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Effect of Nitrogen Application and Spacing on Plant Height, Spread, Dry Matter Accumulation and Fresh Herbage Yield of Patchouli (*Pogostemon cablin* Benth.) under Humid sub-tropical Climate of Tripura

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ABSTRACT

A field experiment was carried out during February–July 2012, at Nagicherra, Tripura (West), to study the effect of nitrogen levels and plant geometry on plant height, spread, dry matter accumulation and fresh herbage yield of patchouli (*Pogostemon cablin* Benth.) under humid sub-tropical climate of Tripura. Results revealed that application of 140 kg nitrogen/ha under square planting (50 × 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.

1. Introduction

A large number of people in developing countries have traditionally depended on products derived from plants, especially from forests, for curing human and livestock ailments. Additionally, several aromatic plants are popular for domestic and commercial uses. Collectively they are called medicinal and aromatic plants (MAPs). About 12.5% of the 4,22,000 plant species documented worldwide are reported to have medicinal values; but only a few hundred are known to be in cultivation (Singh et al. 2002). With dwindling supplies from natural sources and increasing global demand, the MAPs will need to be cultivated to ensure their regular supply as well as conservation. Since many of the MAPs are grown under forest cover and are shade tolerant, agroforestry offers a convenient strategy for promoting their cultivation and conservation. Several approaches are feasible: integrating shade tolerant MAPs as lower strata species in multistrata systems; cultivating short cycle MAPs as intercrops in existing stands of plantation tree-crops and new forest plantations; growing medicinal trees as shade providers, boundary markers, and on soil conservation structures; interplanting MAPs with foodcrops; involving them in social forestry programs; and so on. The growing demand for MAPs makes them remunerative alternative crops to the traditional ones for smallholders in the tropics (Sumathi et al. 2012). Among many MAPs, Patchouli (*Pogostemon cablin* Benth.) syn. (*Pogostemon patchouli* Pellet.) is one of the important aromatic crops which belong to the family Lamiaceae and its native to Philippines (Saha et al. 2014). 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 worth other essential oils like vetiver, sandal wood, 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 flavour ingredients in the major food products, including alcoholic and non-alcoholic beverages. In Indo –Malayan region, it has been used as insecticide and leach repellent.There is no synthetic chemical to replace the oil of patchouli which further enhances its value (Sumathi et al. 2012).

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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 (Singh and Rao 2009). 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 grown under proper spatial arrangements. Among the macronutrients, nitrogen is one of the important nutrients that 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 (Saha et al. 1992).Studies on the performance of patchouli in a humid sub-tropical climate are limited. It has been reported that the productivity of patchouli increases with application of N fertilizers (Bhaskar 1995, Singh 1999). However the response of patchouli to nitrogen under different planting geometry is not well understood. In most cases, the apparent recovery is applied N in geranium and other aromatic crops <30% (Rao et al. 1988) which may be due to losses of N through leaching in several light texture soils. In such situation, use of nitrification inhibitors was suggested (Rao and Puttanna 1987; Rao et al. 1990). However, information on use of different levels of nitrogen under various planting geometry for enhancing the nitrogen use efficiency is very little. There is a scarcity of information on the optimization of nitrogen requirement of patchouli planted under different planting geometry (Saha et al. 2014). Therefore, a field experiment was conducted to study the effect of nitrogen levels and different planting geometry on plant height, plant spread, leaf area index, dry matter accumulation and fresh herbage yield of patchouli (*Pogostemon cablin* Benth.) under humid sub-tropical climate of Tripura.

2. Materials and Methods

Experimental site

The present investigation was carried out during February – July 2012 at The North Eastern Development Finance Corporation Ltd Research & Development Centre (NEDFIR&D) on MAP, Nagicherra, Tripura West, situated at a latitude of 22°56'N and 24°32'N and 90°10'E and92°20'E longitude and altitude of 105 meters from the above mean sea level. The state has a sub-tropical climate and receives rainfall during the monsoons having hot dry summer and cold winter. The daily average minimum temperature in the coldest month varies from 5ºC to 17ºC and during summer the maximum temperature varies from 27ºC to 36 ºC. The mean annual rainfall is about 2200 mm. Soil of experimental field was clay loam with soil pH 6.1, 310 kg/ha available N, 5 kg/ha available P, 175 kg/ha available K and 0.62% organic carbon.

