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Floral biology studies in cucumber (*Cucumis sativus* L.)

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Abstract

Artificial pollination of vegetable crops necessitates the knowledge of crop's floral biology. In this aspect present investigations were carried out, to gather the information on the floral biology of monoecious (K-75 and UHF-CUC-101) and gynoecious (GYNO-1 and GYNO-2) varieties of cucumber at the Experimental Research Farm, Department of Vegetable Science, Dr. YSPUHF Nauni, Solan (HP) during Kharif, 2016. The experiment was laid out in a RCBD with three replications. The observations were recorded on time of anthesis, dehiscence, pollen viability (%), stigma receptivity and node number bearing first female flower. The experimental results showed that anthesis started at 6AM and completed by 8AM with the maximum anthesis between 6AM to 7AM in monoecious varieties whereas, in gynoecious varieties it was maximum upto 6:00AM in both open and controlled conditions and similar pattern was observed for dehiscence. Dehiscence occurs soon after anthesis. Maximum pollen viability was recorded on the day of anthesis and viability of pollen under refrigerated condition did not decrease as rapidly as it was under room temperature condition with the duration of pollen storage. Maximum stigma receptivity was noticed at anthesis time and pollination during this interval recorded maximum fruit-set. Gynoecious lines were earlier in flowering and fruiting than monoecious varieties.

Key words: Anthesis, cucumber, dehiscence, gynoecious, monoecious

Introduction

Cucumber (*Cucumis sativus* L.) belongimg to the family cucurbitaceae is the second most widely cultivated cucurbit after watermelon. Cucumber locally known as "Khira" is native to Asia and Africa, where it has been used for 3,000 years (Aslam *et al.,* 2008). Cucumber is basically monoecious in nature which means that both male and female flowers borne separately on the same plant. Male flowers occur in clusters with each flower on a slender stem and housing three stamens. Female flowers occur singly and are distinguishable by the large ovary at the flower base. However, gynoecious sex form is also found in which only female flowers are produced. Most cucumbers, whether monoecious or gynoecious, require insects to transfer pollen between flowers of the same or different plant. Fruit abortion can reach 100 per cent in flowers bagged to exclude insect visitors, but self-pollination rates of 30-36 per cent have been documented in the absence of insects (Gingras *et al*., 1999).

In cucumber, a higher hybrid seed yield can be obtained from the seed parent if the stigma receptiveness and pollen viability are perfectly aligned. Present study focussed on floral biology, such as anthesis time, anther dehiscence, stigma receptivity, and pollen viability. All subsequent work is likely to fail without a complete understanding of the crop's floral mechanism. (Naik *et al*., 2013). The introduction and success of F_1 in cucumber has made it imperative for the breeder to find out more appropriate combinations to develop superior F_1 hybrids. Use of gynoecious lines in F_1 seed production ensures higher yields in the resultant hybrids. Thus, in order to obtain the maximum fruit-set percentage and number of seed per fruit, it is imperative to know about the floral biology (Revanasidda and Belavadi, 2019; Verma *et al.*, 2020). Several researchers have studied the cucumber pollination system, with interesting and varied results in terms of floral biology and pollinator diversity across different geographical locations (Thu, 2012; Ekeke *et al.,* 2018). However, information on floral biology in gynoecious as well as monoecious lines under the mid-hill conditions of Himachal Pradesh, India, is lacking.

The present study was undertaken to obtain information pertaining to floral biology in both monoecious and gynoecious cucumber genotypes.

Materials and methods

Floral biology studies were carried out for one week from 6:00 AM onwards till 6:00 PM, involving two methods of pollination *i.e.* open and controlled (hand) pollination on four cultivars *viz.*, two monoecious (Khira-75 and UHF-CUC-101) and two gynoecious lines (GYNO-1 and GYNO-2) of cucumber planted in Randomized Complete Block Design (RCBD) with 3 replications. Row to row and plant to plant spacing of 100 cm × 50 cm was kept in a plot having size 3.0 m × 3.0 m accommodated 18 plants per plot. As there is no male flower in gynoecious lines, so male flowers were induced after spraying chemical solutions (Gibberellic acid, silver nitrate and silver thiosulphate) to study the anthesis, anther dehiscence, pollen viability and also the requirement of the male flower for pollination to study stigma receptivity (Verma *et al.,* 2018). The 10 randomly selected competitive plants from each replication of every genotype were used for observations pertaining to the following characters:

Anthesis and dehiscence: Flowers expected to open next day were tagged in the evening and observations were recorded at hourly intervals from 6:00 AM onwards till complete opening

and dehiscence of all flowers. The opened flowers were removed every time at an interval of hour. Time of complete opening of flowers was noted and percentage was determined by computing the mean frequency of flower opening over various time slots. Similarly, time of anther bursting and release of pollen from pollen sac were noted to determine the peak period of dehiscence in various cultivars under study (Njoroge *et al.,* 2010).

