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Influence of nitrogen and nitrogen carrier on herbage, oil yield and nitrogen uptake of patchouli [*Pogostemon cablin* (Blanco) Benth.] in semi-arid tropical condition

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Abstract

A field experiment was conducted at Bangalore (Karnataka) in a semi-arid tropical climate of South India to study the influence of two nitrogen levels (100 and 200 kg N ha^{-1}) and three nitrogen carriers (prilled urea, ammonium sulphate and dicyandiamide (DCD)-coated urea) on herbage, oil yield, nitrogen uptake and oil quality of patchouli [*Pogostemon cablin* (Blanco.) Benth.] grown on red sandy loam soil. Nitrogen @ 200 kg ha^{-1} and DCD-coated urea produced maximum herbage, oil yield, nitrogen uptake and benefit : cost ratio. The oil content varied from 2.48% to 2.60% and was not influenced by nitrogen level and carrier.

Keywords : nitrogen carrier, nitrogen uptake, oil yield, patchouli, *Pogostemon cablin*.

Introduction

Patchouli (*Pogostemon cablin* (Blanco) Benth.), is grown mainly in Karnataka, coastal Tamil Nadu, Assam and Maharastra in India. Steam distillation of its leaves yield an essential oil called patchouli oil. The crop normally responds to application of nitrogen fertilizer (Singh 1999a; Singh *et al.* 2002; Bhaskar 1995) and thrives under irrigated conditions. Generally, the apparent recovery is <30% of applied nitrogen in aromatic crops such as geranium (Rao *et al.* 1988), which may be due to leaching losses of nitrogen owing to the light texture of the soil and frequent irrigation. In such situations, use of nitrification inhibitors was suggested (Rao & Puttanna 1987; Rao *et al.* 1990). In patchouli, no information on use of nitrification inhibitors and very little information is available on nitrogen uptake pattern (Puttanna *et al.* 2005). There is also paucity of information on the influence of nitrogen and N carriers on patchouli. Therefore, field experiments were conducted to study the influence of nitrogen and N carrier on herbage, oil yield, nitrogen uptake, nitrogen utilization efficiency and quality of patchouli.

Materials and methods

The field experiments were conducted for 3 years (2002–05) in an irrigated red sandy loam (*Alfisols*) soil at the Research Farm of Central Institute of Medicinal and Aromatic Plants, Resource Centre Farm, Bangalore. The soil (0–30 cm) characteristics were : pH 6.2 and organic carbon 0.35%–0.38%. The soil had 190–210 kg ha^{-1} available N, 11.5–13.7 kg ha^{-1} available P and 95–100 kg ha^{-1}

exchangeable K and a bulk density of 1.5 g cc^{-1}. The water holding capacity of the soil was 15.6% at -0.3 Mpa and 6.5% at -1.5 Mpa. The water table of the experimental plot was below 20 m depth and therefore, had no effect on water supply to the root zone of the crop.

The treatments, with two nitrogen levels (100 and 200 kg ha^{-1}) and three N carriers (prilled urea, dicyandiamide (DCD) - coated urea (20% N) and ammonium sulphate), and a control (no fertilizer), were arranged in a randomized block design with three replications.

Forty-five day old rooted cuttings of patchouli cv. Johore were planted in flat beds with a spacing of 50 cm x 45 cm on 16 August 2002, 14 August 2003 and 10 August 2004. At planting, uniform rates of fertilizer application of 17.5 kg P_2O_5 ha^{-1} and 35.7 kg K_2O ha^{-1} were applied as basal dose. Nitrogen was applied in four equal splits at 60 day intervals in the form of urea/ammonium sulphate. DCD was mixed with urea at the rate of 20% N using castor oil (2%) as an adhesive. Superphosphate and muriate of potash were used to supply P and K, respectively. Two harvests each were taken during first (January 2003 and April 2003), second (January 2004 and May 2004) and third year (January 2005 and April 2005). The crop was harvested 20 cm above ground level and plot-wise fresh herbage yield was recorded from an area of 7.2 m^2. The oil content in the air dried herbage was estimated using Clevenger's apparatus.

The quality of the essential oil was determined by GLC on a Perkin Elmer 8500 Gas Chromatograph fitted with flame ionization detector and an electronic integrator, using a bonded phase fused silica capillary column (BP-1; 25 m x 0.25 mm id; film thickness - 0.22 mm). Column oven was heated from 120°C (3 min) to 230°C at 5°C min^{-1}. Injector and detector temperature were kept at 250°C and 300°C, respectively. Nitrogen content in the plant samples was estimated by Micro-Kjeldahl method (Novozamsky *et al.* 1974). Nitrogen utilization efficiency (NUE) for oil yield (unit of oil produced per unit of N uptake was also calculated (Moll *et al.* 1984). The experimental data were statistically analysed by analysis of variance technique, and the results were interpreted based on mean value of three years.

