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Studies on the effect of fertilizer levels and plant densities on yield of Ambrette (*Abelmoschus moschatus* Medic.)

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Abstract
A field experiment was conducted at herbal garden, College of Horticulture, Dr. Y. S. R Horticultural University, Rajendranagar, Hyderabad during the year 2010-2011 on Studies on the effect of fertilizer levels and plant densities on growth and yield of Ambrette (*Abelmoschus moschatus* Medic.). The experiment was laid out in Split Plot Design with nine treatments and four replications. It consisted of three different spacings as one factor (50 × 30 cm, 50 × 40 cm, 50 × 50 cm) and three different fertilizer levels as another factor (75-50-40 NPK kg/ha, 100-50-50 NPK kg/ha, 125-50-60 NPK kg/ ha). The fertilizer level of N, P and K at 100: 50: 50 kg per ha recorded significantly maximum seed yield per ha (4.52 q/ha). Among the spacings 50 × 30 cm recorded maximum seed yield per ha (4.29 q/ha). Interaction between 50 × 30 cm spacing and fertilizer level of N, P and K at 100: 50: 50 kg per ha recorded significantly maximum seed yield per ha (5.44 q/ha).

Keywords: NPK, seed yield, oil yield, Ambrette, *Abelmoschus moschatus* Medic

1. Introduction
Ambrette (*Abelmoschus moschatus* Medic.) is used as a medicine and in perfumery industry. Ambrette popularly known as muskmallow yields scented seed possessing an aroma similar to that of musk (kasturi) obtained from the Musk-deer (*Moschatus moschifera*) and valued for its volatile oil. connected to other outer surface by stomium cells. The different grades of essential oil consisting mainly of macrocyclic lactone, ambrettolide and sesquiterpene alcohol, farnesol are isolated from the aromatic substances obtained from its seed (Hegde *et al*., 1994) [12]. The liquid ambrette oil of commerce blends excellently with many other oils including rose, neroli and sandalwood oil.
In medicines, seeds are used as a tonic, aphrodisiac, antispasmodic and carminative. They allay thirst, check vomiting and cure diseases like kapha and vata and are useful in healing intestinal disorders, stomatitis, dyspepsia, urinary discharge, nervous debility, hysteria, and skin diseases like itch and leucoderma and also valued as cardiotonic.

2. Materials and Methods
The present investigation was conducted at herbal garden, College of Horticulture, Dr. Y. S. R Horticultural University, Rajendranagar, Hyderabad during the year 2010-2011. The experiment was laid out in Split Plot Design with nine treatments and four replications. It consisted of spacing as one factor containing three different spacings of 50 × 30 cm, 50 × 40 cm and 50 × 50 cm. Fertilizer level was taken as another factor consisting of three different fertilizer levels of 75-50-40 NPK kg/ha, 100-50-50 NPK kg/ha and 125-50-60 NPK kg/ha. The total number of treatments comprise as 9 treatments laid out in 36 plots. The different treatments are T_1= 75 kg N + 50 kg P + 40 kg K and 50 × 30cm, T_2= 100 kg N + 50 kg P + 50 kg K and 50 × 30cm, T_3= 125 kg N + 50 kg P + 60 kg K and 50 × 30cm, T_4= 75 kg N + 50 kg P + 40 kg K and 50 × 40cm, T_5= 100 kg N + 50 kg P + 50 kg K and 50 × 40cm, T_6= 125 kg N + 50 kg P + 60 kg K and 50 × 40cm, T_7= 75 kg N + 50 kg P + 40 kg K and 50 × 50cm, T_8= 100 kg N + 50 kg P + 50 kg K and 50 × 50cm, T_9= 125 kg N + 50 kg P + 60 kg K and 50 × 50cm. Each plot is of 5 × 4 cm size and

laid as flat beds. After complete preparation of the experimental plots, seeds of ambrette were sown on August 25th, 2010 by dibbling method.