Experimental design and treatments

The experiment was laid out in randomized complete block design comprising four levels of Nitrogen (N) and three spacings (S) with three replications. Treatment comprised twelve combinations *viz.* T_1: N_1S_1-80 kg N/ha + 70×50 cm; T_2: N_1S_2-80 kg N/ha+ 50×50 cm; T_3: N_1S_3-80 kg N/ha+ 50×35 cm; T_4: N_2S_1-100 kg N/ha+ 70×50 cm; T_5: N_2S_2-100 kg N/ha+ 50×50 cm; T_6: N_2S_3-100 kg N/ha+ 50×35 cm; T_7: N_3S_1-120 kg N/ha+ 70×50 cm; T_8: N_3S_2-120 kg N/ha+ 50×50 cm; T_9: N_3S_3-120 kg N/ha+ 50×35 cm; T_{10}: N_4S_1-140 kg N/ha+ 70×50 cm; T_{11}: N_4S_2-140 kg N/ha+50×50 cm and T_{12}:N_4S_3-140 kg N/ha+ 50×35 cm.

Cultural operations

The land selected for Patchouli cultivation was flood free and not subjected to water stagnation for any length of period. The experimental field was cleared bushes and perennial weeds removed through digging. The land was thoroughly ploughed with power tiller to get fine tilth for better crop establishment. Land preparation work was done before the beginning of the rainy season, on 7th March 2012. A well decomposed Farm Yard Manure (FYM) was applied at the time of land preparation @ 20 t/ha. Besides that neem cake 1 t/ha was applied for supplying additional plant nutrients and controlling nematode population. Nematicides, Dasanit 5% @ 60 kg/ha was broadcast and mixed well into the soil before planting. The main and sub channels for irrigation were laid out taking into consideration the gradient of the site and ridge and furrow was made as per treatment. Individual bed was levelled to avoid water stagnation and to ensure quick surface drainage. The beds were irrigated a day before planting. The treatments were assigned randomly in each replication. The healthy, vigorous and forty five day-old rooted cuttings (20-25 cm length) of patchouli cv. Indonesia were planted as per treatment. Irrigation was given immediately after planting. The planting was done on 5th March 2012. Further gap filling was done after 15 days of planting. The recommended dose of phosphorus and potash were applied in the form of single super phosphate (16% P_2O_5) and muriate of potash (60% K_2O). The nitrogen was applied in the form of urea (46% N) 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. The nitrogen was applied in four equal split doses. The first dose of 25% nitrogen was given as basal application. The second dose of another 25% was applied 45 days after planting. Remaining 50% was applied in two equal splits once after the first harvest and again after the second harvest. Weekly irrigation was applied depending upon the climatic conditions. Weeds were removed by hand whenever necessary. Plants were harvested after they attained satisfactory vegetative growth after four months (120 days) of planting on 5th July 2012. Harvesting was done in such a manner, around 70% of the herbage was harvested and 30% growth was retained for further regeneration.

Crop measurements

The plant height, number of leaves/plant and leaf area were recorded at 30, 45, 60, 75, 90 days after planting (DAP) and finally at harvest. However, plant spread and dry matter accumulation was recorded before harvesting of crop. The observations were recorded from five randomly selected plants in each treatment under all replication. And the mean were worked out for analysis. 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±2°C separately until a constant dry weight was recorded for two consecutive days. Dry matter accumulation in different parts of the plant was recorded. Total dry matter production was calculated by adding dry weight of leaves and stem and expressed in g per plant. Total number of the functional leaves obtained from the plant sampled for dry matter studies were graded into three sizes (small, medium and large) and representative leaf from each category was taken for measurement with the help of Leaf area meter. The total leaf area of individual category multiplied by the total number of leaves in that category gave the total leaf area. Plants from net plot area were harvested and used for recording yield parameters. Herbage was harvested and its fresh weight was recorded immediately. The herbage yield was computed in t/ha.

