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Reproductive Biology, Flowering Phenology, and Floral Dynamics of Cicer arietinum L. in Arvi Region (Wardha, Maharashtra)

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Abstract

Cicer arietinum L. (Gram) is an economically vital pulse crop widely cultivated across semi-arid regions of India. Understanding its reproductive biology, flowering phenology, and floral dynamics is essential for evaluating breeding systems and optimizing yields. Field investigations were conducted across three agro-ecological sites in Arvi, Wardha district, Maharashtra. Parameters including flowering timelines, anthesis schedules, quantitative pollen production, pollen viability, pollen-to-ovule ratios, stigma receptivity, and diurnal nectar secretion dynamics were systematically evaluated. Flowering initiated in the third week of November, peaking from the last week of November to the second week of December. Mechanical anthesis occurred at 08:30 AM, but anther dehiscence took place precociously at the bud stage (06:00 AM–06:30 AM). Mean pollen production per flower ranged from 14,994.54 ± 1,161.26 to 15,765.75 ± 1,580.21, with a high viability rate (>91%). The pollen-to-ovule ratio ranged between 7,497.27:1 and 7,882.87:1. Stigma receptivity peaked between 08:30 AM and 09:30 AM. Nectar secretion showed a distinct diurnal curve, peaking between 01:00 PM and 03:00 PM(0.33±0.01µl). Despite significant energetic investments in pollen and nectar rewards, macro-insect floral visitors were absent, with biotic interactions restricted to micro-thrips. The chronological separation between bud-stage dehiscence and anthesis confirms that C. arietinum relies primarily on an autonomous self-pollination (autogamous) breeding system.

Keywords: *Cicer arietinum, Phenology, Pollen Production, Pollen-Ovule Ratio, Nectar Dynamics.*

Introduction

The temporal regulation of sexual reproduction is a critical determinant of fitness and reproductive success in angiosperms. Selection pressures shape flowering phenology to optimize fecundity and seed development in response to local climatic variables (Godoy et al., 2009). Phenological synchronization between anthesis and mutualistic pollinator availability serves as a mechanism for reproductive isolation and evolutionary speciation (Schmitt, 1983; Sihag, 1993).

Floral rewards, primarily nectar and pollen, mediate insect-plant interactions. Pollinators associate visual and olfactory floral cues with caloric rewards (Menzel, 1985), establishing a direct correlation between nectar production rates and anthophilous visitor frequency (Heinrich, 1976). This study evaluates the floral biology, phenological phases, and reproductive allocation of *Cicer arietinum* L., an economically vital pulse crop widely cultivated across semi-arid regions of India, including Uttar Pradesh, Punjab, Maharashtra, Rajasthan, Bihar, and Madhya Pradesh.

Methodology

Field investigations were conducted on cultivated populations of *Cicer arietinum* L. across three distinct agro-ecological sites in and around Arvi city, Wardha district, Maharashtra, India.

- **Phenological Monitoring:** Phenological phases were recorded via daily or alternate-day field visitations. The flowering period was defined as the interval between initial anthesis and terminal flower senescence.
- **Palynological Analysis:** The chronology of anthesis and anther dehiscence was recorded. Quantitative pollen production per anther and per flower was determined following the methodology of Nair and Rastogi (1963). Pollen viability was assessed *in vitro* using the Tetrazolium (TTC) test (Loken, 1942). The pollen-to-ovule ratio was computed based on absolute pollen counts and ovule numbers according to Cruden (1977).
- **Floral Dynamics:** Stigma receptivity was determined by monitoring morphological changes (glossiness and turgidity) post-anthesis. Nectar volume was extracted from the intra-floral nectaries at 2-hour intervals using microcapillary tubes inserted via precise incisions.

Results and Discussion

Floral Morphology and Phenology

Cicer arietinum L. (commonly known as "Gram") exhibits a much-branched, bushy, erect herbaceous habit. Leaves are imparipinnately compound (2.5–5.0 cm long) with 5–7 pairs of ovate-elliptic, cuneate, and sharply dentate leaflets. Flowers are axillary and solitary, possessing a pubescent calyx and a yellow corolla.

The phenological timeline was highly synchronized across all three study sites:

- **Initiation Phase:** Third week of November.
- **Peak Flowering Phase:** Last week of November to the second week of December.
- **Termination Phase:** Last week of December.

Anthesis, Dehiscence, and Pollen Dynamics

Floral anthesis was initiated at 08:30 AM, achieving full geometric opening by 09:00 AM. In contrast to general crop trends documented by Patil and Zingre (1976), anther dehiscence occurred precociously between 06:00 AM and 06:30 AM while the flower remained in the bud stage, indicating a cleistogamous or highly autonomous self-pollination mechanism.

Quantitative palynological indices varied slightly across the selected sites (Table 1). A positive correlation was observed between flower size parameters and absolute pollen production.

Table 1: Palynological and Reproductive Allocation Data across Three Study Sites

Parameter	Site 1	Site 2	Site 3
Pollen Production / Flower	14,994.54 ± 1,161.26	15,112.35 ± 1,156.87	15,765.75 ± 1,580.21
Pollen Viability (%)	92.22%	91.65%	93.98%
Pollen: Ovule Ratio	7,497.27: 1	7,556.17: 1	7,882.87: 1

Stigma Receptivity and Nectar Kinetics

The stigma exhibited peak receptivity between 08:30 AM and 09:30 AM, characterized by a whitish, glistening macroscopic appearance. Senescence and loss of receptivity occurred between 03:30 PM and 05:00 PM, evidenced by tissue desiccation and blackish discoloration. Notably, under cloudy or high-humidity conditions, stigma receptivity was prolonged up to the third day post-anthesis, aligning with observations by Gori (1983), Dafni (1992) and Dahat and Kale (2021).

Temporal monitoring of nectar secretion revealed a diurnal peak during mid-day intervals (Table 2).

Table 2: Diurnal Kinetics of Nectar Secretion

Time Interval	Mean Nectar Volume (µl)	Physical State of Nectary
09:00 AM – 11:00 AM	0.21 ± 0.01	Active secretion onset
01:00 PM – 03:00 PM	0.33 ± 0.01	Peak secretory phase
04:00 PM – 06:00 PM	0.05 ± 0.00	Secretion cessation / Dryness

Pollination Observations

Despite substantial quantitative nectar and pollen rewards, macro-insect floral visitors or specialized melittophilous (bee) pollinators—generally expected in pulse crops (Deodikar and Suryanarayana, 1977)—were absent. Biotic interactions were restricted to occasional foraging by micro-thrips (red and white morphs), suggesting that the high pollen-to-ovule ratios and early bud-dehiscing traits serve primarily to secure autonomous self-pollination.

Conclusion

The present investigation successfully quantifies the reproductive traits of *Cicer arietinum* L. in the Wardha region. The chronological separation between bud-stage anther dehiscence and mechanical anthesis reinforces a primary autogamous breeding system, despite the high energetic allocation toward pollen and nectar synthesis.

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Conflicts of interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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