Results and discussion

Herbage and oil yields

The application of 200 kg N ha^{-1} produced significantly higher fresh herbage and oil yields than 0 and 100 kg N ha^{-1}. Herbage yield increased by 142.9% and 88.3% with application of 200 and 100 kg N ha^{-1} than control (no nitrogen). Similarly, oil yield increased by 156.3% and 91.0%, respectively (Table 1). These results are in agreement with those of Singh *et al.* (2002).

DCD-coated urea significantly increased the yields over prilled urea and ammonium sulphate. Herbage yield increased by 52.3% and 29.2% by DCD-coated urea and ammonium sulphate, compared with prilled urea. Similarly, oil yield increased by 63.8% and 28.5%, respectively. The conditions of the present experiments (light texture soil with low Cation Exchange Capacity (CEC) and frequent flood irrigation to the crop) might have resulted in leaching of nitrogen (Table 1). DCD-coated urea was reported to reduce leaching losses in *Mentha arvensis* (Ram *et al*. 1988) and geranium (Rao *et al.* 1990; Singh 1999b) and this might be the reason for the yield increase obtained with DCD.

Interaction effects of nitrogen x *N carrier*

Nitrogen rates and N carrier interaction effect was significant. Nitrogen @ 200 kg ha^{-1} along with DCD-coated prilled urea produced maximum herbage and oil yield of patchouli (Table 2).

Nitrogen uptake pattern and nitrogen utilization efficiency (NUE)

Application of 200 kg N ha^{-1} significantly increased the uptake of nitrogen compared with that of 100 and 0 kg N ha^{-1} (Table 3). Nitrogen uptake increased by 146.7% and 75.9% with application of 200 and 100 kg N

Table 1. Influence of nitrogen levels and N carriers on herbage, oil yield and oil content of patchouli

Treatment	Herbage yield (t ha^{-1})				Oil content (%)*			Oil yield (kg ha^{-1})			
	Year				Year			Year			
	1	2	3	Mean	1	2	3	1	2	3	Mean
N level (kg ha^{-1})											
100	12.87	11.84	7.73	10.81	2.52	2.60	2.55	67.03	66.80	47.40	60.41
200	14.97	13.45	13.42	13.95	2.50	2.61	2.54	77.96	75.88	89.38	81.07
SEd	0.70	0.54	0.66	-	0.11	0.12	0.11	3.64	3.05	5.38	-
CD (P=0.05)	1.66	1.15	1.44	-	NS	NS	NS	8.65	6.49	11.73	-
N carrier											
PU	12.82	10.14	6.23	9.73	2.45	2.59	2.55	66.77	57.21	38.30	54.09
$(NH_4)_2SO_4$	13.64	12.65	11.41	12.57	2.50	2.60	2.57	71.04	71.37	66.02	69.48
DCDCU	15.28	15.14	14.04	14.82	2.48	2.61	2.53	79.58	85.42	100.85	88.62
SEd	0.85	0.64	0.81	-	0.25	0.24	0.22	4.42	3.61	6.59	-
CD (P=0.05)	1.88	1.41	1.76	-	NS	NS	NS	9.79	7.95	14.36	-
Control	8.16	5.50	3.56	5.74	2.40	2.60	2.55	42.50	31.04	21.34	31.63
SEd	1.32	0.99	1.23	-	0.30	0.30	0.28	6.87	5.58	10.06	-
CD (P=0.05)	2.88	2.17	2.69	-	NS	NS	NS	15.00	12.24	21.94	-

Years 1, 2, 3 = 2002-03, 2003-04, 2004-05; PU=Prilled urea; $(NH_4)_2SO_4$ =Ammonium sulphate; DCDCU=Dicyandiamide coated urea; NS=Not significant; * Mean value of two harvests

Table 2. Interaction effects of nitrogen levels and N carriers on herbage and oil yield of patchouli (pooled data of 3 years)

N level (kg ha^{-1})	Herbage yield (t ha^{-1})			Oil yield (kg ha^{-1})		
	N carrier			N carrier		
	Urea	Ammonium sulphate	DCD-coated urea	Urea	Ammonium sulphate	DCD-coated urea
100	4.66	8.98	10.07	24.78	50.58	66.83
200	7.86	13.81	18.55	51.80	81.46	134.87
CD (P=0.05)	2.48			20.31		

DCD=Dicyandiamide

ha^{-1} than control (no nitrogen). DCD-coated urea increased the nitrogen uptake compared with ammonium sulphate and prilled urea. Nitrogen uptake increased by 45.9% and 11.2% with the DCD-coated urea and ammonium sulphate, respectively. The NUE varied from 1.07% to 1.64 % and was better in ammonium sulphate and DCD-coated urea than prilled urea (Table 3).

