Pollination requirements of seeded and seedless mini watermelon varieties cultivated under protected environment

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Abstract – The objective of this work was to evaluate the floral biology and pollination requirements of seeded and seedless mini watermelon varieties, and to determine the best varieties to cultivate under protected environment. Three seedless (HA-5106, HA-5158, and HA-5161) and two seeded (Minipol and Polimore) genotypes were tested. Flowers were monitored from the pre-anthesis stage to senescence, and fruit quality was also evaluated. The evaluated treatments were hand-geitonogamous pollination (MG), cross-pollination with pollen from the Polimore variety (MCP), cross-pollination with pollen from the Minipol variety (MCM), and restricted pollination. All varieties had monoecious plants with diclinous flowers, and the stigmas remained receptive throughout anthesis. Fruit set rates of 84.62% (MG), 61.54% (MCP), 48% (MCM), and 0% (restricted) were obtained for seeded varieties, but of 0% (MG), 76.36% (MCP), 82.69% (MCM), and 0% (restricted) for seedless varieties. Fruits did not differ in quality among treatments within each genotype. Therefore, all the studied varieties require a pollination agent and diploid pollen for fruit set to occur, regardless of the donor variety; and Minipol or Polimore with HA-5106 or HA-5158 are the varieties recommended for cultivation in protected environment.

Index terms: *Citrullus lanatus*, flowering, fruit quality, fruit set, greenhouse.

Requerimentos de polinização de variedades de minimelancia com e sem semente cultivadas em ambiente protegido

Resumo – O objetivo deste trabalho foi avaliar a biologia floral e os requerimentos de polinização de variedades de minimelancia com e sem sementes, e determinar as melhores variedades para cultivo em ambiente protegido. Três genótipos sem semente (HA-5106, HA-5158 e HA-5161) e dois com semente (Minipol e Polimore) foram testados. As flores foram monitoradas da pré-antese à senescência, e a qualidade dos frutos também foi avaliada. Avaliaram-se tratamentos de polinização manual por geitonogamia (MG), de pólen cruzado da variedade Polimore (MCP), de pólen cruzado da variedade Minipol (MCM) e de polinização restrita. Todas as variedades apresentaram plantas monoicas e flores díclinas, e os estigmas permaneceram receptivos durante toda a antese. Foram obtidas taxas de vingamento de 84,62% (MG), 61,54% (MCP), 48% (MCM) e 0% (restrita) para as variedades com semente, mas de 0% (MG), 76,36% (MCP), 82,69% (MCM) e 0% (restrita) para aquelas sem semente. Os frutos não diferiram quanto à qualidade entre os tratamentos dentro de cada genótipo. Portanto, todas as variedades estudadas requerem um agente polinizador e pólen diploide para o vingamento de frutos, independentemente da variedade doadora; e Minipol ou Polimore com HA-5106 ou HA-5158 são as variedades recomendadas para cultivo em ambiente protegido.

Termos para indexação: *Citrullus lanatus*, florescimento, qualidade dos frutos, vingamento de frutos, casa de vegetação.

Introduction

Traditionally, watermelon [*Citrullus lanatus* (Thunb.) Matsum. & Nakai] is a plant cultivated in open field and usually produces large-sized fruit with great amount of seeds scattered throughout their flesh. However, motivated by new consumer demands, breeders have developed smaller fruits and seedless varieties (Walters, 2009; Bomfim et al., 2013).

The arrival of these new varieties, such as mini watermelons, make feasible the cultivation of this vegetable in protected environments, which make

it possible to minimize losses in yield, improve fruit quality, and provide early or out-of-season harvest (Seabra Júnior et al., 2003; Cruz & Campos, 2009; Campagnol et al., 2012). However, watermelon plants do not produce fruits without a pollination agent (Walters, 2005; Guerra Sanz, 2008), and this artificial environment blocks the entrance of natural pollinators in the system (Cruz & Campos, 2009). Consequently, for highly pollinator-dependent crops to produce fruits under protected environment, it is necessary to introduce biotic pollinators (Slaa et al., 2006; Cruz & Campos, 2009) or to hire manpower to manually pollinate the flowers (Slaa et al., 2006).

Understanding the floral biology and pollination requirements of a crop variety is essential to adequately hand pollinate the flowers or to choose a pollinator capable to meet pollination requirements (Delaplane et al., 2013). Even for seedless watermelon varieties (triploid, 3n), adequate pollination is necessary to release the amount of phytohormones needed to stimulate not only the fruit set, but also a good fruit development (Walters, 2005). Walters (2005) also stated that, for fruit set to occur in triploid varieties, these must be grown close to a diploid variety, planted as a pollen donor.

