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Phenology, Pollination And Breeding System Of *Spathodea Campanulata* P. Beauv From Gujarat, India

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Abstract

Research on reproductive biology is challenging yet valuable when studying species such as *Spathodea campanulata* P. Beauv, which has morphogenetic variety and greater soil adaptability. These species are important from a socioeconomic standpoint. This study examined a variety of factors, including phenology, pollination, breeding systems, and seed germination. In this species, natural pollen transmission was quite effective. Fruit set was rather high after open pollination and significantly lower after hand pollination, most likely as a result of damage to stigma during experimentation. However, some selfing happened by xenogamy mode, since 39 fruit sets were obtained from bagged panicles. Pollen germination was at its optimum at 5% (50.44±1.16%) sucrose solution, while the best combination of 5% sucrose and 100 ppm boric acid produced a maximum tube length of 112 µm and 51.77±2.33%. The species appropriate for wind and insect pollination. A significant quantity of airborne pollen grains on glass microscopy slides with glycerine put on them indicated that pollination was occurring by wind. *Acridotheres tristis* was the primary and authentic pollinator among insects, with the others acting as either minor or passing visitors. Our research showed that inadequate xenogamous pollination and resources may be limiting natural fruit set in *S. campanulata*.

1. INTRODUCTION

According to the IPCC (2014), one of the best markers of global warming is thought to be plant phenology. Variations in plant phenology can have significant effects on greenhouse gas emissions, species interactions, and ecological processes (Chaturvedi & Raghubanshi, 2016). Worldwide, seasonal events' timing, or phenology, has been considerably impacted by climate change (Parmesan & Yohe, 2003 & Bajpai *et al*., 2015).

Plant phenology gives information on the growth and development patterns of plants as well as the effects of environmental factors and selective pressures on the behaviour of flowers and fruits (Zhang *et al*., 2006). Phenological research is necessary in order to comprehend ecological processes such as plant growth pattern, biomass production, and plant water stress (Kikuzawa & Lechowicz, 2011). Plant phenological events are influenced by a variety of environmental factors, including temperature, duration of the day, insolation, precipitation, and soil nutrients (Bajpais, 2017). Global warming affects plant phonological traits differently depending on the species (Fu *et al*., 2015). The study also revealed that differences in growth seasons were imposed by climate change, and that resource use patterns across species could vary as a result of competition (Singh & Kushwaha, 2005). The biotic and abiotic environmental circumstances are reflected in the occurrence of different phenological occurrences, which aids in understanding the effects of the changing global climate. A deeper comprehension of species phenology can greatly improve natural system conservation and management (Morellato *et al*., 2016 & Sudip *et al*., 2017).

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According to Amusan *et al*., (1996) and Niyonzima *et al*., (1999), the plant is extensively dispersed throughout Africa and possesses hypoglycemic, anti-complement, anti-HIV, and anti-malarial effects in its stem bark. The ability of *S. campanulata* to heal wounds is greatly enhanced by its antimicrobial and antioxidant qualities. Our findings from recent research indicate that *S. campanulata* stem bark extracts and topical preparations have broad-spectrum antibacterial activity, with the methanol extract showing the highest level of antibacterial activity among all of them (Ofori-Kwakye *et al*., 2009). The wound-healing characteristics of *S. campanulata* stem bark have been linked to a number of identified chemical compounds.

The plant's leaves are utilized as an antidote for animal poison and to treat kidney and urethral inflammations, while its flowers have anti-inflammatory and diuretic qualities (Mensah *et al*., 2016). *S. campanulata* is the source of several phytochemicals that have been identified, including steroids, ursolic acid, tomentosolic acid, triterpene acid, spathodic acid, and sitosterol-3-β-D-glucopyranoside (Ngouela *et al*., 1990 & Ngouela *et al*., 1998). Polyphenols, tannins, saponins, and glycosides are found in the fruits, while triterpenoids 3-β acetoxyoleanolic acid, siaresinolic acid, oleanolic acid, and spathodol are thought to be present in the leaves (Ngouela *et al*., 1991 & Amusan *et al*., 1995). Flowers include the following compounds: oleic acid, anthocyanin, 1, 2-benzenedicarboxylic acid, N-hexadecanoic acid, and diisooctyl ester (Wagh & Butle, 2019). Numerous biological actions of the plant, such as molluscicidal (Mendes *et al*., 1986), hypoglycemic, antibacterial, analgesic and anti-inflammatory (Emmanuel & Peter, 2009), antimalarial, and cytotoxic (Victor *et al*., 2016), have been demonstrated.

The capacity of stem bark from *S. campanulata* to heal wounds has been associated with its antimicrobial and antioxidant properties (Mensah *et al*., 2003, 2006). When tested with four strains of microorganisms and a yeast, the extract is said to have broad spectrum antibacterial activity, despite the fact that the level of antimicrobial activity was reportedly low at the dose used (Mensah *et al*., 2003). Mensah & associates, (2006). The plant is said to be efficient against Pseudomonas solanecearum, according to Amusan *et al*., (1995). Chemicals including spathoside and p-hydroxybenzoic acid that were isolated from the stem bark of *S. campanulata* significantly inhibited the growth of both grampositive and gram negative bacteria (Mbosso *et al*., 2008). Utilizing the DPPH (2, 2-diphenyl-1-picrylhydrazyl) assay, the antioxidant properties of the stem bark extract were demonstrated. According to Houghton *et al*. (2005), the extract possessed notable reactive scavenging activities for oxygen species.

