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TEMPORAL SYNCHRONY OF STIGMA RECEPTIVITY AND POLLINATION: IMPLICATIONS FOR YIELD AND QUALITY IN OKRA (*ABELMOSCHUS ESCULENTUS* L. MOENCH) HYBRIDS

Dachani Sruthi^{1*}, C.A. Babariya¹, Bandari Naresh² and K. Bhargava³

¹Junagadh Agricultural University, Junagadh, Gujarat- 362 001, India.

²Sri Konda Laxman Telangana Horticultural University, Mulugu, Siddipet, Telangana-502279, India

³School of Agricultural Science, Malla Reddy University, Hyderabad- 500014, India

*Corresponding author E-mail: sruthireddydachani@gmail.com,

(Corresponding author's present address, School of Agricultural Science, Malla Reddy University, Hyderabad- 500014, India)

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ABSTRACT

Efficient hybrid seed production in okra (*Abelmoschus esculentus* L. Moench) relies on the precise coordination between stigma receptivity and the timing of pollination. This study was undertaken to examine how the interaction between these two factors affects seed yield and quality in okra hybrids. A field experiment was conducted during the *kharif* 2019 season at Junagadh Agricultural University using a factorial randomized block design. The treatments included three emasculation timings (D_1 -on the same day, D_2 -one day before, and D_3 -two days before pollination) and three pollination intervals (T_1 -8:00–10:00 AM, T_2 -11:00 AM–1:00 PM, and T_3 -2:00–4:00 PM), involving the hybrid combination of female parent JF-55 and male parent JOM-2K-19. Findings revealed that pollinating on the same day as emasculation during the early morning (8:00–10:00 AM) produced significantly higher fruit set (63.33%), seed yield per plant (31.82 g), seed number (49.33), and seed weight (6.31 g). This timing also resulted in improved seed quality traits, including maximum germination percentage (90.03%) and seedling vigour. Delayed pollination, especially two days post-emasculation during afternoon hours, led to a noticeable decline in seed set and vigour, likely due to reduced stigma receptivity and unfavourable environmental conditions. The results underscore the importance of timing in reproductive processes for okra hybrid seed production. Aligning pollination with the peak receptive phase of the stigma, particularly during morning hours, enhances both yield and seed quality, offering a practical approach for improving hybrid seed efficiency in okra.

Key words: Okra, hybrid seed production, stigma receptivity, pollination timing, seed yield, seed quality.

Introduction

Okra (*Abelmoschus esculentus* L. Moench) is a prime vegetable crop cultivated extensively in tropical and subtropical regions for its succulent green pods, which are rich in vitamins, minerals, and mucilage. Hybrid breeding in okra has become increasingly significant for enhancing yield potential, resistance traits, and quality attributes (Singh *et al.*, 2020). However, the success of hybridization in okra, a crop with ephemeral flowers and a narrow pollination window, hinges largely on the precise synchronization between stigma receptivity and pollination timing (Kumar *et al.*, 2018).

Stigma receptivity—the period during which the stigma is physiologically capable of accepting and facilitating pollen germination—varies across genotypes and is influenced by both biotic and abiotic factors such as temperature, humidity, and flower age (Patel & Singh, 2017). Similarly, the timing of pollination impacts not only the success of fertilization but also subsequent pod development, seed set, and quality parameters (Reddy *et al.*, 2019). Despite the critical role these two factors play individually, their interactive effect has received narrow attention in okra hybridization programs.

Temporal misalignment between peak stigma

Table 1: Interaction between time of pollination and stigma receptivity i.e. effects the different yield attributes on hybrid seed production.

Interaction	NFCP	NCFP	FS	FWP	FL	FG	HSWF	NSF	SYP	100SW
$D_1 \times T_1$	10	6.33	63.33	32.32	19.63	5.30	4.09	49.33	31.82	6.31
$D_1 \times T_2$	9.66	6.00	62.20	32.03	19.16	5.21	4.04	48.33	30.77	6.20
$D_1 \times T_3$	9.33	4.33	46.29	31.81	18.23	5.15	4.02	44.00	28.97	6.14
$D_2 \times T_1$	9.33	4.33	46.29	28.29	18.10	5.13	4.01	41.33	23.50	6.08
$D_2 \times T_2$	9.33	4.00	42.96	24.06	17.40	5.04	3.67	34.33	22.35	5.60
$D_2 \times T_3$	9.33	3.33	35.91	23.62	17.10	4.93	3.38	30.66	20.38	5.48
$D_3 \times T_1$	9.33	2.00	21.48	23.30	16.76	4.84	3.01	30.00	19.37	5.47
$D_3 \times T_2$	9.33	1.66	17.77	22.54	16.43	4.75	2.96	20.66	15.99	5.08
$D_3 \times T_3$	9.33	1.33	14.44	21.30	16.03	4.63	2.92	21	12.81	5.01
Mean	9.44	3.70	38.96	26.58	17.65	5.00	3.57	35.51	22.88	5.71
S. Em. \pm	0.31	0.18	1.58	0.63	0.11	0.04	0.08	0.96	0.52	0.06
C.D. at 5 %	NS	0.56	4.73	1.89	0.33	NS	0.26	2.90	1.56	0.20

