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Effect of different mode of pollination on fruit and seed characteristics of cucumber (*Cucumis sativus* L.)

Neha Verma[1*], Ramesh Kumar[1], Jasmeen Kaur[1] and Dinesh Singh[2]

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Abstract

Effect of different mode of pollination *viz*., open pollination and self pollination on fruit and seed setting as well as their characteristics in monoecious (K-75 and UHF-CUC-101) and gynoecious (GYNO-1 and GYNO-2) varieties was studied at the Experimental Research Farm, Department of Vegetable Science, Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan (HP) during Kharif, 2016. Open pollination had better effect on all the parameters (Mean fruit set, mean fruit weight, number of seeds per fruit and thousand seed weight) studied compared to self pollination method. Maximum fruit weight of 278.02g was recorded in open pollination system than in selfing (263.54g) and it was recorded maximum in cultivar UHF-CUC-101 (289.28g) and minimum in GYNO-2 (259.89g). Similarly, number of seeds per fruit was more in open pollination system (190.05 seeds/ fruit) than in selfing (160.72 seeds/fruit) and among cultivars, it was found maximum in K-75 (256.30) and minimum in GYNO-1 (99.81). Likewise, thousand seed weight was recorded higher in open pollination system (20.12g) than in selfing (18.32g) and amid cultivars maximum in K-75 (22.65g) whereas minimum in GYNO-2 (18.26g). Interactions (Varieties × Conditions) had a significant effect on percent fruit set as well as number of seeds per fruit and non-significant effect on mean fruit weight and thousand seed weight.

Keywords: Cucumber, Gynoecious, Monoecious, Pollination and Seed

Introduction

Cucumber (*Cucumis sativus* L.) is one of the most important cucurbitaceous crops grown throughout the country. It is the fourth most important vegetable crop after tomato, cabbage and onion in Asia (Thakur et al. 2017). At present in India, cucumber is grown in an area of 109 thousand hectares with annual production of 1696 thousand MT and productivity of 15.5 t/ha (Anonymous 2019). It is one of the potent crops suitable for protected as well as open field conditions to meet the year round domestic demand as well as for export (Pal et al. 2016). Cucumber plants are mainly "monoecious" which produces both male and female flowers somewhat in equal proportions separately on same plants and "gynoecious" which produce only female flowers. Flowers of cucumber are attractive, yellow in colour and visited by many insects. Due to its monoecious nature, the flowers are neither wind pollinated nor self-pollinated (it is possible only through hand pollination). Pollen grains, being large and sticky need an external agent for transfer between flowers (Mehdi et al. 2012). Adequate pollination assured the uniform development of fruits with even maturity while incomplete pollination result in improper and misshapen development of fruits and ultimately lower the yield and marketability of fruits.

Cucumber is an insect-pollinated crop; therefore, its success is directly dependent upon the methods of pollination. Very little information is available on pollination and its effects on the fruit and seed characteristics of cucumber. Pollinators, such as honey bees and insects play a crucial role in pollination of cucumber. Without the assistance of pollinators, most plants could not breed, and farmers would face great yield losses. In fact, approximately 90% of all the flowering plants depend on pollinators. Pollination success of these plant species depends on the activity of insects that visit and successfully pollinate the flowers. Every insect pollinator has its own pollination efficiency

[1]Department of Vegetable Science, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan-173230, Himachal Pradesh

[2]Department of Fruit Science, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan-173230, Himachal Pradesh

*Corresponding author, E-mail: neha-vs@pau.edu

Table 1: List and source of cucumber cultivars used in the present study

Sr. No.	Cultivar	Source
1	K-75	Deptt. of Vegetable Science, UHF, Nauni Solan (HP) India.
2	UHF-CUC-101	
3	GYNO-1	
4	GYNO-2	

Table 2: Analysis of variance for per cent fruit set, mean fruit weight, number of seeds per fruit and thousand seed weight in cucumber varieties under different method of pollination