Given the significance of this plant species, a current study on the reproductive phenology of *S. campanulata* has been conducted in order to improve cultivation and conservation efforts.

2. MATERIALS AND METHODS

2.1 Study site

The current studies were conducted at Gokul Global University, which is situated in Sidhpur in the Patan district in the northern region of the state of Gujarat, between 2021 and 2023. The district, which represents the northern region of Gujarat, is located between 23.9290782 N and 72.3784552 ° E (Fig. 1). Sidhpur is the town, municipality, and taluka headquarters of Sidhpur in the Indian state of Gujarat. It is located in the Patan district. Situated on the endorheic Sarasvati River (Sarasvati River, 2012), a historical site is likely what's left of the ancient Sarasvati River. Precipitation, temperature, relative humidity, and other climatic variables all have a major role in how a given plant develops in any given location (Fig. 2A, 2B & 2C). The climate in Sidhpur is subtropical steppe. The district experiences 30.59ºC (87.06ºF) annually, which is 4.62% hotter than the average for India. Every year, Sidhpur experiences 22.63 days with rain (6.2%) and 30.8 millimetres (1.21 inches) of precipitation.

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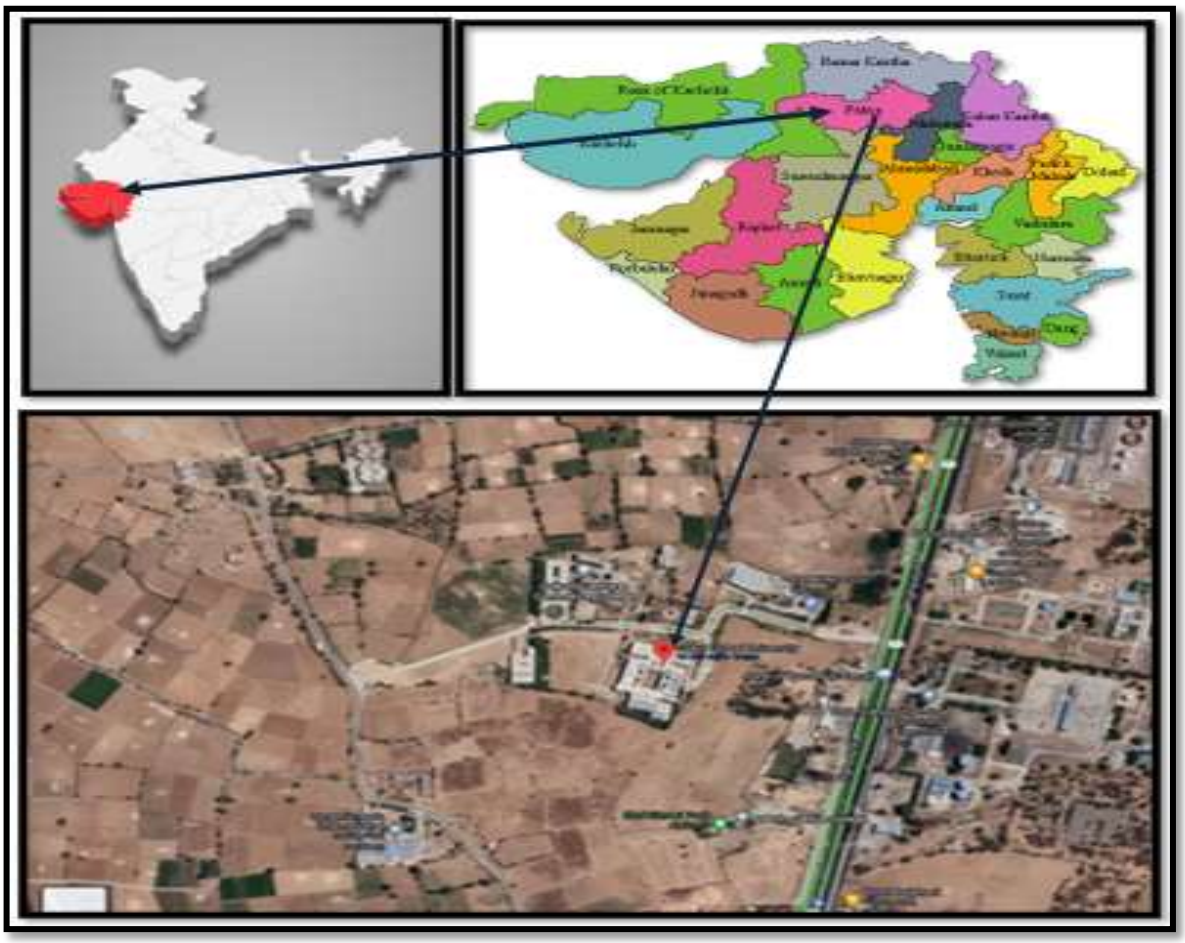

Fig. 1: Satellite image of Sidhpur in Patan, Gujarat.