Oil content and quality were not influenced by nitrogen level and carrier (Tables 1 & 4). These results are similar to that reported earlier in patchouli (Singh *et al.* 2002). The benefit : cost ratio varied from 1.18 to 2.21 and was highest at nitrogen @ 200 kg ha^{-1} along with DCD-coated urea compared with other treatments (Table 5). The study indicated that patchouli can be grown with application of 200 kg N ha^{-1} along with DCD-coated urea in red sandy loam soils of semi-arid tropical climate to obtain maximum yield.

Table 3. Influence of nitrogen levels and N carriers on nitrogen uptake and nitrogen utilization efficiency in patchouli

Treatment	N uptake (kg ha^{-1})				Nitrogen utilization efficiency			
	Year				Year			
	2002–03	2003–04	2004–05	Mean	2002–03	2003–04	2004–05	Mean
N level (kg ha^{-1})								
100	44.42	40.86	26.68	37.32	1.51	1.63	1.78	1.64
200	56.82	50.16	50.04	52.34	1.37	1.51	1.79	1.56
SEd	3.45	2.95	3.48	-	0.06	0.07	0.08	-
CD (P=0.05)	7.52	6.42	7.60	-	0.15	N.S.	N.S.	-
N carrier								
PU	48.32	40.75	26.88	38.65	1.38	1.40	1.42	1.07
$(NH_4)_2SO_4$	50.00	42.00	36.98	42.99	1.42	1.70	1.79	1.64
DCDCU	59.73	58.22	51.21	56.40	1.33	1.47	1.97	1.59
SEd	4.10	3.95	4.27	-	0.08	0.09	0.10	-
CD (P=0.05)	8.93	8.60	9.31	-	N.S.	0.20	0.22	-
Control	28.75	21.50	13.41	21.22	1.48	1.44	1.59	1.50
SEd	7.85	7.50	6.62	-	0.12	0.13	0.15	-
CD (P=0.05)	17.11	16.34	14.42	-	N.S.	N.S.	N.S	-

PU=Prilled urea; $(NH_4)_2SO_4$ =Ammonium sulphate; DCDCU=Dicyandiamide coated urea; NS=Not significant

Table 4. Effect of nitrogen levels and N carriers on oil quality of patchouli (pooled data for 3 years)

Treatment	Patchouli alcohol (%)		a-Bulnesene (%)		Seychellene (%)		a-d-Patchoulene (%)		a-Guaiene (%)	
	Harvest number		Harvest number		Harvest number		Harvest number		Harvest number	
	1	2	1	2	1	2	1	2	1	2
N level (kg ha^{-1})										
100	43.5	39.6	12.6	15.6	11.2	4.7	4.9	3.3	4.3	10.3
200	44.3	37.7	12.8	15.1	11.3	4.6	4.3	3.2	4.2	10.0
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
N carrier										
PU	43.0	38.5	12.8	15.7	11.3	4.8	4.5	3.3	4.4	10.4
$(NH_4)_2SO_4$	44.6	41.2	12.7	15.1	11.3	4.6	4.6	3.1	3.9	9.9
DCDCU	44.2	36.4	12.6	15.4	11.3	4.6	4.6	3.2	4.4	10.2
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Control	42.1	38.6	12.7	15.9	11.0	4.9	4.9	3.3	4.5	10.7
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

PU=Prilled Urea; $(NH_4)_2SO_4$ =Ammonium sulphate; DCDCU=Dicyandiamide coated urea; NS=Not significant

Table 5. Influence of nitrogen levels and N carriers on cost of cultivation, mean oil yield, net return and benefit : cost ratio of patchouli

Treatment	Cost of cultivation ha^{-1} (Rs)	Mean oil yield ha^{-1} (kg)	Gross return ha^{-1} (Rs)	Net return ha^{-1} (Rs)	B : C ratio
N level (kg ha^{-1})					
100	41,465	60.41	1,02,697	61,232	1.48
200	42,930	81.07	1,37,819	94,889	2.21
N carrier					
PU	42,198	54.09	91,953	49,755	1.18
$(NH_4)_2SO_4$	45,000	69.48	1,18,116	73,116	1.62
DCDCU	50,000	88.62	1,50,654	1,00,654	2.01
Control	40,000	31.63	53,771	13,771	0.34

PU=Prilled urea; $(NH_4)_2SO_4$ =Ammonium sulphate; DCDCU=Dicyandiamide coated urea; Patchouli oil price @ Rs 1700.00 kg^{-1}; urea @ Rs 6.75 kg^{-1}; $(NH_4)_2SO_4$ @ Rs 8.00 kg^{-1} and DCD @ Rs 500.00 kg^{-1}

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