Standardization of crop geometry and major nutrients for enhancing the growth, yield and quality of davana under (*Artemisia pallens* Wall) *cv. Theni* under northern dry zone of Karnataka

ABSTRACT

The study was conducted on the effect of spacing and fertilizers on growth, quality and yield of *Artemisia pallens* Wall. *cv.* Theni in northern Karnataka (Zone III) for two consecutive years in *rabi* 2021 and 2022. The research was set out in a factorial RCBD and replicated thrice in nine treatment combinations, that is three levels of spacing (S_1: 15 x 7.5 cm, S_2: 20 x 10 cm and S_3: 30 x 10 cm) and three fertilizer levels (F_1: 60:30:20 N, P_2O_5, K_2O kg ha^{-1}, F_2: 90:30:30 N, P_2O_5, K_2O kg ha^{-1} and F_3: 120:40:40 N, P_2O_5, K_2O kg ha^{-1}). The pooled data of two years was statistically analysed using the Fisher's method of "Analysis of variance". Among the spacing levels, 20 x 10 cm spacing was noticed the maximum inflorescences $plant^{-1}$ (87.40), hundred flower weight (3.83 g), fresh herbage yield (11.29 t ha^{-1}), dry herbage yield (2.83 t ha^{-1}) & essential oil yield (13.23 kg ha^{-1}). Among various fertilizer doses application of F_3 (120:40:40 N, P_2O_5, K_2O kg ha^{-1}) was noticed economically feasible, it has obtained maximal growth and yield parameters. The highest fresh herb yield (12.78 t ha^{-1}), dry herbage yield (3.16 t ha^{-1}) and essential oil yield of (15.46 kg ha^{-1}) were noticed with 120:40:40 N, P_2O_5, K_2O kg ha^{-1} (F_3) application. Spacing of 20 x 10 cm (S_2) and application of 120:40:40 N N, P_2O_5, K_2O kg ha^{-1} (F_3) found to be economical with highest benefit cost ratio of 4.08.

Keywords: *Artemisia pallens* Wall., Davana, fertilizer, growth, spacing, yield

1. INTRODUCTION

The natural source of perfumes and fragrances are aromatic plants widely exploited by essential oil industries across the world. India ranks third with a proportion of roughly 16–17 per cent of the global essential oil production. Davana having diploid chromosome number of 2n=16 and it is a valuable Asteraceae family aromatic herb of India. The herb grows erect about 60 cm height with small yellow flowers and much divided leaves. The tomentum, a greyish white colour mass covers externally around the leaf and stem. Its cultivation is mainly intensive in Tamil Nadu, southern parts of Karnataka and to a meagrely in Andhra Pradesh, Kerala and Maharashtra. Davana oil has established a solid name for itself as a flavouring for cakes, pastries, cigarettes, beverages and also used in perfumery, cosmetic and pharmaceutical industries.

Davana oil is mainly composed of esters (65%), oxygenated molecules (15%) and hydrocarbons (20%). The distinctive odour of oil is caused by a novel sesquiterpene ketone named cis-davanone. High-end perfumery highly values this peculiar quality since it allows for the creation of scents with genuinely distinctive undertones. Davana is a winter-irrigated crop, the growth period between December to March is excellent. There is a significant opportunity to increase the area under cultivation in India where suitable soil and climate are present.

The micro environment in the field is decided by the one of crucial factor that is crop geometry. The higher yield in crop can be obtained by the optimization of crop geometry can lead to a higher yield in the crop favourably. Increased productivity and crop quality, as well as oil quality, are aided by optimal fertilization. Nitrogen is one of the most well-known elements in plants and it is a significant ingredient of protein molecules. Phosphorus is needed is greater quantities for immature cells like root tips and shoots. Increasing Potassium as a fertilizer has been demonstrated to boost reproductive yields and inflorescence production. felicitous nutrition and crop geometry are the most crucial factors for obtaining higher yields. Given the significance of these elements, the current study was carried out to investigate the influence of geometry and fertiliser levels on davana growth, yield and quality of davana.