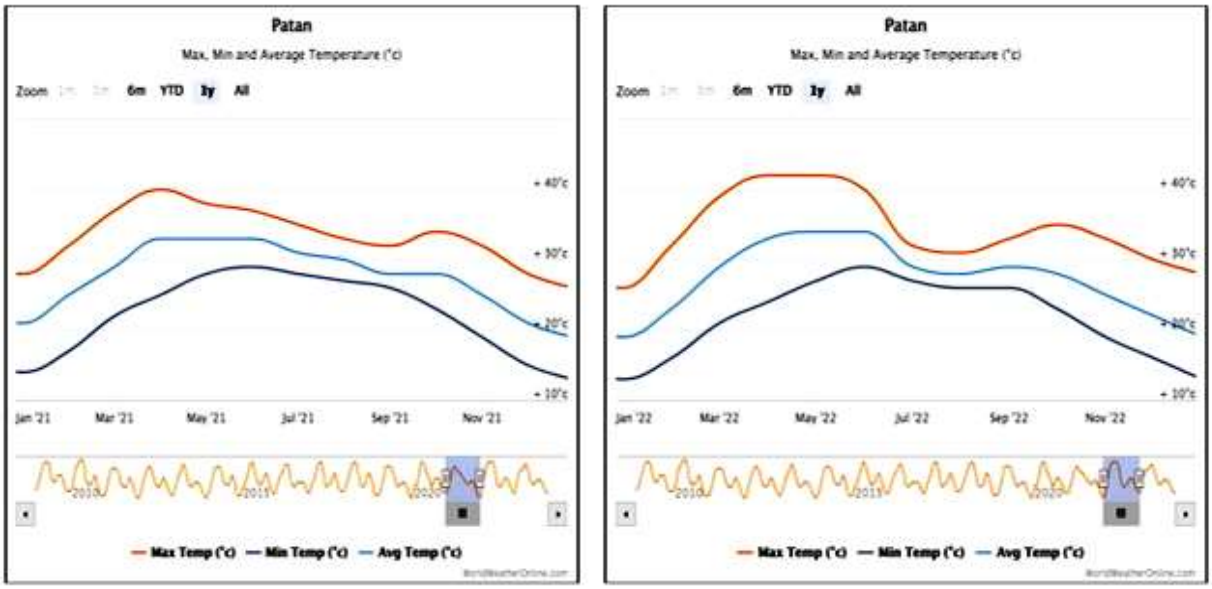

Fig. 2A: Minimum and Maximum temperature at study site of 2021 and 2022 year. (Source: worldweatheronline.com)

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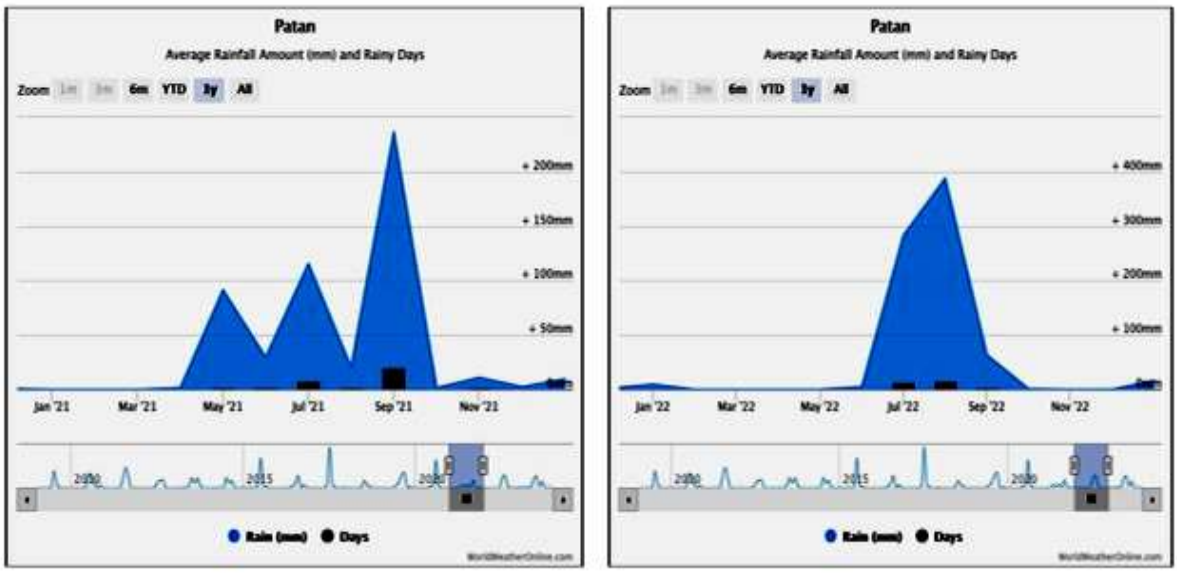

Fig. 2B: Average rainfall amount at study site of 2021 and 2022 year. (Source: worldweatheronline.com)