Moreover, although there is some knowledge about pollination of conventional watermelon varieties (Adlerz, 1966; Stanghellini et al., 1997, 1998, 2002; Araújo et al., 2014), little has been done to define the floral biology and pollination requirements of modern genotypes, including mini watermelon varieties. Sometimes breeders, aiming to improve vegetable traits, also, unintentionally, alter floral traits, which, to some extent, affect the pollination process. This probably happens since floral aspects regarding pollination are not normally targeted by breeders (Guerra Sanz, 2008; Klatt et al., 2013).

The objective of this work was to evaluate the floral biology and pollination requirements of seeded and seedless mini watermelon varieties, and to determine the best varieties to cultivate under protected environment.

Materials and Methods

The experiment was carried out from August to October 2011 in a greenhouse covered with transparent plastic film, fitted with automated drip fertigation and temperature control systems, comprising an area of 160 m^2 (8 m wide x 20 m long x 3.5 m high), located at Embrapa Agroindústria Tropical, in the municipality of Fortaleza, in the state of Ceará, Brazil (3°45'05"S, 38°34'35"W, at 36 m altitude).

Five different mini watermelon genotypes were tested: three triploid seedless (HA-5106, HA-5158, and HA-5161) and two diploid seeded (Minipol and Polimore) genotypes.

Seeds were sown in 200 cell-plastic trays filled with a commercial substrate prepared using dried and powdered coconut fiber. Twelve days later, seedlings were transplanted to 5 L plastic jars, which were previously filled with raw coconut fiber and powdered coconut fiber (1:1). Jars were spaced at 0.8 m between rows and 0.4 m between plants. Following recommendations for the cultivation of seedless varieties, a 3:1 ratio between triploid and diploid varieties was used in dedicated rows (Dittmar et al., 2009). On the seventeenth day after transplanting, staking was done with a plastic trellis for vertical conduction of plants, a procedure that facilitates crop management in greenhouse conditions (Campagnol et al., 2012). Throughout cultivation, plants were drip fertigated, and provided with a suitable amount of water and nutrients for each growth stage.

In order to study the floral characteristics and the period of anthesis of the five genotypes, 30 buds of each variety were monitored hourly, from the pre-anthesis phase until petal closure, along the entire flowering phase. Collected data were related to sexual expression, basic floral morphology, available floral resource, longevity, and opening and closing time of flowers and petals during anthesis (Andrade et al., 2014).

In addition, data on luminosity (klux) were collected and determined by a digital lux meter, and data on temperature (°C) and relative humidity (%) of air were measured hourly by a datalogger placed inside the greenhouse.

The pollination requirements of all varieties were studied in a completely randomized design, with only one hand-pollination treatment performed per plant. For analysis of pollination requirements, four pollination treatments were carried out in the female flowers of the five varieties, according to Delaplane et al. (2013), with some adaptations, as described below. The number of flowers per treatment corresponded to the maximum

pollination treatments possible for each variety. Therefore, these numbers varied among varieties.

The cited adaptations included: hand-geitonogamous pollination (MG); manual cross-pollination with pollen from the Minipol variety (2n) (MCM); manual cross-pollination with pollen from the Polimore variety (2n) (MCP); and restricted pollination.

In MG, pre-anthesis pistillate floral buds (female) were protected by tulle bags in the late afternoon. The next morning, the flower buds that opened were unpacked and subjected to manual pollination using pollen from staminate flowers (male) of the same plant. This was accomplished by collecting two staminate flowers (three staminate flowers for triploid varieties) and folding back their petals before manually rubbing the anthers of these flowers against the whole surface of the three stigma lobes of the female flowers. Immediately after pollination, the female flowers were tagged and bagged again, remaining protected until the following morning, in order to avoid any contamination with other pollen grains (Ferreira, 2005).

In MCM, pistillate flower buds were subjected to the same procedure of the previous treatment. However, when the flower was unbagged, pollination was carried out with staminate flowers from the Minipol variety.

MCP was similar to the treatment described before, but the pollen donor variety used to pollinate the flowers was Polimore.

Finally, in restricted pollination, considered as the control treatment, pistillate flowers remained bagged from pre-anthesis until the end of the anthesis period.