Pollen viability: Per cent pollen viability was determined by the aceto-carmine staining methods and slide was examined under a microscope (Carl Zeiss, Gottingen, Germany; McKellar and Quesenberry, 1992 and Marutani *et al.,* 1993). Took 2-3 readings of same sample and then average pollen viability in per cent was calculated.

Stigma receptivity: It was determined by two methods *viz.*, visual and fruit-set method.

a) Visual method: Observations were made every day for one week on freshly opened female flowers in each variety and the changes in the stigmatic surface were noted with the help of hand lens. Presence of exudates (water fluid) on stigmatic surface, shinning and glossy stigmatic surfaces were considered receptive.

b) Fruit-set method: Used Sandra *et al*. (2018) technique to determine the peak period of stigma receptivity. Hand pollinations were performed at the time of anthesis, 4 hours, 6 hours, 8 hours, and 10 hours later, and jewel tags with the time of pollination were placed on these flowers. On the basis of fruit-set, the average fruit-set obtained in each category was calculated.

Node number bearing first female flower: Node number of each cultivar, at which the first female flower appeared, was counted from the ground surface in each replication and mean values was worked out to estimate the earliness of variety.

The data for anthesis and anther dehiscence were analysed using three factor analysis and for stigma receptivity by two factorial analysis in RCBD, whereas pollen viability was estimated in the laboratory and data were analysed using two factor analysis in completely randomized design (CRD) as model suggested by Panse and Sukhatme (2000). The statistical analysis was carried out for each observed character under the study using MS-Excel and OPSTAT 16.0 software as per the designs of experiments.

Results and discussion

Anthesis: The anthesis begin from 6:00 AM early in the morning and continued up to 8:00 AM in all the cultivars (Table 1). Maximum anthesis occurred in K-75 between 6:00 AM to 7:00 AM, in open and controlled conditions. When compared to controlled conditions (60.87%), anthesis in open conditions was higher (63.25%). Similar trend of anthesis in UHF-CUC-101 was recorded, but anthesis in controlled conditions was more than open pollination. In cultivar GYNO-1 maximum anthesis took place up to 6:00 AM and found statistically at par with GYNO-2, thereafter gradual decline in anthesis was noticed with passage of time. In open pollination and controlled conditions, 78.96 per cent and 66.66 per cent flower anthesised, respectively up to 6:00 AM in GYNO-1, while a similar trend was observed in GYNO-2, where maximum flower anthesis occur upto 6:00AM. After 7:00 AM rate of anthesis sharply declined and was completed by 8:00 AM with no flower anthesis occur at 9:00 AM. The current findings are consistent with the results of Bomfim *et al*. (2015) in watermelon, Tschoeke *et al*. (2015), Kiill *et al*. (2016), Revanasidda and Belavadi (2019) in muskmelon, Thu (2012), Nicodemo *et al*. (2012) and Ekeke *et al.* (2018) in cucumber.

Dehiscence: All cultivars completed anther dehiscence within two hours of anthesis (Table 2), with peak dehiscence observed between 6:00AM and 7:00AM in K-75 and UHF-CUC-101. More flowers dehisced in open pollinated conditions than in controlled pollinated conditions in both cultivars. While in gynoecious cultivars, peak period of dehiscence was observed upto 6:00AM in both conditions. Controlled conditions resulted in greater flower dehiscence than open pollination in GYNO-1 and GYNO-2. The dehiscence rate in all cultivars showed a sharp decline after 7:00 AM, and by 8:00AM, the process was complete. The present findings are in conformity with Naik *et al.* (2013) in *Momordica sp.* and Tschoeke *et al*. (2015) and Revanasidda and Belavadi (2019) in muskmelon.