2. MATERIAL AND METHODS

The current investigation was carried out for two consecutive years during during the *rabi* 2021 and 2022 at Department of Plantation, Spices, Medicinal and Aromatic Crops at College of Horticulture, Bagalkot. The research site was located at 74° 42’ East longitudes and 16° 10’ North latitude. Altitude of 542.0 m MSL. This domain comes under the Zone-III of Karnataka. The research was set out in a factorial RCBD and replicated thrice in nine treatment combinations, that is three levels of spacing (S_1: 15 x 7.5 cm, S_2: 20 x 10 cm and S_3: 30 x 10 cm) and three fertilizer levels (F_1: 60:30:20 N, P_2O_5, K_2O kg ha^{-1}, F_2: 90:30:30 N, P_2O_5, K_2O kg ha^{-1} and F_3: 120:40:40 N, P_2O_5, K_2O kg ha^{-1}). Six tonnes of Farm yard manure ha^{-1} applied at the time of land preparation. Three split dose of nitrogen was given in concerned treatments (10, 20 and 30 days after transplanting), phosphorus and potassium were given as basal dose at full doses. In each plot, five plants were chosen at random and tagged to record observations on growth and yield metrics. The pooled data of two years was statistically analysed using the Fisher's method of "Analysis of variance" (ANOVA), as proposed by Panse and Sukathme (1967). The F-test was run at a 5% level of significance.

3. RESULTS AND DISCUSSION:

3.1 Growth characters as influenced by the crop geometry and fertilizer levels in davana

The observations on number of branches $plant^{-1}$, stem girth, and plant height, at the time of harvest presented in Table 1. The plant spacing of S_1 (15 x 7.5 cm) at harvest recorded maximum (60.83 cm) plant height was recorded. The shorter plant height (53.76 cm) at harvest was recorded under S_3 (30 x 10 cm) spacing. The observed crop behaviour at closer spacing is similar with Damtew *et al*. (2011) findings, according to which Plant height is directly related to density of plant population. There was more intra and inter-plant competition for available light at higher densities. As a result, plants redirected their resources to vertical growth in order to capture the available light. The maximum stem girth (1.32 cm) and number of branches $plant^{-1}$ (23.34) at harvest was recorded in planting geometry of 30 x 10 cm. The minimum no. of branches (21.67) and stem girth (1.26 cm) were recorded at 15 x 7.5 cm. The decreased plant population and increased spacing per unit area leads to a significant increase in stem girth and primary branches $plant^{-1}$, which could be related to the availability of larger area $plant^{-1}$, as it is understood that each plant planted at wider row spacing receives greater growth inputs while competing less. (Nath *et al*., 2008) and (Naruka *et al*., 2012) in ajwain.

Greater number of branches plant^{-1} (25.10), maximum stem girth (1.39 cm) and plant height (60.03 cm) at harvest were observed with an applying higher levels of fertilizer F_3 (120:40:40 N, P_2O_5, K_2O kg ha^{-1}) which proceeds surge in number of leaves, stem girth and plant height, which abet in attaining greater dry weight. It is well understood that nitrogen promotes vegetative development, which rises with increasing nitrogen levels, resulting in luxuriant plant growth, as seen by a greater number of branches and stem girth. (Senthil *et al.,* 2009) and (Nath *et al*., 2008) and (Naruka *et al*., 2012).

Table 1. Plant height (cm), Number of branches per plant and stem girth of pooled data of davana as influenced by different levels of spacing and fertilizer (Mean of 2 years)

Spacing/ Fertilizer	Plant height (cm)				Number of branches at harvest				Stem girth at harvest (cm)			
	S1	S2	S3	Mean	S1	S2	S3	Mean	S1	S2	S3	Mean
F1	58.00	54.50	51.50	54.67	19.13	20.06	21.08	20.09	1.19	1.24	1.25	1.23
F2	61.00	57.75	53.79	57.52	21.68	22.36	22.89	22.31	1.22	1.28	1.31	1.27
F3	63.50	60.60	56.00	60.03	24.20	25.06	26.05	25.10	1.38	1.38	1.41	1.39
Mean	60.83	57.62	53.76		21.67	22.49	23.34		1.26	1.30	1.32	
For comparing means of	**S. Em.±**		**CD at 5%**		**S. Em.±**		**CD at 5%**		**S. Em.±**		**CD at 5%**	
Spacing	0.12		0.36		0.07		0.20		0.01		0.04	
Fertilizer	0.12		0.36		0.07		0.20		0.01		0.04	
S×F	0.21		0.62		0.12		0.35		0.03		0.08	

F_1-60:30:20 N, P_2O_5, K_2O kg ha^{-1} F_2-90:30:30 N, P_2O_5, K_2O kg ha^{-1} F_3-120:40: 40 N, P_2O_5, K_2O kg ha^{-1} S_1- 15 X 7.5 cm S_2 - 20 X 10 cm S_3 - 30 X 10 cm