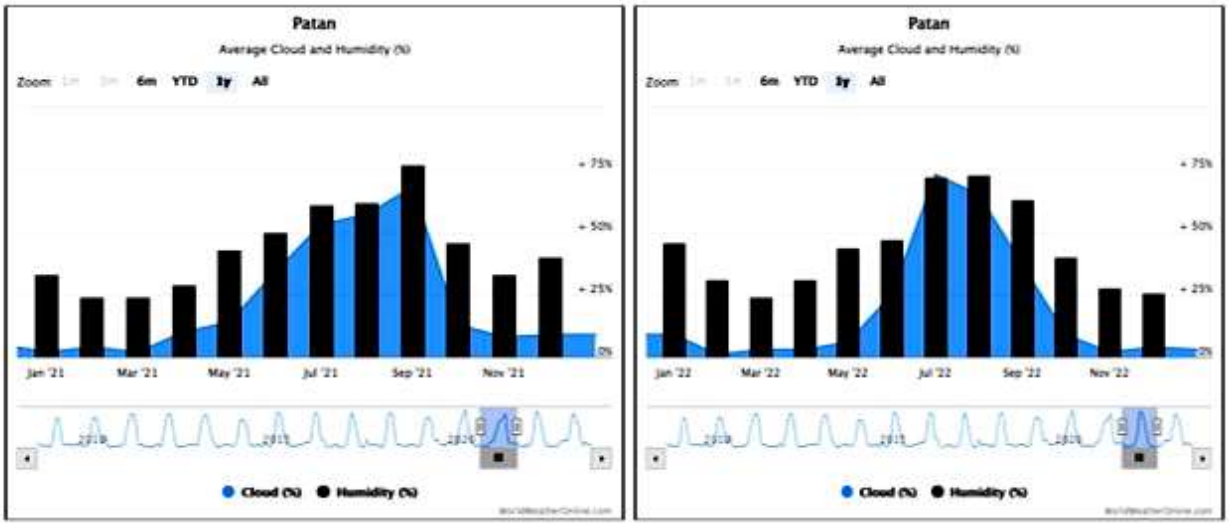

Fig. 2C: Average cloud and Humidity at study site of 2021 and 2022 year. (Source: worldweatheronline.com)

2.2 Phenology and floral biology

The timing and duration of recurring biological phenomena in plants, such as sprouting, reproductive events like bud burst, leaf expansion, emergence, and maturity, flowering, fruiting, fertilization and seed set, seed dispersal, and germination, all occur in their proper seasons, are referred to as plant phenology. Determining the ecological requirements of the species requires a thorough understanding of the phenology, especially of medicinal plants, from leaf emergence through vegetative growth to fruit-set and seed dispersal under various environmental conditions. The phenology of flowering is therefore a developmental process that is crucial to the success of plant reproduction. Plant phenology is a result of both climate change and variability. The degree to which plant phenophases, such as leafing, blooming, and fruit ripening, is responding to regional variations in temperature and rainfall has been measured through extensive research conducted over the study period. Among the biological reactions to climate change that are most susceptible are changes in phenological events, including as leafing, flowering, and fruiting. Fall activities are

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happening later and many spring events are happening earlier than they did in the past all throughout the planet. Using a hand lens (10X), fresh stigmas were removed from ripe, open flowers and examined. Subsequently, the removed stigma was examined under a microscope. The stigmatic surface's form and condition were noted. A minimum of five stigmas were taken from every single plant. After mounting the tissues whole or in part in phosphate O-buffert sucrose (0.05M, pH 7.2) of the proper toxicity to preserve the stigma papillae's form, detailed features were inspected (Heslop-Harrison and Shivanna, 1997). An ocular micrometer was used to measure the length of the stigmatic papillae. To determine the stigma receptivity, a few chosen flowers were routinely watched on the day of flower opening and on the days that followed. In the hollow slide, the removed pistil was submerged in a mixture of 1% benzene, 3% H_2O_2, and water (4:11:12) (Dafni, 1992). The oxidation of benzene and H_2O_2 produce a blurred color if the receptive stigmas break. After submerging the Stigma in the 3% hydrogen peroxide, bubbles were seen. The observation was made using a 10X hand-held lens.

2.3 Pollination

Utilizing the approach recommended by Kearns & Inouye (1993), the pollination efficiency of several pollinating insects was measured by observing the pollen load on their body parts under a microscope. The average ten drops (50% glycerine) in a 50 ml total volume were counted when using the drop method to count pollen (Nair and Rastogi, 1963). Utilizing a standardized ophthalmic micrometer and a microscope, pollen size was determined in accordance with Shivanna & Rangaswamy's (1992) methodology. According to Hauser and Morrison (1964), pollen vitality was assessed using a 10% Triphenyl Tetrazolium chloride salt (TTC) solution in 50% sucrose. Observations of the germination of pollen and the expansion of pollen tubes in the pistil were conducted using Shivanna & Rangaswamy (1992) methods. Using varying concentrations of sucrose solution, incubating pollen growth was observed. According to Cruden (1981), the pollen-ovule ratio was computed by dividing the mean number of ovules per flower by the average quantity of grains of pollen produced in a flower.

