crops. This includes standardization of nutritional requirements. Some research work in patchouli has already been carried out to find out optimum fertilizer requirements etc. But these findings are to be suitably

fine-tuned by further research to suit under Tamil Nadu conditions. Among the various nutrients, nitrogen, phosphorus, potassium are the three important nutrients that are frequently 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, the modern and intensive agriculture calls for the heavy dependence of fertilizers, and chemicals, which are not only costly but also cause soil and water pollution. Thus, by considering the recent concept of ecofriendly technology, application of bio fertilizers in combination with inorganic fertilizers substitutes the above need in many crops. Thus, keeping the above facts in the view the present investigation was under taken to find out the "Effect of nitrogen and VAM levels on herbage and oil yield of patchouli (*Pogostemon patchouli*) under coconut shade with the following objectives *i.e.*To fix the optimum dose of nitrogen and VAM levels for patchouli & to maximize herbage and oil yield of patchouli.

MATERIALS AND METHODS

FYM at the rate of 15 tonnes per hectare was incorporated at the time of last ploughing. The recommended dose of 50 kg phosphorus and 50kg potash per hectare were applied in the form of single super phosphate and muriate of potash as a basal dose. In addition uniform dose of biofertililizers viz., Azospirillum and Phosphobacteria, at the rate of 2kg/ha were applied around the root zone of the crops. Tissue culture plants of uniform size variety Johore had planted at uniform spacing of 45 X 45 cm in the plot size of 2.5 X 2.5M which accommodates 30 plants/plot. The experiment was laid out in Factorial Randomized Block Design, replicated twice with five levels of Nitrogen viz., 0(N_1), 50 (N_2), 100 (N_3), 150 (N_4) and 200 (N_5) kg/ha, five levels of VAM viz., 0 (V_1), 12.5 (V_2),25 (V_3), 37.5 (V_4) and 50 (V_5) kg/ha. At the time of planting, 1/3rd of nitrogen was applied as basal dose and the remaining quantity was applied in two equal split doses after 30th and 60th days of planning. The entire quantity of VAM (*Glomus fasciculatum*) was applied after 10days of planning by farming small furrows around the root zone of the crop. Periodical hand weeding was carried out to keep the plot free of weeds. Irrigation was given at an interval of 5-6 days depending upon the soil moisture conditions. There was no serious pest and disease incidence observed throughout the experimental period. However, stray incidences of leaf eating caterpillar (*Pronomus profusalis*), rhizoctonia wilt and root knot nematode (*Meloidogyne incognita*) were noticed. Matured shoots of 25 to 30 centimeter length were harvested by cutting with sharp secateurs in such a way that the plants retains some of the bottom leaves to ensure better growth at next year. After harvesting herbage was dried for 5 to 6 days by spreading it in a thin layer on hard, dry, cement surface. The leaves were turned periodically to ensure uniform drying and to prevent mould formation. Latter, the dried leaves were steam distilled for oil extraction. In each treatment, five plants were randomly selected and tagged, biometric observations like plant height, number of laterals, plant spread, leaf area and leaf area index, stalk length, herbage yield and oil content was taken that plants after 180 days of planting. Mycorrhizal parameters like per cent root colonization also observed. Collected data were analyzed adopting the procedure described by panes and Sukhatme (1957), Correlation Coefficients were worked out as suggested by Snedecor and Cochran (1967).

RESULTS AND DISCUSSION

Plant height

Nitrogen levels significantly improved plant height and there is a linear relationship was observed in plant height and the levels of nitrogen application. This may be due to the effect of nitrogen in promoting the vegetative growth by the enhanced cell division and the greater synthesis of chlorophyll, protein and amino acids. Irulappan and Ponnusami (1982) and Saha et al (1992) have obtained similar results in Patchouli.

