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FLORAL AND REPRODUCTIVE PHENOLOGY OF *ALOE VERA*

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ABSTRACT
The studies on floral and reproductive phenology in *Aloe vera* revealed that peak flowering period was ranged from last week of November to second week of December. Brightly colored tubular flowers developed on cylindrical raceme. The flowers are bisexual, containing both female and male parts. The perianth is of 6 lobes, in which sepals and petals are considered together. The flower comprises of 6 stamens and the ovary is superior, where the sepals, petals and stamens are inserted beneath the ovary. Anthesis period is of 5 to 10 days within raceme, start from 7.00 am and continued up to 3.00 pm. The receptivity of stigma was observed high at anthesis. The peak period of dehiscence observed from 10.00 to 12.00. The fruits *Aloe vera* matures within 60 to 67 days.

INTRODUCTION

The sobriquet of *Aloe vera* is "Gwarpatta" (Jain *et al.*, 2013). The *Aloe* name derived from the Arabic word *Alloeh* means *"shining bitter substances"* (Ahlawat and Khatkar, 2011). *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). The genus *Aloe* L. belongs to the family Liliaceae (Tribe Aloineae), which represent perennial succulent plants, often arboreal, bearing rosettes of leaves at the end of juicy green branches (Surjushe *et al.,* 2008).

Aloe vera is native to Africa (Akinyele and Odiyi, 2007) and introduced to India (Chandra and Choudhari, 2014). The species occur in the Arabian Peninsula, through North Africa as well as Sudan and neighboring countries (Hossain *et al.,* 2013). *Aloe vera* grows in arid climates and is widely distributed in Africa, India, and other dry areas. In India, it is commonly observed in Rajashthan, Andhra Padesh, Gujarat, Maharashtra and Tamil Nadu (Surjushe *et al.,* 2008). Anselm (2004) reported over 325 species of the genus *Aloe*.

From the days of yore around 1500 B.C. the *Aloe vera* used for numerous medical and cosmetic applications (Morton, 1961). 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).

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. It has anti-inflammatory, antioxidant, antimicrobial, anticancer, antidiabetic, immuneboosting, 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).

On behalf of ameliorations of such a divine medicinal plant, flower study is prerequisite for breeding programme. By considering the socio-economic importance of *Aloe vera*, the present study was therefore undertaken with a view to collect detailed information on reproductive biology which included phenology, pollination mechanism and breeding system.

MATERIALS AND METHODS

The study of floral and reproductive biology been done at the Department of Genetics and Plant Breeding, S.D. Agricultural University, Sardarkrushinagar, Gujarat, India in 2011-12. The ten racemes each of the ten selected mature plants were used and subsequently ten flowers from these ten racemes were selected to study floral and reproductive biology under nursery field condition. The *Aloe vera* is polycarpic *i.e.* it flowers and fruit sets many time in its life. Data were recorded under various flowering characters which are important for breeding viz., duration and habit of flowering, raceme development, anthesis and dehiscence, mode of pollination and fruit development. Pollen viability was estimated by using acetocarmine stain. The mode of pollination was observed by fruit setting within bagged and open flower condition.

RESULTS AND DISCUSSION

Duration and habit of flowering

Duration and habit of flowering in *Aloe vera* was observed

Table 1: Phenological data on flowering behavior in *Aloe vera*

Plant No.	No. of racemes tagged before anthesis	No. of flowers opened	Percent of flowers opened	Days required for flower opening (Range)	Average days required for raceme development	Length of raceme (cm)	Number of branches within raceme	Number of days required for complete anthesis	No. of days required for fruit development	Number of flower tagged in each condition within raceme	No. of matured fruits attained in	
											Open flower	Bagged flower
1	10	7	70	50-55	52.5	75	1	10	62	10	4	5
2	10	6	60	51-54	52.5	58	3	8	60	10	5	5
3	10	7	70	50	50	95	1	9	62	10	5	4
4	10	5	50	50-55	52.5	50	1	8	65	10	4	4
5	10	8	80	51	51	115	3	10	67	10	5	5
6	10	7	70	51-53	52	105	2	10	62	10	5	3
7	10	7	70	50-54	52	90	1	5	63	10	4	4
8	10	8	80	50-58	54	120	1	7	65	10	5	5
9	10	4	40	0	0	30	1	9	64	10	4	3
10	10	7	70	53	53	90	2	10	62	10	4	4
	Mean ± S.Em	6.6 ± 0.40	66 ± 4.00	-	-	82.8 ± 9.25	1.6 ± 0.26	8.6 ± 0.52	63.2 ± 0.64	100	45	42
	S.D.	1.26	12.64			29.26	0.84	1.64	2.04	-	-	-