Statistical analysis

All the data were subjected to statistical analysis by using the technique analysis of variance (ANOVA) to test the significance of the overall differences among treatments by the 'F' test. When the 'F' value was found to be significant, the critical difference (CD) at *p=0.05* was computed to test the significance of the difference between the two treatment means (Gomez and Gomez 1984). However, the data of oil content and oil yield were not subjected to statistical analysis.

3. Results and Discussion

The results obtained during the course of investigation on different characters *viz.* growth parameters, yield and yield attributes of *Pogostemon* as influenced by various levels of Nitrogen with different spacing's.

Plant height

The *Pogostemon* plant height (cm/plant) measured at different days after planting (DAP) was significantly influenced with different level of nitrogen and spacing during 30, 45, 60, 75 DAP and at harvest, whereas, remainunaffected on 90 DAP (Table 1).

Table 1. Plant height as influenced by different N-levels and Spacing

Treatments	**Plant height (cm)**					
	30 DAP	**45 DAP**	**60 DAP**	**75 DAP**	**90 DAP**	**Harvest**
N_1S_1	29.23	41.29	61.47	72.54	83.05	102.92
N_1S_2	30.09	41.44	62.51	75.50	84.76	115.45
N_1S_3	30.38	42.19	60.55	76.36	82.78	104.96
N_2S_1	32.16	46.47	62.02	74.14	81.77	104.03
N_2S_2	30.20	43.27	61.92	71.00	84.72	96.97
N_2S_3	29.48	43.49	54.98	73.58	90.01	94.16
N_3S_1	32.68	54.38	64.73	73.58	84.77	97.46
N_3S_2	30.12	42.39	65.92	76.59	92.35	118.03
N_3S_3	31.30	43.68	65.76	76.93	81.97	94.83
N_4S_1	30.42	44.06	62.05	75.00	83.37	93.47
N_4S_2	31.84	53.83	65.24	77.16	82.76	96.51
N_4S_3	30.29	51.90	66.14	76.86	71.31	108.46
SEm±	0.51	0.69	1.20	1.17	9.50	1.89
CD (*p=0.05*)	1.49	2.03	3.53	3.42	NS	5.55

The trend was similar during 30 and 45 DAP, the maximum (32.68 and 54.38cm) plant height was observed under treatment N_3S_1 which was significantly higher than N_1S_1, N_1S_2, N_1S_3, N_2S_2, N_2S_3, N_3S_2, N_4S_1 and N_4S_3 treatments during both 30 and 45 DAP and also N_2S_1 and N_3S_3 during 45 DAP. However, were at par with N_2S_1 and N_3S_3 treatments at 30 DAP and N_4S_2 treatment during both 30 and 45 DAP. At 60 DAP, the tallest (66.14 cm) plant height was obtained under treatment N_4S_3 which was statistically higher than rest of the treatments except N_3S_1, N_3S_2, N_3S_3 and N_4S_2. After 75 DAP, the highest (77.16 cm) plant height was retained under N_4S_2, which was statistically at par with other treatment combinations except N_1S_1, N_2S_2, N_2S_3 and N_3S_1. During final stage i.e. at harvest, the maximum (118.03 cm) plant height was recorded under N_3S_2, which was statistically significant than all the other treatments except N_1S_2. Similar results were also reported by others (Saha et al. 1992; Singh 1999; Singh and Rao 2009; Singh et al. 2002; Sumathi et al. 2012; Saha et al. 2014).

