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Varsha V Tapre
AICRP on Medicinal and Aromatic Plants and Betelvine, Nagarjun Medicinal Plants Garden, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

SD Deshmukh
AICRP on Medicinal and Aromatic Plants and Betelvine, Nagarjun Medicinal Plants Garden, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

AG Deshmukh
AICRP on Medicinal and Aromatic Plants and Betelvine, Nagarjun Medicinal Plants Garden, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

AR Pawar
AICRP on Medicinal and Aromatic Plants and Betelvine, Nagarjun Medicinal Plants Garden, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

BM Muradi
AICRP on Medicinal and Aromatic Plants and Betelvine, Nagarjun Medicinal Plants Garden, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

RB Sarode
AICRP on Medicinal and Aromatic Plants and Betelvine, Nagarjun Medicinal Plants Garden, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

Corresponding Author:
Varsha V Tapre
AICRP on Medicinal and Aromatic Plants and Betelvine, Nagarjun Medicinal Plants Garden, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

Studies on floral biology and breeding behavior of Aloe (*Aloe barbadensis*)

Varsha V Tapre, SD Deshmukh, AG Deshmukh, AR Pawar, BM Muradi and RB Sarode

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Abstract
Aloe vera has anti-inflammatory, antioxidant, anti-microbial, anticancer, anti-diabetic, immune boosting and hypoglycemic properties. There are more than 75 active ingredients found in Aloe vera, including amino acids, vitamins, minerals, saponin aloesin, aloeemodin, methylchromones, flavonoids etc. from the inner gel of leaves. On behalf of ameliorations of such a divine medicinal plant, flower study is prerequisite for breeding programme. By considering the medicinal and economical importance of Aloe, the present study was therefore undertaken at Nagrjuna Medicinal Plants Garden, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola with a view to collect detailed information on floral biology breeding behavior of this divine plant. The flowers are bisexual, containing both male and female reproductive parts. The flowers had perianth of 6 petals with six stamens and ovary is superior, where the petals and stamens are inserted below the ovary. Maximum anthesis was observed from 09.00 to 10.00 am at RH of 61-66% and temperature ranged of 32.9-38.3 ^{0}C. Anther dehiscence was maximum between 10.00 and 11.00 am. It is observed that the time between anthesis and anther dehiscence was nearly 1.00 hr.

Keywords: floral biology, breeding, Aloe vera

Introduction
Aloe barbadensis (2n = 14) is an important medicinal plant of India belongs to the family Liliaceae (Tribe Aloineae) consisting of perennial tropical plants of African origin (Akinyele and Odiyi, 2007) and introduced to India (Chandra and Choudhari, 2014) [5]. The species occur in the Arabian Peninsula, through North Africa as well as Sudan and neighboring countries (Hossain *et al*., 2013) [7]. In India, it is commonly observed in Rajashthan, Andhra Padesh, Gujarat, Maharashtra and Tamil Nadu (Surjushe *et al*., 2008, Das and Chattopadhay, 2004) [14, 6]. The Aloe name derived from the Arabic word Alloeh or Hebrew "halal" means “shining bitter substances” (Ahlawat and Khatkar, 2011) [1]. Aloe vera is a stemless, perennial, drought resisting, succulent plant and has reportedly been used since ancient times for medicinal purposes (Klein and Penneys, 1988) [9]. Aloe vera is small, stem less, herbaceous and perennial plant with shallow root system. The fleshy, sword-shaped leaves are gray-green and grow to 80-90 cm long at the end of juicy green branches (Surjushe *et al*., 2008 and Akinyele, 2006) [14, 2]. There is some preliminary evidence that Aloe vera extracts may be useful in the treatment of wound and burn healing, minor skin infections, sebaceous cyst, diabetes, and elevated blood lipids in humans (Boudreau and Beland, 2006) [4]. There are more than 75 active ingredients found in Aloe vera, including aloesin, aloeemodin, acemannan, aloeride, methylchromones, flavonoids, saponin, amino acids, vitamins, and minerals from the inner gel of leaves (Roy *et al*., 2012, Saeed *et al*., 2004, Patidar *et al*., 2012) [12, 13, 11]. It has anti-inflammatory, antioxidant, antimicrobial, anti-cancer, anti-diabetic (Patke *et al*., 2018) [10], immune boosting and hypoglycemic properties which act as panacea for stroke, heart attacks, leukemia, anemia, hypertension, AIDS, radiation burns, digestive disorders (Hossain *et al*., 2013; Khyade and Shendage, 2012) [7, 8].

