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Research Article

Study of Flowering Phenology in an Important Medicinal Plant *Costus Pictus* D. Don

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Abstract

This study deals with the flower phenology of plant *Costus pictus* D. Don, commonly known as "Insulin plant" that has potential medicinal properties. It provides information regarding phenology of inflorescence and individual flower. The present studies were carried out in the field and laboratory, department of Botany, RG PG College, Meerut on 50 inflorescence spikes/cones. Phenological studies of 50 inflorescence cones was carried out in the garden of shastrinagar, Meerut. It was reported that initiation of generative shoot started after 30-45 days of sprouting of rhizome. Period of initiation of inflorescence cone to inflorescence senescence lasts for about 75-90 days. Longevity of a single flower was one day (22-24 hrs). Anthesis was reported in the morning. Stigma became receptive after the dehiscence of anthers. At maturity inflorescence started producing loose sterile bracts, which do not flower. It was observed that the temperature was the main environmental factor to influence flowering. In scorching heat inflorescence stops flowering and become dried. During heavy rainfall the inflorescence get rotten. The present study will help to prepare the calendar of phenoevents, conservation strategies, and reintroduction of medicinally important plants to new environmental conditions.

Keywords: *Costus pictus* D.Don, phenology, inflorescence, anthesis, temperature.

Introduction

Reproductive biology of *C.pictus* D. Don flowers have not been studied comprehensively. Understanding the floral biology is important for conventional breeding purposes. The objective of this study was to examine phenology of flower development of *C.pictus* D. Don. Elucidating the reproductive biology of *C. pictus* D. Don is essential for its effective cultivation, conservation, and phylogenetic analysis. The reproductive biology of *C. pictus* D. Don, plant's inflorescence and individual flower have not been studied although very few work is available related to other members of the family Costaceae. The study of floral phenology will enlighten upon the pattern of growth of flower of insulin plant *C. pictus* D. Don.

Materials and Methods

Floral parameters of fresh flowers of **C**. *pictus* D. Don. Were investigated in the field and laboratory. The different **floral phenological events** viz. inflorescence bud initiation and individual flower bud initiation, inflorescence cone/spike growth and individual flower bud growth, anthesis, flowering season, anther maturation and dehiscence, pollination, stigma receptivity, fertilization, number of flowers per cone, and length of inflorescence per plant records were identified and explained on the basis of daily monitoring of inflorescence during the field studies by tagging the 50 inflorescence taken into consideration. This study has been carried out on *Costus pictus* D. Don species of Costaceae which is medicinally important. This work was carried out on plants growing in the garden size 10 feet x 4 feet. The phenological studies were conducted in Shastrinagar, Meerut, UP. Rainfall is about 33 in

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per annum, which is good for farming. Humidity varies from 30 to 100%. (https://en.wikipedia.org/wiki/Meerut)

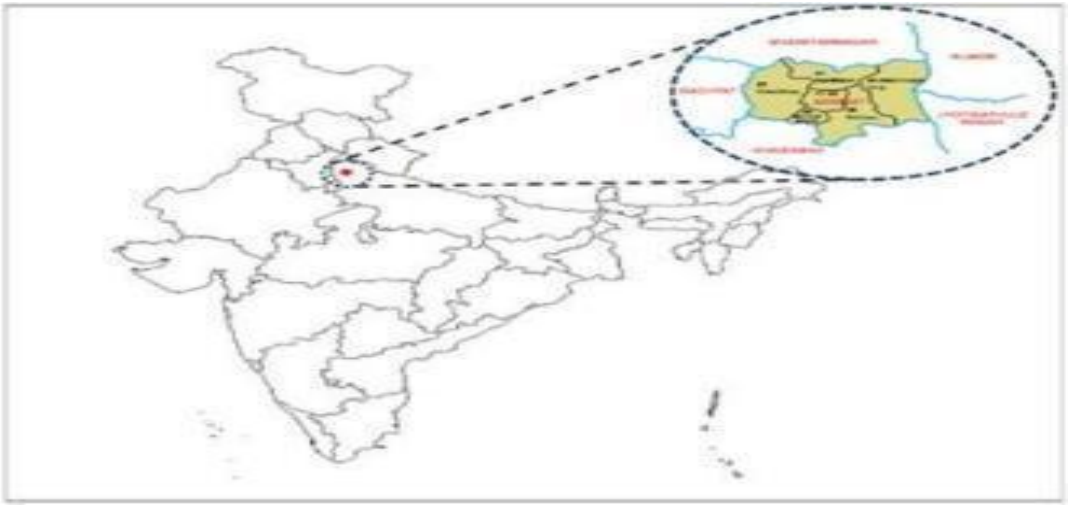

Figure 1: Physical map of Meerut showing Coordinates. Latitude 28.9845° N, Longitude 77.7064

Floral parameters were investigated in the field and laboratory and were summarized in tabular form.

