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Studies on effect of planting dates and plant density on seed yield contributing 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 yield 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 T_4 (D_1 + S_4) recorded a significantly maximum pod length (9.15), maximum pod diameter (2.81), number of seeds per pod (102.31), seed weight per pod (1.25) and test weight (1.51) over other treatments, T_1 (D_1 + S_1) June 1st sown crop with spacing S_1 (50 cm) recorded maximum seed yield per hectare (25.05) (q) whereas T_{13} (D_4 + S_1) recorded the minimum pod length (7.39), pod diameter (2.15), number of seeds per pod (87.25), seed weight per pod (0.97), test weight (1.23), as compared to the other treatments during *Kharif.*

Keywords: Ambrette, dates of sowing, planting densities, seed yield

1. Introduction
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. Medicinal and aromatic plants play a vital role in the medicine and perfumery industry. Sowing dates play an important role in 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, Telanagana during *Kharif* seasons of 2016. The experiment was laid out in a split plot design with 16 treatments replicated thrice. The trail was conducted with recommended dose of fertilizers (RDF) 100:50:50 kg NPK ha^{-1} and farm yard manure @ 10 t ha^{-1}. 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). Treatment comprised of T_1 = D_1S_1 (June 1st and 50 × 20 cm), T_2 = D_1S_2 (June 1st and 50 × 50 cm), T_3 = D_1S_3 (June 1st and 60 × 40 cm), T_4 = D_1S_4 (June 1st and 60 × 50 cm), T_5= D_2S_1 (July 1st and 50 × 20 cm), T_6 =D_2S_2 (July 1st and 50 × 50 cm), T_7 = D_2S_3 (July 1st and 60 × 40 cm), T_8 = D_2S_4 (July 1st and 60 × 50 cm), T_9= D_3S_1 (August 1st and 50 × 20 cm), T_{10} =D_3S_2 (August 1st and 50 × 50 cm), T_{11}= D_3S_3 (August 1st and 60 × 40 cm), T_{12} = D_3S_4 (August 1st and 60 × 50 cm), T_{13} = D_4S_1 (September 1st and 50 × 20 cm), T_{14} = D_4S_2 (September 1st and 50 × 50 cm), T_{15} = D_4S_3 (September 1st and 60 × 40 cm), T_{16} = D_4S_4 (September 1st and 60 × 50 cm). The observations on pod length, maximum pod diameter, number of seeds per pod, seed weight per pod, test weight and seed yield per hectare (q).

3. Results and Discussion

3.1 Pod length (cm)

The data enunciated on pod length was significantly influenced by dates of sowing, plant density and their interaction are presented in Table 1.

Regarding the dates of sowing evaluated, significantly maximum pod length (8.94) was recorded with D_1 (June 1st) sowing, followed by D_2 (July 1st) sowing (8.46), whereas D_4 (September 1st) sowing recorded minimum pod length (7.66).

Among the different plant geometries evaluated, significantly maximum pod length (8.50) was recorded with the plant geometry S_4 (60 × 50 cm), followed by S_3 (60 × 40 cm) (8.35). The minimum pod length (8.08) was recorded with plant geometry S_1 (50 × 20 cm).

Among the interaction effects between dates of sowing and plant density, maximum pod length (9.15) was observed with the application of T_4 (D_1 + S_4) June 1st sown crop with spacing S_4 (60 × 50 cm) and was at par with T_3 (D_1 + S_3) June 1st sown crop with spacing S_3 (60 × 40 cm) (9.06), followed by T_2 (D_1 + S_2) June 1st sown crop with spacing S_2 (50 × 50 cm) (8.86), while the minimum pod length (7.39) was recorded with T_{13} (D_4 + S_1) September 1st sown crop with spacing S_1 (50 × 20 cm), followed by T_{14} (D_4 + S_2) September 1st sown crop with spacing S_2 (50 × 50 cm) (7.57), T_{15} (D_4 + S_3) September 1st sown crop with spacing S_3 (60 × 40 cm) (7.77), T_{16} (D_4 + S_4) September 1st sown crop with spacing S_4 (60 × 50 cm) (7.91) and T_9 (D_3 + S_1) August 1st sown crop with spacing S_1 (50 × 20 cm) (7.99).

3.2 Pod diameter (cm)

The data pertaining to pod diameter (cm) as affected by the dates of sowing and plant density is tabulated in Table 1. The interaction effect was found non-significant.

The plants grown with D_1 (June 1st) sowing recorded significantly maximum Pod diameter (cm) (2.66), followed by D_2 (July 1st) sowing (2.45), whereas D_4 (September 1st) sowing recorded minimum Pod diameter (2.20).

Among the different plant densities evaluated, significantly maximum pod diameter was recorded (2.53) at S_4 (60 × 50 cm), followed by S_3 (60 × 40 cm) (2.44), while S_1 (50 × 20 cm) recorded significantly minimum pod diameter (2.31).

