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Effect of planting dates and plant density on germination and seed yield parameters of ambrette (*Abelmoschus moschatus* Medic.)

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Abstract
An experiment was conducted to find out the effect of planting dates and plant density on germination parameters of *Abelmoschus moschatus.* The experiment was laid out in a split plot design with 16 treatments in *Kharif* replicated thrice. The treatments included four plant densities S_1 (50 × 20 cm), S_2 (50 × 50 cm), S_3 (60 × 40 cm) and S_4 (60 × 50 cm) at four dates of sowing in *Kharif i.e.*, D_1 (June 1st), D_2 (July 1st), D_3 (August 1st), D_4 (September 1st). The results indicated that D_1 + S_4 (T_4) recorded less number of days taken for sprouting (4.92 and 4.92 respectively) and maximum percentage of germination (77.85 and 74.29 respectively) and seed yield per plant (g) (28.72 and 27.89 respectively) as compared to other treatments.

Keywords: dates of sowing, planting densities, sprouting, germination percentage, seed yield, ambrette

1. Introduction
Medicinal and aromatic plants play a vital role in the medicine and perfumery industry. In India because of varied climatic conditions, more than 2000 species of medicinal and aromatic plants have been reported. The use of medicinal and aromatic plants and their products is as old as history. Due to harmful side effects associated with the use of synthetic drugs and antibiotics, there is good scope for these plants in Ayurvedic as well as Unani medicines. Among the several medicinal and aromatic plant species, Ambrette has a prominent place and is used in medicinal as well as in the perfumery industry. Ambrette (*Abelmoschus moschatus* Medic.) belonging to the family Malvaceae, is a close relative to okra, a popular vegetable crop. It is universally known as Ambrette and the oil extracted from the seed is called Ambrette oil. It is also known as Musk mallow. The crop is native to India and grows throughout the tropical regions. Sowing dates play an important role in germination, growth and seed yield in many crops. Elrasheed *et al*. (2014) [2] reported that seasonal variation affected oil content in mint. Available reports suggest that sowing dates play an important role in growth and pod formation in many crops. It is the need of the hour to test the planting dates, plant density is one of the most important agronomic practices that affect Ambrette seed production. Therefore, different dates of sowing and different plant densities on the germination and seed yield of Ambrette.

2. Material and Methods
The present investigation was carried out at the Medicinal & Aromatic Crop Research Station, Rajendranagar, Hyderabad during Kharif seasons of 2016. The experimental site is situated at an altitude of 530.38 meters above mean sea level and geographically lies at a latitude of 17°20’ N and a longitude of 78°25’ E. The experimental area was ploughed and harrowed. Weeds and stubbles were removed and brought to a fine tilth. The land was made into plots each measuring 5.0 × 4.0 m with an adjoining bund of 30 cm width and laid out as per the plan. The clods within the plot were crushed and levelled. The treatments were allocated to individual plots at random. Good quality bold seeds of Ambrette were obtained from Medicinal and Aromatic Research Station, Rajendranagar. The seeds were soaked in water for 24 hours. At the time of sowing, the seeds were dibbled at a depth of 2.5 cm. After the preparation of land and formation of plots, the recommended dose of fertilizers. During the initial stages of growth, irrigation was given at three to four days interval and once in eight to ten days at the later stages and it varied based on the weather and soil moisture conditions.

A total of three earthing up was done at 45 days interval to provide better anchorage to the plants. The harvesting stage of the pods was identified when the pods turned blackish and with the appearance of white strips on pods, the harvesting was done regularly at 6-7 days intervals before the pods split and shed the seeds. Seeds were separated and dried. The experiment was laid out in a split plot design with 16 treatments in *Kharif* replicated thrice. The treatments included four plant densities S_1 (50 × 20 cm), S_2 (50 × 50 cm), S_3 (60 × 40 cm) and S_4 (60 × 50 cm) at four dates of sowing in *Kharif i.e.*, D_1 (June 1^{st}), D_2 (July 1^{st}), D_3 (August 1^{st}), D_4 (September 1^{st}).