D_1 -on the same day, D_2 -one day before, and D_3 -two days before pollination;
 T_1 -8:00–10:00 AM, T_2 -11:00 AM–1:00 PM, and T_3 -2:00–4:00 PM
NFCP: Number of flowers crossed per plant; NCFP: Number of crossed fruits retained per plant; FS: Fruit set (%);
FWP: Fruit weight per plant (g); FL: Fruit length (cm); FG: Fruit girth (cm); HSWF: Hybrid seed weight per fruit (g);
NSF: Number of seeds per fruit; SYP: Seed yield per plant (g); 100SW: 100 seed weight (g)

receptivity and the actual time of pollination can lead to poor fertilization efficiency, resulting in reduced pod formation and compromised seed quality. Conversely, a well-coordinated pollination event during the optimal receptive phase of the stigma can significantly enhance hybrid vigor and expression of key yield traits (Chandran *et al.*, 2021). Understanding this synchrony is especially vital in okra, where floral biology is highly time-sensitive, with anthesis, anther dehiscence, and stigma receptivity occurring within a narrow time frame.

This study, therefore, aims to investigate the temporal synchrony between stigma receptivity and pollination timing, and its impact on the yield and quality traits in okra hybrids. By integrating reproductive physiology with practical pollination schedules, this work seeks to contribute a novel framework for optimizing hybrid seed production in okra.

Materials and Methods

The present research entitled “Temporal Synchrony of Stigma Receptivity and Pollination: Implications for Yield and Quality in Okra Hybrids” was carried out in *kharif* 2019 at Sagdividi Farm, Department of Seed Science and Technology, College of Agriculture, Junagadh Agricultural University, Junagadh. The seed field was separated from fields of other varieties by 400 m as recommended by seed certification agency. The experiment was laid out in randomized block design with factorial concept in black soil. The seed material of “Female Parent: JF-55 and Male Parent: JOM-2K-19” was acquired from Vegetable Research Station, Junagadh Agricultural University, Junagadh. There were nine

treatment combinations consisting of three days of emasculation such as emasculation on the same day of pollination (no stigma starvation), emasculation one day before pollination, emasculation two days before pollination and three pollination treatments *viz.*, 8.00 am to 10.00 am, 11.00am to 1.00 noon and 2.00 pm to 4.00 pm with three replications. The seeds of female and male parent were sown in main field as per treatments with spacing of 60 × 30 cm following all recommendation (Abhishekkatagi *et al.*, 2013.) The emasculation was carried out daily as per the treatments and the pollination i.e. the transfer of pollen from male parent (JOM-2K-19) to female parent (JF-55) was made. To ensure accurate identification, different colored threads were attached to the pedicels of the crossed buds corresponding to each treatment. Pollination was carried out daily in accordance with the treatments. Five plants were picked at random in each treatment and replication and tagged to record the observations. The yield and yield parameters were recorded at and after harvest of the crop. Seed germination was assessed following the ISTA guidelines (Anonymous, 1999), and the seedling vigour index was computed using the formula described by Abdul-Baki and Anderson (1973), as the product of germination percentage and the sum of root and shoot lengths. Additional seedling quality traits, including root length, shoot length, and dry weight, were also measured.

Results and Discussion

Seed Yield and Its Attributes

Effect of Stigma Receptivity (Day of Emasculation):

The present study disclosed that pollination conducted

Table 2: Interaction between time of pollination and stigma receptivity i.e effects the different quality attributes on hybrid seed production.

Interaction	Seed germination percentage	Seedling shoot length (cm)	Seedling root length (cm)	Seedling dry weight (g)	Seedling vigour index I (length)	Seedling vigour index II (Mass)
$D_1 \times T_1$	90.03	15.60	8.93	0.30	2208.73	27.34
$D_1 \times T_2$	85.27	15.10	8.77	0.25	2035.11	21.49
$D_1 \times T_3$	82.77	14.63	8.73	0.24	1933.89	20.19
$D_2 \times T_1$	80.10	14.33	8.53	0.24	1831.77	19.46
$D_2 \times T_2$	78.17	14.13	7.90	0.24	1722.33	18.68
$D_2 \times T_3$	74.10	14.07	7.53	0.24	1600.43	17.78
$D_3 \times T_1$	71.07	13.50	7.20	0.23	1471.28	16.65
$D_3 \times T_2$	67.23	13.33	6.97	0.22	1364.80	15.08
$D_3 \times T_3$	62.67	11.63	6.47	0.21	1133.98	13.01
Mean	76.82	14.03	7.89	0.24	1700.26	18.85
S. Em. \pm	0.40	0.26	0.11	0.003	22.47	0.26
C.D. at 5 %	1.21	0.78	0.33	0.009	66.78	0.79
D_1 -on the same day, D_2 -one day before, and D_3 -two days before pollination; T_1 -8:00–10:00 AM, T_2 -11:00 AM–1:00 PM, and T_3 -2:00–4:00 PM						

on the same day of emasculation (D_1) significantly improved yield parameters. This treatment resulted in the highest fruit set (57.27%), seed yield per plant (30.52 g), number of seeds per fruit (47.22), and 100-seed weight (6.21 g). This suggests that the stigma is most receptive on the day of flower opening and emasculation, with receptivity declining sharply afterward due to desiccation of the stigmatic surface. Similar results were described by Singh *et al.*, (2010) and Abhishek *et al.*, (2013), who also found maximum seed setting when pollination was synchronized with peak stigma receptivity.