3.2 Yield characters as influenced by the crop geometry and fertilizer levels in davana

The observations on hundred flower weight, number of inflorescences plant^{-1}, and flower head to biomass ratio showed significant differences at different levels of spacing

(Table 2). The maximal hundred flower weight and number of inflorescences plant^{-1} (3.83 and 87.40 g respectively) were obtained at 20 x 10 cm spacing. The minimal hundred flower weight and number of inflorescences plant^{-1} (3.53 and 84.71g respectively) recorded at S_1 (15 x 7.5 cm). The maximum flower head to biomass ratio (0.64) fallowed by S_2 (20 x 10 cm) *i.e.,* 0.62 and the minimum flower head to biomass ratio (0.59) were observed under spacing of 30 x 10 cm. This was because under wider planting geometry, there was adequate supply of moisture and nutrients resulted in sufficient vegetative growth like a greater number of branches, more canopy spread which ultimately led to a greater number of inflorescences plant^{-1}, with maximum hundred flower weight and minimum flower head to biomass ratio. Closer spacing may reduce number of flower heads plant^{-1} which also resulted in lower yield. Similar results were noticed in Narayanappa (2004) in davana, Kumar *et al*. (2020) in chia.

The number of inflorescences plant^{-1}, hundred flower weight and flower head to biomass ratio showed significant differences at different levels of fertilizer (Table 2). The maximum (96.51) number of inflorescences plant^{-1}, maximum (4.12g) hundred flower weight and minimum (0.58) flower head to biomass ratio was recorded at F_3 (120:40:40 N, P_2O_5, K_2O kg ha^{-1}). The minimal (76.08) number of inflorescences plant^{-1}, minimum (3.30g) hundred flower weight and maximum (0.65) flower head to biomass ratio was noticed in 60:30:20 N, P_2O_5, K_2O kg ha^{-1} (F_1). This might be due to the efficient translocation of carbohydrates, their conversion and efficient utilization of NPK, which lead to an increase in reproductive parameters. Higher dose of fertilizer lead to raise in leaf number, leads to greater the herbage yield of davana. (Rao and Singh, 1982).

Davana dry herbage yield, essential oil output, and fresh herbage yield all showed substantial variance. (Table 3). The maximum fresh herbage yield (11.29 t ha^{-1}) and dry herbage yield (2.83 t ha^{-1}) was observed at a spacing of 20 x 10 cm. The minimum fresh herbage yield (10.04 t ha^{-1}) and dry herbage yield (2.50 t ha^{-1}). was recorded at a spacing of 30 x 10 cm. Maximum fresh herbage yield, dry herbage yield and oil yield was observed at medium spacing of S_2 than wider spacing (S_3) and closer spacing (S_1) because plants utilised resources to the greatest extent possible at the optimum plant density, which aids in plant establishment. As a result, selecting the appropriate plant density removes constraints on the utilisation of available resources to achieve optimal output. (Rao *et al.,* 1983) in davana and (Arslan *et al.,* 2012) in micromeria.

Table 2. Number of inflorescences per plant, hundred flower weight and flower head to biomass of pooled data of davana as influenced by different levels of spacing and fertilizer (Mean of 2 years)

Spacing/ Fertilizer	No. of inflorescence plant-1				Hundred flower weight (g)				Flower head: Biomass			
	S1	S2	S3	Mean	S1	S2	S3	Mean	S1	S2	S3	Mean
F1	75.05	77.01	76.17	76.08	3.21	3.38	3.30	3.30	0.66	0.65	0.63	0.65
F2	84.07	87.10	86.25	85.81	3.51	3.81	3.59	3.63	0.64	0.63	0.60	0.62
F3	95.00	98.09	96.43	96.51	3.88	4.30	4.18	4.12	0.61	0.58	0.55	0.58
Mean	84.71	87.40	86.28		3.53	3.83	3.69		0.64	0.62	0.59	
For comparing means of	S. Em.±		CD at 5%		S. Em.±		CD at 5%		S. Em.±		CD at 5%	
Spacing	0.13		0.39		0.02		0.07		0.003		0.008	
Fertilizer	0.13		0.39		0.02		0.07		0.003		0.008	
S×F	0.23		0.68		0.04		0.13		0.005		0.014	

