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Effect of bee pollination on qualitative parameters of muskmelon (*Cucumis melo* L.)

Mitul Karkar and Lalit Ghetiya

Abstract
The present study was carried out with the object of "Effect of bee pollination on qualitative parameters of muskmelon (*Cucumis melo* L.)" during summer 2020 to 2021 at College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari (Gujarat). In the present experiment, the maximum flesh thickness of fruit was recorded in Open Pollination (3.13 cm) and Pollination by *A. mellifera* (2.86 cm) as compared to the pollination exclusion plot. The greater cavity size of fruit (25.09 cm/fruit) was recorded in Hand pollination and Pollination by *A. mellifera* and Open pollination, followed by Pollination by *A. cerana*. The least cavity size of fruit (14.01 cm) was noted in Absolute control, in muskmelon fruit. 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 Hand Pollination (8.06 g/100 g). The minimum (4.26 g/100 g) sugar content was recorded in Absolute control, of muskmelon fruit.

Keywords: Pollination, *Apis mellifera*, *Apis cerana*, stingless bees, honey bees, muskmelon

Introduction
Muskmelon is an important truck and kitchen garden crop. It is named 'muskmelon' because of the delightful musky flavour of the ripened fruits. It is a good source of water, minerals, carbohydrates, protein, lipid, iron and vitamins in human diet. 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 circumference, fruit flesh thickness and fruit total soluble solids of muskmelon (Al-Ghzawi and Zaitoun, 2007) [1]. The information on the foraging behaviour and the effect of different mode of pollination on qualitative parameters of muskmelon is scanty in South Gujarat situations. Therefore, it is necessary to evaluate the effect of bee pollination on qualitative parameters of muskmelon.

Materials and Methods
The studies on "Effect of bee pollination on qualitative parameters of muskmelon (*Cucumis melo* L.)" were 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 9 x 6 x 3.25 m 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. The hand-pollinated flower was immediately covered with a butter paper bag. In the open pollination treatment, twenty female flowers were tagged in each replication. 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) [13].

Results and Discussion

Fruit shape

The data revealed that the perfect fruit shape (>85%) was observed in T_5-Hand pollination, T_4-Open pollination and T_3-Pollination by stingless bees, due to uniform pollination. Whereas, in the case of T_2-Pollination by *A. mellifera* and T_1-Pollination by *A. cerana* the moderately perfect fruit shape (50 to 85%) was observed due to slightly less uniform pollination, but in T_6-Absolute control plot the higher per cent of misshaped fruit was recorded due to improper uneven pollination of muskmelon during both the years (Table 1). McGregor (1976) [6] 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) [4]. The result of the present finding is in close agreement with Thakur and Rana (2008) [12] who reported a maximum percentage of misshapen fruits of cucumber in open pollination compared to hand pollination and bee pollination at Solan.

Table 1: Effect of different pollination treatments on the shape of muskmelon fruit

Treatments		2020	2021
		Fruit shape (%)	
T_1	Pollination by *A. cerana*	82.92**	84.82**
T_2	Pollination by *A. mellifera*	84.74**	81.58**
T_3	Pollination by stingless bees	90.84*	92.04*
T_4	Open pollination	86.06*	85.08*
T_5	Hand pollination	92.82*	95.14*
T_6	Absolute control	40.94***	37.74***
Above 85% = Perfect* 50 to 85% = Moderately perfect** Less than 50% = Misshaped***			

Flesh thickness

The results of summer 2020 showed that the maximum flesh thickness of fruit was observed in T_4-Open pollination (3.16 cm) which was found at par with T_2-Pollination by *A. mellifera* followed by T_5-Hand pollination and remained at par with T_1-Pollination by *A. cerana* and T_3-Pollination by the stingless bee. The least flesh thickness (1.49 cm) was recorded in T_6-Absolute control. The descending order of the effect of different pollinators on the flesh thickness of fruit was recorded as $T_4 \geq T_2 > T_5 \geq T_1 \geq T_3 > T_6$. 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 2).

