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Research Paper

Effect of pollination methods on growth, maturity, seed yield and yield components in open-pollinated varieties of maize (*Zea mays* L.)

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ABSTRACT

Maize being a cross-pollinated crop increases the complexity of the breeding scheme. Controlled pollination has been carried out in maize for the development of improved cultivars. Maize is favored for controlled pollination for scientific investigation because of the ease with which selfing and crossing are made. The present study was undertaken to analyse the effect of different pollination methods on growth, maturity, seed yield and yield components in open-pollinated varieties of maize. Two open-pollinated varieties (SMC-6 and SMC-7) of maize were evaluated. The seed material was developed by using five different pollination methods viz., *Viz.*, bulk pollination method (M_1), isolated random method (M_2), half sib pollination method (M_3), isolated half-sib nursery method (M_4) and reciprocal full sib method (M_5). The seeds were then evaluated for growth, maturity, seed yield and yield components in a randomised block design with three replications. Analysis of variance showed significant variability for days to 50 per cent silking, plant height, ear height and seed yield due to variety (V), pollination method (M) and their interactions (VxM). Whereas significant variability was observed for days to 50 per cent pollen shedding due to variety and pollination method only and interaction for these two traits were non-significant. ANOVA also revealed significant variability for days to 75 per cent dry husk due to pollination method and VxM. The significant variability was observed for ear length and 100 seed weight only due to varieties. Significant differences were observed between SMC-6 and SMC-7 concerning traits *viz.*, days to 50 per cent pollen shedding and silking, plant and ear height, ear length, 100 seed weight and seed yield. The study revealed that a suitable pollination method needs to be standardized in open-pollinated varieties for improvement of the yield.

Key words: Components, growth, maize, pollination, seed yield.

Maize (*Zea mays* L.) is one of the most important crops of world agricultural economy and ranks third next to rice and wheat in production (Kyenpia *et al*., 2009). Plant breeders are interested in developing cultivars with improved yield and other desirable agronomic and phenological characters. In order to achieve this goal, the breeders had the option of selecting desirable genotypes in early generations or delaying intense selection until advanced generations (Puri *et al*., 1982). The selection criteria may be yield or one or more of the yield component characters. However, breeding for high yielding yield crops requires require information on the nature and magnitude of variation in the available materials, relationship of yield with other agronomic traits characters and the degree of environmental influence on the expression of these component characters. Since grain yield in maize is quantitative in nature and polygenically controlled, effective yield improvement and simultaneous improvement in yield components is are imperative (Bello and Olaoye, 2009). Cross-pollinating crops increase the complexity of the breeding scheme because selections are often made after fertilization has occurred and unless the pollinations have been controlled by hand, pollen from both desirable and undesirable genotypes within the population contributes to the next cycle of selection. Selections made on half-sib progeny decrease the gain from selection made with each progressive cycle relative to full-sib progeny (Fehr, 1987). In the case of populations and open pollinated

varieties, recurrent selection has been widely used by maize breeders for crop improvement. It increases the favourable alleles in maize pools especially for traits of quantitative nature (Ceballos *et al*., 1991). Despite the importance of pollination in the development of new improved varieties and seed multiplication, little or no information is available on the effects of the pollination methods on seed quality and quantity in maize. Therefore, the objective objectives of this study was to determine the effect of pollination methods on growth, maturity, seed yield and yield components in open-pollinated varieties of maize.

MATERIALS AND METHODS

The experimental plants material comprised of two open-pollinated varieties (SMC-6 and SMC-7). The fieldwork was carried out in phased manner at Dry land Agricultural Research Station (DARS), Budgam, SKUAST-Kashmir, during the year *2019-20.* In the first phase of the experiment, the seed material was developed by using five different pollination methods viz., *Viz.,* bulk pollination method (M_1), isolated random method (M_2), half sib pollination method (M_3), isolated half-sib nursery method (M_4), reciprocal full sib method (M_5) SMC-6 and SMC-7 during *kharif* 2019. In the second phase of experiment, the seeds were evaluated for growth, maturity, seed yield and yield components in a randomised block design with three replications and analysis was performed with respect to following two factors:

Factor-I: Open-pollinated varieties (V)
Factor-II: Pollination methods (M)

RESULTS AND DISCUSSION

Growth and Maturity traits: The data pertaining to days to 50 per cent pollen shedding, days to 50 per cent silking and days to 75 per cent dry husk is presented in Table-1.