2.3.1 Pollen viability

Fresh pollen was gathered shortly before anthesis and placed in sterile Petri dishes to conduct the pollen viability test. A 10% triphenyl tetrazolium chloride salt solution was made in a 50% sucrose solution to examine the pollen vitality (Shivanna and Rangaswamy, 1992). A brush was used to dust fresh pollen onto the microscope slide, and then one or two drops of a 10% tetrazolium salt solution were added. A cover slip was quickly placed over the slide. After 15 to 30 minutes, pollen grains stained with TTC were inspected under a compound microscope. The basis of the tetrazolium test is the reduction of the colorless tetrazolium salt solution in the presence of dehydrogenase to a reddish insoluble material known as formazan. The pollen viability percentages were computed.

2.3.2 In vitro pollen germination

Different concentrations of sucrose were used to conduct in vitro pollen germination. (Rangaswamy and Shivanna, 1992). Fruit set: A random selection of inflorescences was made, tagged, and observed in order to estimate the fruit set. The formula below was used to compute the percentage of fruit set.

$$\text{Fruit set \%} = \frac{\text{Number of fruit per inflorescence}}{\text{Number of flower per inflorescence}} \text{x } 100$$

2.4 Data analysis

All data analyses were carried out utilizing the statistical software SPSS version 15.0 (SPSS, Chicago, IL). Each population's observations were compared, and if there was no discernible difference, they were combined. Prior to analysis, the percentage data were transformed into arcs (Sokal & Rohlf, 1995). Since there was little variation in the growth of flowers between populations

and years, the data were combined. Two-way ANOVA was used to examine the fruit set outcomes following hand pollinations in various populations in order to assess any variations resulting from the interaction between the pollination treatment and the population location, as well as the effects of the treatments alone. The population of the site was a fixed factor, while the dependent variable was the amount of fruit. The Tukey's honestly significant difference (HSD) analysis was utilized to compare the three populations numerous times. One-way ANOVA was used to examine the natural fruit set resulting from open pollination, and a Tukey-Kremer test was then used to determine the location with the largest fruit set following pairwise comparisons of the mean values. The significance level for each test was set at 0.05.

3. RESULTS AND DISCUSSION

3.1 Phenology

The time of recurrent events is the focus of plant phenology. Animals that rely on plant resources are likewise impacted by the time of plant reproductive cycles. While the timing of pollinator and disperser activities might restrict a plant species' range, the timing of blooming can operate as an isolation strategy in plant speciation. Furthermore, the dynamics of populations can be significantly impacted by the time of seed production (Newstrom *et al*., 1994). Conflicts amongst species for insects that pollinate, choice opposing interspecific gene flow, pollinator accessibility and floral rewards, and selection for life history features other than blooming all affect when tropical plants flower (Bawa 1983).

Known as the "South African tulip tree," *Spathodea campanulata* is an exotic tree. This elegant, upright evergreen tree can reach a height of 70 feet or higher. Nearly every tropical region has seen its introduction, mainly as a decorative. Wherever it grows, it is a very valuable floral food source for peckish birds. The tree blooms during February-April. Flowering is slightly asynchronous among individuals occurring in different areas. Some individuals commence flowering late in late-March and extend into late-May. Leaf-fall and fleshing activities take place throughout the year. *Spathodia campanulata* shows a combination of bird and bat floral characteristics. Bird floral characteristics include the showy scarlet, bell-shaped flowers clumped at the top of the inflorescences, providing a perch for probing birds, copious nectar, the stamens and stigma distant from nectar and location of ovary at the flower base which confers protection against the probing bill of the bird. Bat floral characteristics are nocturnal anthesis, slightly foetid smell and nectar immediately after start of anthesis.

Table 1: Different parameters of flower of *S. campanulata.*

Parameters	Flowering period	Flower Shaped	Flower colour	No. Of stamens per flower	Flower opening time	Anther dehiscence time	Mode of anther dehiscence	Stigma	Style
Observation	February-April	Bell shaped	Red	4	21:00 h (Night)	Midnight After Flower opening (04:30 h)	By Apical pores (Longitudinal slit)	Simple, long	Simple, Yellow & long

3.2 Floral Biology

The flowers are showy, scarlet, large and bell-shaped. They may be seen for a considerable distance and are fairly lovely. They are hypogynous, zygomorphic, bisexual, and somewhat foetid. The calyx is bilabiate, spathaceous, and golden brown. They grow in clusters at the terminals of branches and have a diameter of around 5 to 10 cm (2-4 inches). The panicle-shaped, dense inflorescence is nearly upright. The terminal portion of the branches is where the panicles emerge. After 30 days, each panicle typically yields 51 blooms (Range 32–83). The panicle will continue to bloom until all of its buds have been used. The flowering panicles appear quite conspicuous against the foliage. The

outermost part of the flower consists of a calyx with several sepals. The corolla consists of a single, large, funnel-shaped petal that forms the showy part of the flower. It is usually brightly colored, serving to attract pollinators.