All hand pollination treatments were performed in the morning between 6:00 and 10:30 a.m., since this interval corresponds to the period of maximum receptivity, although the stigmas remain receptive throughout anthesis (Ferreira, 2005; Kwon et al., 2005). Furthermore, only female flowers from the plant's eighth node onwards were pollinated, as suggested by Seabra Júnior et al. (2003). The quantification of the number of fruit sets was conducted three days after the pollination treatments and then at harvest. Only one fruit per plant was allowed; therefore, the exceeding fruits were removed during the early days of development, in order to not affect the development and setting of the first fruit (Walters, 2005; Campagnol et al., 2012).

All fruits produced as a result of each pollination treatment were harvested 30–35 days after pollination and taken to the Laboratory of Plant Breeding and Genetic Resources, of Embrapa Agroindústria Tropical, for analysis of quality traits. The number of fruits analyzed varied according to the fruit set rate of each pollination treatment for each variety. The evaluated variables included: fruit weight (g), length (cm), width (cm), deformation score, rind thickness (cm), flesh firmness (N), soluble solids content (°Brix), and number of seeds per fruit (Lima Neto et al., 2010; Delaplane et al., 2013). In particular, for deformation parameters (qualitative variable), fruits were scored from 1 to 4, with score 1 for perfect fruit, score 2 for slightly deformed fruits, score 3 for fruits with moderate deformation, and score 4 for fruits with severe deformation (Delaplane et al., 2013).

Due to the binomial character (in which 1 is developed; and 0 is not developed) of fruit setting, data for this parameter were subjected directly to the nonparametric Kruskal-Wallis test, at 5% probability. The R statistical software, version 2.9.1 (R Development Core Team, 2012) was used to perform this analysis. All data of variables related to fruit quality parameters were subjected to normality tests. Those variables with normal distribution were subjected to analysis of variance using the SAS software, version 9.1 (SAS Institute, 2003), through the procedure of generalized linear models (PROC GLM), and means were compared by the Tukey test, at 5% probability. However, when there was no normal distribution, even after data transformation, nonparametric statistical analysis and mean comparisons were performed. Therefore, data regarding flesh firmness were analyzed using the SAS software, version 9.1 (SAS Institute, 2003), through the routine PROC NPAR1WAY, and the obtained results were compared, depending on the number of treatments compared within each variety, by the Wilcoxon (two treatments compared) or the Kruskal-Wallis (three treatments compared) tests, at 5% probability.

Results and Discussion

The five evaluated varieties presented monoecy as a sexual expression. Therefore, both types of flowers were located within the same plant, but separated into distinct flowers (diclinous): staminate (male) and pistillate (female). In all studied varieties, the corolla was slightly tubular, shallow, with five petals fused

only at their bases, and a slightly greenish-yellow color that faded throughout the day, probably due to sun exposure. The observed characteristics corroborate the studies of Delaplane & Mayer (2000) and Guerra Sanz (2008).

For all five varieties, the staminate flowers had three stamens separated from each other and inserted into the center of the flower, surrounding a shallow floral nectary located at the inner base of the corolla. Each stamen was formed by a filament that held an anther with longitudinal dehiscence. When flowers opened, anther dehiscence and the consequent exposure of pollen grains had already occurred, but pollen grains remained firmly adhered to each other and to the anthers, forming a pollen mass. However, during anthesis, as temperature increased and humidity decreased, the pollen grains became loose, although still forming a pollen mass adhered to the anther. From this moment on, pollen grains could fall onto the petals of the same flower by any movement suffered by the flower or the plant. Staminate flowers of triploid varieties (HA-5106, HA-5158, and HA-5161) visually presented less pollen than the diploid ones (Figure 1 A and B); however, some presented anthers with a dehydrated appearance, brown in color, and visually with little or no pollen grains, even at the beginning of anthesis (Figure 1 C). Conversely, Stanghellini et al. (2002) found no differences in the amount of pollen between diploid and triploid genotypes.

