



RESEARCH PAPER

Effect of different modes of pollination in muskmelon (*Cucumis melo* L.)

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Abstract : The present study was carried out with the object of “Effect of different modes of pollination in muskmelon (*Cucumis melo* L.)” during summer 2020 and 2021 at College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari (Gujarat). In the present experiment, the highest fruit set and fruit weight were recorded in Hand pollination (HP) (89.00% and 626.42 g, respectively), Open pollination (OP), Pollination by *A. mellifera* and pollination by the stingless bee. Whereas, in the case of absolute control, an 18.00 per cent fruit set and minimum fruit weight (221.62 g) were noticed. The highest horizontal and vertical diameter of fruit (35.59 and 37.71 cm/fruit, respectively) was noted in HP and OP and pollination by *A. mellifera* followed by pollination by *A. cerana* and pollination by the stingless bee. The maximum flesh thickness of fruit was recorded in OP (3.13 cm) and pollination by *A. mellifera* (2.86 cm) as compared to the pollination exclusion plot. The highest (89.60%) seed germination was noticed in pollination by *A. mellifera* and OP (87.60%). The highest sugar content was detected in OP (8.21 g/100 g), pollination by the stingless bee (8.07 g/100 g) and HP (8.06 g/100 g). The minimum (4.26 g/100 g) sugar content was recorded in Absolute control of muskmelon fruit.

Key Words : Pollination, *Apis mellifera*, *Apis cerana*, Stingless bees, Honey bees, Muskmelon

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INTRODUCTION

Muskmelon is an important truck and kitchen garden crop. The muskmelon pollen is heavy and sticky, so it does not move through wind flows. The muskmelons are pollinated by many insects, including bees. Exploration of insect pollinators on muskmelon flowers provided food (nectar and pollen) to them. The anthesis and dehiscence are the important characters to understand the plant-pollinator interaction. Honey bees play an important role in the production of greater fruit quality, fruit set, seed set, fruit weight, fruit circumference,

fruit flesh thickness and fruit total soluble solids of muskmelon (Al-Ghzawi and Zaitoun, 2007). The information on the foraging behaviour and the effect of different mode of pollination on muskmelon is scanty in South Gujarat situations. Therefore, it is necessary to evaluate the effect of the number of floral visits of different bee species on the fruit set in muskmelon.

MATERIAL AND METHODS

The studies on “Effect of different modes of pollination in muskmelon (*Cucumis melo* L.)” were

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conducted during summer 2020 and 2021 at College Farm, N.M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat. The effect of insect pollinators on muskmelon crop production was investigated using pollination by three different domesticated bee species viz., *Apis cerana indica*, *Apis mellifera* and stingless bees and compared with open pollination (OP), hand pollination (HP) and crop without insect pollination (WIP). The data was subject to analyzed of variance by a Completely Randomized Design (CRD).

The experimental plots of treatment T₁, T₂, T₃, T₅ and T₆ were covered by insect-proof double sewed nylon net measuring 9x 6x 3.25m having a fastener at one side, before initiation of flowering in the muskmelon crop. Healthy colonies with a young queen and large brood area of test species viz., *A. cerana indica*, *Apis mellifera* and stingless bees having around three thousand bee workers were kept at the initiation of flowering in the caged crop. Twenty female flowers were hand-pollinated in a hand-pollinated plot. Fruit setting, fruit diameter, fruit weight, seed setting, fruit shape, fruit flesh thickness, cavity size, seed germination and total soluble solids were recorded from randomly selected 10 fruits from each treatment. The total sugar of muskmelon pulp was analyzed through Anthrone methods suggested by Thimmaiah (1999).

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Effect of bee pollination on quantitative parameters of muskmelon :

Per cent fruit setting :

During the summer of 2020, the result showed that the highest (90.00%) fruit set was recorded in Open pollination, which was found at par with Hand pollination and Pollination by *A. mellifera* followed by Pollination by *A. cerana* and pollination by the stingless bee in muskmelon crop. While in the case of Absolute control, the lowest 20.00 per cent fruit set was observed. In 2021, the same trend with little variation was recorded (Table 1).