Number of leaves

The significant variation was also observed under number of leaves of *Pogostemon* during every observation taken at 30,45, 60, 75, 90 and finally at harvest (Table 2).Initially at 30 DAP, the maximum (22.33) number of leaves was recorded under N_3S_3, which was significantly higher than N_1S_1, N_1S_2, N_1S_3, N_2S_1 and N_4S_2, whereas at par with other treatments. Then at 45 DAP, the highest (35.33) number of leaves was observed under N_3S_2, which was statistically higher than every other treatment.During 60 DAP, more (58.00) number of leaves was developed under N_1S_1, which was significantly superior to other treatment combinations. Second highest (50.33)number of leaves were recorded under treatment N_3S_1.On 75 DAP, like in 60 DAP, the maximum (65.67) number of leaves was attained under N_1S_1, which was statistically higher than other treatments. Second highest (60.33) number of leaves were grown under N_4S_3. Whereas, differ with 60 DAP, the lowest (45.33) number of leaves was observed under N_1S_3, which was significantly lower than others except N_2S_1, N_2S_2 and N_4S_2 treatments. In 90 days after planting (DAP), the more (78.00) numbers of leaves were seen under N_1S_2, which was statistically higher than rest of the treatment combinations except N_1S_1. Consecutively, the second highest (70.67) numbers of leaves were observed under two treatments i.e. N_3S_3 and N_4S_1. Finally at harvest, the maximum (101.33) numbers of leaves were attained under treatment N_4S_1, which was statistically higher than all other treatment combinations. The second and third highest (96.00 and 89.33) number of leaves were developed under N_1S_1 and N_1S_2, respectively. These results are in accordance with the result of other researchers (Saha et al. 1992; Singh 1999; Singh and Rao 2009; Singh et al. 2002; Sumathi et al. 2012; Saha et al. 2014).

Number of Primary branches

The maximum (4.96) numbers of primary branches were attained under treatment N_4S_2, which was statistically higher than all other treatment combinations. Following this, the second highest (4.52) number of primary branches were grown with N_3S_3, which was at par with N_3S_2, N_4S_1 and N_4S_3 treatments only (Figure 1).The application of nitrogen under optimum plant spacing increased the number of primary branches also reported by several researchers (Saha et al. 1992; Singh 1999; Singh and Rao 2009; Singh et al. 2002; Sumathi et al. 2012; Saha et al. 2014).

Table 2. Number of leaves as influenced by different N- levels and Spacing

Treatments	**Number of leaves**					
	30 DAP	**45 DAP**	**60 DAP**	**75 DAP**	**90 DAP**	**Harvest**
N_1S_1	15.33	30.33	58.00	65.67	74.00	96.00
N_1S_2	17.33	24.67	43.33	56.00	78.00	89.33
N_1S_3	16.67	28.33	36.67	45.33	52.33	70.67
N_2S_1	17.33	23.67	33.67	46.33	55.67	71.67
N_2S_2	20.67	27.00	40.33	47.33	56.67	64.33
N_2S_3	18.67	31.33	47.00	55.00	68.33	77.67
N_3S_1	21.33	33.00	50.33	60.00	66.33	75.33
N_3S_2	20.33	35.33	49.33	57.67	69.33	80.33
N_3S_3	22.33	34.33	46.67	54.33	70.67	81.00
N_4S_1	20.33	33.67	48.67	59.67	70.67	101.33
N_4S_2	16.33	29.33	37.67	49.00	59.67	72.67
N_4S_3	21.00	29.67	44.33	60.33	68.33	86.33
SEm±	1.31	1.38	1.78	1.80	1.44	1.44
CD ($p=0.05$)	3.84	4.06	5.22	5.27	4.21	4.21

Figure 1. Number of primary branches as influenced by different N-levels and Spacing.