Pooled data showed the maximum flesh thickness of fruit was recorded in T_4-Open pollination (3.13 cm), followed by T_2-Pollination by *A. mellifera* and that was remained at par with T_5-Hand pollination. The next in order was T_1-Pollination by *A. cerana* which was found at par with T_3-Pollination by the stingless bee, while in the case of T_6-Absolute control, the least flesh thickness (1.46 cm) was noted. The descending order of the effect of different pollinators on the flesh thickness of fruit was recorded as $T_4 > T_2 \geq T_5 > T_1 \geq T_3 > T_6$ (Table 2). The results of the present research are corroborated with the work of Al-Ghzawi and Zaitoun (2007) [1], 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.

Table 2: Effect of different pollination treatments on flesh thickness of fruit in muskmelon

	Treatments	2020	2021	Pooled
		Flesh thickness (cm)		
T_1	Pollination by *A. cerana*	2.51	2.46	2.49
T_2	Pollination by *A. mellifera*	3.08	2.65	2.86
T_3	Pollination by stingless bees	2.31	2.38	2.35
T_4	Open pollination	3.16	3.09	3.13
T_5	Hand pollination	2.66	2.89	2.77
T_6	Absolute control	1.49	1.43	1.46
S.Em (±)		0.10	0.11	0.08
C.D. (P=0.05)		0.29	0.33	0.21
*NS= Nonsignificant				

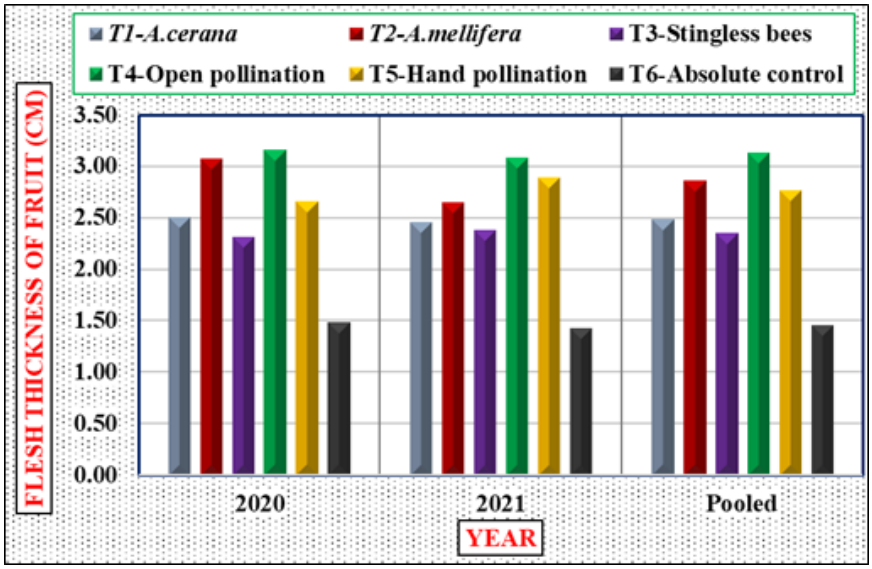

Fig 1: Effect of different pollination treatments on flesh thickness of fruit in muskmelon

Cavity size

In summer 2020, the significantly highest (24.43 cm) cavity size of fruit was recorded in T_4-Open pollination, which was remained at par with T_2-Pollination by *A. mellifera* and T_5-Hand pollination, followed by T_1-Pollination by *A. cerana* and that was at par with T_3-Pollination by the stingless bee. The lowest cavity size of fruit (14.16 cm) was shown in T_6-Absolute control. The descending order of the effect of

different modes of pollinations on the cavity size of fruit was recorded as $T_4 \geq T_2 \geq T_5 > T_1 \geq T_3 > T_6$. 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 T_5-Hand pollination, it was at par with T_2-Pollination by *A. mellifera* and T_4-Open pollination, followed by T_1-Pollination by *A. cerana* and that has remained at par with T_3-Pollination by the stingless bee, in muskmelon fruit. The least cavity size of fruit (14.01 cm) was noted in T_6 - Absolute control. The descending order of the effect of different pollinators on the cavity size of fruit was recorded as $T_5 \geq T_2 \geq T_4 > T_1 \geq T_3 > T_6$ (Table 3). The result of the present work is in agreement with the work of Pokhrel and Thapa (2012) [9] who recorded maximum size of fruit in open-pollinated followed by a hand-pollinated bitter gourd 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) [5].