Study of pollinator types, and visitation were recorded in the field during peak flowering months.

RESULTS AND DISCUSSION

Floral parameters of fresh flowers of *C. pictus* D. Don. were investigated in the field and laboratory and were summarized in tabular form (Table-1)

Table 1 Floral parameters of *Costus pictus* D.Don

PARAMETERS	DESCRIPTION
Initiation of Generative shoot from rhizome	30-45 days in March
Inflorescence	Spike (cone) with broad green bracts arranged spirally
Bracts	Cone covered with broad, coracious,green bracts
Flower	Tubular in shape, yellow in colour, papery in texture
Bracteoles	1 folded red coloured
Sepals	3 red coloured, persistent
Petals	3 yellow coloures
Labellum	Yellow with red spots and stripes, a unique cup shaped structure formed by fusion of 5 staminodes
Stamen	1 with two anther lobes, present on petalloid process of yellow colour with dark red stripes on apex
Carpel	one bi-lamellate stigma with dorsal bifid appendage positioned above anther lobes, style one long, filiform positioned in-between two anther lobes, ovary tricarpellary, syncarpous, inferior with three locules and many ovules, placentation axile
Extra Floral Nectary	Dark green coloured lines on bracts
Intra Floral Nectary	Inside, on the roof of the ovary in prolongation region
Nectar guide	Dark red colour on apical part of labellum and petalloid process

Floral Phenological study: For floral phenological study, morphology of flower was monitored daily starting from initiation of inflorescence until the flower/inflorescence under goes senescence. In *C. pictus* D. Don the period of study of floral phenology was from May, 2022 to

January, 2025. Flowering commences at warmer days, temperature ranges from 25°C- 30°C to 30^0-40^0C. In severe winters of 2022, 2023 and 2024 January flowering was not reported but during field observations flowering was reported in December 2024 and January 2025 which was a deviation from previous year observations. The relative humidity ranged from 15%-96%. Vigorous flowering is observed in the month of May, August, September and October. During the months of June and July scarce flowering was reported. Floral phenological events recorded were inflorescence cone bud initiation, cone growth, flower bud initiation on cone, flower bud appearance on cone, bud maturation, flower opening, anther maturation, anther dehiscence, pollination, stigma receptivity, fertilization and fruiting. The changes were recorded and selected. The observations obtained were ordered according to the chronological succession of the floral phenological stages. The flowering period lasted for approximately six months. The peak flowering period recorded in field was from May to October except during hottest months. According to field observations it was recorded that longevity of an inflorescence cone was about 2.5-3 months. During flowering period 12-20 flowers appeared on one cone. Inflorescence cone attained a maximum height of about 12 cm-18.5 cm. Another cone arose from the base of the cone. The emergence of inflorescence cone bud started during the summer season in the end of April at the top of the stem (bearing spiral arrangement of leaves) and few millimetre in size. When inflorescence cone attains about 5.5-6.0 cm length after 25-26 days of cone bud emergence, yellow coloured apical part of the bud peeps out from the green broad leathery bracts. Bracts are arranged spirally on the inflorescence cone, which protect the delicate growing buds. Older buds are present at the base and the newer buds appear above in spiral manner. Every day a bud emerges out from the bract. Within 2-4 days bud grows into a bright yellow coloured flower with red stripes on the frill at the mouth of the flower after 27-28 days of cone emergence. The flower blooms for only one day. Anther dehiscence takes place before anthesis at 10.00 am in the morning. Dehiscence of anther takes place through longitudinal slit. Pollen lost its fertility in the evening after 4.00 pm. Peak receptivity of stigma was reported in the morning at 11-12 pm on the flower blooming day. During peak receptivity, stigma becomes transparent due to secretions. It looses its receptivity till 12.00 pm in the night. Next day bright yellow flower colour changes to light yellow. Discolouration of the nectar guide on labellum and petalloid stamen process represents that the flower is no longer pure. Petalloid stamen process closes the mouth of the flower which is the marker of fertilization. After the process of pollination and fertilization corolla wilts and dries off and calyx remains on the fruit. On 2nd day of flower blooming, wilting of flower starts. Flower becomes dull and the bright brown stripes of frill colour turn into pinkish and size get reduced. Now 2-3 flowers are in full bloom and 1-2 flowers started to wilt. After 30- 35 days of cone inflorescence 2-3 flowers finished blooming. After 35-37 days of cone bud emergence, inflorescence cone attains a 10-14 cm height. Mature cones at the end after about 35- 40 days, starts producing loose bracts at the terminal position producing young flowers. An inflorescence cone produces about 12-20 flowers. It was reported during studies that anther matured earlier than the stigma became receptive. So cross-pollination is prevalent in the species. Only entomophilly was reported during the field studies. Our studies are in conformity with the work of Kamer et.al (2016) where they reported that labellum, nectar guide, hidden nectar at the base of the floral tube, co-occurrence of both anthers and stigma, all indicate plant's strong inclination towards cross-pollination. When an insect pollinator lands on the flower, it will trace the nectar guide towards the centre of flower causing the reflexed apex of the fertile stamen to be lifted, granted axis to the floral throat. All these special traits suggest insect pollination syndrome. According to Mass (2016) and several workers, the main characters forming potential pollination syndromes is the colour and the texture of the flower and shape of the labellum which are in conformity with the investigation reports during field survey regarding *C. pictus* D. Don. *Costus* flowers offer nectar as a reward to pollinators, which helps to ensure pollination. A mature cone persists for about 65-90 days depending upon the temperature. It was noted that the individual inflorescence has flower buds of three stages of development. Opening of the buds in the inflorescence cone is one by one in the sequential pattern. Every day 1-2 flowers open and 2-3 flowers in different stages of maturity like colour change, closing of lips, shrinking of frill, and reduction in the size of flowers are present. For food and forage insects like *Solenopsis invicta*, *Chalybion californicum*, *Vespa orientalis* and spiders visited the inflorescence cone bearing flowers. Insects perform the service of pollination