Methods and material
The study of floral biology and breeding behavior of aloe been done at the Nagrjuna Medicinal Plants Garden, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (MS). The ten mature plants were selected for study, racemes and flowers from these ten plants were selected to

study floral biology and breeding behavior under field condition for 10 days. The flowers are bisexual, containing both male and female reproductive parts and also it is polycarpic i.e. it flowers and fruit sets many time in its life. Data were recorded under various morphological such as, length of racemes, no. of flowers per raceme, no. perianth, no. of stamens, length of perianth, androecium and style and flowering characters which are important for breeding *viz*., time and duration of anthesis and dehiscence in Aloe vera was estimated by using acetocarmine stain.

Results

Raceme development:

Inflorescences of Aloe vera were bright colored, cylindrical raceme & tubular flowers grown from the center of the rosette of the leaves. It was observed that the development of flowers started from base to top of the raceme. The number of flowers in the raceme ranged from 57 to 116. The length of fully developed raceme was ranged from 97 to 124 cm. Profuse branching has not been observed so far. (Table 1)

The flowers are bisexual, containing both female and male parts. The flowers are perianth of 6 lobes, where sepals and petals are considered together. They have 6 stamens and the ovary is superior, where the sepals, petals and stamens are inserted beneath the ovary.

Table 1: Flower morphology of Aloe vera

Traits	Dimension	Range	SD ±
Length of raceme	109.75 cm	(97-124)	10.229
No. of flower per raceme	94.3	(57-131)	21.07
No. of Perianth	6		
No. of Stamens	6		
Shape of Ovary	Oval		
Length of Perianth	3.34 cm	(3.2-3.6)	0.117
Length of Androecium	3.44 cm	(3.2-3.6)	0.135
Length of Style	2.59 cm	(2.3-2.8)	0.119
Weight of Flower	0.622 g	(0.55-0.72)	0.058

Anthesis and dehiscence

Anthesis and anther dehiscence of Aloe vera was observed at regular intervals of one hour from 6.00 am to 5.00 pm for 10 days. Flowers were observed throughout the day to record the time of anthesis and anther dehiscence. Similarly time required by an individual inflorescence to bloom was also recorded.

Anthesis

The flowers were pendulous with orange color. The first opening of flower is called anthesis. The first sign of anthesis was indicated by appearance of longitudinal crack at the apex of corolla and it widens up to the middle of the bud and slowly one after another or simultaneously the petals of the bud separated and six stamens and stigma became visible.

Maximum anthesis was observed from 08.00 to 09.00 am at RH of 62-67 % and temperature ranged 27-30^0 C. (Table 2)

Table 2: Time and duration of anthesis in Aloe vera

Day of observations	Percentage of flower opened at different intervals											
	6.00 A.M.	7.00 A.M.	8.00A.M.	9.00 A.M.	10.00 A.M.	11.00 A.M.	12.00 A.M.	1.00 P.M.	2.00 P.M.	3.00 P.M.	4.00 P.M.	5.00 P.M.
Day 1	0.00	6.45	19.35	3.23	0.00	9.68	6.45	12.90	3.23	6.45	12.90	19.35
Day 2	0.00	19.05	4.76	4.76	4.76	9.52	4.76	4.76	23.81	9.52	9.52	4.76
Day 3	0.00	15.38	19.23	26.92	3.85	3.85	7.69	0.00	7.69	11.54	0.00	3.85
Day 4	0.00	10.87	17.39	13.04	10.87	8.70	15.22	2.17	15.22	4.35	2.17	0.00
Day 5	3.03	21.21	24.24	9.09	0.00	12.12	9.09	3.03	3.03	3.03	6.06	6.06
Day 6	0.00	17.50	17.50	15.00	2.50	7.50	0.00	15.00	2.50	7.50	10.00	5.00
Day 7	0.00	11.11	14.81	16.67	11.11	9.26	7.41	7.41	5.56	7.41	3.70	5.56
Day 8	0.00	8.33	18.75	18.75	8.33	6.25	14.58	4.17	6.25	0.00	8.33	6.25
Day 9	0.00	14.58	18.75	20.83	10.42	6.25	10.42	0.00	8.33	4.17	4.17	2.08
Day 10	0.00	10.34	17.24	17.24	13.79	10.34	6.90	6.90	6.90	3.45	3.45	3.45
Mean	0.30	13.48	17.20	14.55	6.56	8.35	8.25	5.63	8.25	5.74	6.03	5.64
Mean RH	68	67	66	62	62	59	58	57	100	52	52	53
Mean Temp	25.1	26.2	27.7	30.1	31.1	31.9	31.9	32.6	33.3	33.0	32.2	31.0