The pooled data indicated the consistent performance of the treatments during both seasons. The highest fruit set was recorded in hand pollination (89.00%), it was found at par with open pollination and pollination by *A. mellifera* followed by pollination by *A. cerana* and pollination by the stingless bee. Whereas, in the case of absolute control, an 18.00 per cent fruit set was noticed (Table 1). The present work is in confirmation with the work of Sarwar *et al.* (2008) who showed that the treatment of open plot gave a maximum (85.4%) fruit set in cucumber and the lowest 12.60 per cent in

Table 1: Effect of different pollination treatments on quantitative parameters of muskmelon

Treatments	Fruit set (%)			Fruit weight (g)			Seed setting (No. of seeds/fruit)		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
T ₁ Pollination by <i>A. cerana</i>	64.11 (80.00)	61.56 (76.00)	62.83 (78.00)	22.46 (505.44)	21.72 (472.80)	22.09 (489.12)	15.85 (251.35)	14.66 (215.01)	15.26 (233.18)
T ₂ Pollination by <i>A. mellifera</i>	68.75 (86.00)	64.11 (80.00)	66.43 (83.00)	24.45 (597.82)	22.74 (517.92)	23.60 (557.87)	16.42 (270.23)	17.52 (307.32)	16.97 (288.78)
T ₃ Pollination by stingless bees	61.43 (76.00)	58.57 (72.00)	60.00 (74.00)	22.11 (489.30)	22.40 (502.52)	22.25 (495.91)	15.55 (242.21)	14.95 (223.55)	15.25 (232.88)
T ₄ Open pollination	72.05 (90.00)	65.76 (83.00)	68.90 (86.00)	24.64 (607.78)	24.30 (590.40)	24.47 (599.09)	17.42 (302.98)	15.89 (252.72)	16.65 (277.85)
T ₅ Hand pollination	70.40 (88.00)	72.05 (90.00)	71.22 (89.00)	26.54 (704.92)	23.40 (547.92)	24.97 (626.42)	17.00 (289.49)	17.94 (321.65)	17.47 (305.57)
T ₆ Absolute control	26.64 (20.00)	23.72 (16.00)	25.18 (18.00)	15.01 (225.34)	14.76 (217.90)	14.88 (221.62)	9.97 (98.99)	8.96 (79.82)	9.46 (89.41)
S.E.±	2.10	2.44	1.61	0.50	0.49	0.63	0.40	0.37	0.56
C.D. (P?0.05)	6.14	7.13	4.59	1.45	1.44	2.27	1.17	1.07	2.05

Note: Figure in parentheses is the original value, those outside are arc sin (Fruit set) and SQRT(Fruit weight and seed setting) transformed values, N = Mean of 10 tagged flowers

crop covered without bees at Rawalpindi, Pakistan. The results of the present works are in corroboration with Al-Ghzawi and Zaitoun (2007) who noted significantly higher fruit setting in pollination by native honey bees (*A. mellifera*) as compared to covered plants in Jordan in muskmelon crop. According to Hossain *et al.* (2018) the fruit set was significantly higher in hand pollination (70.68%) and open pollination (62.09%) than without honey bee pollination (48.96%) in Dhaka, Bangladesh.

Fruit weight :

In summer 2020, the highest weight of fruit (704.92 g) was recorded in Hand pollination followed by Open pollination and it was found at par with pollination by *A. mellifera*. The next in order pollination by *A. cerana* was found at par with pollination by the stingless bee. The lowest fruit weight was observed in absolute control (225.34 g). However, in summer 2021, the maximum fruit weight (590.40 g) was recorded in Open pollination, which was found at par with Hand pollination. The lowest fruit weight (217.90 g) was detected in Absolute control.

The pooled data indicated the highest (626.42 g) fruit weight in Hand pollination, which was remained at par with Open pollination and pollination by *A. mellifera* followed by pollination by the stingless bee and pollination by *A. cerana*. The minimum fruit weight was observed in absolute control (221.62 g) (Table 1).