and they get nectar and pollen in reward. According to Zhang et.al (2017), floral nectar guide shows the intrafloral nectary where pollinators will get rewards from flowers such as nectar and pollen. Floral phenological stges are summarized in table 2.

Table 2 Floral phenological growth stages of *Costus pictus* D. Don

FLORAL GROWTH STAGE	**FLORAL GROWTH STAGE TIME PERIOD**
Initiation of Generative shoot from rhizome	30-45 days after favourable period
Longevity of Inflorescence	75-90 days
Duration of Flowering	Six months mid May to Novemember
Number of flowers open each day	one per inflorescence in the axil of the bract
Time of anthesis	Morning hours
Flower longevity	One day
Total flowers on the inflorescence spike/cone	12-20 flowers
Inflorescence emergence	
Emergence of reproductive bud	After 30-45 days
Visible terminal inflorescence bud	5th day after spike/cone bud emergence
10% of its full length	8-10 days after spike/cone bud emergence
50% of its full length	25-28 days after spike/cone bud emergence
90% of its full length	36-39 daysafter spike/cone bud emergence
Flowering	
Loose pocket of bract	7-8 days of inflorescence emergence
Slight impression of bud in bract pocket	10-12 days of inflorescence emergence
Flower bud visible from green large bracts	20-22 days of inflorescence emergence
Flower bud completely developed and emerged from the bract	29-30 days of inflorescence emergence, in bud condition corolla is folded and dark brown nectar guides are not visible
Flower completely developed and emerged from the bract	30-32 days of inflorescence émergence, corolla opens
Total number of flowers bloom at a time on inflorescence cone	Usually 2 flowers, sometimes 1 flower at the base of inflorescence spike/cone
Flower opening/anthesis	In the morning, labellum and petalloid process move apart
Flower wilting	
Flower fading	Bright red colour of petal changes to light yellow and membranous and sticky on 2nd day of blooming
Discolouration of nectar guides	brown stripes turns faded wrinkled on 2nd day of blooming
Size of flower	Reduced on 2nd day of blooming
Corolla fall	After 24 hrs of blooming
Inflorescence senescence	
Loose bracts on the spike	After 35-40 days of cone emergence sterile loose bracts on the terminal parts appear
Life span of inflorescence	75-90 days during peak flowering period. Cone dried due to scorching heat