Treatment details

T_1	=	D_1S_1	- June 1^{st} and 50 × 20 cm
T_2	=	D_1S_2	- June 1^{st} and 50 × 50 cm
T_3	=	D_1S_3	- June 1^{st} and 60 × 40 cm
T_4	=	D_1S_4	- June 1^{st} and 60 × 50 cm
T_5	=	D_2S_1	- July 1^{st} and 50 × 20 cm
T_6	=	D_2S_2	- July 1^{st} and 50 × 50 cm
T_7	=	D_2S_3	- July 1^{st} and 60 × 40 cm
T_8	=	D_2S_4	- July 1^{st} and 60 × 50 cm
T_9	=	D_3S_1	- August 1^{st} and 50 × 20 cm
T_{10}	=	D_3S_2	- August 1^{st} and 50 × 50 cm
T_{11}	=	D_3S_3	- August 1^{st} and 60 × 40 cm
T_{12}	=	D_3S_4	- August 1^{st} and 60 × 50 cm
T_{13}	=	D_4S_1	- September 1^{st} and 50 × 20 cm
T_{14}	=	D_4S_2	- September 1^{st} and 50 × 50 cm
T_{15}	=	D_4S_3	- September 1^{st} and 60 × 40 cm
T_{16}	=	D_4S_4	- September 1^{st} and 60 × 50 cm

The number of days taken for the first initiation of sprouting was recorded. The number of days taken from sowing of seeds to initiation of germination for each plot was observed and recorded separately.
The germination percentage was recorded separately for each plot.

$$\text{Germination \%} = \frac{\text{Number of seeds germinated}}{\text{Total number of seeds sown}} \times 100 \qquad (1)$$

The statistical analysis of data was analyzed as per ANOVA outlined by Panse and Sukhatme (1985) [4].

3. Results and Discussion

The findings on planting dates, plant densities and their interaction had shown significant effect on germination and seed yield parameters in Ambrette. Non-significant differences were observed among the different dates of sowing, plant density and their interaction effect on this parameter.
Among the different dates of sowing, crop sown during D_1 (June 1^{st}) recorded the earliest germination (4.92 days) followed by D_2 (July 1^{st}) (5.17 days) and D_3 (August 1^{st}) (5.17 days), whereas more number of days taken for sprouting was observed with D_4 (September 1^{st}) sown crop (5.25 days). Among the different plant geometry evaluated, the lowest number of days taken for sprouting was observed with 60 × 50 cm spacing (4.92 days) followed by 60 × 40 cm (5.08 days) and 50 × 50 cm (5.17 days).
Among the interaction effect T_4 crop sown during June 1^{st} with spacing S_4 (60 × 50 cm) recorded the lowest number of days taken for sprouting (4.67 days) (Table 1).
Germination percentage was significantly influenced by different dates of sowing and plant density, whereas their interaction effect was shown to be non-significant.
Among the different dates of sowing, significantly maximum germination percentage (77.85) was recorded with crop sown during D_1 (June 1^{st}), followed by D_2 (July 1^{st}) (73.11) crop sown. The lowest germination percentage (67.32) was observed at D_4 (September 1^{st}) sown crop.
It was observed that among different plant geometries evaluated, significantly highest germination percentage (74.29) was recorded with plant geometry S_4 (60 × 50 cm), followed by S_3 (60 × 40 cm) (72.20), whereas S_1 (50 × 20 cm) recorded the lowest germination percentage (69.73) over the other plant geometries.
Regarding the interaction between different dates of sowing and plant density shown to be Non-significant, the germination percentage was maximum (81.75) with the application of T_4 crop sown during D_1 (June 1^{st}) with spacing S_4 (60 × 50 cm), followed by T_3 crop sown during D_1 (June 1^{st}) with spacing S_3 (60 × 40 cm) (77.88), T_2 crop sown during D_1 (June 1^{st}) with spacing S_2 (50 × 50 cm) (76.67), while the minimum was observed in T_{13} crop sown during D_4 (September 1^{st}) with spacing S_1 (50 × 20 cm) (65.22).
Seed yield per plant was significantly influenced by dates of sowing, plant density and their interaction is presented in Table 1.
Regarding the dates of sowing evaluated, significantly maximum seed yield per plant (28.72) was recorded with D_1 (June 1^{st}) sowing, followed by D_2 (July 1^{st}) sowing (26.84) and D_3 (August 1^{st}) sowing (22.50), whereas D_4 (September 1^{st}) sowing recorded minimum seed yield per plant (19.53).
Among the different plant geometries evaluated, significantly maximum seed yield per plant (27.89) was recorded with the plant geometry S_4 (60 × 50 cm), followed by S_3 (60 × 40 cm) (25.24). The minimum seed yield per plant (21.16) was recorded with plant geometry S_1 (50 × 20 cm).
Among the interaction effects between dates of sowing and plant density, maximum seed yield per plant (32.46) was observed with the application of T_4 (D_1 + S_4) June 1^{st} sown crop with spacing S_4 (60 × 50 cm), followed by T_8 (D_2 + S_4) July 1^{st} sown crop with spacing S_4 (60 × 50 cm) (30.77), T_3 (D_1 + S_3) June 1^{st} sown crop with spacing S_3 (60 × 40 cm) (29.91), T_7 (D_2 + S_3) July 1^{st} sown crop with spacing S_3 (60 × 40 cm) (27.91), T_2 (D_1 + S_2) June 1^{st} sown crop with spacing S_2 (50 × 50 cm) (27.51), T_{12} (D_3 + S_4) August 1^{st} sown crop with spacing S_4 (60 × 50 cm) (26.33) and T_6 (D_2 + S_2) July 1^{st} sown crop with spacing S_2 (50 × 50 cm) (25.75), while the minimum seed yield per plant (17.16) was recorded with T_{13} (D_4 + S_1) September 1^{st} sown crop with spacing S_1 (50 × 20 cm), followed by T_{14} (D_4 + S_2) September 1^{st} sown crop with spacing S_2 (50 × 50 cm) (18.82), T_9 (D_3 + S_1) August 1^{st} sown crop with spacing S_1 (50 × 20 cm) (19.53), T_{15} (D_4 + S_3) September 1^{st} sown crop with spacing S_3 (60 × 40 cm) (20.13) and T_{10} (D_3 + S_2) August 1^{st} sown crop with spacing S_2 (50 × 50 cm) (21.13).