Pollen viability: At room temperature, maximum pollen viability (97.74%) was found in freshly stored pollen. After 24 hours of storage, pollen viability was 88.20 per cent and thereafter, pollen viability was reduced gradually (Table 3). Amongst various cultivars, K-75 showed maximum pollen viability followed by UHF-CUC-101, GYNO-2 and GYNO-1. Interactions (Age of pollen × Varieties) showed significant effect on pollen viability

Table 1 Time of anthesis in different varieties of cucumber

Varieties	Mean number of flowers anthesised (%)											
	Open				Bagging				Varieties × Time			
	At 6 AM	At 7 AM	At 8 AM	Mean	At 6 AM	At 7 AM	At 8 AM	Mean	At 6 AM	At 7 AM	At 8 AM	Mean
K-75	31.58 (34.17)	63.25 (52.68)	5.16 (13.04)	33.33 (33.30)	37.08 (37.48)	60.87 (51.26)	2.22 (8.35)	33.39 (32.36)	34.33 (35.83)	62.06 (51.97)	3.69 (10.69)	33.36 (32.83)
UHF-CUC-101	42.46 (40.63)	52.62 (46.49)	4.60 (12.38)	33.23 (33.16)	39.84 (39.12)	57.93 (49.55)	2.54 (8.86)	33.44 (32.51)	41.15 (39.87)	55.28 (48.02)	3.57 (10.62)	33.33 (32.84)
GYNO-1#	78.96 (62.69)	19.75 (26.36)	1.27 (5.10)	33.33 (31.39)	66.66 (54.72)	31.35 (ـ 4.03)	1.98 (8.08)	33.33 (32.28)	72.81 (58.70)	25.55 (30.20)	1.62 (6.59)	33.33 (31.83)
GYNO-2#	77.61 (61.75)	20.32 (26.76)	2.06 (8.16)	33.33 (32.22)	68.09 (55.65)	30.07 (33.20)	1.82 (7.22)	33.33 (32.02)	72.85 (58.70)	25.20 (29.98)	1.94 (7.69)	33.33 (32.12)
Mean	57.65 (49.81)	38.98 (38.08)	3.27 (9.67)	33.30 (32.52)	52.92 (46.74)	45.06 (42.01)	2.14 (8.13)	33.37 (32.29)	55.29 (48.28)	42.02 (40.04)	2.71 (8.90)	
Varieties (V)	NS				V×C		NS					
Time (T)	1.78 (1.37)				T×C		2.51 (1.93)					
Condition (C)	NS				V×T×C		5.03 (3.87)					
V×T	3.56 (2.74)											

*Significant at P=0.05. Figures in parenthesis are Arc sine transformed. #In induced male flower after spray

Table 2. Time of anther dehiscence in different varieties of cucumber

Varieties	Mean number of flowers showing dehiscence (%)											
	Open				Bagging				Varieties × Time			
	At 6 AM	At 7 AM	At 8 AM	Mean	At 6 AM	At 7 AM	At 8 AM	Mean	At 6 AM	At 7 AM	At 8 AM	Mean
K-75	36.59 (37.19)	61.59 (51.68)	1.82 (7.22)	33.33 (32.03)	42.70 (40.76)	55.55 (48.18)	1.75 (7.40)	33.33 (32.11)	39.64 (38.98)	58.57 (49.93)	1.79 (7.31)	33.33 (32.07)
UHF-CUC-101	41.90 (40.32)	55.71 (48.26)	2.38 (8.35)	33.33 (32.31)	43.97 (41.51)	54.68 (47.67)	1.35 (6.63)	33.33 (31.94)	42.94 (40.92)	55.20 (47.96)	1.87 (7.49)	33.33 (32.12)
GYNO-1#	68.49 (55.86)	28.97 (32.52)	1.74 (7.39)	33.07 (31.92)	82.85 (65.51)	15.55 (23.20)	1.59 (5.79)	33.33 (31.50)	75.67 (60.69)	22.26 (27.86)	1.67 (6.59)	33.20 (31.71)
GYNO-2#	72.30 (58.36)	26.67 (30.91)	1.03 (4.67)	33.33 (31.31)	81.98 (64.89)	16.74 (24.09)	1.27 (5.10)	33.33 (31.36)	77.14 (61.63)	21.70 (27.50)	1.15 (4.89)	33.33 (31.34)
Mean	54.82 (47.93)	43.23 (40.84)	1.74 (6.91)	33.27 (31.89)	62.87 (53.17)	35.63 (35.79)	1.49 (6.23)	33.33 (31.73)	58.85 (50.55)	39.43 (38.31)	1.62 (6.57)	