TABLE -I

		V_2	V_3	V_4	V_5	Mean
N_1	35.37	39.55	44.26	49.53	50.27	43.79
N_2	55.38	59.46	64.28	69.33	73.30	64.35
N_3	61.30	67.17	70.25	74.77	78.55	70.40
N_4	68.37	71.58	75.41	79.64	85.26	76.05
N_5	72.54	76.96	80.46	84.15	89.51	80.72
Mean	58.59	62.94	66.93	71.48	75.38	67.06

The highest value of plant height was recorded with 50kg VAM/ha, this may be due to the effective utilization of VAM that enhanced availability of nutrients along with the production of some growth promoting substances, which might have caused cell elongation and multiplication. Same findings have reported in many horticultural crops like palmarosa (Gupta and Janardhanan, 1991) and African marigold (Rajadurai *et al* 2000).

The interaction between Nitrogen and VAM had a significant effect on plant height and the maximum plant height was observed with 200kg/ha of nitrogen coupled with 50kg VAM/ha. This findings was in agreement with the findings of Shivalingappa (1998) in tuberose.

Number of laterals per plant

Application of nitrogen at 150kg/ha recorded the maximum numbers of laterals per plant. This may be due to enhanced vegetative growth because of increased meristamatic activity and increased supply of photosynthates. Arul Arasu and Sambandamurthi (1999) reported similar results in Ocimum.

VAM at different levels significantly increased the number of laterals per plant, the maximum laterals were observed with application of 50kg VAM/ha. Similar results were reported by Manjunatha *et al* (2002) in patchouli. In the

treatment that received 150g nitrogen/ha and 50kg VAM/ha recorded maximum number of laterals followed by 200kg Nitrogen and 50kg VAM/ha.

TABLE -II

		V_2	V_3	V_4	V_5	Mean
N_1	5.05	5.87	6.23	7.01	7.47	6.32
N_2	8.11	9.67	11.26	13.39	14.35	11.35
N_3	10.36	12.06	14.23	16.12	17.10	13.97
N_4	12.31	14.27	16.12	18.04	20.27	16.27
N_5	12.06	14.08	16.10	17.57	19.63	15.88
Mean	9.57	11.19	12.85	14.42	15.76	12.72

Number of leaves

Number of leaves per plant increased with corresponding increase in dose of nitrogen up to 150kg/ha, any further increase in the dose of Nitrogen above this slightly reduces leaf yield. This is because of shedding up of lower leaves due to increased nitrogen application. These results are in accordance with the results of Saha *et al*. (1992) in Patchouli and Chauhan *et al*(2000) in Palmarosa. VAM application at different levels had a significant influence on number of leaves per plant. Similar results were reported by Rajadurai *et al* (2000) in african marigold. Present study also indicated that the maximum number of leaves per plant (361.00) was recorded with combined application of 150kg nitrogen/ha along with 50 kg VAM/ha. This may be due to better growing conditions that prevailed in the vicinity of root zone due to the application of VAM that helps the plants to absorb more nutrients from the soil Manjunatha *et al*. (2002) in patchouli.

TABLE –III

		V_2	V_3	V_4	V_5	Mean
N_1	130.50	140.50	161.00	180.50	200.50	162.60
N_2	230.50	241.00	261.00	281.00	305.50	263.80
N_3	255.50	260.50	280.50	301.00	320.50	283.60
N_4	299.00	302.00	320.50	341.00	361.00	324.70
N_5	284.50	291.00	311.00	331.00	352.00	313.90
Mean	240.00	247.00	266.80	286.90	307.90	269.72

Stalk length

Stalk length was significantly influenced by Nitrogen and VAM application.

TABLE –IV

		V_2	V_3	V_4	V_5	Mean
N_1	2.73	3.07	3.23	3.31	3.47	3.16
N_2	3.90	3.97	4.28	4.35	4.47	4.19
N_3	4.23	4.48	4.64	4.83	5.01	4.64
N_4	4.66	4.87	5.03	5.21	5.48	5.05
N_5	4.45	4.56	4.83	5.05	5.33	4.83
Mean	3.99	4.19	4.40	4.55	4.75	4.38

Nitrogen levels found to significantly influence the stalk length. Application of 150 kg nitrogen/ha recorded maximum stalk length (5.05cm) followed by nitrogen @ 200kg/ha (4.84 cm). Application of 50kg VAM/ha recorded a maximum stalk length (4.75 cm) followed by 37.5kg/ha (4.55 cm and the shortest stalk length was registered in the control (3.99cm).