Table 1: Effect of Dates of sowing and Plant density on number of days taken for sprouting, germination percentage and seed yield per plant (g) in Ambrette during *Kharif* 2016-17

	Number of days taken for sprouting				
Treatments	S_1	S2	S3	S4	Mean
D_1	5.00	5.00	5.00	4.67	4.92
D_2	5.33	5.33	5.00	5.00	5.17
D_3	5.67	5.00	5.00	5.00	5.17
D_4	5.33	5.33	5.33	5.00	5.25
Mean	5.33	5.17	5.08	4.92	
Factors	D	S	D×S	S×D	
S.Em±	0.09	0.13	0.25	0.27	
CD at 5%	NS	NS	NS	NS	
	Germination percentage				
D_1	75.11	76.67	77.88	81.75	77.85
D_2	71.56	71.85	73.43	75.58	73.11
D_3	67.00	67.58	69.68	70.51	68.70
D_4	65.22	66.92	67.81	69.33	67.32
Mean	69.73	70.75	72.20	74.29	
Factors	D	S	D×S	S×D	
S.Em±	0.61	0.99	1.82	1.98	
CD at 5%	2.12	2.89	NS	NS	
	Seed yield per plant (g)				
D_1	25.02	27.51	29.91	32.46	28.72
D_2	22.93	25.75	27.91	30.77	26.84
D_3	19.53	21.13	23.00	26.33	22.50
D_4	17.16	18.82	20.13	22.00	19.53
Mean	21.16	23.30	25.24	27.89	
Factors	D	S	D×S	S×D	
S.Em±	0.23	0.20	0.42	0.40	
CD at 5%	0.80	0.59	1.29	1.17	

Dates of sowings	**Spacings**
D_1- June 1st	S_1- 50×20 cm
D_2- July 1st	S_2- 50×50 cm
D_3- August 1st	S_3- 60×40 cm
D_4- September 1st	S_4- 60×50 cm

At higher populations, inter and intra-plant competition between source and sink for photosynthates increases. As florets develop after considerable vegetative growth, the extreme competition among vegetative bud and reproductive parts affects reproduction as a whole. More plant population per unit area increases respiration and decreases photosynthesis which leads to the decrease in the transfer of assimilates to seeds and consequently, seed yield loss. Similar results were reported by Ajay *et al.* (2016) [1] in Coriandrum and Krishnamoorthy *et al.* (2000) [3] in ajowan.

4. Conclusions
From the experiments, it can be concluded that results of this present investigation it may state that June sowing with wider spacing recorded minimum days for sprouting and maximum percentage of germination and seed yield per plant in Ambrette in Telangana region.

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