Table 2: Time and duration of anthesis in *Aloe vera*

Date of observations	Percentage of flower opened at different intervals											Temperature		Relative humidity (%)	
	6.00A.M.	7.00A.M.	8.00A.M.	9.00A.M.	10.00A.M.	11.00A.M.	12.00A.M.	1.00P.M.	2.00P.M.	3.00P.M.	4.00P.M.	Max^{O}C	Min^{O}C	RH I	RH II
23/12/09	0	0	0.6	6.4	16	22.4	25.6	19.4	6.4	3.2	0	29.1	7.4	86	13
24/12/09	0	0	4.2	10.2	12.7	21.2	29.7	16.9	5.1	0	0	29.1	7.0	86	22
25/12/09	0	2.4	5.9	8.9	14.8	23.7	24.9	15.4	3	1	0	30.3	8.0	75	15
26/12/09	0	4.5	9.1	12.9	16.4	20.5	22.2	7.6	5.3	1.5	0	28.9	7.5	89	15
27/12/09	0	0	5.9	8.8	19.2	21.3	23.5	13.2	8.1	0	0	29.1	7.5	90	22
28/12/09	0	0	9.4	14.8	16	20.7	23.7	6.5	5.9	3	0	29.0	8.6	86	20
29/12/09	0	0	9.3	10.7	14.3	24	26.4	8.6	5.7	1	0	29.0	8.6	86	20

Table 3: Time and duration of anther dehiscence in *Aloe vera*

Date of observation	Percentage of anthers dehisced at different intervals											Temperature		Relative humidity (%)	
	6.00A.M.	7.00A.M.	8.00A.M.	9.00A.M.	10.00A.M.	11.00A.M.	12.00A.M.	1.00P.M.	2.00P.M.	3.00P.M.	4.00 P.M.	Max^{O}C	Min^{O}C	RH I	RH II
23/12/09	0.0	0.0	0.7	16.8	20.1	23.5	13.4	12.1	10.1	3.4	0.0	29.1	7.4	86	13
24/12/09	0.0	0.0	5.1	15.2	18.2	20.2	22.2	13.1	6.1	0.0	0.0	29.1	7.0	86	22
25/12/09	0.0	0.0	1.4	10.4	17.4	24.3	26.4	15.3	3.5	1.4	0.0	30.3	8.0	75	15
26/12/09	0.0	4.6	7.7	13.1	17.7	20.8	23.1	7.7	5.4	0.0	0.0	28.9	7.5	89	15
27/12/09	0.0	0.0	4.1	9.8	21.3	23.8	22.1	9.8	9.0	0.0	0.0	29.1	7.5	90	22
28/12/09	0.0	0.0	5.9	11.8	17.6	22.9	26.1	7.2	5.2	3.3	0.0	29.0	8.6	86	20
29/12/09	0.0	0.0	9.3	10.7	14.3	25.0	26.4	8.6	5.7	0.0	0.0	29.0	8.6	86	20

Plate 1: Stages of inflorescence in *Aloe vera*

Plate 2: Branching habit in *Aloe vera*

Plate 3: Different stages of anthesis in *Aloe vera*

Plate 4: Different stages of dehiscence in *Aloe vera*

from November to February. The peak period of flowering was during last week of November to second week of December. Bisexual flowers of *Aloe vera* were arranged obliquely on spike in pendulum manner. These results are close akin to Jain *et al.* (2013).

Raceme development

Inflorescences were brightly colored cylindrical raceme with 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 within the raceme ranged from 20 to 64 which is the close agreement with Akinyele (2006) who reported 20 to 94 flowers per raceme in *Aloe*. The length of fully developed raceme was ranged from 30 to 120 cm with mean 82.8 $\pm$ 9.25. The 2 to 3 branches were observed within the raceme (Plate 2 and Table 1). The intensity of flowers was more on main branch of raceme which matured first.

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. The developmental stages of raceme are shown in Plate 1.

Anthesis and dehiscence

The flowers were hermaphrodite, pendulus with orange and red colour. 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. This process completed within 30 to 50 min. Anthesis started in the morning hours from 7.00 am and continued up to 3.00 pm on 25th December, 2012 when the maximum temperature was 30.3ºC and relative humidity was 75 per cent and 26th December, 2012 when the maximum temperature was 28.9ºC and relative humidity was 89 per cent, whereas on remaining days it started at 8.00 am and continued up to up to 3.00 pm when the temperature was in the range of 29.0 to 29.1ºC and relative humidity was 86 to 90 per cent. This showed marked effect of the temperature

Plate 5: Different stages of fruit devlopment in *Aloe vera*

and relative humidity on anthesis. The head shaped stigma remains receptive for 48 hours after the opening of flower. The receptivity was higher on the next day of the anthesis. The bursting of pollen from anther i.e. dehiscence was maximum between 10.00 am to 12.00 am. Stages of anthesis and dehiscence are shown in Plate 3 and 4 respectively.

Pollen viability, shape and colour

Pollen viability was estimated by using acetocarmine stain. Dehisced pollen grain appeared as smooth, creamish yellow mass and remained accumulated on the surface of the two lobed anthers. Freshly dehisced pollen grains examined under the microscope were yellow coloured spheroidal oval in shape these results are also consolidated with Steyn *et al*. (1998) who reported elliptical shape of pollen in *Aloe*. Pollen viability was recorded 80 to 90 percent. Pollen remains viable for 6 to 8 hours.

Mode of pollination and fruit development

There was fruit setting in the bagged raceme, which corroborate the self pollination (Table 1) and it is due to hermaphrodite nature flower. Since there were honeybees observed on flower indicates some extent of cross pollination. These results are in congruence to the findings of Jain *et al*. (2013), Hargreaves *et al*. (2012) who reported that bees and sunbird are responsible for pollination. The fruit development in the *Aloe vera* takes 62 to 67 days. The stages of fruit development are shown in Plate 5.

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