In the present study interaction between nitrogen and VAM significantly influenced the stalk length. The maximum stalk length of 5.84 cm was reported in the treatment with 150kg nitrogen application coupled with 50kg VAM/ha (5.33 cm) followed by nitrogen at 200kg/ha and VAM at 50kg/ha (5.33 cm).

Leaf area and leaf area index

The present study revealed that a linear increase in leaf area with increase in nitrogen levels up to 200kg/ha. This might be due to increased auxin activity, Carbohydrates and other organic compounds produced as a result of nitrogen application. Increased nitrogen levels caused on increased in chlorophyll synthesis and there by increased the leaf area in *Ocimum sanctum* (Arul Arasu and Sambandamurthi, 1999). VAM application at 50kg/ha recorded maximum leaf area. Application of VAM might have enhanced the availability of nitrogen, phosphorus, and other nutrients along with production of growth hormones which might have increased the length, and breadth of the leaves leading to increased leaf area.

Similar observations were recorded by Rajadurai *et al* in african marigold and Manjunatha *et al* (2002) in patchouli.

The interaction between Nitrogen and VAM was found to significantly influence the leaf area at all the treatments. Treatment combination receiving 150kg nitrogen/ha and 50kg VAM/ha recorded a maximum leaf area index of 2.01 which was on par with 200kg Nitrogen and 50kg VAM/ha (2.01)

Plant spread

Application of nitrogen 15kg/ha recorded maximum plant spread. This may be due to more number of branches. Similar results were obtained by Kiruthika devi (2002) in ashwagandha . Increased VAM application at 50 kg/ha increased the plant spread. This can be attributed to the production of more number of branches, which in turn have increased the plant spread (Manjunatha *et al*. 2002. in patchouli).

TABLE –V

		V_2	V_3	V_4	V_5	Mean
N_1	20.60	22.00	27.91	29.89	31.47	26.37
N_2	29.18	30.03	34.50	39.57	40.10	34.67
N_3	31.87	33.12	38.87	45.31	47.63	39.36
N_4	43.59	44.34	48.66	52.50	55.58	48.93
N_5	42.37	43.08	46.00	50.05	54.28	47.15
Mean	33.52	34.51	39.18	43.46	45.81	39.29

The present study indicated that 150 kh nitrogen with 50 kg VAM/ha recorded the highest spread followed by 200kg nitrogen with 50kg VAM/ha. This may be due to increased availability of nutrient elements by VAM, further VAM fungi are known to increase water uptake also (Christopher *et al*., 1994).

Fresh herbage yield per hectare

The individual and pooled effect of fresh herbage yield (g/plant) as influenced by nitrogen and VAM levels were recorded at time of harvest. It could be observed that both individual and interaction effect found significant. The maximum herbage yield (10.64t/ha) was obtained with application of 150kg N/ha followed by 200kg N/ha (10.02). The higher herbage yield may be due to increased height of plants with more number of laterals per plants as reported by Sadasakthi (1986) in marjoram.

VAM application had a linear effect on herbage yield. Maximum herbage yield of 9.99 t/ha was obtained with application of 50kg VAM/ha followed by 37.5kg/ha (9.08t/ha). Similar results were reported by Krishna Naik (1998) in java citronella and Ratti and Janardhanan (1996) in palmarosa.

The treatment combination of 150kg Nitrogen with 50 Kg VAM/ha recorded maximum herbage yield (13.60t/ha) followed by application of 200kg nitrogen and 50kg VAM/ha (12.83 t/ha) and the lowest herbage yield of 3.16t/ha was obtained with control. This may be due to the increased uptake of both macro and micro by the application of nitrogen and VAM.

TABLE –VI

		V_2	V_3	V_4	V_5	Mean
N_1	20.60	22.00	27.91	29.89	31.47	26.37
N_2	29.18	30.03	34.50	39.57	40.10	34.67
N_3	31.87	33.12	38.87	45.31	47.63	39.36
N_4	43.59	44.34	48.66	52.50	55.58	48.93
N_5	42.37	43.08	46.00	50.05	54.28	47.15
Mean	33.52	34.51	39.18	43.46	45.81	39.29

Dry herbage yield

Dry herbage yield was calculated after 6 days of shade drying. The interaction between nitrogen and VAM was significant in increasing the herbage yield. Application of 150kg n/ha followed by 50kg VAM/ha recorded maximum herbage yield (4.07) followed by application of 200kg nitrogen and 50kg VAM (3.61t/ha). Similar results were obtained by Manjunatha *et al*. (2002) in patchouli, Earanna *et al.* (2001) in *Coleus aromaticus*.