Delayed pollination, particularly two days post-emasculation (D_3), led to significantly lower fruit set (17.90%) and seed yield (16.05 g/plant), likely due to reduced receptivity or complete non-receptivity of the stigma. These findings are consistent with reports in other crops such as chilli (Priya *et al.*, 2009), brinjal (Desai & Biradarpatil, 2016), and tomato (Sujatha *et al.*, 2015), which showed stigma receptivity peaking within 24 hours of anthesis.

Effect of Time of Pollination:

The morning pollination period (8:00–10:00 AM, T_1) significantly outperformed other time intervals. Higher values were recorded for fruit set (43.70%), seed yield (24.89 g), and number of seeds per fruit (40.22), compared to midday (T_2) and afternoon (T_3) pollination. This advantage is attributed to favorable microclimatic conditions such as moderate temperature and humidity that preserve pollen viability and enhance stigma receptivity during early hours (Rao *et al.*, 1979; Basavaraj, 2006).

Pollination done during 2:00–4:00 PM (T_3) resulted in the poorest performance due to elevated temperatures

and lower humidity, leading to stigma drying and pollen desiccation. Similar trends have been reported in okra and other vegetable crops (Veerashaet *et al.*, 2018; Sandra *et al.*, 2012; Sharma *et al.*, 2017).

Interaction Effects of Stigma Receptivity and Pollination Time:

The interaction between day of emasculation and time of pollination ($D \times T$) was statistically significant for all major traits except fruit girth. The combination $D_1 \times T_1$ (pollination on the same day of emasculation between 8:00–10:00 AM) recorded the highest values across fruit set (63.33%), seed yield (31.82 g/plant), hybrid seed weight (4.09 g), and 100-seed weight (6.31 g). These findings emphasize the importance of both physiological readiness (stigmatic receptivity) and optimal environmental conditions during pollination.

Comparable observations have been documented by Singh *et al.* (2010), Abhishek *et al.* (2013), and Priya *et al.* (2009), reinforcing the concept of temporal synchronization as a key determinant of hybrid seed productivity in crops like okra and chilli.

Seed Quality Parameters

Germination and Seedling Vigour:

Seeds harvested from the $D_1 \times T_1$ treatment combination exhibited significantly superior germination percentage (90.03%), shoot length (15.60 cm), root length (8.93 cm), and seedling vigour indices—SVI-I (2208.73) and SVI-II (27.34). These results indicate that optimal pollination timing not only improves seed quantity but also enhances physiological seed quality (Dev, 1998; Patil *et al.*, 2008).

In contrast, the $D_3 \times T_3$ combination (pollination two

days after emasculation in the afternoon) resulted in the lowest germination (62.67%) and seedling vigour, likely due to suboptimal seed development and reduced metabolic reserves. These findings echo those of Sanjeev *et al.*, (2008) and Sharma *et al.*, (2017), who also reported improved seedling performance when pollination occurred under optimal stigma receptivity and environmental conditions.

Seedling Dry Weight:

Seedling dry weight followed the same trend, with $D_1 \times T_1$ recording the maximum value (0.30 g), suggesting that timely pollination leads to heavier, more nutrient-rich seeds. Minimum dry weight (0.21 g) in $D_3 \times T_3$ further reinforces the adverse impact of delayed or ill-timed pollination.

Conclusion

The results of the present study unequivocally demonstrate that synchronizing stigma receptivity with optimal pollination timing ($D_1 \times T_1$) significantly enhances seed yield, quality, and seedling vigour in okra hybrids. Early morning pollination on the day of emasculation is recommended as a best practice for maximizing hybrid seed productivity and ensuring high-quality planting material.

Conflict of Interest: The authors declare that there is no conflict of interest exist (both financial and non- financial).

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Authors' Contributions

Dachani Sruthi: Conceptualized the study, designed the experimental layout, conducted field evaluation, collected data, carried out statistical analysis, interpreted the results and prepared the first draft of the manuscript.

Dr. C.A. Babariya: Provided overall supervision, guided the experimental methodology, contributed to data validation and interpretation, critically reviewed the manuscript, and approved the final version for publication.

Bandari Naresh: Assisted in literature review, data tabulation, preparation of tables and contributed to editing and final proofreading of the manuscript.

Dr. K. Bhargava: Assisted in literature review, data tabulation, preparation of tables and contributed to editing

and final proofreading of the manuscript.

All authors read and approved the final manuscript.

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