3. Results and Discussion

3.1 Number of pods per plant

Among different spacings, wider spacing of 50 × 50 cm produced significantly higher number of pods per plant (32.36) followed by 50 × 40 cm (30.93) and 50 × 30 cm (30.12). Among different fertilizers levels of N, P and K at 100: 50: 50 kg per ha produced the highest number of pods per plant (34.2) followed by N P and K at 125: 50: 60 kg per ha (31.09) and 75: 50: 40 kg per ha (28.11). Interactions of spacings and fertilizers did not show any significance with regard to number of pods per plant.

Table 1: Effect of spacings and fertilizer levels on number of pods per plant in ambrette

Treatments	Fertilizers			
Spacings	**F_1**	**F_2**	**F_3**	**Mean**
S_1	27.13	33.00	30.23	30.12
S_2	28.00	33.78	31.00	30.93
S_3	29.20	35.83	32.05	32.36
Mean	28.11	34.20	31.09	

Factors	S	F	S×F	F×S
S.Em±	0.262	0.416	0.644	0.454
C.D. (5%)	0.904	1.236	NS	NS

Spacings (cm)
S_1- 50×30
S_2- 50×40
S_3- 50×50

Fertilizer doses (kg ha^{-1})
F_1- 75- 50- 40
F_2- 100-50-50
F_3- 125-50-60

3.2 Pod length (cm)

Significantly maximum pod length (8.94) was recorded with wider spacing of 50 × 50 cm ambrette produced significantly longer pods (5.83 cm) followed by 50 × 40 cm (5.68 cm) and 50 × 30 cm (5.49 cm). Among the different fertilizer levels evaluated, significantly maximum pod length N, P and K at 100: 50: 50 kg K per ha produced significantly longer pods (5.85 cm) followed by N, P and K at 75: 50: 40 kg per ha (5.65 cm) and N, P and K at 125: 50: 60 kg per ha (5.51 cm). Among the interaction of spacings and fertilizers did not significantly influence the length of the pod.

Treatments	Fertilizers			
Spacings	**F_1**	**F_2**	**F_3**	**Mean**
S_1	5.53	5.61	5.36	5.49
S_2	5.61	5.89	5.53	5.68
S_3	5.81	6.06	5.63	5.83
Mean	5.65	5.85	5.51	

Factors	S	F	S×F	F×S
S.Em±	0.014	0.039	0.057	0.025
C.D. (5%)	0.049	0.116	NS	NS

Spacings (cm)
S_1- 50×30
S_2- 50×40
S_3- 50×50

Fertilizer doses (kg ha^{-1})
F_1- 75- 50- 40
F_2- 100-50-50
F_3- 125-50-60

3.3 Pod diameter (cm)

Among the different spacings, pod diameter at wider spacing of 50 × 50 cm significantly produced greater thickness, in terms of diameter of the pod (2.42 cm) followed by 50 × 40 cm (2.30 cm) and 50 × 30 cm (2.16 cm). Among the different fertilizer levels evaluated, significantly maximum N, P and K at 125: 50: 60 kg per ha (2.39 cm) produced significantly thicker pods followed by N, P and K at 100: 50: 50 kg K per ha (2.29 cm) and 75: 50: 40 kg per ha (2.12 cm). The interaction effect was found non-significant. 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.

Table 2: Effect of spacings and fertilizer levels on pod diameter (cm) in ambrette

Treatments	Fertilizers			
Spacings	**F_1**	**F_2**	**F_3**	**Mean**
S_1	2.05	2.14	2.28	2.16
S_2	2.21	2.29	2.41	2.30
S_3	2.34	2.44	2.49	2.42
Mean	2.2	2.29	2.39	