TABLE –VII

		V_2	V_3	V_4	V_5	Mean
N_1	0.95	0.97	1.08	1.11	1.15	1.05
N_2	1.22	1.62	2.02	2.52	2.57	1.99
N_3	1.59	1.89	2.47	2.98	3.36	2.45
N_4	2.38	2.64	3.15	3.58	4.07	3.16
N_5	2.25	2.45	3.13	3.53	3.61	2.99
Mean	1.67	1.91	2.37	2.74	2.95	2.32

Oil content and essential oil yield

The variation in oil content was not significant among the treatments, however, it varied from 2.15 to 2.90 per cent among the treatments, indicating that nitrogen and VAM have only marginal effect on oil content in patchouli. This is in line with the findings of Manjunatha *et al.* (2002) in patchouli.

Essential oil yield per hectare

Application of nitrogen at 150kg/ha significantly recorded higher oil yield. This may be due to the influence of nitrogen in promoting the vegetative growth, which resulted in increased herbage production, consequently, essential oil yield increased to greater extent. The similar results were reported by Venugopal (2006) in Patchouli. The essential oil yield increased with every successive increase in VAM levels and he maximum yield was obtained with 50 kg VAM/ha, this might be due to influence of VAM in enhancing nutrient uptake, which resulted in increased herbage yield, consequently the essential oil yield per hectare to a greater extend. This is in line with findings of Manjunatha *et al*., (2002) in patchouli. The present study also revealed that the application of nitrogen 150kg/ha with VAM 50kg/ha (110.42kg/ha).

TABLE –VIII

		V_2	V_3	V_4	V_5	Mean
N_1	23.43	25.26	26.52	27.04	28.08	26.06
N_2	31.09	42.92	52.65	62.01	63.80	50.49
N_3	37.90	47.13	62.18	77.86	82.98	61.61
N_4	62.84	65.33	78.17	90.00	110.42	81.35
N_5	56.68	58.25	72.07	81.17	93.98	72.43
Mean	42.38	47.77	58.31	67.61	75.85	58.38

Per cent root colonization of VAM

Application of VAM at different levels had significant effect on root colonization.

TABLE –IX

		V_2	V_3	V_4	V_5	Mean
N_1	2.50	30.50	40.50	65.50	72.50	42.30
N_2	4.50	60.50	68.50	70.50	75.50	55.90
N_3	5.50	65.50	70.00	76.50	80.50	59.60
N_4	6.50	76.50	83.32	86.50	90.50	68.66
N_5	6.00	72.50	80.50	85.18	88.00	66.43
Mean	5.00	61.10	68.56	76.83	81.40	58.57

Nitrogen application at 150kg/ha recorded the higher colonization percent. Higher level of nitrogen trigged the vegetative growth, which in turn increases the colonization percentage. Similar results were obtained by Rajadurai *et al*. (2000) in african marigold.

Plants receiving 50kg VAM/ha were found to have higher percentage of root colonization (81.40) followed by VAM at 37.50kg/ha (76.83). whereas the plants in control plot recorded the least colonization of 5.00%. in general, treatments with VAM produced better root colonization, this suggest that the native fungus is not more efficient than the inoculated VAM fungus. Thus, inoculation of plants with fungus helps in better root colonization thereby improving the growth and yield of the crops. This is in agreements with the findings of Sreeramulu *et al*., (1996) in amaranthus and methi, Madhaiyan *et al*. (2000) in marigold.

Interaction between nitrogen and VAM were found to be statistically significant. Application of nitrogen at 150 kg/ha with VAM 50kg/ha recorded the highest colonization percentage of 90.50 followed by 200kg nitrogen with 50kg VAM/ha (88.00). the lowest colonization percentage was recorded in the control.

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