The results indicated that irrespective of different treatments, crop raised under wider spacing recorded maximum pod length and pod diameter. Significant improvement in pod length and pod diameter was due to an increase in higher availability of space, sunlight, water and nutrients as reported by Yadav *et al.* (2002) [10] in fennel. This response may be attributed to more intra row plant competition under closer spacing for moisture, space, nutrients, light and other environmental resources. This result was supported by Baurah (1997) [1], Randhawa and Pannu (1969) [7], Tai *et al*. (1968) [8] and Gupta *et al*. (1981) [3] in okra.

3.3 Number of seeds per pod

The data enunciated on the number of seeds per pod as affected by the dates of sowing and plant density is tabulated in Table 1. The interaction effect was found non-significant.

The plants grown with D_1 (June 1st) sowing recorded significantly maximum number of seeds per pod (99.49), followed by D_2 (July 1st) sowing (97.01), whereas D_4 (September 1st) sowing recorded a minimum number of seeds per pod (88.91).

Among the different plant densities evaluated, a significantly maximum number of seeds per pod were recorded (96.94) at S_4 (60 × 50 cm), followed by S_3 (60 × 40 cm) (95.76), while S_1 (50 × 20 cm) Significantly recorded a minimum number of seeds per pod (93.74).

The above results indicated that plant grown at wider spacing recorded more number of seeds per pod due to maximum pod length and pod diameter compared to plants grown in closer spacing. These findings are in close conformity of Randhawa and Pannu (1969) [7] in okra, Tai *et al*. (1968) [8] in okra.

3.4 Seed weight per pod (g)

The data pertaining to seed weight per pod as affected by the dates of sowing and plant density is tabulated in Table 2. The interaction effect was found non-significant.

The plants grown with D_1 (June 1st) sowing recorded significantly maximum seed weight per pod (1.23), followed by D_2 (July 1st) sowing (1.18), whereas D_4 (September 1st) sowing recorded minimum seed weight per pod (0.99).

Among the different plant densities evaluated, significantly maximum seed weight per pod recorded (1.16) at S_4 (60 × 50 cm) and was at par with S_3 (60 × 40 cm) (1.14), while S_1 (50 × 20 cm) recorded significantly minimum seed weight per pod (1.10).

The above results indicated that plant grown at wider spacing recorded maximum seed weight per pod due to the maximum number of seeds per pod compared to plants grown in closer spacing. These findings are in close conformity of Randhawa and Pannu (1969) [7] and Tai *et al.* (1968) [8] in okra.

3.5 Test weight

The data enunciated on test weight was significantly influenced by dates of sowing, plant density and their interaction is presented in Table 2.

Regarding the dates of sowing evaluated, the significantly highest test weight (1.44) was recorded with D_1 (June 1st) sowing, followed by D_2 (July 1st) sowing (1.37), whereas D_4 (September 1st) sowing recorded lowest test weight (1.27).

Among the different plant geometries evaluated, the significantly highest test weight (1.39) was recorded with the plant geometry S_4 (60 × 50 cm), followed by S_3 (60 × 40 cm) (1.36), while the lowest test weight (1.30) was recorded with plant geometry S_1 (50 × 20 cm).

Table 1: Effect of Dates of sowing and Plant density on Pod length (cm), Pod diameter (cm) and number of seeds per pod in Ambrette during *Kharif* 2016-17.

	Pod length (cm)				
Treatments	S_1	S_2	S_3	S_4	Mean
D_1	8.70	8.86	9.06	9.15	8.94
D_2	8.24	8.38	8.47	8.74	8.46
D_3	7.99	8.05	8.11	8.21	8.09
D_4	7.39	7.57	7.77	7.91	7.66
Mean	8.08	8.22	8.35	8.50	
Factors	D	S	D×S	S×D	
S.Em±	0.02	0.02	0.03	0.03	
CD at 5%	0.06	0.05	0.10	0.09	
	Pod diameter (cm)				
Treatments	S_1	S_2	S_3	S_4	Mean

D_1	2.53	2.60	2.71	2.81	2.66
D_2	2.34	2.39	2.48	2.57	2.45
D_3	2.23	2.27	2.35	2.45	2.33
D_4	2.15	2.17	2.21	2.26	2.20
Mean	2.31	2.36	2.44	2.53	
Factors	D	S	D×S	S×D	
S.Em±	0.01	0.01	0.03	0.03	
CD at 5%	0.04	0.04	NS	NS	
	Number of seeds per pod				
Treatments	S_1	S_2	S_3	S_4	Mean
D_1	97.25	98.17	100.24	102.31	99.49
D_2	95.92	96.74	97.31	98.06	97.01
D_3	94.55	94.87	95.97	96.72	95.53
D_4	87.25	88.18	89.53	90.68	88.91
Mean	93.74	94.49	95.76	96.94	
Factors	D	S	D×S	S×D	
S.Em±	0.23	0.28	0.54	0.56	
CD at 5%	0.80	0.82	NS	NS	
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		
NS – Non-significant					

Table 2: Effect of dates of sowing and plant density on seed weight per pod (g) test weight (100 seed weight in g) and seed yield per hectare (q) in Ambrette during *Kharif* 2016-17