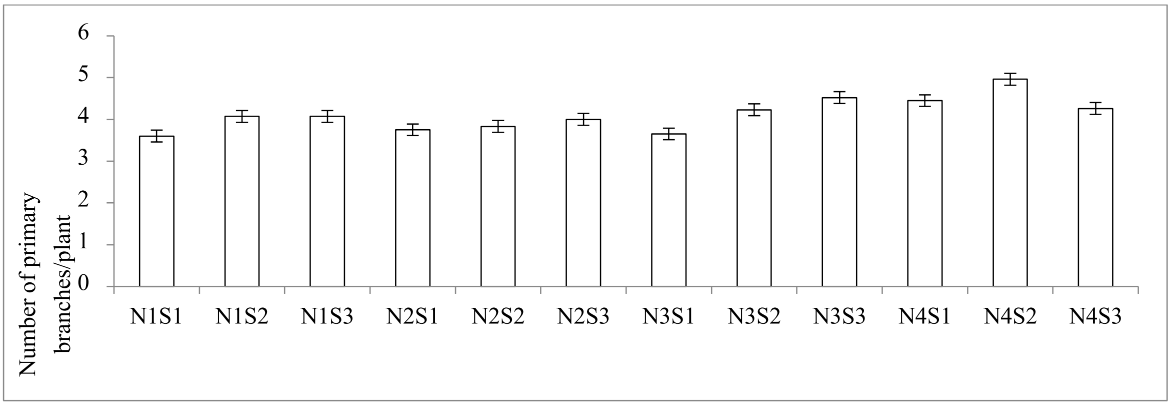


Figure 2. Plant spread as influenced by different N-levels and Spacing

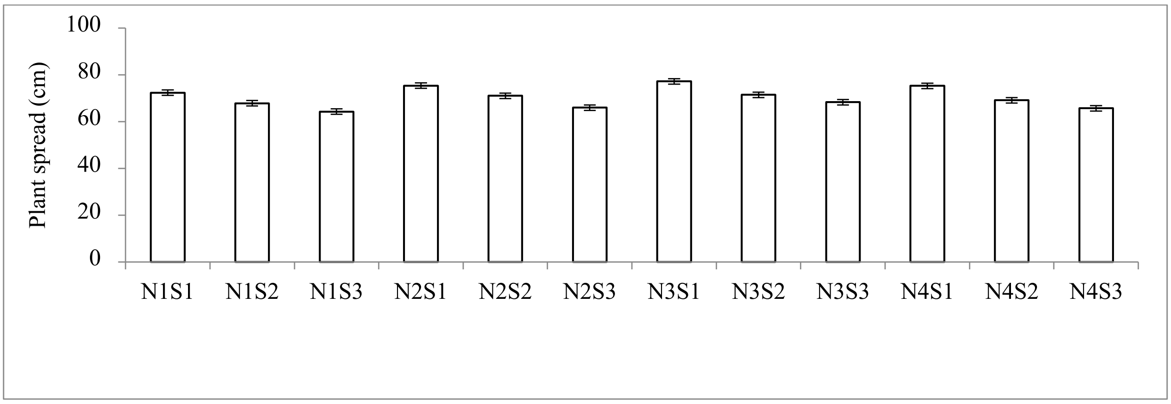


Figure 3. Dry matter accumulation as influenced by different N-levels and Spacing