Table 2: Values of different floral attributes of *S. campanulata.*

Floral attributes	Number of Inflorescence / plants	Number of flowers / inflorescences	Number of fruits/inflorescences	Number of fruits/ plants	Number of seeds/Fruit	No. of pollen produced/flower	No. of ovules/Ovary	Pollen: ovule ratio
Value	21±0.86	51±1.96	7±0.019	147±0.03	62,272±2003	62,272±2003	1310±21	47:1

3.2.1 Floral types

A calyx's length is 60 mm. 90 mm in length and 60 mm in width make up the corolla. It begins orange and progressively deepens into a bright crimson as it approaches the mouth's rim. The corolla's borders are quite thin and readily separated. It is bright yellow with crimson streaks inside the petals. There are four stamens, which are didynamous, epipetalous, and have dangling dark crimson anthers at the tips. The two short stamens measure 46 mm in length, and the two long stamens measure 62 mm. near the calyx, on the inner side of the corolla section, are virtually exactly where the stamens are appressed. The lobes of the dithecous, introrsely anthers are parallel to one another and appear to be one above the other. There is a noticeable basal annular disc all around the ovary. There are ovules placed on the axile during bilocular, syncarpous, and bicarpellary placentation. There are many ovules—1,310 on average (Range 1,216–1,393) per ovary. Style is simple, yellow, 70 mm long, and ends in a bifid stigma. The stigmatic lobes are 8 mm long, golden, and nearly equal in size. The stigma is located below the short stamens' level.

Table 3: Values of different floral traits of *S. campanulata.*

Floral traits	Calyx diameter	Calyx length	Corolla diameter	Corolla tube length	Stamen height		Style plus stigma height	No. of stamens
Observation	40.5± 0.2 mm wide	60.2± 0.6 mm long	60.3± 0.02 mm long	90± 0.1 mm	Long stamen 62± 2.4	Short stamen 46 ± 1.3	70±1.9 mm long	4

3.2.2 Pollen morphology

Pollen grains are radially symmetrical, isopolar, apiculate, subprolate, P × E is 62 × 45 µm, amb subtriangular, planoaperturate; tri-zonocolpate, colpi narrowly elliptic with acute ends, 50 µm in length and 7.4 µm wide at the equator, tenuimarginate; exine tegillate, 2.9 µm in thickness, crassisexinous; surface coarsely reticulate, lumina irregularly polygonal, reaches to a maximum diameter of 2.7 µm, heterobrochate, lumina diameter gradually decreases towards the margin of colpi.

Pollen morphology is a branch of palynology, which is the study of pollen grains and spores. Pollen grains are essential reproductive structures produced by seed plants (angiosperms and gymnosperms). These microscopic particles play a crucial role in plant reproduction, as they are responsible for the transfer of male gametes to female reproductive organs, leading to fertilization and the production of seeds. Understanding pollen morphology is essential in various scientific disciplines, including botany, paleobotany, agriculture, and environmental science.

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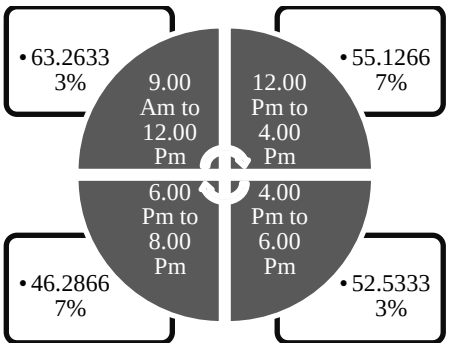

Fig. 3: Pollen viability at 10% TTC at different time interval.

3.2.3 In vitro pollen germination

Boric acid also somewhat affects the percentage of pollen germination. The effect of sucrose on in vitro pollen germination in *Spathodea campanulata* P. Beauv revealed that the investigated taxa required very low sucrose concentration for their optimal pollen germination. Optimal pollen germination at 5% (50.44±1.16%) sucrose solution but the best result 51.77±2.33% and a maximum tube length of 112 µm was obtained from 5% sucrose and 100 ppm boric acid in combination.

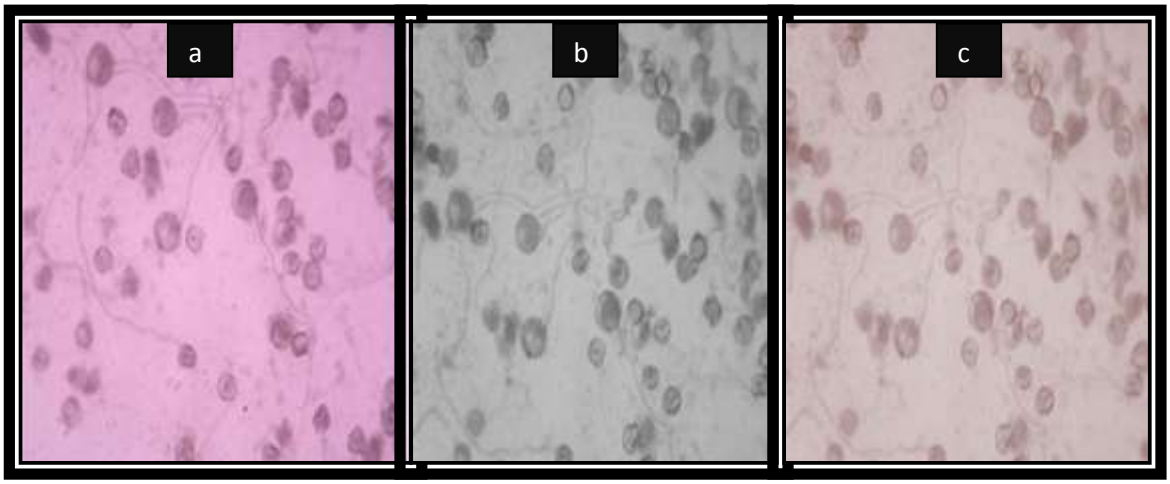

Fig. 4: (a) Pollen germination at 5% sucrose solution showing normal pollen tubes; (b-c) Pollen germination at 5% and 10% sucrose solution in combination with 100 Ppm boric acid showing normal and abnormal pollen tubes.