$CD_{0.05}$				
	Varieties (V):	NS	V×C:	NS
	Time (T):	2.12 (1.78)	T×C	3.00 (2.52)
	Condition (C):	NS	V×T×C	6.00 (5.04)
	V×T:	4.24 (3.56)		

*Significant at P=0.05. Figures in parenthesis are Arc sine transformed. #In induced male flower after spray

per cent, with values ranging from 58.55-98.30per cent. At room temperature, maximum viability of fresh pollen was recorded in cultivar K-75 and minimum in GYNO-1. After 3 hours of storage, pollen viability in different genotypes was reduced to 98.07 (K-75), 97.19 (GYNO-2), 97.04 (UHF-CUC-101) and 95.67 (GYNO-1) per cent. Thereafter, pollen viability decreased gradually over time, with maximum remaining in K-75 and minimum in GYNO-1. However, decline in pollen viability under refrigerated conditions was not as rapid as it was under room temperature conditions (Table 4). Pollen viability in refrigerated conditions decreased by 3.61 (K-75), 1.70 (UHF-CUC-101), 3.68 (GYNO-2) and 3.69 percent (GYNO-1) after 24 hours, compared to 8.64, 8.72, 11.09, and 9.70 percent at room temperature for K-75, UHF-CUC-101, GYNO-2, and GYNO-1, respectively. UHF-CUC-101 showed highest pollen viability after 120 hours of refrigeration, followed by K-75, GYNO-1, and GYNO-2. These findings supported previous research by Ekeke *et al*. (2018) in cucumber and Revanasidda and Belavadi (2019) in muskmelon, which concluded pollen viability declines due to dehydration of pollen grain around pore where intine is exposed.

Table 3. Percent viability of pollen in different varieties of cucumber at room temperature conditions

Age of pollen	Room temperature				Mean
	GYNO-1#	GYNO-2#	K-75	UHF-CUC-101	
Fresh	96.33 (78.95)	98.14 (82.13)	98.30 (82.49)	98.17 (82.20)	97.74 (81.44)
After 3 h	95.67 (77.97)	97.19 (80.31)	98.07 (81.98)	97.04 (80.06)	96.99 (80.08)
After 6 h	95.21 (77.38)	95.95 (78.36)	97.18 (80.30)	96.57 (79.30)	96.23 (78.84)
After 9 h	94.36 (76.24)	94.99 (77.04)	96.03 (78.48)	96.01 (78.44)	95.35 (77.55)
After 24 h	86.63 (68.54)	87.05 (68.89)	89.66 (71.21)	89.45 (71.02)	88.20 (69.92)
After 48 h	80.85 (64.03)	83.86 (66.29)	81.37 (64.41)	80.59 (63.83)	81.67 (64.64)
After 72 h	74.44 (59.61)	71.59 (57.77)	74.49 (59.64)	71.61 (57.78)	73.03 (58.70)
After 96 h	58.55 (49.91)	59.44 (50.42)	64.63 (53.49)	60.81 (51.22)	60.86 (51.26)
Mean	85.26 (69.08)	86.03 (70.15)	87.47 (71.50)	86.28 (70.48)	

$CD_{0.05}$		
	Age of pollen	: 0.52 (0.46)
	Varieties	: 0.37 (0.33)
	Age of pollen × Varieties	: 1.03 (0.92)

*Significant at P=0.05. Figures in parenthesis are Arc sine transformed. #In induced male flower after spray

Stigma receptivity

Visual method: Maximum stigma receptivity was observed during anthesis, as evidenced by the presence of stigmatic secretions, shine, glossiness, and greenish white colour.