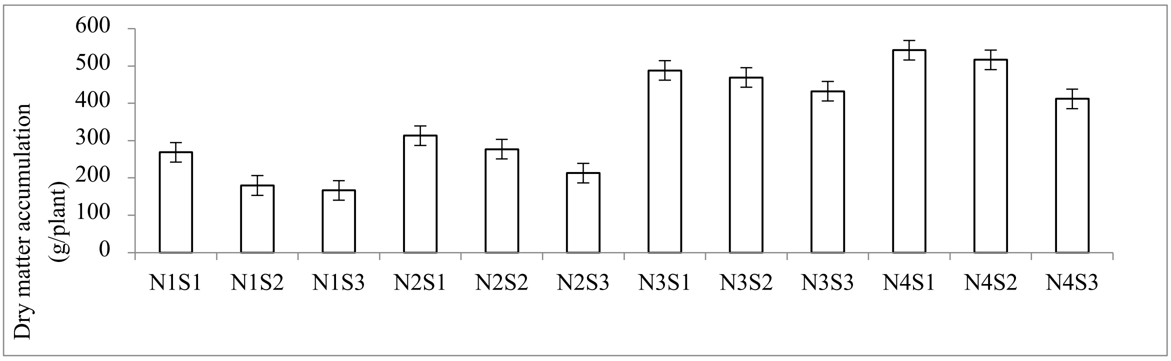
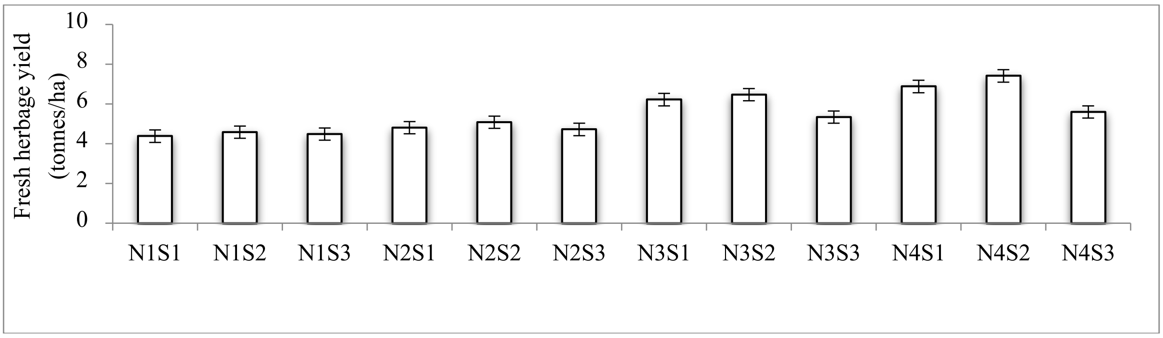


Figure 4. Fresh herbage yield influenced by different N-levels and Spacing



Plant spread

The maximum (77.22 cm) plant spread was observed under N_3S_1, which was statistically influenced with rest of the treatments but, was at par with N_2S_1 and N_4S_1 (Figure 1). Whereas, second highest (71.04cm) plant spread was recorded under treatment combination N_2S_2 (Saha et al., 1992, Singh 1999, Singh and Rao 2009, Singh et al. 2002, Sumathi et al. 2012, Saha et al. 2014).

Dry matter accumulation

The maximum (542.33 g/plant) dry matter accumulation was retained under N_4S_1, which was significantly influenced with other treatment combinations except N_4S_2. Second highest (487.67 g/plant) dry matter accumulation was observed under N_3S_1 (Saha et al. 2014). While, the minimum (166.67 g/plant) dry matter was accumulated with N_1S_3 (Figure 3). Dry matter accumulation increased with appropriate nutrient supply under optimum planting spacing (Saha et al. 1992, Singh 1999, Singh and Rao 2009, Singh et al. 2002, Sumathi et al. 2012, Saha et al. 2014)

Fresh herbage yield

With significant variation, the maximum (7.41 t ha^{-1}) fresh herbage yield was recorded with N_4S_2, which was significantly higher than rest of the treatments except N_4S_1 (Saha et al. 2014). The second highest (6.47 t ha^{-1}) fresh herbage yield was attained with N_3S_2. Whereas, the minimum (4.38 t ha^{-1}) fresh herbage yield was observed under N_1S_1, which was statistically inferior/ lesser than N_3S_1, N_3S_2, N_4S_1 and N_4S_2 but was at par with other treatments (Figure 4). These results have shown close conformity with findings of several other researchers (Saha et al. 1992; Singh 1999; Singh and Rao 2009; Singh et al. 2002; Sumathi et al. 2012; Saha et al. 2014).

Conclusion

Based on the above discussion it may be concluded that the application of 140 kg N/ha under square planting (50×50 cm spacing) favoured most for higher growth and fresh herbage yields patchouli under humid sub-tropical climate of Tripura.

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