The results of the present study are more or less similar to the results of Al-Ghzawi and Zaitoun (2007) who recorded the higher fruit weight in muskmelon due to pollination by *A. mellifera* as compared to covered plants in Jordan. Present work closely matched with work done by Bhowmik *et al.* (2017) who reported the higher fruit weight of coriander in open pollination conditions. The results are in corroboration with Hossain *et al.* (2018) who recorded equally higher fruit weight in hand (985.13 g) and open pollination (977.87 g), whereas lower fruit weight was found in without bee pollination in cucumber crops in Dhaka, Bangladesh. Gothi (2021) at Dantiwada also recorded higher fruit weight in open pollination in muskmelon. Present work is a little bit deviated from Rasool (2018), who reported the highest fruit weight in *A. cerana* (11.73 g/1000 seeds) followed by open pollination (10.82 g/1000 seeds), *A. mellifera* (10.50 g/1000 seeds) and control 8.77 g/1000 seeds at Wadura (Jammu and Kashmir) in coriander, these might be due to pollinators' deficiency in the open pollination crop plot during investigation.

Seed setting :

In summer 2020, the maximum number of seed settings in single fruit (302.98 seeds) was noted in Open pollination, it was at par with Hand pollination and pollination by *A. mellifera*, followed by pollination by *A. cerana* and it was found at par with pollination by the stingless bee. The minimum number of seeds (98.99 seeds) was noted in absolute control (Table 1).

The pooled data showed the highest number of seed settings (305.57 seeds) in Hand pollination, it was at par with pollination by *A. mellifera* and Open pollination followed by pollination by *A. cerana* and it remained at par with pollination by the stingless bee in muskmelon. The results of the current experiment are very close to the work of Al-Ghzawi and Zaitoun (2007) who noted a higher seed setting in pollination by *A. mellifera* treatment as compared to covered plants in muskmelon in Jordan. The present work is more or less in agreement with Hossain *et al.* (2018) as they reported the highest seed yield of cucumber from netting with honey bees followed by an open field, whereas the lowest seed yield was recorded from netting without bees at Dhaka (Bangladesh). As per Lalita *et al.* (2018), the maximum number of seeds per fruit was found in open + hand pollination followed by open pollination and hand-pollination, no seed set was observed in without insect pollination treatment in the pumpkin at Hisar, India. Correspondingly, Gothi (2021) at Dantiwada recorded a higher number of seeds/fruit in open pollination than in close pollination.

Fruit diameter (cm) :

In the summer of 2020, the maximum horizontal diameter of fruit (35.50 cm/fruit) was noted in Open pollination, it was found at par with pollination by *A. mellifera* and Hand pollination followed by pollination by *A. cerana* and pollination by the stingless bee, the minimum fruit diameter (14.50 cm) was recorded in absolute control. The same trend was also noted in the vertical diameter of the fruit.

The maximum horizontal diameter of fruit (37.95 cm/fruit) was noted in Hand pollination in the summer of 2021 followed by Open pollination and pollination by *A. mellifera*. The next in order was pollination by the stingless bee and pollination by *A. cerana*. In absolute control, minimum fruit diameter (12.88 cm) was noted. The more or less same trend was also noted in the vertical diameter of the fruit (Table 2).

The pooled data showed the highest horizontal and vertical diameter of fruit (35.59 and 37.71 cm/fruit, respectively) in Hand pollination and remained at par with Open pollination and pollination by *A. mellifera* followed by pollination by *A. cerana* and pollination by the stingless bee. While, the least horizontal and vertical fruit diameter (13.69 and 14.62 cm) was noted in absolute control (Table 2). The results of the present study are in close conformity with the results of Hossain *et al.* (2018) who recorded higher fruit diameter in hand pollination (27.1 cm/fruit) followed by open pollination (26.8 cm/fruit) and lower fruit diameter was found in without bee pollination in cucumber crop at Dhaka, Bangladesh. According to Al-Ghzawi and Zaitoun (2007), fruit circumference was found significantly higher in muskmelon due to pollination by *A. mellifera* as compared to covered plants in Jordan.