Table-1: Effects of pollination methods on Days to 50 % pollen shedding, Days to 50 % silking and Days to 75 % dry husk in open-pollinated varieties of maize

Treatments	Days to 50 % pollen shedding			Days to 50 % silking			Days to 75 % dry husk		
	SMC-6 (V_1)	SMC-7 (V_2)	Mean	SMC-6 (V_1)	SMC-7 (V_2)	Mean	SMC-6 (V_1)	SMC-7 (V_2)	Mean
M_1	70.00	68.33	69.17	72.00	70.33	71.16	111.00	109.67	110.33
M_2	70.00	69.67	69.83	72.00	71.67	71.83	112.00	110.00	111.00
M_3	68.00	67.67	67.83	71.00	70.00	70.50	110.67	113.00	111.83
M_4	69.00	69.00	69.00	70.00	71.33	70.66	111.00	112.00	111.50
M_5	68.00	67.00	67.50	70.00	69.00	69.50	112.00	110.67	111.33
Mean	**69.00**	**68.33**	**68.67**	**71.00**	**70.47**	**70.73**	**111.33**	**111.07**	**111.20**
For comparing the means of	**SEm ±**	**CD (p<0.05)**		**SEm ±**	**CD (p<0.05)**		**SEm ±**	**CD (p<0.05)**	
Varieties (V)	0.26	0.54		0.28	0.59		0.28	NS	
Methods (M)	0.41	0.86		0.44	0.93		0.45	0.95	
VxP	0.58	NS		0.63	1.32		0.64	1.35	

M_1 = Bulk pollination method, M_2 = Isolated random method, M_3= Half sib pollination method, M_4 = Isolated half-sib nursery method, M_5 = Reciprocal full sib method

Days to 50 per cent pollen shedding: The data on days to 50 per cent pollen shedding reported statistically significant differences due to pollination method. Among the different pollination-methods, M_5 recorded significantly less (67.50 days) number of days and other methods are at par with each other. Between the two varieties, SMC-7 recorded significantly less number of days (68.33 days) for pollen shedding as compared to SMC-6 (69.00 days).

Days to 50 per cent silking: The data on days to 50 per cent silking reported significant difference due to the methods of pollination. Among the pollination-methods, M_5 recorded significantly less (69.50 days) number of

days and was highest for M_2 (71.83 days). Among varieties, SMC-7 reported significantly less (70.47 days) number of days when compared to SMC-6 (71.00 days). Different treatment combinations were at par with each other.

Days to 75 per cent dry husk: The data on days to 75 per cent dry husk revealed significant difference due to pollination-methods. Among different pollination methods, M_1 reported numerically less (110.33 days) number of days for 75 per cent dry husk and other methods are at par with each other. In terms of days to 75 per cent dry husk, varieties did not show any significant differences

Plant height and Ear height: The data pertaining to plant height and ear height is presented in Table-2.

Table-2: Effects of pollination methods on Plant height, Ear height and Ear Length in open-pollinated varieties of maize

Treatments	Plant Height (cm)			Ear Height (cm)			Ear Length (cm)		
	SMC-6 (V_1)	SMC-7 (V_2)	Mean	SMC-6 (V_1)	SMC-7 (V_2)	Mean	SMC-6 (V_1)	SMC-7 (V_2)	Mean
M_1	182.30	200.70	191.50	96.00	107.30	101.65	17.38	17.99	17.68
M_2	193.00	208.00	200.50	99.67	110.30	104.98	17.50	18.18	17.84
M_3	182.00	209.00	195.50	95.30	113.70	104.50	17.56	18.04	17.80
M_4	191.30	206.00	198.65	99.30	110.00	104.65	17.65	18.21	17.93
M_5	188.71	198.70	193.70	94.70	104.70	99.70	17.54	18.13	17.83
Mean	**187.46**	**204.48**	**195.97**	**96.99**	**109.20**	**103.09**	**17.52**	**18.11**	**17.81**
For comparing the means of	**SEm ±**	**CD (p<0.05)**		**SEm ±**	**CD (p<0.05)**		**SEm ±**	**CD (p<0.05)**	
Varieties (V)	0.14	0.30		0.14	0.30		0.15	0.32	
Methods (M)	0.23	0.48		0.23	0.48		0.24	NS	
VxP	0.32	0.68		0.32	0.68		0.35	NS	