Factors	S	F	S×F	F×S
S.Em±	0.017	0.029	0.044	0.029
C.D. (5%)	0.058	0.086	NS	NS

Spacings (cm)
S_1- 50×30
S_2- 50×40
S_3- 50×50

Fertilizer doses (kg ha^{-1})
F_1- 75- 50- 40
F_2- 100-50-50
F_3- 125-50-60

3.4 Number of seeds per pod

Among different spacings, wider spacing of 50 × 50 cm produced significantly higher number of seeds per pod (92.60) followed by spacing of 50 × 30 cm (76.2) and 50 × 40 cm (76.12). Among different fertilizer levels, N, P and K at 125: 50: 60 kg per ha produced the highest number of seeds per pod (81.77) followed by N, P and K at 125: 50: 60 kg per ha (76.45) and 75: 50: 40 kg per ha (7.45). The interaction between spacings and fertilizer levels was found to be significant producing maximum number of seeds per pod (106) with the combination of 50 × 50 cm spacing and fertilizer level of N, P and K at 100: 50: 50 kg per ha.

Table 3: Effect of spacings and fertilizer levels on number of seeds per pod in ambrette

Treatments	Fertilizers			
Spacings	**F_1**	**F_2**	**F_3**	**Mean**
S_1	74.40	76.00	78.20	76.20
S_2	72.40	78.10	77.85	76.12
S_3	82.55	106.00	89.25	92.60
Mean	76.45	76.45	81.77	

Factors	S	F	S×F	F×S
S.Em±	2.753	1.646	3.606	4.769
C.D. (5%)	9.502	4.892	11.723	9.270

Spacings (cm)
S_1- 50×30
S_2- 50×40
S_3- 50×50

Fertilizer doses (kg ha^{-1})
F_1- 75- 50- 40
F_2- 100-50-50
F_3- 125-50-60

3.5 Seed weight per pod (g)

Spacings influenced the seed weight per pod. With increase in spacing there was an increase in the seed weight per pod. Significantly maximum seed weight per pod (1.133 g) was recorded with a spacing of 50 × 50 cm followed by 50 × 40 cm (1.09 g) and 50 × 30 cm (1.02 g). With the increasing levels of fertilizers there was an increase in seed weight per pod. Among fertilizer levels, significantly maximum seed weight per pod (1.13 g) was recorded with application of N, P and K at 125: 50: 60 kg per ha followed by 100: 50: 50 kg per ha (1.08 g) and 75: 50: 40 kg per ha (1.02 g). The interaction effects of spacings and fertilizer levels on seed weight per pod were found to be significant.

Table 4: Effect of spacings and fertilizer levels on seed weight per pod (g) in ambrette

Treatments	Fertilizers			
Spacings	F_1	F_2	F_3	Mean
S_1	0.91	1.06	1.07	1.02
S_2	1.06	1.08	1.12	1.09
S_3	1.09	1.11	1.20	1.13
Mean	1.02	1.08	1.13	

Factors	S	F	S×F	F×S
S.Em±	0.007	0.016	0.024	0.012
C.D. (5%)	0.024	0.047	NS	NS

Spacings (cm)
S_1- 50×30
S_2- 50×40
S_3- 50×50

Fertilizer doses (kg ha^{-1})
F_1- 75- 50- 40
F_2- 100-50-50
F_3- 125-50-60

3.6 Test weight

Among different spacings, test weight decreased with increase in spacing. Significantly highest test weight (1.42 g) was recorded with 50 × 50 cm spacing followed by 50 × 40 cm (1.39 g) and 50 × 30 cm (1.35 g). Among the different fertilizer levels of N, P and K at 125: 50: 60 kg per ha recorded significantly maximum test weight (1.41 g) followed by 100: 50: 50 kg per ha (1.39 g) and 75: 50: 40 kg per ha (1.36 g). The interaction effect of spacings and fertilizer levels did not show any significant effect on seed test weight.