The pistillate flower was easily distinguished from the staminate flower, because the former had a prominent ovary at its base that resembled the ripened fruit, though still much reduced in size. Its ovary was also attached to a thick and very short style, whose base was surrounded by a shallow nectary and whose top presented an adhesive stigma divided into three or, less frequently, four large lobes. The surface of these lobes remained moist, sticky, and shiny during the time the pistillate flower remained open. According to Njoroge et al. (2010), a stigma with glossy secretion may be considered receptive, that is, ready for pollination. This information is important to define when these varieties can be pollinated, either in watermelon breeding programs or in commercial production in greenhouses. This result is also an indicative that, based on stigma receptivity, these varieties can benefit from pollinator visits along the entire time the flowers remain open. It is important to highlight that, in systems in which pollinators are present, pollen grains, unlike nectar, are quickly reduced during the first hours after anthesis due to pollinator activity and are no longer replenished (Araújo et al., 2014).

Regarding the flower opening and closing time, the five varieties showed the same period of anthesis. In general, flowers of both sexes began corolla expansion in the first few hours of sunshine, approximately at 5:20 a.m. (at 24.2°C, 97.1% humidity, and 0.430 klux), and remained open throughout the morning until they finally closed in the early afternoon, around 2:20 p.m. (at 33.2°C, 65.6% humidity, and 36.9 klux), with a total anthesis period of 9 hours. These results are similar to those reported by Stanghellini et al. (2002) and Azo'o Ela et al. (2010). Regarding the movement of petals, corolla expansion and retraction for both pistillate (Figure 2 A to K) and staminate flowers (Figure 3 A to K) behaved as follows: soon after opening, the

Figure 1. Pollen grains on anthers: A, staminate flower (2n) of the Minipol variety with typical amount of pollen; B, HA-5161 staminate flower (3n) with typical amount of pollen; C, HA-5161 staminate flower (3n) with anthers with a dehydrated appearance.

corolla exhibited a cup-shape structure and continued its expansion, transitioning to the plate format, and, finally, fully expanding to an inverted umbrella. After this period, which lasted about 4 hours, the corolla started to retract, returning through all stages until finally closing and not opening again, even if not pollinated. This petal movement throughout the day was also observed by Emuh & Ojeifo (2011).

The evaluated set of characteristics, including type of sexual expression, corolla shape and color, anthesis, and the presence of nectar and pollen, reveals that the flowers of all five varieties still have traits that are important in attracting bees to promote pollination. This indicates that bees are a suitable pollinator to be introduced in areas cultivated with these varieties.

Pistillate flowers of both diploid varieties (Minipol and Polimore), when subjected to the treatment of restricted pollination with tulle bag, differed significantly from the other treatments, setting no fruits (Table 1). These results are not surprising, since the watermelon plant, independently of being diploid or triploid, is not capable to produce fruit through asexual reproduction (Walters, 2005; Taha & Bayoumi, 2009), unlike other cucurbits, as some cucumber (*Cucumis sativus* L.) varieties (Nicodemo et al., 2013), except when chemicals, such as growth