	Seed weight per pod (g)				
Treatments	S_1	S_2	S_3	S_4	Mean
D_1	1.21	1.21	1.23	1.25	1.23
D_2	1.16	1.17	1.19	1.20	1.18
D_3	1.07	1.12	1.14	1.16	1.12
D_4	0.97	0.98	0.99	1.03	0.99
Mean	1.10	1.12	1.14	1.16	
Factors	D	S	D×S	S×D	
S.Em±	0.01	0.01	0.01	0.01	
CD at 5%	0.03	0.02	NS	NS	
	Test weight (100 seed weight in g)				
Treatments	S_1	S_2	S_3	S_4	Mean
D_1	1.35	1.44	1.47	1.51	1.44
D_2	1.32	1.32	1.38	1.45	1.37
D_3	1.29	1.30	1.31	1.31	1.31
D_4	1.23	1.26	1.28	1.30	1.27
Mean	1.30	1.33	1.36	1.39	
Factors	D	S	D×S	S×D	
S.Em±	0.00	0.01	0.01	0.01	
CD at 5%	0.01	0.02	0.03	0.03	
	Seed yield per hectare (q)				
Treatments	S_1	S_2	S_3	S_4	Mean
D_1	25.05	11.08	11.92	10.33	14.60
D_2	22.92	10.34	11.19	9.85	13.57
D_3	19.55	8.47	9.21	8.42	11.42
D_4	17.15	7.51	8.12	7.03	9.95
Mean	21.17	9.35	10.11	8.91	
Factors	D	S	D×S	S×D	
S.Em±	0.024	0.031	0.058	0.062	
CD at 5%	0.081	0.090	0.18	0.18	
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		
NS – Non-significant					

Among the interaction effects between dates of sowing and plant density, maximum test weight (1.51) was observed with the application of T_4 (D_1 + S_4) June 1st sown crop with spacing S_4 (60 × 50 cm), followed by T_3 (D_1 + S_3) June 1st sown crop with spacing S_3 (60 × 40 cm) (1.47) and was at par with T_8 (D_2 + S_4) July 1st sown crop with spacing S_4 (60 × 50 cm) (1.45) and T_2 (D_1 + S_2) June 1st sown crop with spacing S_2 (50 × 50 cm) (1.44), while the minimum test weight (1.23) was recorded with T_{13} (D_4 + S_1) September 1st sown crop with spacing S_1 (50 × 20 cm) and was at par with T_{14} (D_4 + S_2)

September 1st sown crop with spacing S_2 (50 × 50 cm) (1.26).

3.6 Seed yield per hectare (q)

Seed yield per hectare was significantly influenced by dates of sowing, plant density and their interaction are presented in Table 2.

Regarding the dates of sowing evaluated, significantly maximum seed yield per hectare (14.60) was recorded with D_1 (June 1st) sowing, followed by D_2 (July 1st) sowing (13.57) whereas D_4 (September 1st) sowing recorded minimum seed yield per hectare (9.95).

Among the different plant geometries evaluated, significantly maximum seed yield per hectare (21.17) was recorded with the plant geometry S_1 (50 × 20 cm), followed by S_3 (60 × 40 cm) (10.11). The minimum seed yield per hectare (8.91) was recorded with plant geometry S_4 (60 × 50 cm).

Among the interaction effects between dates of sowing and plant density, maximum seed yield per hectare (25.05) was observed with the application of T_1 (D_1 + S_1) June 1st sown crop with spacing S_1 (50 cm), followed by T_5 (D_2 + S_1) July 1st sown crop with spacing S_1 (50 × 20 cm) (22.92), while the minimum seed yield per hectare (7.03) was recorded with T_{16} (D_4 + S_4) September 1st sown crop with spacing S_4 (60 × 50 cm), followed by T_{14} (D_4 + S_2) September 1st sown crop with spacing S_2 (50 × 50 cm) (7.51), T_{15} (D_4 + S_3) September 1st sown crop with spacing S_3 (60 × 40 cm) (8.12), T_{12} (D_3 + S_4) August 1st sown crop with spacing S_4 (60 × 50 cm) (8.42) and T_{10} (D_3 + S_2) August 1st sown crop with spacing S_2 (50 × 50 cm) (8.47).

It is clear from the results that plant with closer spacing leads to more seed yield per hectare compared to the wider spacing that might be due to more plant population per unit area resulting in higher yield per hectare. These results were in close conformity with those of Naik and Singh (1999) [5], Tai *et al.* (1968) [8] in okra and Baurah (1997) in okra, Muvel *et al.* (2015) [4], Tripathi and Dwivedi (2009) [9] and Premnath *et al*. (2008) [6] in ajowan.

4. Conclusions

From the results of research experiment based on these findings it is concluded that the Ambrette seeds sown on June 1st sown crop with spacing S_4 (60 × 50 cm) recorded maximum values for pod length, maximum pod diameter, number of seeds per pod, seed weight per pod, test weight, June 1st sown crop with spacing S_1 (50 × 20 cm), recorded maximum seed yield per hectare (q) due to more plant population per unit area resulting in higher yield per hectare.

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