Table 5: Effect of spacings and fertilizer levels on Test weight (100 seed weight in g) in ambrette

Treatments	**Fertilizers**			
Spacings	**F_1**	**F_2**	**F_3**	**Mean**
S_1	1.33	1.35	1.36	1.35
S_2	1.37	1.40	1.40	1.39
S_3	1.38	1.40	1.46	1.42
Mean	1.36	1.39	1.41	

Factors	**S**	**F**	**S×F**	**F×S**
S.Em±	0.010	0.011	0.019	0.017
C.D. (5%)	0.035	0.033	NS	NS

Spacings (cm)
S_1- 50×30
S_2- 50×40
S_3- 50×50

Fertilizer doses (kg ha^{-1})
F_1- 75- 50- 40
F_2- 100-50-50
F_3- 125-50-60

3.7 Seed yield per hectare (q)

Among different spacings, 50 × 30 cm produced significantly high seed yield per ha recording 4.29 q followed by 50 × 40 cm (3.66 q) and 50 × 50 cm (3.57 q). By virtue of high plant density in closer spacing might have facilitated to record maximum yield at higher plant density. The fertilizer levels of N, P and K at 100: 50: 50 kg per ha maximized the production to the tune of 4.52 q per ha followed by application of fertilizers at 125: 50: 60 kg per ha (3.64 q) and 75: 50: 50 kg per ha (3.36 q). The interactions of plant spacings and fertilizer levels also produced significant difference on seed yield per hectare. The maximum seed yield per hectare (5.43 q) was obtained with the combination of fertilizer levels of N, P and K at 100: 50: 50 kg per ha and plant density at 50 × 30 cm spacing.

Table 6: Effect of spacings and fertilizer levels on Seed yield per hectare (q) in ambrette

Treatments	**Fertilizers**			
Spacings	**F_1**	**F_2**	**F_3**	**Mean**
S_1	3.65	5.44	3.79	4.29
S_2	3.26	4.16	3.57	3.66
S_3	3.18	3.97	3.55	3.57
Mean	3.36	4.52	3.64	

Factors	**S**	**F**	**S×F**	**F×S**
S.Em±	0.057	0.070	0.115	0.099
C.D. (5%)	0.198	0.208	0.354	0.375

Spacings (cm)
S_1- 50×30
S_2- 50×40
S_3- 50×50

Fertilizer doses (kg ha^{-1})
F_1- 75- 50- 40
F_2- 100-50-50
F_3- 125-50-60

3.8 Seed oil content (%)

Among different plant spacings, significantly maximum seed oil content (0.82 ml) was produced at 50 × 30 cm followed by 50 × 50 cm (0.71 ml) and 50 × 40 cm (0.69 ml). Among different fertilizer levels, N, P and K at 100: 50: 50 kg per ha maximized the oil production to the tune of 0.9 ml followed by 75: 50: 40 kg per ha (0.68 ml) and 125: 50: 60 kg per ha (0.64 ml). The interactions of the fertilizer levels and plant spacings also produced significant difference on seed oil content. The maximum seed oil content per plot (0.99 ml) was obtained with the combination of fertilizer level of N, P and K at 100: 50: 50 kg per ha and plant spacing at 50 × 30 cm.

Table 7: Effect of spacings and fertilizer levels on seed oil content (ml) in ambrette

Treatments	**Fertilizers**			
Spacings	**F_1**	**F_2**	**F_3**	**Mean**
S_1	0.84	0.98	0.65	0.82
S_2	0.59	0.83	0.66	0.69
S_3	0.63	0.87	0.62	0.71
Mean	0.68	0.9	0.64	

Factors	**S**	**F**	**S×F**	**F×S**
S.Em±	0.001	0.013	0.021	0.017
C.D. (5%)	0.033	0.040	0.066	0.071

Spacings (cm)
S_1- 50×30
S_2- 50×40
S_3- 50×50

Fertilizer doses (kg ha^{-1})
F_1- 75- 50- 40
F_2- 100-50-50
F_3- 125-50-60

4. Conclusion

From the results of research experiment based on these findings it is concluded that the pod length, number of seeds per pod,

seed yield per plant were maximum (6.06 cm, 106, 15.44 g respectively) at a combination of spacings at 50 × 50 cm and fertilizer levels at 125: 50: 60 kg per ha. Seed yield per plot (1086.50 g) and oil content (0.98 ml) was maximum at 50 × 30 cm and fertilizer levels N, P and K at 100: 50: 50 kg per ha.

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