M_1 = Bulk pollination method, M_2 = Isolated random method, M_3= Half sib pollination method, M_4 = Isolated half-sib nursery method, M_5 = Reciprocal full sib method

The data on plant height revealed significant differences due to pollination methods. Among the pollination methods, M_2 reported statistically highest (200.50 cm) plant height and was found lowest (191.50 cm) in M_1. Among the varieties, statistically significant results were observed and SMC-7 reported significantly higher plant height (204.48 cm) when compared to SMC-6 (187.46 cm).Interaction effects due to methods of pollination and variety reported significant differences in plant height.

The data on ear height reported statistically significant differences due to pollination-methods. Among the pollination methods, M_5 reported a significantly lowest (99.70 cm) ear height compared to and was found highest (104.98 cm) in M_2. In terms of ear height, the varieties reported statistically significant differences. Among the varieties, SMC-7 reported significantly higher ear height (109.20 cm) when compared to SMC-6 (96.99 cm).The interaction effects showed significant differences in ear height.

The data on growth and maturity traits *viz,* days to 50 per cent pollen shedding, days to 50 per cent silking, days to 75 per cent dry husk, plant height and ear height reported significant difference due to pollination methods. Between the genotypes, a significant difference was observed for all the traits mentioned above except days to 75 per cent dry husk. These results are in agreement with those of Noor *et al.* (2013) who observed significant difference in half-sib families of maize variety. Pahari for growth and maturity traits. However, Khan (2017) reported significant differences in full-sib families of different maize varieties for growth and maturity traits. Similarly, Ullah *et al.* (2006) also observed significant differences for growth and maturity traits while evaluating the performance of local and exotic inbred lines of maize under agro-ecological conditions in Peshawar. Carlone and Russell (1989) observed similar results in a testcross evaluation of maize synthetic BSSS lines. Akbar *et al.* (2008) also reported significant differences for growth and maturity traits

while evaluating 3-way crosses of maize through genetic variability, broad-sense heritability, character association, and path analysis. Similarly, Rahman *et al.,* 2007. Estimated significant differences for growth and maturity traits among their experimental material

SEED YIELD AND ITS COMPONENTS:

Ear length: The data on ear length reported statistically significant differences due to pollination-method (Table-2). Among the pollination methods, M_4 reported numerically higher value (17.93 cm) for ear length and was found lowest (17.68 cm) in M_1. However, the varieties reported statistically non-significant differences. Among the varieties, SMC-7 recorded numerically higher (18.11 cm) value for ear length as compared to variety SMC-6 (17.52 cm). The interaction effects due to pollination-methods and varieties were found to be non-significant.

Ear girth: The data on ear girth as influenced by pollination-methods reported statistically non-significant differences (Table-3). However, among pollination methods, numerically higher value (14.49 cm) for ear girth was recorded in M_4 and was lowest with M_3 (14.39 cm). Among the varieties, the ear girth of SMC-7 was numerically greater (14.48 cm) compared to SMC-6 (14.40 cm).Interaction effect due to varieties and methods of pollination was statistically non-significant.

100-seed weight (g): The data on 100 seed weight reported non-significant differences due to pollination-methods (Table-3). Among the pollination-methods, M_4 recorded numerically more (35.11 g) seed weight and with M_2 it was found to be the least (34.83 g). However, varieties reported statistically significant differences. Among the varieties, SMC-7 had a significantly higher seed weight (35.44 g) than SMC-6 (34.45 g). The Interaction effects for 100 seed weight due to pollination methods and varieties didn't show any significant difference.