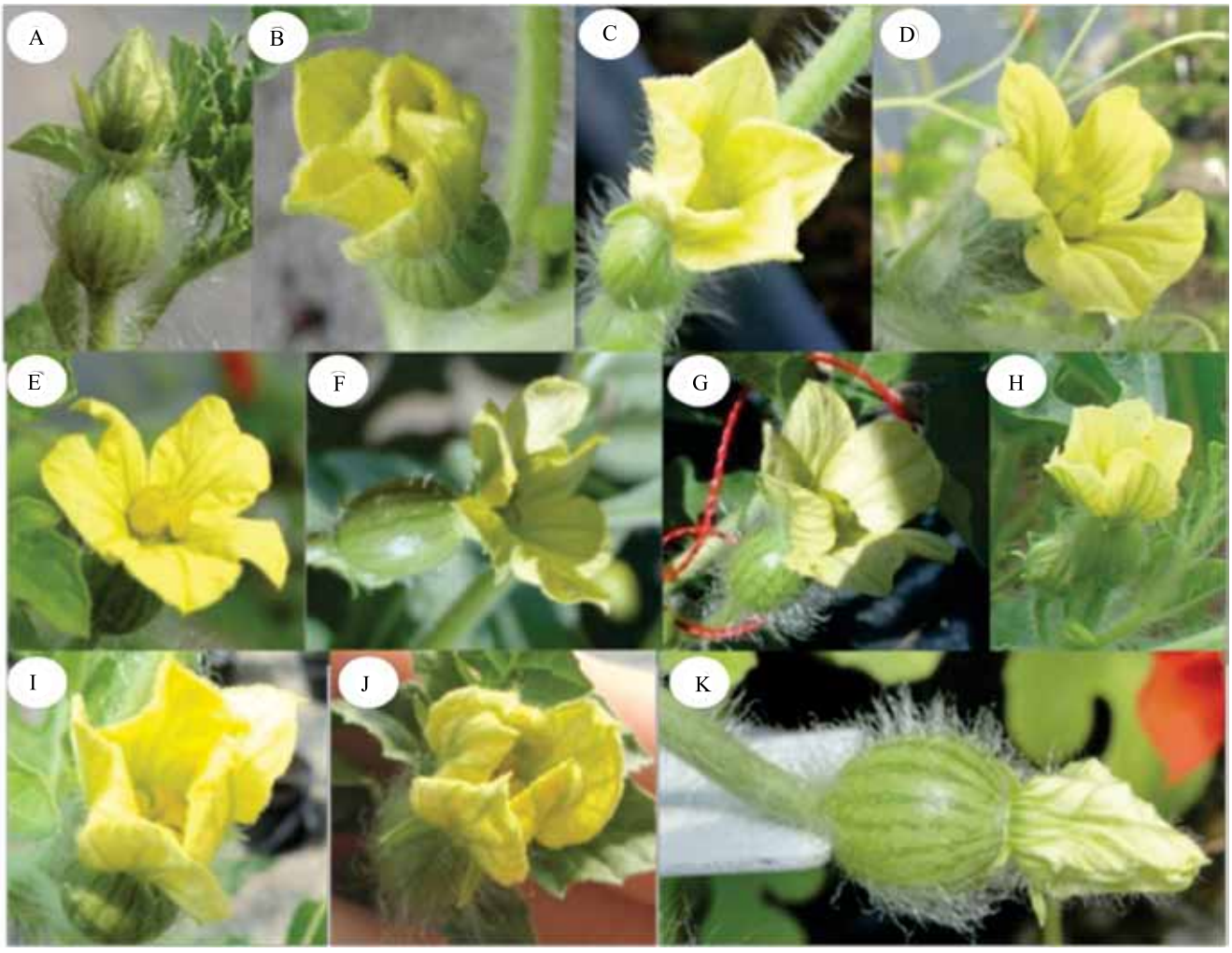

Figure 2. Corolla movements during the anthesis of pistillate flowers (♀) in mini watermelon (*Citrullus lanatus*) varieties under protected cultivation: A, floral bud in pre-anthesis; B, beginning of anthesis at 5:25 a.m.; C, flower at 6:00 a.m.; D, flower at 7:00 a.m.; E, flower at 8:00 a.m.; F, flower at 9:00 a.m.; G, flower at 10:00 a.m.; H, flower at 11:00 a.m.; I, flower at 1:00 p.m.; J, flower at 2:00 p.m.; K, flower one day after anthesis.

regulators, are applied to the flower ovaries (Huitrón et al., 2007). For the Polimore variety, the other pollination treatments did not differ significantly from each other with respect to the percentage of fruit set (Table 1). Therefore, the Polimore variety accepted well pollen grains from the same plant, from another individual of the same variety, and from the Minipol variety. According to Souza (2003), although the conventional watermelon (2n) is a xenogamous species (cross-pollination), it is also a self-compatible plant. In other words, it accepts autogamy (pollination within the same flower) in the case of andromonoecious varieties, and geitonogamy (pollination between different flowers of the same plant). Therefore, this variety presents a mixed pollination breeding system.

For the Minipol variety, although MG differed significantly from MCM ($p \leq 0.05$), it did not differ from the MCP treatment, which in turn was similar to MCM (Table 1). In the present study, the percentage of fruit