Effect of bee pollination on qualitative parameters of muskmelon:

Fruit shape :

The data revealed that the perfect fruit shape (>85%) was observed in Hand pollination, Open

pollination and pollination by stingless bees, due to uniform pollination. Whereas, in the case of pollination by *A. mellifera* and pollination by *A. cerana* the moderately perfect fruit shape (50 to 85 %) was observed due to slightly less uniform pollination, but in absolute control plot the higher per cent of misshaped fruit was recorded due to improper uneven pollination of muskmelon during both the years (Table 3). McGregor (1976) provoked that adequate pollination usually assures uniform and perfectly formed fruits with even maturity, while incomplete pollination results in improperly formed fruits (Hodges and Baxendale 1991). The result of the present finding is in close agreement with Thakur and Rana (2008) who reported a maximum percentage of misshapen fruits of cucumber in open pollination compared to hand pollination and bee pollination at Solan.

Flesh thickness :

The results of summer 2020 showed that the maximum flesh thickness of fruit was observed in Open pollination (3.16 cm) which was found at par with Pollination by *A. mellifera* followed by Hand pollination and remained at par with Pollination by *A. cerana* and

Table 2: Effect of different pollination treatments on muskmelon fruit diameter

Treatments	2020		2021		Pooled	
	HD* (cm)	VD* (cm)	HD (cm)	VD (cm)	HD (cm)	VD (cm)
T ₁ Pollination by <i>A. cerana</i>	30.60	32.48	28.88	31.83	29.74	32.15
T ₂ Pollination by <i>A. mellifera</i>	33.70	35.55	33.40	35.28	33.55	35.41
T ₃ Pollination by stingless bees	30.28	32.35	29.03	30.73	29.65	31.54
T ₄ Open pollination	35.50	37.13	33.60	36.73	34.55	36.92
T ₅ Hand pollination	33.25	34.93	37.95	34.50	35.59	37.71
T ₆ Absolute control	14.50	15.13	12.88	14.10	13.69	14.62
S.E.±	1.13	1.04	0.66	1.02	1.27	0.73
C.D. (P?0.05)	3.31	3.05	1.92	2.97	4.61	2.07

N = Mean of 10 fruits, HD - Horizontal diameter, VD - Vertical diameter

Table 3: Effect of different pollination treatments on qualitative parameters of muskmelon

Treatments	Fruit shape (%)		Flesh thickness (cm)			Size of fruit cavity (cm)		
	2020	2021	2020	2021	Pooled	2020	2021	Pooled
T ₁ Pollination by <i>A. cerana</i>	82.92**	84.82**	2.51	2.46	2.49	22.30	21.88	22.09
T ₂ Pollination by <i>A. mellifera</i>	84.74**	81.58**	3.08	2.65	2.86	24.23	25.75	24.99
T ₃ Pollination by stingless bees	90.84*	92.04*	2.31	2.38	2.35	22.13	21.41	21.77
T ₄ Open pollination	86.06*	85.08*	3.16	3.09	3.13	24.43	23.86	24.14
T ₅ Hand pollination	92.82*	95.14*	2.66	2.89	2.77	23.70	26.48	25.09
T ₆ Absolute control	40.94***	37.74***	1.49	1.43	1.46	14.16	13.85	14.01
S.E.±	-	-	0.10	0.11	0.08	0.50	0.60	0.72
C.D. (P?0.05)	-	-	0.29	0.33	0.21	1.47	1.76	2.61

Above 85% = Perfect* 50 to 85% = Moderately perfect** Less than 50% = Misshaped***

Pollination by the stingless bee. The least flesh thickness (1.49 cm) was recorded in Absolute control. In 2021, the more or less same trend with little dissimilarity was recorded with $T_4 \geq T_5 > T_2 \geq T_1 \geq T_3 > T_6$ order (Table 3).

Pooled data showed the maximum flesh thickness of fruit was recorded in Open pollination (3.13 cm), followed by pollination by *A. mellifera* and that was remained at par with Hand pollination. The next in order was pollination by *A. cerana* which was found at par with pollination by the stingless bee, while in the case of Absolute control, the least flesh thickness (1.46 cm) was noted (Table 3). The results of the present research are corroborated with the work of Al-Ghzawi and Zaitoun (2007), who noted that the fruit flesh thickness was significantly higher in uncovered muskmelon plants due to pollination by native honey bees (*A. mellifera*) compared to covered plants in Jordan.