Source Character	df	Mean sum of square				
		Per cent fruit set		Mean fruit weight	Mean number of seeds per fruit	Thousand seed weight
		No transformation	Angular transformation			
Replication	2	3.00	1.05	57.64	34.87	0.48
Factor (Varieties)	3	285.38*	100.15*	1361.32*	16026.89*	21.85*
Factor (Conditions)	1	3143.25*	1070.09*	2745.97*	35404.26*	22.03*
Int (Varieties × Conditions)	3	32.64*	11.50*	1261.65	5164.13*	86.45
Error	14	7.61	2.63	9.89	270.43	0.14
Total	23			76.12	27.95	1.11

*Significance at 5% level of significance

Table 3: Per cent fruit set in cucumber varieties under different methods of pollination

	Per cent fruit set		
Varieties	Conditions		Mean (Varieties)
	Self Pollination	Open Pollination	
GYNO-1	27.94 (31.89)	53.19 (46.81)	40.57 (39.35)
GYNO-2	35.33 (36.44)	63.64 (52.89)	49.49 (44.67)
K-75	46.66 (43.07)	65.65 (54.10)	56.16 (48.59)
UHF-CUC-101	44.44 (41.78)	63.44 (52.79)	53.94 (47.28)
Mean (Conditions)	38.59 (38.30)	61.48 (51.65)	
$CD_{0.05}$	Varieties: 3.42 (2.01), Condition: 2.42 (1.42), Varieties × Conditions: 4.83 (2.84)		
CV(%)	5.51(3.61)		

*Significance at 5% level of significance
Figures in parenthesis are Arc sine transformed

for flowers, based on behavioral features, such as foraging speed, flower constancy, pollen load on the body, pollen collection and pollen transfer to the stigma (Bashir et al. 2017). In cucumber, hybrid seed production is performed manually, and higher hybrid seed yield can be obtained from the seed parent. Thus, pollination plays a crucial role in hybrid seed production and pollination is done usually on the day of flower opening when the stigma is receptive till noon of the day but most receptive in early morning hours. But success rate of pollination varies from 50-90 per cent, as transfer of pollen to female flower manually during crossing period is most sensitive aspect in large scale hybrid seed production within open and protected conditions. Considering the importance and to generate valuable information required for hybridization, the present study was therefore undertaken to obtain information pertaining to effect of various methods of pollinations on fruit and seed characteristics of new cucumber lines/genotypes under mid hills condition of HP to get higher economic and seed yield.

Materials and Methods

Experimental Site and Environment: The present investigation was carried out at the Experimental Research Farm of the Department of Vegetable Science, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh during rainy season of 2016. The experimental site is located at an altitude of 1,270 meters above mean sea level lying between 30°52'00" North latitude and 77°11'30" East longitude in the mid hill zone of Himachal Pradesh. During the crop period (June-Sep; 2016) mean temperature, relative humidity and rainfall varied from 23.0°C (September) to 24.4°C (June), 69.00 per cent (June) to 83.00 per cent (August) and 11.20mm (September) to 164.10mm (August), respectively.

Experimental material, layout and observations: During Kharif 2016, pollination studies were carried out in Randomized Complete Block Design (RCBD) with 3 replications by planting four lines of cucumber (Table

1). 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. The standard cultural practices for raising a healthy crop of cucumber as recommended in the "Package of Practices" for Vegetable Crops, published by the Directorate of Extension Education, UHF, Nauni, Solan, HP (Anonymous 2014) were adopted during the growing period. After chemicals [Gibberellic Acid (500, 1000 and 1500ppm), Silver Nitrate (250, 500 and 750ppm) and Silver Thiosulphate (250, 500 and 750ppm)] spray for induction of male flowers in gynoecious lines (Golabadi et al. 2015), observation for effect of open and hand pollination on fruit and seed characteristics has been recorded. The observations pertaining to the following characters were recorded on 10 randomly selected competitive plants from each plot and the average was worked out to record the mean value in each replication. The characters studied were:

Mean fruit set (%): Mean fruit set was studied under two system *viz*., open and controlled pollination system (bagging). In case of controlled pollination, the female flowers were covered with the butter paper bag in the evening one day prior to anthesis to avoid the chances of outcrossing in the open field and pollination was done manually next day in the morning at the time of anthesis. In open pollination, flowers were tagged and left open for pollination. Mean fruit set was worked out in both the cases by taking the average of fruit set in all the cultivars. Per cent fruit set was calculated as follows:

$$\text{Per cent fruit set} = \frac{\text{Number of cucumber fruits produced}}{\text{Number of female flower pollinated}} \times 100$$

Mean fruit weight (g): Ten selected fruits from each replication were weighed and average fruit weight was calculated for open and self pollination system.

Number of seeds per fruit: Number of seeds per fruit in each cultivar was worked out by tagging 50 flowers in each variety for setting seeds by both the systems of pollination and then average number of seeds obtained was worked out in each case on the basis of 10 randomly selected fruit.

Thousand seed weight (g): The thousand seed weight was recorded as per the procedure given by ISTA (Anonymous 2007) and expressed in grams.

Statistical Analysis: The per cent fruit set, mean fruit weight, number of seeds per fruit and thousand seed weight were analysed by two factor analysis in randomized block design (RBD) by using the model as 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

Analysis of variance presented in table 2 indicated a significant difference among varieties, conditions (open and self pollination) for all the traits studied and their interactions (Varieties × Conditions) for per cent fruit

Table 4: Mean fruit weight of different varieties of cucumber under self and open pollination systems (g)

Mean fruit weight (g)			
Varieties	Conditions		Mean (Varieties)
	Self Pollination	Open Pollination	
GYNO-1	266.22	281.67	273.94
GYNO-2	304.55	315.22	259.89
K-75	252.00	268.00	260.00
UHF-CUC-101	281.33	297.22	289.28
Mean (Conditions)	263.54	278.02	
$CD_{0.05}$ Varieties	:	5.26	
Condition	:	4.56	
Varieties × Conditions	:	NS	

Table 5: Mean number of seeds per fruit in different varieties of cucumber under self and open pollination systems

Number of seeds per fruit			
Varieties	Conditions		Mean (Varieties)
	Self Pollination	Open Pollination	
GYNO-1	89.50	110.12	99.81
GYNO-2	110.37	130.87	120.62
K-75	242.63	269.97	256.30
UHF-CUC-101	200.37	249.27	224.82
Mean (Conditions)	160.72	190.05	
$CD_{0.05}$ Varieties	:	6.55	
Condition	:	4.63	
Varieties × Conditions	:	9.26	

Table 6: Thousand seed weight of different varieties of cucumber under self and open pollination systems (g)

Thousand seed weight (g)			
Varieties	Conditions		Mean (Varieties)
	Self Pollination	Open Pollination	
GYNO-1	17.20	21.27	19.23
GYNO-2	16.57	19.94	18.26
K-75	20.67	24.63	22.65
UHF-CUC-101	18.84	22.63	20.74
Mean (Conditions)	18.32	20.12	
$CD_{0.05}$ Varieties	:	1.31	
Condition	:	0.92	
Varieties × Conditions	:	NS	

set and number of seeds per fruit but the interactions showed non-significant variations for average fruit weight and thousand seed weight. The results obtained from the present investigation are presented and discussed under the following sub headings:

Fruit set by hand pollination and open pollination: The major objective of any breeding programme is to have maximum fruit set and better returns. The observations recorded on fruit set showed significant variation among the cultivars, conditions (open and self pollination) and their interactions under selfing and open pollinated conditions (Table 3). Mean fruit set was more in open pollination system (61.48%) in comparison to selfing (38.59%). The per cent fruit set among the varieties varied from 40.57-56.16 per cent. Maximum fruit set of 56.16 per cent was recorded in cultivar K-75 which was found statistically at par with the UHF-CUC-101 (53.94%), whereas minimum fruit set of 40.57 per cent was recorded in GYNO-1. Interactions (Varieties × Conditions) had significant effect on per cent fruit set. It ranged from 27.94-65.65 per cent. Maximum fruit set of 65.65 per cent was recorded in K-75 in open pollination system and found significantly at par with the GYNO-2 (63.64%) and UHF-CUC-101 (63.44%) and minimum was observed in GYNO-1 (53.19%). Similarly, under selfing, maximum fruit set was recorded in K-75 (46.66%) followed by 44.44, 35.33 and 27.94 per cent in UHF-CUC-101, GYNO-2 and GYNO-1 respectively. Highest rate of fruit set was obtained in open pollination than selfing. The reason for maximum fruit set in open method of pollination can be attributed to the natural pollinating agents like honey bees involvement in pollination. On the other hand, in case of hand pollination methods the flowers were pollinated only once, the chances of improper pollination and some injuries might have taken place to the floral buds leading to reduction in fruit set. Higher rate of fruit set from open pollination has also been reported by Steinhauer (1971), Cauto and Calmona (1993), Gingras et al. (1999), Hanh (2008), Aslam et al. (2008), and Deyto and Cervancia (2009) in cucumber. They reported that under open pollination conditions honeybee pollinated flowers resulted in more than 85 per cent of fruit set as compared with hand-pollination where the per cent fruit set was recorded less than 20 per cento

Fruit weight (g): The average fruit weight is one of the most important traits which contribute towards yield. The observations recorded for this trait showed significant variation among the varieties and conditions (selfing and open pollination conditions) and are presented in table 4. Maximum fruit weight of 278.02g was recorded in open pollination system than in selfing (263.54g). The fruit weight among the varieties varied from 259.89-289.28g. Maximum mean fruit weight of 289.28g was recorded in cultivar UHF-CUC-101 and minimum (259.89g) was reported in GYNO-2 and found statistically at par with K-75. Interactions (Varieties × Conditions) had non-significant effect on fruit weight. All the cultivars under study exhibited greater mean fruit weight in open pollination system than selfing. This may be attributed to better pollination by pollinating insects as stated by Prakash et al. (2004), Thakur and Rana (2008), Hanh (2008) and Gaire and Yubak (2015) in cucumber.

Number of seeds per fruit: Number of seeds per fruit is a varietal characteristic. It is a major seed yield contributing character as if there will be a greater number of seeds per fruit, more will be the seed yield and economic returns. This is influenced to some extent by mode of pollination. It is considered as one of the most important characters as far as hybrid seed production is concerned. Number of seeds per fruit in cucumber cultivars GYNO-1, GYNO-2, K-75 and UHF-CUC-101 were worked out under selfing and open pollination system. The observations (Table 5) recorded indicated that mean number of seeds per fruit was more in open pollination system (190.05 seeds/fruit) than in selfing (160.72 seeds/fruit). Significant differences were observed among the varieties for number of seeds per fruit. Maximum number of seeds per fruit was recorded in the K-75 (256.30) whereas minimum was in the GYNO-1 (99.81). Similarly, interactions (Varieties × Conditions) also had significant effect on number of

seeds per fruit. It ranged from 89.50–269.97 seeds. In open pollination system, maximum numbers of seeds were reported in cultivar

K-75 (269.97 seeds/fruit) and minimum in GYNO-1 (110.12 seeds/fruit). Under selfing, maximum number of seeds per fruit were found in K-75 (242.63 seeds/fruit) which was higher than UHF-CUC-101 (200.37 seeds/fruit), GYNO-2(110.37 seeds/fruit) and GYNO-1 (89.50 seeds/fruit). All the cultivars differed significantly under both the system of pollination. These results are in line with views of Cervanica and Begonia (1991), Prakash et al. (2004), Thakur and Rana (2008) and Gaire and Yubak (2015) for number of seeds per fruit in cucumber.

