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

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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, aloezemon, 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 °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 (Akinjeye and Odiyi, 2007) and introduced to India (Chandra and Choudhari, 2014) [3]. The species occur in the Arabian Peninsula, through North Africa as well as Sudan and neighboring countries (Hossain et al., 2013) [9]. In India, it is commonly observed in Rajasthan, Andhra Pradesh, 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 resistant, succulent plant and has reportedly been used since ancient times for medicinal purposes (Klein and Penney, 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 Akinjeye, 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) [8]. There are more than 75 active ingredients found in Aloe vera, including aloesin, aloezemon, 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. if 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 aceticarnine 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.

| Length of raceme | Range | SD + |
|------------------|-------|------|
| 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 |

### Table 1: Flower morphology of Aloe vera

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°C. (Table 2)

| Day of observations | 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. | 2.00 P.M. | 3.00 P.M. | 4.00 P.M. | 5.00 P.M. |
|---------------------|-----------|-----------|-----------|-----------|------------|------------|------------|-----------|-----------|-----------|-----------|-----------|
| Day 1               | 0.00      | 6.45      | 19.35     | 25.23     | 0.00       | 9.68       | 6.45       | 12.90     | 5.25      | 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      | 4.76      | 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               | 3.03      | 21.21     | 24.24     | 9.09      | 0.00       | 12.12      | 9.09       | 3.03      | 3.03      | 6.06      | 6.06      | 6.06      |
| Day 5               | 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      |

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

### Table 3: Time and duration of dehiscence in Aloe vera

| Day of observations | 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. | 2.00 P.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      |

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**

**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°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)
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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 °C. Anther dehiscence was maximum between 10.00 and 11.00 am. The time between anthesis and anther dehiscence was nearly 1.00 hr.