Cavity size :

In summer 2020, the significantly highest (24.43 cm) cavity size of fruit was recorded in Open pollination, which was remained at par with Pollination by *A. mellifera* and Hand pollination, followed by Pollination by *A. cerana* and that was at par with Pollination by the stingless bee. The lowest cavity size of fruit (14.16 cm) was shown in Absolute control. In 2021, the same trend with little variation was recorded with $T_5 \geq T_2 > T_4 > T_1 \geq T_3 > T_6$ order (Table 3).

Pooled data showed the greater cavity size of fruit (25.09 cm/fruit) was recorded in Hand pollination, it was at par with Pollination by *A. mellifera* and Open pollination, followed by pollination by *A. cerana* and that has remained at par with pollination by the stingless bee, in muskmelon fruit. The least cavity size of fruit (14.01 cm) was noted in absolute control (Table 3). The result of the present work is in agreement with the work of Pokhrel and Thapa (2012) who recorded maximum size of fruit in open-pollinated followed by a hand-pollinated bitter melon but in control fruit size was very small at Chitwan, Nepal. Whereas, in pumpkin the maximum fruit length was observed in open + hand pollination followed by open and hand pollination at Hisar, India (Lalita *et al.*, 2018).

Seed germination :

Significantly highest (91.20%) seed germination was recorded in Open pollination and remained at par with Hand pollination and pollination by *A. mellifera*, followed by pollination by *A. cerana* and pollination by the stingless bee with the equal effect of both the pollinators on seed germination during summer 2020. Whereas, the lowest (42.40%) seed germination was recorded in absolute control (Pollination exclusion treatment). In 2021, the same trend with little variation was recorded (Table 4).

Pooled data showed the highest (89.60%) seed germination in Pollination by *A. mellifera*, which was

Table 4: Effect of different pollination treatments on TSS and sugar content of muskmelon fruit

Treatments	Seed germination (%)			TSS (%)			Total sugar (g/100 g)		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
T ₁ Pollination by <i>A. cerana</i>	67.21	63.03	65.12	3.32	3.31	3.32	2.82	2.81	2.81
	(84.40)	(78.80)	(81.60)	(10.55)	(10.47)	(10.51)	(7.46)	(7.40)	(7.43)
T ₂ Pollination by <i>A. mellifera</i>	69.75	74.34	72.05	3.35	3.33	3.34	2.76	2.78	2.77
	(87.20)	(92.00)	(89.60)	(10.71)	(10.60)	(10.65)	(7.11)	(7.26)	(7.18)
T ₃ Pollination by stingless bees	66.27	64.19	65.23	3.28	3.35	3.32	2.92	2.94	2.93
	(83.20)	(80.40)	(81.80)	(10.28)	(10.76)	(10.52)	(8.02)	(8.13)	(8.07)
T ₄ Open pollination	73.49	66.87	70.18	3.37	3.40	3.38	2.93	2.97	2.95
	(91.20)	(84.00)	(87.60)	(10.90)	(11.05)	(10.98)	(8.11)	(8.30)	(8.21)
T ₅ Hand pollination	70.32	63.56	66.94	3.40	3.37	3.39	2.92	2.93	2.92
	(88.00)	(79.60)	(83.80)	(11.09)	(10.89)	(10.99)	(8.03)	(8.08)	(8.06)
T ₆ Absolute control	40.89	36.90	38.90	3.04	3.03	3.04	2.17	2.19	2.18
	(42.40)	(35.60)	(39.00)	(8.86)	(8.80)	(8.83)	(4.21)	(4.31)	(4.26)
S.E.±T	1.41	1.24	2.10	0.09	0.08	0.06	0.05	0.04	0.03
C.D. (P?0.05)	4.13	3.61	7.63	NS	NS	0.17	0.13	0.11	0.09

Note: Figure in parentheses is the original value, those outside are arc sin (Seed germination) SQRT (TSS and total sugar) transformed values
NS= Non-significant

found at par with Open pollination followed by Hand pollination, pollination by the stingless bee and pollination by *A. cerana*. The lowest (39.00%) seed germination was recorded in absolute control in muskmelon seed (Table 4).