Table-3: Effects of pollination methods on ear girth, 100-seed weight (g) and seed yield in open-pollinated varieties of maize

Treatments	Ear girth (cm)			100-seed weight (g)			Seed yield (kg/ha)		
	SMC-6 (V_1)	SMC-7 (V_2)	Mean	SMC-6 (V_1)	SMC-7 (V_2)	Mean	SMC-6 (V_1)	SMC-7 (V_2)	Mean
M_1	14.44	14.47	14.45	34.53	35.15	34.84	5156.0	5662.0	5409.0
M_2	14.34	14.60	14.47	34.31	35.35	34.83	5179.6	5695.0	5437.3
M_3	14.50	14.29	14.39	34.44	35.55	35.00	5146.7	5584.0	5365.3
M_4	14.31	14.68	14.49	34.64	35.60	35.11	5171.6	5728.6	5450.1
M_5	14.41	14.40	14.40	34.33	35.58	34.95	5124.8	5537.7	5331.5
Mean	**14.40**	**14.48**	**14.44**	**34.45**	**35.44**	**34.94**	**5155.7**	**5641.5**	**5398.6**
For comparing the means of	**SEm ±**	**CD (p<0.05)**		**SEm ±**	**CD (p<0.05)**		**SEm ±**	**CD (p<0.05)**	
Varieties (V)	0.20	NS		0.22	0.47		6.71	14.10	
Methods (M)	0.32	NS		0.35	NS		10.6	22.30	
VxP	0.46	NS		0.50	NS		15.0	31.54	

M_1 = Bulk pollination method, M_2 = Isolated random method, M_3= Half sib pollination method, M_4 = Isolated half-sib nursery method, M_5 = Reciprocal full sib method

The data on ear length, ear girth and 100 seed weight did not show any significant difference due to pollination methods. Although between genotypes, a significant difference was observed concerning ear length and 100 seed weight. SMC-7 recorded significantly higher value for ear length (18.11 cm) and 100 seed weight (35.44 g) compared to SMC-6. This might be attributed to the varietal difference.as the results are in agreement with those of Gurumurthy (2005) who also observed that there was no significant effect of pollination method

on ear length, ear girth and 100 seed weight while investigating the effect of pollination methods on seed quality in several open-pollinated varieties of maize.

Seed yieldkgha^{-1}: Yield is a complex trait which is the interaction of several yield attributing traits (Table-3). Because of pollination-methods, the data on seed yield reported statistically significant differences. Among the different pollination-methods, M_4 reported numerically highest (5450.10 kg ha^{-1}) value for seed yield and was lowest (5331.5 kg ha^{-1}) for M_5. Between varieties, significant differences were observed and SMC-7 reported significantly more (5641.5 kg ha^{-1}) seed yield per hectare compared to SMC-6 (5155.7 kg ha^{-1}). The interaction effects (VxM) due to pollination-methods (M) and varieties (V) reported significant differences for seed yield per hectare. Among different treatment combinations, V_2M_4 reported significantly more (5728.6 kg ha^{-1}) seed yield per hectare.

The yield superiority of SMC-7 over SMC-6 might be attributed to the presence of higher ear length and 100 seed weight recorded with SMC-7 as compared to SMC-6. Further, this might be due to the varietal difference. Our results are in conformity with the findings of Rahman *et al.* (2007), who also reported significant differences for seed yield while comparing original and selected maize populations for grain yield traits. Similarly, Sharifi *et al.* (2009), Badu-Apraku *et al.,* (2008), Menkir and Kling (2007) and Doerksen *et al.* (2003) observed significant differences for grain yield in various open-pollinated varieties of maize.

CONCLUSION

Among different pollination methods half-sib mating (M_3) and isolated half-sib nursery method (M_4) can be conveniently adopted for the maintenance of open-pollinated maize varieties over more than one generation. Suppose, the quantity of nucleus seed requirement is less, full-sib method (M_5) can be conveniently used for maintenance of maize open-pollinated varieties for one or two generations only. Although, half-sib mating (M_3) and isolated half-sib nursery method (M_4) proved to be superior over other methods but their superiority over generations is yet to be confirmed.

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