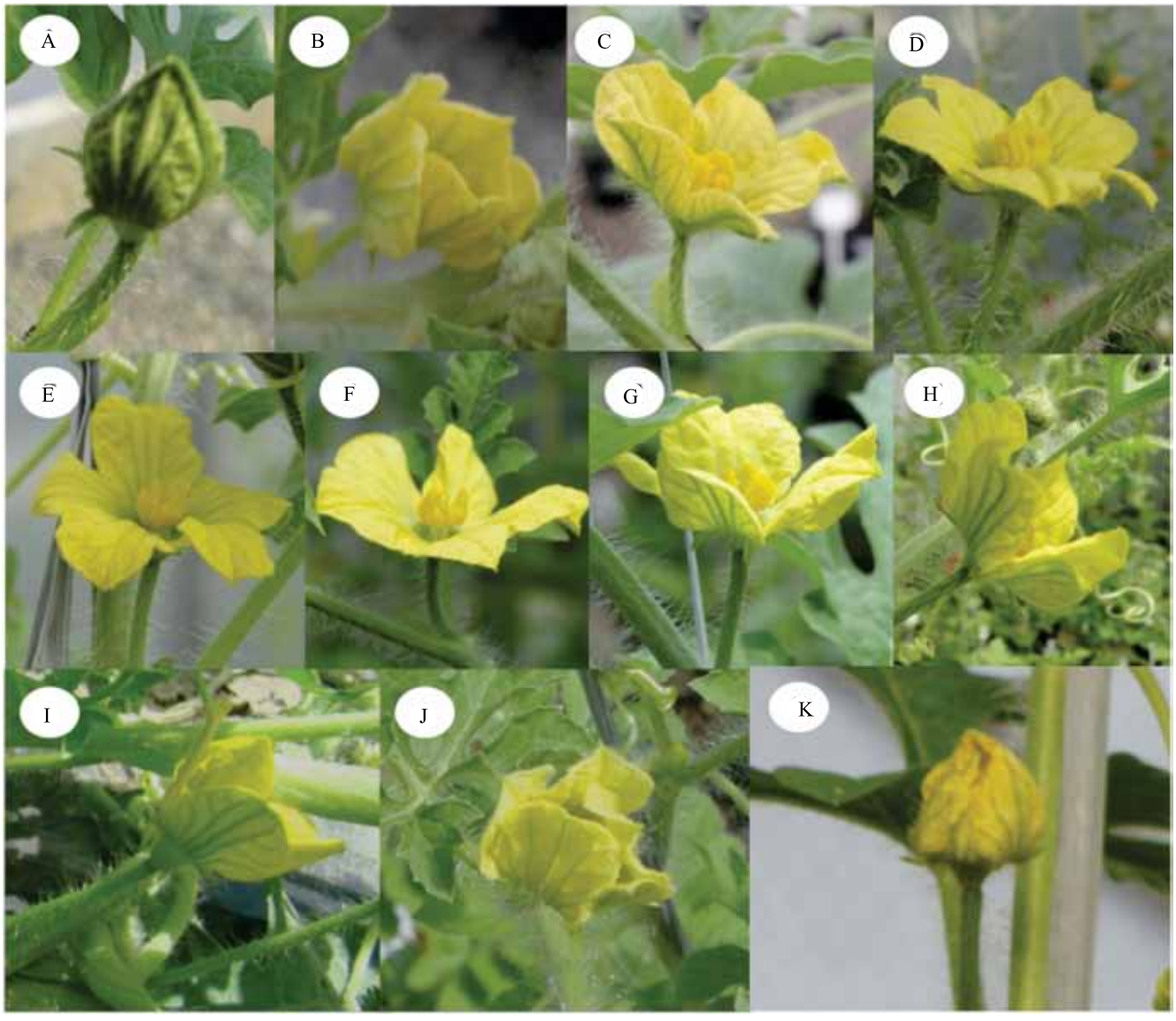

Figure 3. Corolla movements during the anthesis of staminate flowers (♂) in mini watermelon (*Citrullus lanatus*) varieties under protected cultivation: A, floral bud in pre-anthesis; B, beginning of anthesis at 5:20 a.m.; C, flower at 6:00 a.m.; D, flower at 7:00 a.m.; E, flower at 8:00 a.m.; F, flower at 9:00 a.m.; G, flower at 10:00 a.m.; H, flower at 11:00 a.m.; I, flower at 1:00 p.m.; J, flower at 2:00 p.m.; K, flower one day after anthesis.

set of the seeded varieties subjected to the three hand pollination treatments (MG, MCP, and MCM) was much higher than that observed by Adlerz (1966) for fruit sets obtained by hand pollination in open fields, which varied from 33.3 to 40.6% between consecutive years for the diploid variety. Ferreira (2005) states that, in general, rates of fruit setting in open field are much lower when compared to pollinations performed in greenhouses, where it is possible to control better the weather conditions and the number of fruits per plant. This is explained by the pre-existence of a developing fruit in the plant, which interferes in the setting of another fruit for at least seven days (Walters, 2005). The fact that seeded mini watermelon varieties set well under MG may indicate that these varieties may be naturally benefited by bee visits, which tend to explore various flowers on the same plant before moving to the next one (Walters & Schultheis, 2009; Delaplane et al., 2013).