Present work is in close confirmation with work done by Bhowmik *et al.* (2017) and Paikara and Painkara (2021) who reported that the seed germination was increased in open pollination conditions over closed treatment. Similarly, Lalita *et al.* (2018) observed the maximum seed germination was in open + hand pollination (90.75%) treatment followed by open pollination (90.00%) and hand pollination (84.65%) in the pumpkin at Hisar, India. Results of the present work are more or less in agreement with Roopashree, (2011) who revealed that higher seed germination was recorded in open plots followed by pollination by *A. cerana* as well as, *T. iridipennis* and pollinators exclusion control plot in coriander at Bengaluru. Likewise, the work of Pokhrel and Thapa (2012) also observed the highest seed viability in Open pollination followed by Hand pollination in bitter gourd at Chitwan (Nepal). The results of the present investigation are slightly different from the work of Patil and Pastagia (2016) who reported slightly higher seed germination in bee pollination followed by Open pollination and the lowest in pollination without insects in coriander at Navsari, Gujarat. Similarly, Rasool (2018), also reported slightly different results at Wadura (Jammu and Kashmir) with the highest seed germination in *A. cerana* followed by open pollination, pollination by *A. mellifera* and pollination exclusion control plot in coriander. The deviation in results might be due to pollinators deficit during experimentation year.

Total soluble solids :

The results showed that a minor difference in Brix reading was observed between all the treatments and results were found non-significant between treatments in summer 2020 and 2021. But, a significant difference was shown in the pooled analysis. The highest TSS content (10.99%) was noticed in Hand pollination, which was found at par with Open pollination, pollination by *A. mellifera*, Pollination by the stingless bee and Pollination by *A. cerana*. The lowest (8.83%) TSS was recorded in Absolute control (Table 4). The TSS was significantly higher in uncovered muskmelon, due to pollination by native honey bees (*A. mellifera*) compared to covered plants under semiarid conditions in Jordan (Al-Ghzawi

and Zaitoun, 2008). One another research was also related to this study (Anonymous, 2022), which revealed that the TSS of fruit from hand-pollinated and bee-pollinated (*T. laeviceps*) treatment was recorded with an average of 11.15 and 11.06 per cent, respectively, of muskmelon in poly house conditions at Navsari, Gujarat.

Total sugars :

In 2020, the maximum sugar content was noticed in Open pollination (8.11 g/100 g), which was found at par with Hand pollination, pollination by the stingless bee and pollination by *A. cerana* followed by pollination by *A. mellifera*. The minimum (4.21 g/100 g) sugar content was recorded in Absolute control, of muskmelon fruit. The same trend with little deviation was recorded during 2021 (Table 4).

While in pooled data, the highest sugar content was detected in Open pollination (8.21 g/100 g) found at par with pollination by the stingless bee and Hand pollination followed by pollination by *A. cerana* and pollination by *A. mellifera*. The minimum (4.26 g/100 g) sugar content was recorded in absolute control (Table 4).

Conclusion:

The decreasing order of the effectiveness of different modes of pollination fruit set, fruit weight, seed setting, fruit diameter, flesh thickness, cavity size of fruit and seed germination was recorded as Open pollination (OP) > Hand pollination (HP) > Pollination by *A. mellifera* > Pollination by *A. cerana* > Pollination by stingless bees during the experiment. The per cent increase in fruit set over pollination exclusion treatments showed HP (495%), OP (481%), *A. mellifera* (464%), *A. cerana* (437%) and the stingless bees (414%) of muskmelon. Plenty of pollinators' availability in research sites leads to the super effect on qualitative and quantitative parameters of muskmelon. Muskmelon crop requires bee pollination as an extra input in enhancing the yield in the pollinator's deficit area.

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