Table 3: Effect of different pollination treatments on size of fruit cavity in muskmelon

	Treatments	Size of fruit cavity (cm)		
		2020	2021	Pooled
T_1	Pollination by *A. cerana*	22.30	21.88	22.09
T_2	Pollination by *A. mellifera*	24.23	25.75	24.99
T_3	Pollination by stingless bees	22.13	21.41	21.77
T_4	Open pollination	24.43	23.86	24.14
T_5	Hand pollination	23.70	26.48	25.09
T_6	Absolute control	14.16	13.85	14.01
S.Em (±)		0.50	0.60	0.72
C.D. (P=0.05)		1.47	1.76	2.61

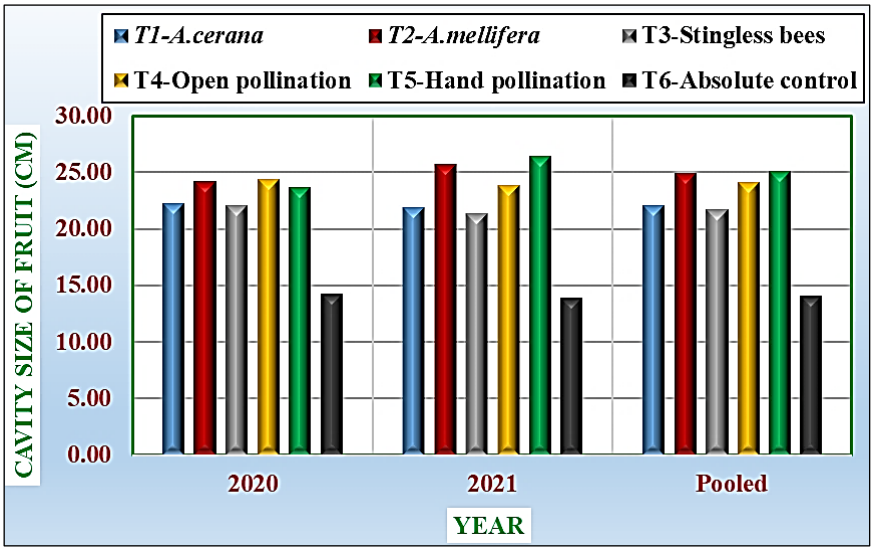

Fig 2: Effect of different pollination treatments on size of fruit cavity in muskmelon

Seed germination

Significantly highest (91.20%) seed germination was recorded in T_4-Open pollination and remained at par with T_5-Hand pollination and T_2-Pollination by *A. mellifera*, followed by T_1-Pollination by *A. cerana* and T_3-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 T_6-Absolute control (Pollination exclusion treatment). The descending order of the effect of different pollinators on seed germination was recorded as $T_4 \geq T_5 \geq T_2 > T_1 \geq T_3 > T_6$. In 2021, the same trend with little variation was recorded with $T_2 > T_4 \geq T_3 \geq T_5 \geq T_1 > T_6$ order (Table 4).

Pooled data showed the highest (89.60%) seed germination in T_2-Pollination by *A. mellifera*, which was found at par with T_4-Open pollination followed by T_5-Hand pollination, T_3-Pollination by the stingless bee and T_1-Pollination by *A. cerana*. The lowest (39.00%) seed germination was recorded in T_6-Absolute control in muskmelon seed. The descending order of the effect of different pollinators on seed germination was recorded as $T_2 \geq T_4 \geq T_5 \geq T_3 \geq T_1 > T_6$ (Table 4).

Present work is in close confirmation with work done by Bhowmik *et al*. (2017) [3] and Paikara and Painkara (2021) [7] who reported that the seed germination was increased in open pollination conditions over closed treatment. Similarly, Lalita *et al.* (2018) [5] 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) [11] 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) [9] 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) [8] 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) [10], also reported slightly different results at Wadura (Jammu and Kashmir) with the highest seed germination in *A. cerena* followed by open pollination, pollination by *A. melliferra* and pollination exclusion control plot in coriander. The deviation in results might be due to pollinators deficit during experimentation year.