Despite geitonogamous pollination having been successful for seeded varieties (2n), it was not suitable for seedless ones (3n): HA-5158, HA-5161, and HA-5106 (Table 2). The pistillate flowers of triploid varieties subjected to the MG treatment showed 0% of fruit set, identical to the results obtained in the treatment of restricted pollination, and both differed from the other treatments, MCP and MCM. Among the three varieties of seedless mini watermelon (3n), the one with worst fruit set for all treatments was HA-5161, which set fruits in only 60 and 58.82% of the flowers pollinated with pollen from the Minipol (MCM) and Polimore (MCP) varieties, respectively; these did not differ from each other.

The other triploid varieties showed high rates of fruit set, and no differences were found among MCM and MCP pollination treatments within each of these varieties. These results agree with the findings of Belfort et al. (2003), who, in protected cultivation, obtained an overall rate of fruit set in seedless watermelon (3n) exceeding 75% when flowers were pollinated with pollen from diploid genotypes. The results of the present study are similar to those

Table 1. Pollination requirements of seeded (2n) mini watermelon (*Citrullus lanatus*) varieties (Minipol and Polimore) under protected cultivation[1].

Pollination treatment[2]	Minipol			Polimore			Overall seeded (2n)		
	Number of flowers	Fruit set		Number of flowers	Fruit set		Number of flowers	Fruit set	
		Fruits	%		Fruits	%		Fruits	%
MG	13	11	84.62a	13	11	84.62a	26	22	84.62
MCP	15	9	60.00ab	11	7	63.64a	-	-	-
MCM	14	6	42.86b	11	6	54.55a	-	-	-
Restricted	10	0	0.00c	10	0	0.00b	20	0	0.00
Total	52	26	-	45	24	-	97	50	-

[1]Means followed by equal letters in the column, do not differ significantly by the Kruskal-Wallis test, at 5% probability. [2]MG, hand-geitonogamous pollination; MCP, manual cross-pollination with pollen from the Polimore variety; MCM, manual cross-pollination with pollen from the Minipol variety; restricted, flower bagged throughout anthesis.

Table 2. Pollination requirements of seedless (3n) mini watermelon (*Citrullus lanatus*) varieties (HA-5158, HA-5161, and HA-5106) under protected cultivation[1].

Pollination treatment[2]	HA-5158			HA-5161			HA-5106			Overall seedless (3n)		
	Number of flowers	Fruit set		Number of flowers	Fruit set		Number of flowers	Fruit set		Number of flowers	Fruit set	
		Fruits	%		Fruits	%		Fruits	%		Fruits	%
MG	10	0	0.00b	10	0	0.00b	10	0	0.00b	30	0	0.00b
MCP	20	17	85.00a	17	10	58.82a	18	15	83.33a	55	42	76.36a
MCM	20	19	95.00a	15	9	60.00a	17	15	88.24a	52	43	82.69a
Restricted	10	0	0.00b	10	0	0.00b	10	0	0.00b	30	0	0.00b
Total	60	36	-	52	19	-	55	30	-	167	85	-

[1]Means followed by equal letters in the column, do not differ significantly by the Kruskal-Wallis test, at 5% probability. [2]MG, hand-geitonogamous pollination; MCP, manual cross-pollination with pollen from the Polimore variety; MCM, manual cross-pollination with pollen from the Minipol variety; restricted, flower bagged throughout anthesis.

of Walters (2005), except for HA-5161, who also observed a fruit set rate of 80% while working with a triploid variety in open field subjected to open pollination (about 24 visits of *Apis mellifera*). The high fruit set rate reported by this author was attributed to the removal of early or subsequent fruits on the same vine. In the present work, for all triploid varieties studied, only manual cross-pollination treatments using pollen derived from diploid varieties were capable to produce fruits (Table 2). This can be explained by the fact that only the diploid varieties have viable pollen grains able to germinate on the stigma of triploid female flowers and, consequently, able to promote the release of plant hormones, which directly influence fruit setting and growth (Walters, 2005; Guerra Sanz, 2008).

Due to the absence of fruit set when flowers were subjected to the restricted pollination treatment, in both types of mini watermelons (2n and 3n), and to the MG treatment for seedless varieties (3n), fruit quality characters were compared only among the other pollination treatments. There were no significant differences ($p>0.05$) between pollination treatments for any of the variables investigated. Therefore, regarding weight, length, width, deformation, rind thickness, flesh firmness, soluble solids content, and number of seeds per fruit, all treatments showed similar results for each of these variables analyzed within each variety (Table 3).