3.2.4 Stigma receptivity

Mature buds start to show indications of opening at 9:00 a.m. and open completely at midnight. The stigma and stamen-filled corolla progressively enlarge and unfold the calyx lobes. It gradually widens into a bell shape, revealing the stigma and stamens. After anthesis, the anthers begin to dehisce through longitudinal slits at approximately 4:30 h. The stigma opens its two lobes to demonstrate receptivity. The stigmatic prongs stay closed during anthesis, indicating that the stigma is not responsive. The stigmatic lobes gradually stretch almost horizontally and separate. At approximately 7:00 a.m., the stigma's current state was noted. One indicator of stigma receptivity is thought to be the open status of the stigmatic lobes. H_2O_2 was also used to assess the stigma receptivity, and the results showed that the stigmatic lobes were receptive from the moment they were open. It goes on till the second day's nightfall. The stigmatic lobes promptly closed in two to three minutes upon coming into contact with a pollinator. It seems that the stigmatic lobes that the pollinator did not touch remained that way until they were exposed to pollen. The indicator of pollination is the closing of stigmatic lobes following contact with the pollinator. In order to verify this, a finger was placed on the inner surface of the stigmatic lobes, but the lobes did not close. Moreover, the stigmatic lobes closed when pollen was manually positioned at their confluence. It

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showed that stigmatic lobes that are exposed to pollen eventually wither away, while those that are not exposed to any pollen close. The corolla, stigma, and stamens fell off first on the third day, followed by the calyx.

3.2.5 Meiotic behaviour

Chromosome number of *Spathodea campanulata* P. Beauv is 2n=38. Again, chromosomes of *Spathodea campanulata* P. Beauv showed both normal and abnormal meiotic division including various abnormalities such as sticky bridge, laggard chromosome, abnormal separation and irregular distribution of chromosome during telophase. The population's low pollen grain fertility was caused by a variety of meiotic defects, such as bridges, chromosomal laggards, and aberrant separation. This may lead to the formation of sterile seeds.

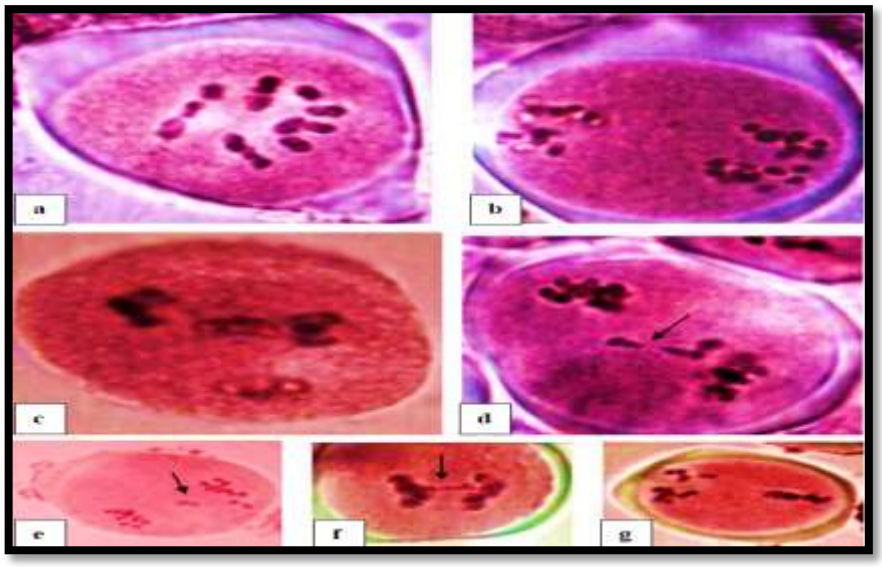

Fig. 5: Different stages in meiosis of *S. campanulata*.

3.3 Pollination

The flower visitors included birds, bees and squirrels. The birds were *Acridotheres fuscus*, *Acridotheres tristis*, *Corvus splendens*, *Psittacula eupatria*, *Arachnothera longirostra* and *Pycnonotus barbatus*. Regular guests are the birds, who come to sip calyx water and nectar from open flowers. The birds perched on the racemes and made their way toward the blossoms. They approached the blooms after landing and stuck their beak inside of them to receive liquid prizes. They used the underside of their beaks and bodies to make contact with the stigma and stamens while doing this. In a single visit to the tree, they harvested five to eleven panicles, spending two to four minutes per panicle. They spent the entire day seeing the flowers, with more visits in the afternoon. During the afternoon, *Acridotheres fuscus* and *Acridotheres tristis* looked for flowers that were shaded by the foliage and held less viscous nectar and calyx water. The corolla, with or without stamens and stigma, was devoured by *Corvus splendens*. *Pycnonotus barbatus* also pays visits to *Spathodea campanulata*. It was discovered that all six bird species frequently flew between conspecific flowering plants in search of more nectar and calyx water. This activity was accepted to effect cross-pollination.