Thousand seed weight (g): Thousand seed weight or test weight is an important parameter which decides the boldness of the seed. Higher seed weight means bolder seeds and hence more will be the vigour of seed. The data related to thousand seed weight of different cultivars under selfing and open pollination conditions showed significant differences for this trait (Table 6). These results indicated that thousand seed weight was recorded higher in open pollination system (20.12g) than in selfing (18.32g). The observation recorded on 1000 seeds weight revealed significant differences among the different cultivars. It ranged from 17.20-24.63g. Maximum thousand seed weight was found in the K-75 (22.65g) whereas minimum in GYNO-2 (18.26g) and found at par with GYNO-1(19.23g). Interactions (Varieties × Conditions) had non-significant effect on 1000 seeds weight. Thousand seed weight was recorded more in open pollination as compared to selfing. This may be due to efficient pollination by pollinators in comparison to manual pollination. Higher 1000 seed weight is an important criteria adopted to assess quality of the seed. The results are in line with the findings of Thakur and Rana (2008), who also reported higher 1000 seed weight under honey bee pollination as compared to open and hand pollination in cucumber.

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सारांश

मोनोएसियस (के.–75) और यू.एस.एफ.–सी.यू.सी–101 एवं मोइनोएसियस जी.वाई.एन.ओ.–1 तथा जी.वाई.एन.सओ.–2 किस्मों पर परागण के विभिन्न विधियों जैसे–मुक्त परागण और स्व–परागण का फल व बीज का बनना और उनकी विशेषताओं पर प्रभाव का प्रायोगिक अनुसंधान प्रक्षेत्र, वनस्पति विज्ञान विभाग, डॉ.वाई.एस. परमार बागवानी और वानिकी विश्वविद्यालय, नौणी, सोलन (एच.पी.) द्वारा वर्ष 2016 (खरीफ) के दौरान अध्ययन किया गया। स्व–परागण विधि की तुलना में, मुक्त परागण का सभी मापदंडों (फल बनना, औसत वजन, प्रति फल बीजों की संख्या और एक हजार बीज का भार (मध्य मूल्य) के आधार पर बेहतर प्रभाव पाया गया। स्व–परागण (263.54 ग्राम) की तुलना में मुक्त परागण विधि में अधिकतम फल वजन (278.02 ग्राम) पाया गया और यह अधिकतम किस्म यू.एच. एफ.–सी.यू.सी.–101 (289.28 ग्राम) और न्यूनतम जी.वाई.एन.ओ.–2 (259.89 ग्राम) में पाया गया। इसी प्रकार प्रति फल बीजों की संख्या स्व–परागण (160.72 बीज/फल) की तुलना में मुक्त परागण विधि (190.05 बीज/फल) में अधिक पाया गया और यह अधिकतम किस्म के.–75 (256.30) और न्यूनतम जी.वाई.एन.ओ.–1 (99.81) में पाई गयी। इसी तरह स्व–परागण (18.32 ग्राम) की तुलना में अधिकतम एक हजार बीज भार मुक्त परागण प्रणाली (20.12 ग्राम) में दर्ज किया गया और ये अधिकतम के.–75 (22.65 ग्राम) जबकि न्यूनतम जी. वाई.एन.ओ.–2 (18.26 ग्राम) में पाया गया। पारस्परिक किया (किस्मों–स्थितियाँ) का महत्वपूर्ण प्रभाव पाया गया लेकिन प्रतिशत फल बनने के साथ–साथ प्रति फल बीज की संख्या, फल के वजन और एक हजार बीज भार पर कोई अंतर नहीं पाया गया था।

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