These results indicate that once the fruit has set, regardless of the type of pollination treatment performed on the flower, it is able to develop well and present similar qualitative traits to those of the fruits produced by treatments that resulted in a higher percentage of fruit setting. According to Serrano & Guerra Sanz (2006), the number of pollen grains deposited on the stigma of a flower is the variable that can affect fruit quality. In the present work, because all pollination treatments tested were carried out by hand pollination, depositing a large amount of pollen grains on the stigmas, there was no pollen limitation. Therefore, it is reasonable to believe that this is the reason for the uniformity in the quality traits observed in the fruits among treatments. Under conditions of natural pollination, however, care should be taken to ensure that pollinators deposit at least the minimum amount of pollen needed in order for the fruits to develop well and fully express desirable traits (Delaplane et al., 2013). Indeed, Guerra Sanz & Serrano (2008) found that the increase in flower visitation by bees resulted in a higher number of fruits per plant, besides heavier and sweeter fruits for triploid varieties, and heavier and sweeter fruits, with more seeds, for diploid varieties.

Table 3. Means and standard deviations of qualitative fruit characters of five mini watermelon (*Citrullus lanatus*) varieties obtained from hand-pollination treatments.

Variety	Pollination treatment[(1)]	n	Weight (g)	Length (cm)	Width (cm)	Deformation score	Rind thickness (cm)	Flesh firmness (N)	Soluble solids content (°Brix)	Number of seeds per fruit
					Seeded (2n)					
Polimore	MG	13	733.4±204.3	11.29±1.28	10.91±1.03	1.38±0.52	1.16±0.23	8.72±2.00	9.85±0.59	105.5±42.3
	MCP	11	635.0±279.5	10.74±1.84	10.38±1.53	1.25±0.50	1.13±0.16	8.36±3.96	9.96±0.95	104.1±52.1
	MCM	11	948.5±288.1	12.31±1.17	12.01±1.18	1.17±0.41	1.14±0.18	8.45±3.34	9.83±1.03	130.7±13.6
Minipol	MG	13	723.9±259.7	11.32±1.46	10.85±1.22	1.25±0.46	1.31±0.35	7.38±2.80	8.84±1.06	60.3±19.9
	MCP	15	780.1±245.0	11.68±1.25	11.25±1.06	1.55±0.53	1.17±0.17	8.18±2.94	8.82±0.90	71.4±29.0
	MCM	14	608.8±175.3	10.63±1.21	10.36±1.14	1.40±0.55	0.97±0.38	8.90±2.85	8.97±1.41	55.0±31.7
					Seedless (3n)					
HA-5158	MCP	17	523.6±144.5	9.93±1.15	10.02±0.93	1.54±0.78	1.46±0.28	9.21±2.14	9.38±0.86	2.2±3.5
	MCM	19	507.2±176.3	9.77±1.25	9.84±1.16	1.43±0.51	1.42±0.26	8.31±3.96	9.56±0.79	3.1±6.9
HA-5106	MCP	15	598.1±217.5	10.34±1.36	10.35±1.19	1.82±0.98	1.63±0.19	7.03±3.02	10.79±1.12	8.5±9.2
	MCM	15	745.4±201.1	11.36±1.01	11.14±0.97	2.08±0.79	1.70±0.20	8.18±3.38	11.13±0.75	15.6±15.9
HA-5161	MCP	17	525.3±180.4	10.46±1.56	10.08±1.20	2.25±0.89	1.36±0.33	6.45±4.40	11.32±0.94	6.4±8.4
	MCM	15	382.3±180.5	9.26±1.56	9.17±1.45	2.33±0.58	1.28±0.19	3.34±3.20	11.34±0.28	13.0±14.3

[(1)]MG, hand-geitonogamous pollination; MCP, manual cross-pollination with pollen from the Polimore variety; MCM, manual cross-pollination with pollen from the Minipol variety.

Conclusions

1. All seeded and seedless mini watermelon (*Citrullus lanatus*) varieties have monoecious plants and diclinous flowers with similar pattern of anthesis, preserve traits for attracting bees, and cannot autopollinate.

2. For fruit set, all mini watermelon varieties need a pollination agent and diploid pollen, regardless of the donor variety, which does not interfere in the quality of the produced fruit.

3. The Minipol or Polimore varieties with HA-5106 or HA-5158 are recommended for cultivation in greenhouses.

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