Bee visitors to the flowers included *Apis cerana indica* and *Apis florea*. These visited the flowers mostly during forenoon hours. They collected only pollen and did not make any attempt to go into the flower base to collect nectar or calyx water. The bees tended to stay almost on the same tree day-long their visits largely bring about self -pollination. As *Spathodea campanulata* fruits only the xenogamy bees visits were found to be almost of no use to the flowers to set fruit. Three-striped squirrel also visited the flowers regularly for collecting calyx water and nectar. But they mostly

teared off the corolla and sex organs causing flower drop subsequently. It also collected calyx water from young and mature buds. Such buds dropped off. Euploea core also visited the flowers regularly for collecting calyx water and nectar.
In *Spathodea campanulata Acridotheres tristis* is the main pollinator because of its frequent visits between conspecific trees and it also drinks nectar and calyx water day-long.

Fig.6: different pollinators on *S. campanulata.*

3.4 Breeding system

Tropical trees exhibit a wide variety of breeding systems, pollination mechanisms, and population structures. They have breeding systems that encourage or insure outcrossing (Kalin-Arroyo 1976). It means that they tend to have both selfing and outcrossing breeding systems. Selfing tend to preserve existing xenotypes while crossing promotes their recombination, Therefore, a tropical forest tree's population structure and inter-population variance should mirror its breeding system (Baker *et al*. 1983). There has been conjecture on how tree species might set seed by outcrossing, given that their individuals are typically widely apart in forested areas. In order for tree species to set seed through outcrossing, leafless conditions and huge floral displays with brief flowering periods have been identified as significant phenological events. Pollen is transported between widely separated individuals of tree species mostly by large bees and birds (Bawa 1983).
Hand -pollination tests indicate that apomixis, autogamy and geitonogamy do not have result in fruit set. When hand-pollinated, it breeds only through with 78% fruit set. In open-pollinations, each fruited raceme produces 1 to 8 fruits; Fruit set is 3% only. The fruits mature within eight weeks. The fruit is a hard capsule and dehiscent.

Table 4: Effect of different pollination methods on fruit set percentage in *Spathodea campanulata* P. Beauv.

Type of pollination	No. of flowers pollinated	No. of Fruit set	Pollination efficiency (%)
Open	2550	77	3%
Bagged	50	0	0%
Geitonogamy	50	0	0%
Xenogamy	50	39	78%
Apomixis	50	0	0%

3.5 Seed germination

In *Spathodea campanulata* P. Beauv, the fruit is a hard capsule with some hundreds of seeds. Seeds are very light, small (8mm) and winged. Seed disperses easily by wind after mature fruit dehisce.

3.5.1 Effect of scarification on seed germination of *Spathodea campanulata* P. Beauv

The treated seeds started germination after 20 days at normal temperature and the seedling emergence with two cotyledonary leaves were observed after 30 days. The development of mature seedling with first leaf appeared after 40 days. The percentage of seed germination was only 51%. To enhance the germination rate, mechanical as well as chemical scarifications were done.

Table 5: Methods used in germination of *S. campanulata.*

Method		**Germination (%) (Mean±SEM)**
Tap water (Control)		51±0.58
Mechanical Scarification with a. Needle pin b. Sand paper		60±0.31 66±0.52
Chemical scarification with		
Dil.H_2SO_4 (5%)	5min	39±0.53
	10min	42±0.95
	15min	45±0.39
	20min	40±0.51
Dil. H_2SO_4 (10%)	5min	37±0.54
	10min	28±0.06
	15min	14±0.53
	20min	8±0.29

3.5.2 Seedling characteristics

Roots brown, very delicate, lateral roots few; germination epigeal; hypocotyls epigeous, straight, ± 0.1-0.01-0.2×0.02 cm, long, white, glabrous; cotyledon 2, opposite, sessile, green; blade foliaceous, oblong, obtuse; apex entire, green, glabrous; first two leaves lanceolate, alternate, simple, ± 0.2-0.4×0.3-0.5 cm, green, hairy, subsequent leaves are ovate, ± 3cm, green, hairy other characters are similar except measurement.

Fig. 7: Growth cycle from seed to plant of *S. campanulata.*

4. CONCLUSION

As a result, variations in the environment, especially in temperature and relative humidity, affect a variety of phenological and reproductive parameters in *S. campanulata* growing in Sidhpur City. Because this plant provides food for a variety of insects, its presence in a community is essential to

the ecosystem's ability to function. This guarantees a high yield even in situations where pollinators are in short supply. In order to provide farmers with visual cues regarding the timing of farming activities in local cultivation methods, plant protection, and an understanding of the crop's susceptible times, a detailed floral biology study was conducted to understand the growth of *S. campanulata*. Better tactics to achieve a good stand may result from an understanding of the entire plant development stages. The floral biology data presented in this study will also support future investigations into breeding strategies and environmental adaption for higher yields.

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