Fruit-set method: In all four varieties, stigma receptivity was recorded nil one day before anthesis. The maximum receptivity was observed at anthesis and then decreased as the time period after anthesis increased (Table 5), confirming the findings of visual method. The maximum stigma receptivity was recorded in K-75 at anthesis in comparison to other cultivars. At 8:00 AM, stigma receptivity was reduced to 50 per cent in K-75 and found significantly at par with UHF-CUC-101 and GYNO-2. A similar trend of maximum and minimum stigma receptivity among cultivars was observed at 10:00 AM, 12:00 noon and 2:00 PM and was nil after 10 hours of anthesis (Table 5). The current

Table 4. Percent viability of pollen in different varieties of cucumber under refrigerated conditions

Age of pollen	Varieties				Mean
	GYNO-1#	GYNO-2#	K-75	UHF-CUC-101	
Fresh	97.14 (80.23)	98.14 (82.12)	98.30 (82.49)	98.16 (82.18)	97.93 (81.75)
After 24 h	93.46 (75.16)	94.46 (76.36)	94.69 (76.65)	96.46 (79.14)	94.77 (76.83)
After 48 h	87.60 (69.35)	86.42 (68.35)	91.35 (72.87)	89.64 (71.19)	88.75 (70.44)
After 72 h	81.48 (64.48)	79.48 (63.04)	86.52 (68.43)	83.64 (66.11)	82.78 (65.51)
After 96 h	76.21 (60.78)	75.57 (60.35)	80.67 (63.89)	81.58 (64.56)	78.51 (62.40)
After 120 h	70.68 (57.19)	69.41 (56.39)	71.29 (57.57)	77.23 (61.52)	72.15 (58.17)
Mean	84.43 (67.87)	83.92 (67.77)	87.13 (70.32)	87.78 (70.78)	

$CD_{0.05}$		
	Age of pollen	0.63 (0.48)
	Varieties	0.51 (0.39)
	Age of pollen × Varieties	1.26 (0.96)

*Significant at P=0.05. Figures in parenthesis are Arc sine transformed. #In induced male flower after spray

Table 5. Percent fruit-set in cucumber varieties at different intervals of pollination

Time of pollination	Percent fruit-set				Mean
	GYNO-1	GYNO-2	K-75	UHF-CUC-101	
1 day before anthesis	-	-	-	-	-
At anthesis (6:00 AM)	51.50 (45.86)	54.85 (47.79)	61.60 (51.74)	56.33 (48.64)	56.07 (48.51)
2 HAA (8:00 AM)	32.12 (34.50)	48.15 (43.94)	50.00 (45.00)	50.00 (45.00)	45.07 (42.11)
4 HAA (10:00 AM)	14.48 (22.34)	38.79 (38.52)	38.79 (38.52)	38.79 (38.52)	32.71 (34.47)
6 HAA (12:00 noon)	2.78 (5.59)	29.52 (32.91)	29.52 (32.91)	18.89 (25.74)	25.18 (28.52)
8 HAA (2:00 PM)	0.00 (0.00)	14.49 (22.34)	18.89 (25.74)	15.08 (22.84)	12.11 (17.73)
10 HAA (4:00 PM)	-	-	-	-	-
Mean (Varieties)	20.18 (21.65)	37.16 (37.10)	39.76 (38.78)	35.82 (36.15)	
$CD_{0.05}$	Time of pollination			: 2.35 (2.24)	
	Varieties			: 2.11 (2.01)	
	Time of pollination × Varieties			: 4.71 (4.49)	

HAA: hour after anthesis. *Significant at P=0.05. Figures in parenthesis are Arc sine transformed

findings are similar to those reported by Bomfim *et al*. (2015) in watermelon, Ekeke *et al.* (2018) in cucumber and Tschoeke *et al*. (2015) and Revanasidda and Belavadi (2019) in muskmelon who reported that fruit-set was maximum when flowers were pollinated between 6 to 8 AM.

Node number bearing first female flower: The GYNO-2 produced the first female flower at lower most node (3.20) and found statistically at par with GYNO-1, whereas first female flower at later nodes was appeared in K-75 (8.86) and found significantly at par with UHF-CUC-101 (8.24; Table 6). The present findings corroborate the study of earlier workers *viz.*, Bommesh *et al*. (2020) and Kumawat *et al*. (2020) in cucumber.

Table 6. Mean performance of different varieties of cucumber for node number bearing first female flower

Varieties	Node number bearing first female flower
GYNO-1	3.73
GYNO-2	3.20
K-75	8.86
UHF-CUC-101	8.24
CD (0.05)	0.76

Overall, the current study suggests that anthesis, anther dehiscence, stigma receptivity, and pollen viability are at their peak between 6:00 and 7:00AM. Gynoecious lines flowered and fruited earlier than monoecious lines. As a result, pollination in cucumber should be done early in the morning for the hybridization programme.

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