F_1-60:30:20 N, P_2O_5, K_2O kg ha^{-1} F_2-90:30:30 N, P_2O_5, K_2O kg ha^{-1} F_3-120:40: 40 N, P_2O_5, K_2O kg ha^{-1} S_1- 15 X 7.5 cm S_2 - 20 X 10 cm S_3 - 30 X 10 cm

Remarkable variation was noticed due to the influence of fertilizers on dry herb yield, fresh herb yield, and oil yield of davana (Table 4). The highest dry herbage yield (3.16 t ha^{-1}) and fresh herb yield (12.78 t ha^{-1}) were observed in 120:40:40 N, P_2O_5, K_2O kg ha^{-1} (F_3) and a lower dry herbage yield (2.25 t ha^{-1}) and yield of fresh herb (9.02 t ha^{-1}) were observed in were observed in 60:30:20 N, P_2O_5, K_2O kg ha^{-1} (F_1). It is due to as an outcome of greater levels of NPK. might be ascribe to a superior nutritional environment in both the root zone and the plant system. Potassium is defined as a quality enhancement factor in crop production, improving nitrogen utilisation, protein synthesis, weight, and oil content indirectly. The marked enhancement in yield and quality characters due to NPK. (Rao *et al.,*1983), (Krishnamoorthy *et al.*, 2000), and Naruka *et al*. (2012).

Table 3. Fresh herbage yield ha^{-1} (t) and Dry herbage yield ha^{-1} (t) of pooled data of davana as influenced by different levels of spacing and fertilizer (Mean of 2 years)

Spacing/ Fertilizer	Fresh herbage yield ha^{-1} (t)				Dry herbage yield ha^{-1} (t)			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
F_1	9.04	9.51	8.50	9.02	2.26	2.36	2.13	2.25
F_2	10.20	11.08	9.58	10.29	2.55	2.77	2.40	2.57
F_3	13.02	13.28	12.04	12.78	3.14	3.36	2.99	3.16
Mean	10.75	11.29	10.04		2.65	2.83	2.50	
For comparing means of	S. Em.±		CD at 5%		S. Em.±		CD at 5%	
Spacing	0.06		0.19		0.01		0.04	
Fertilizer	0.06		0.19		0.01		0.04	
S×F	0.11		0.32		0.02		0.07	

F_1-60:30:20 N, P_2O_5, K_2O kg ha^{-1} F_2-90:30:30 N, P_2O_5, K_2O kg ha^{-1} F_3-120:40: 40 N, P_2O_5, K_2O kg ha^{-1} S_1- 15 X 7.5 cm S_2 - 20 X 10 cm S_3 - 30 X 10 cm

There was considerably non-significant difference with different levels of spacing with respect to essential oil content. Significantly varied in oil yield ha^{-1} with different levels of spacing. The highest oil yield (13.23 kg ha^{-1}) was noticed spacing of 20 x 10 cm (S_2) followed by S_1 (15 x 7.5) *i.e.,* 12.30 kg ha^{-1}. The lower essential oil yield (11.60 kg ha^{-1}) was recorded in S_3 (30 x 10 cm). The maximal oil yield was acquired at a spacing of 20 x 10 cm (S_2) due presence of optimum plant population results in better availability of inputs like sunlight, soil moisture and nutrients which results in higher herbage yield which ultimately leads to higher essential oil yield. (Rao *et al*., 1983) in davana, Arslan (2012) in Micromeria.

The results showed that raising fertilizer levels considerably enhanced essential oil content and production. The peak value for essential oil (0.13 %) content and essential oil yield (15.46 kg ha^{-1}) was noticed in plants supplied with 120:40:40 N, P_2O_5, K_2O kg ha^{-1} (F_3) fertilizer compared to F_2 and F_1 (Table 4). It is due to as a outcome of greater levels of NPK. might be ascribe to a superior nutritional environment in both the root zone and the plant system. Potassium is defined as a quality enhancement factor in crop production, improving nitrogen utilisation, protein synthesis, weight, and oil content indirectly. The marked enhancement in yield and quality characters due to NPK. (Rao *et al.,*1983), (Krishnamoorthy *et al*., 2000), and Naruka *et al*. (2012).