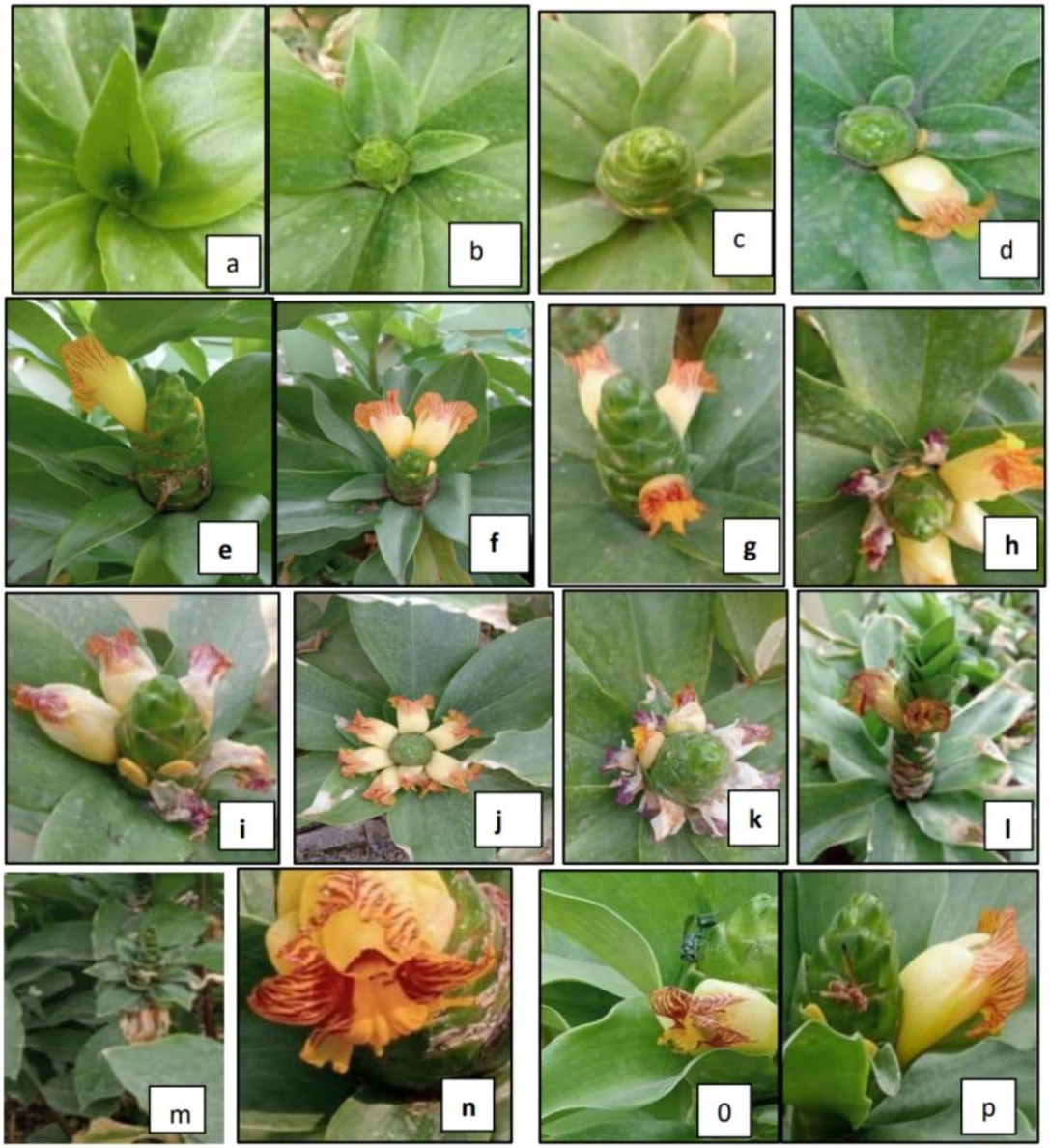

Figure 7 Phenoevents (a-p) Fig. a)Emergence of reproductive bud on vegetative shoot; b)inflorescence bud grown to 10% of it's original size, flower bud initiation starts with the development of pockets; c)terminal inflorescence cone bud reaches to 40% of it's full growth, emergence of flower buds from the bracts; d)inflorescence cone bud reaches to 50% of it's full growth, blooming of flower; e)single flower blooming on the cone; f) two flowers blooming together on the cone; g)inflorescence cone grown to 70% of it's maximum size, 3 flowers can be seen on the cone and dark green colour extra floral nectary on green bracts; h) inflorescence cone showing three stages of maturity of flower- bud, open flower and wilted flower; i) inflorescence cone reaches to 90% of full growth, showing bud, full bloom, closed, wilted and shrink flower; j) maximum flower bloom in the inflorescence spike; k) cone/spike showing one fresh flower and rest in different wilting stages; l)inflorescence cone showing growth of cone at the apex as presence of loose bracts and two flowers blooming on compact cone; m)fully mature inflorescence cone showing hard bracts marker of fertilization and development of ovary; n)flower anthesis and showing ants on open flower mouth; o-p)pollination and visitation of insect and bees.

CONCLUSION

Costus pictus D. Don inflorescence cones showed various growth patterns. The growth stages commence with emergence of reproductive bud, continued with cone growth, followed by flower bud emergence on inflorescence cone, flowering and wilting of flower. It is concluded that the flowering is affected by temperature as too high and too low temperature do not favour flowering. The flower shape of *C. pictus* D. Don shows co-evolution and floral adaptations. It appears that they co-evolved with pollinators like bees.

The result of the study of phenology shows clear picture of floral shoot growth and effect of environment on floral growth which is important for the crop improvement and for production of desirable new varieties.

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