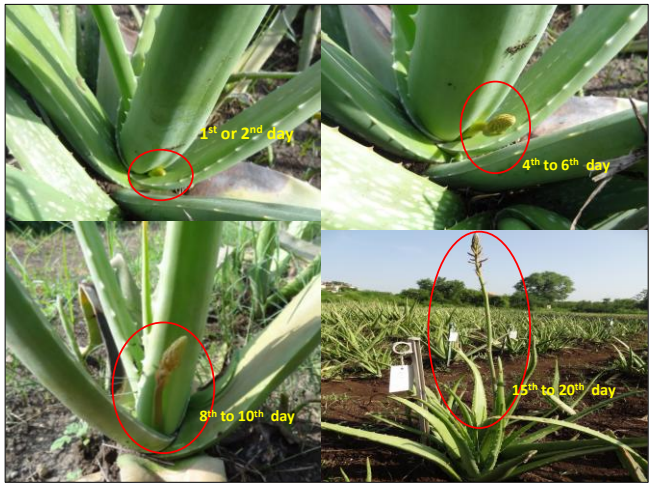
Dehiscence

The bursting of pollen from anther i.e. dehiscence was maximum between 09.00 am to 10.00 am. Since the Relative humidity and temperature was 62 % and 30-31^0 C at the time of peak pollen bursting. The bees and sunbird are responsible for pollination. The time between anthesis and Dehiscence was nearly 1.00 hr. (Table 3)

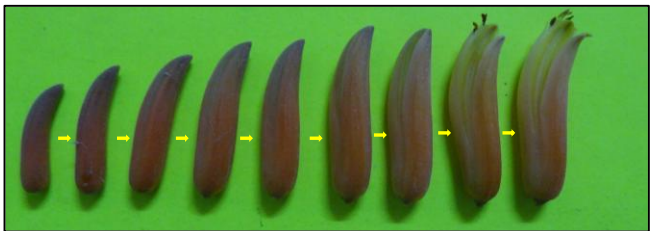
Table 3: Time and duration of dehiscence in Aloe vera

Day of observations	Percentage of anther dehiscence in Aloe vera											
	6.00 A.M.	7.00 A.M.	8.00 A.M.	9.00 A.M.	10.00 A.M.	11.00 A.M.	12.00 A.M.	1.00 P.M.	2.00P.M.	3.00 P.M.	4.00 P.M.	5.00 P.M.
Day 1	0.00	0.00	0.00	9.09	31.82	0.00	13.64	4.55	9.09	13.64	4.55	13.64
Day 2	0.00	0.00	5.26	21.05	5.26	5.26	10.53	5.26	5.26	21.05	15.79	5.26
Day 3	0.00	0.00	20.00	16.00	16.00	12.00	8.00	8.00	0.00	8.00	12.00	0.00
Day 4	0.00	0.00	13.16	23.68	10.53	18.42	10.53	10.53	2.63	5.26	5.26	0.00
Day 5	0.00	0.00	24.14	17.24	6.90	0.00	10.34	10.34	13.79	6.90	3.45	6.90
Day 6	0.00	0.00	19.44	19.44	11.11	5.56	8.33	0.00	16.67	2.78	8.33	8.33

Day 7	0.00	0.00	11.76	15.69	17.65	11.76	9.80	7.84	7.84	5.88	7.84	3.92
Day 8	0.00	0.00	11.43	17.14	25.71	0.00	0.00	17.14	8.57	5.71	0.00	14.29
Day 9	0.00	0.00	18.75	14.58	20.83	10.42	6.25	10.42	0.00	10.42	4.17	4.17
Day 10	0.00	0.00	13.04	17.39	13.04	13.04	13.04	8.70	4.35	8.70	8.70	0.00
Mean	0.00	0.00	13.70	17.13	15.89	7.65	9.05	8.28	6.82	8.83	7.01	5.65
Mean RH	68	67	66	62	62	59	58	57	100	52	52	53
Mean Temp	25.1	26.2	27.7	30.1	31.1	31.9	31.9	32.6	33.3	33.0	32.2	31.0



Development of Raceme in Aloe vera



Stages of flower opening in Aloe vera

Dehiscence in Aloe vera

Conclusion

The flowers are bisexual, containing both male and female reproductive parts. The flowers had perianth of 6 petals with six stamens and ovary is superior, where the petals and stamens are inserted below the ovary. Maximum anthesis was observed from 09.00 to 10.00 am at RH of 61-66% and temperature ranged of 32.9-38.3 ^{0}C. Anther dehiscence was maximum between 10.00 and 11.00 am. The time between anthesis and anther dehiscence was nearly 1.00 hr.

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