Table 4. Essential oil content (%) and oil yield (kg ha^{-1}) of pooled data of davana as influenced by different levels of spacing and fertilizer (Mean of 2 years)

Spacing/ Fertilizer	Essential oil content (%)				Essential oil yield (kg ha^{-1})			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
F_1	0.10	0.11	0.10	0.10	9.04	10.46	8.50	9.33
F_2	0.12	0.12	0.13	0.12	12.24	13.30	11.50	12.34
F_3	0.13	0.14	0.12	0.13	15.62	15.94	14.81	15.46
Mean	0.12	0.12	0.12		12.30	13.23	11.60	
For comparing means of	**S. Em.±**		**CD at 5%**		**S. Em.±**		**CD at 5%**	
Spacing	0.00		NS		0.02		0.06	
Fertilizer	0.00		0.01		0.02		0.06	
S×F	0.00		NS		0.03		0.10	

F_1-60:30:20 N, P_2O_5, K_2O kg ha^{-1} F_2-90:30:30 N, P_2O_5, K_2O kg ha^{-1} F_3-120:40: 40 N, P_2O_5, K_2O kg ha^{-1} S_1- 15 X 7.5 cm S_2 - 20 X 10 cm S_3 - 30 X 10 cm

The data indicated, non-significant difference in the mixed effect of different spacing and fertilizers levels of for essential oil content (Table 4). The essential oil yield showed significant variation by the mixed effect of different spacing and fertilizers levels. The maximal essential oil yield (15.94 kg ha^{-1}) was recorded in treatment combination of S_2F_3 (20 x 10 cm + 120:40:40 N, P_2O_5, K_2O kg ha^{-1}) and it was *on par* with S_1F_1 (15 x 7.5 cm + 60:30:20 N, P_2O_5, K_2O kg ha^{-1}) *i.e.,* 15.62 kg ha^{-1}. The minimal essential oil yield (8.50 kg ha^{-1}) was recorded in S_3F_1 (30 x 10 cm + 60:30:20 N, P_2O_5, K_2O kg ha^{-1}). The higher oil yield was in medium spacing and higher fertilizer application might be due to the influence of nitrogen and plant density. An increased dose of NPK promotes higher vegetative growth which ultimately gives higher oil yield. (Rao *et al*., 1983), (Ravindra *et al*., 1987) and (Rao *et al*., 1989) in davana.

Among interaction of spacing and fertilizer, the interaction of S_2F_3: 20 x 10 cm + 120:40:40 N, P_2O_5, K_2O kg ha^{-1} resulted in higher gross returns (Rs 199200.00 ha^{-1}), net returns (Rs 160002.00 ha^{-1}) and B:C ratio (4.08) in Table 5. Higher gross returns and net returns and B:C ratio was due to higher herbage yield attributed to the interaction of S_2F_3: 20 x 10 cm + 120:40:40 N, P_2O_5, K_2O kg ha^{-1}.

Table 5. Economics of cultivation of davana crop as influenced by different spacing and fertilizers levels

Spacing/ Fertilizer	Cost of cultivation (Rs ha^{-1})				Net income (Rs ha^{-1})				B:C ratio			
	S_1	**S_2**	**S_3**	**Mean**	**S_1**	**S_2**	**S_3**	**Mean**	**S_1**	**S_2**	**S_3**	**Mean**
F_1	36620.50	35120.50	34120.50	**35287.17**	98979.50	107529.50	93379.50	**99962.83**	2.70	3.06	2.74	**2.83**
F_2	37373.50	36873.50	35873.50	**36706.83**	115626.50	129326.50	107826.50	**117593.17**	3.09	3.51	3.01	**3.20**
F_3	39698.00	39198.00	38198.00	**39031.33**	155602.00	160002.00	142402.00	**152668.67**	3.92	4.08	3.73	**3.91**
Mean	**37897.33**	**37064.00**	**36064.00**		**123402.67**	**132286.00**	**114536.00**		**3.24**	**3.55**	**3.16**	

Herb price: 15 Rs kg^{-1}

F_1-60:30:20 N, P_2O_5, K_2O kg ha^{-1} F_2-90:30:30 N, P_2O_5, K_2O kg ha^{-1} $F_3$120:40: 40 N, P_2O_5, K_2O kg ha^{-1}

S_1- 15 X 7.5 cm S_2 - 20 X 10 cm S_3 - 30 X 10 cm

4. CONCLUSION:

Davana planted at 20 x 10 cm crop geometry with applying 120:40:40 N, P_2O_5, K_2O kg ha^{-1} (F_3) showed economically feasible because it obtained maximum number of inflorescence $plant^{-1}$, maximal fresh herbage yield, hundred flower weight, dry herbage yield and essential oil yield with highest benefit cost ratio of 4.08.

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