Table 4: Effect of different pollination treatments on germination per cent of muskmelon seed

Treatments		Seed germination (%)		
		2020	2021	Pooled
T_1	Pollination by *A. cerana*	67.21 (84.40)	63.03 (78.80)	65.12 (81.60)
T_2	Pollination by *A. mellifera*	69.75 (87.20)	74.34 (92.00)	72.05 (89.60)
T_3	Pollination by stingless bees	66.27 (83.20)	64.19 (80.40)	65.23 (81.80)
T_4	Open pollination	73.49 (91.20)	66.87 (84.00)	70.18 (87.60)
T_5	Hand pollination	70.32 (88.00)	63.56 (79.60)	66.94 (83.80)
T_6	Absolute control	40.89 (42.40)	36.90 (35.60)	38.90 (39.00)
S.Em (±)		1.41	1.24	2.10
C.D. (P=0.05)		4.13	3.61	7.63

Note: Figure in parentheses is original values, those outside are arc sin transformed values, N = Mean of 50 seed

Total soluble solids

The results showed that a minor difference in Brix reading was observed between all the treatments and results were found nonsignificant 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 T_5-Hand pollination, which was found at par with T_4-Open pollination, T_2-Pollination by *A. mellifera*, T_3-Pollination by the stingless bee and T_1-Pollination by *A. cerana*. The lowest (8.83%) TSS was recorded in T_6-Absolute control. The descending order of the effect of different pollinators on TSS was recorded as $T_5 \geq T_4 \geq T_2 \geq T_3 \geq T_1 > T_6$ (Table 5). 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 (Anon., 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.

Table 5: Effect of different pollination treatments on TSS and sugar content of muskmelon fruit

Treatment		TSS (%)			Total sugar (g/100 g)		
		2020	2021	Pooled	2020	2021	Pooled
T_1	Pollination by *A. cerana*	3.32 (10.55)	3.31 (10.47)	3.32 (10.51)	2.82 (7.46)	2.81 (7.40)	2.81 (7.43)
T_2	Pollination by *A. mellifera*	3.35 (10.71)	3.33 (10.60)	3.34 (10.65)	2.76 (7.11)	2.78 (7.26)	2.77 (7.18)
T_3	Pollination by stingless bees	3.28 (10.28)	3.35 (10.76)	3.32 (10.52)	2.92 (8.02)	2.94 (8.13)	2.93 (8.07)
T_4	Open pollination	3.37 (10.90)	3.40 (11.05)	3.38 (10.98)	2.93 (8.11)	2.97 (8.30)	2.95 (8.21)
T_5	Hand pollination	3.40 (11.09)	3.37 (10.89)	3.39 (10.99)	2.92 (8.03)	2.93 (8.08)	2.92 (8.06)
T_6	Absolute control	3.04 (8.86)	3.03 (8.80)	3.04 (8.83)	2.17 (4.21)	2.19 (4.31)	2.18 (4.26)
S.Em (±)		0.09	0.08	0.06	0.05	0.04	0.03
C.D. (P=0.05)		NS	NS	0.17	0.13	0.11	0.09

Note: Figure in parentheses is original value, those outside are SQRT transformed values, N = Mean of 10 fruits, NS = Nonsignificant

Total sugars

In 2020, the maximum sugar content was noticed in T_4-Open pollination (8.11 g/100 g), which was found at par with T_5-Hand pollination, T_3-Pollination by the stingless bee and T_1-Pollination by *A. cerana* followed by T_2-Pollination by *A. mellifera*. The minimum (4.21 g/100 g) sugar content was recorded in T_6-Absolute control, of muskmelon fruit. The descending order of the effect of different pollinators on total sugars was recorded as $T_4 \geq T_5 \geq T_3 \geq T_1 > T_2 > T_6$. The same trend with little deviation was recorded with $T_4 \geq T_3 \geq T_5 > T_1 \geq T_2 > T_6$ order during 2021 (Table 5).

While in pooled data, the highest sugar content was detected in T_4-Open pollination (8.21 g/100 g) found at par with T_3-Pollination by the stingless bee and T_5-Hand pollination followed by T_1-Pollination by *A. cerana* and T_2-Pollination by *A. mellifera*. The minimum (4.26 g/100 g) sugar content was recorded in T_6-Absolute control. The descending order of the effect of different pollinators on total sugars was recorded as $T_4 \geq T_3 \geq T_5 > T_1 \geq T_2 > T_6$ (Table 5).

Conclusion

The decreasing order of the effectiveness of different modes of pollination on fruit shape, 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. Plenty of pollinators' availability in research sites leads to the super effect on 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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