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Assessment of male types for pollination in commercial date palm (*Phoenix dactylifera* L.) varieties cultivated at Khairpur, Sindh, Pakistan

Jaffar Ali Jagirani[1], Ameer Ahmed Mirbahar[1], Muhammad Mahmood-ur-Rahman Jamro[2*], Muzafar Hussain Sirohi[1] and Zulfiqar Ali Abbasi[2]

[1] *Department of Botany, Faculty of Natural Sciences, Shah Abdul Latif University, Khairpur, Sindh – Pakistan.*
[2] *Shaheed Zulfiqar Ali Bhutto Agricultural College Dokri, Larkana, Sindh-Pakistan*
[*]*Corresponding author:* mmrehman@sau.edu.pk

Abstract

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In Sindh province of Pakistan, Date palm growers always use pollens of wild male plants or any other type of male spathes, which are available in the market. That present study was aimed to identify potential male for pollination to obtain better yield. Five male types (viz; M1, M2, M3, M4 and M5) were identified on morphometric basis and pollens of these males were applied on two commercial female varieties i.e., Aseel and Gajar. Maximum results were recorded in Gajar variety with application of M1; weight of single bunch (9.12 kg), yield plant^{-1} (39.62 kg) at flesh stage, (10.50 g) single fruit weight at flesh stage, (2.03 cm) fruit diameter at flesh stage, (15.99) number of fruits strand^{-1}, (4.68 cm) fruit length at mature fruit dev=elopment stage, (4.35 cm) at flesh stage, (2.32 cm) fruit diameter at mature stage and minimum (1.22 cm) seed stone length.

Results regarding the various male type characters depicted that, maximum (31.20 feet) plant height M2, (11.29 inch) frond length M4, (177.43) number of leaflets frond^{-1} M4, **(**23.21) number of spines frond^{-1}M1, (6.03feet) trunk diameter of lower plant portion M2, middle (5.70 feet) M4 and upper (5.43 feet) M4, number of spathe male^{-1} (19.55) M4, the number of flowers 6417.5, 5498.6 and 4620.3 was produced by large, medium, and small spathes respectively by M4. According to results M1 performed better on yield and yield contributing parameters of Gajar as compare to Aseel, hence it is recommended for future as a potential male. As per results, all male types were established diversely in morphometric and reproductive characteristics.

*Keywords***:** *Phoenix dactylifera* L; male types; pollen grains; pollination; fruit yield

Introduction

The fruit of Date palm *Phoenix dactylifera* L. is consumed widely (Asadi et al., 2018), because it is rich source of cheap food and energy for increasing populace, as well as promotes good health, thus improves food security Igiehon et al., 2020; Maqsood et al., 2020. Date palm is a dioecious plant, that can be cultivated up to height of 1500 m Bhatt & Thaker, 2019. It is an imperative to pollinate date palm by using pollen grains from potential male palm to get good quality fruit Ashour et al., 2008. Many studies have confirmed that, there are several morphological and genetical differences among male palms Iqbal et al., 2009. Male pollen grains differ in diameter and shape Daluz et al., 2013. It is also proved that the fruit set percentage is different in cultivars because male pollen grains affect directly on female flowers Iqbal et al., 2012; Omar et al., 2014a. The female flower acceptability differs among varieties due to sexual incompatibility or other genetical reasons, which prevent in flower set Abbas et al., 2012. Furthermore, pollen grains influence directly on quality and quantity of fruit, known as Metaxenia Usman et al., 2013; Hafez et al., 2014.

In the pollination process, pollen source has major effect on fruit yield Bacha et al., 2000. Different males vary in their pollen viability, germination percentage and genetic makeup, which ultimately affects on the retention of fruit after fertilization. Impact of pollen sources also reported on the production of Siwi (Ghaffar & Iqbal, 2003), Hallawy, Khadrawy, Hayyani (Muhtaseb & Ghnaim, 2006) and Dhakki dates (Shafique et al., 2011). Similarly, Al-Ghandi et al., 2002 reported that Sukkary males were distinguished from others by their morphological traits. A lot of studies also have been conducted on the yield parameters of female plants. One of them showed that pollination of Zaghloul date palms with pollens from the Meghal 2 recorded highest bunch weight (20.75 kg palm^{-1}), fruit weight (25.71 g), highest flesh weight (20.01 g) in comparison to other males Omar et al., 2014b.

None of the study has been conducted earlier on the effect of different male type pollens on female varieties in Sindh, Pakistan. Therefore, present study was carried out to characterize the male palms and their effect on fruit yield of date palm cultivars, cultivated commercially in Khairpur, Sindh.

Materials and Methods

There is no any recommended male variety of date palm in Sindh, hence the present study is conducted, so as male variety can be established. On the basis of varied morphological characteristics, five male plants were selected from different locations of district, Khairpur. These male plants were not identified earlier; therefore the names were assigned as per location/village; viz, Haji khan (Male 1), Gul Muhammad (Male 2), Ghulam Qadir (Male 3), Safdar (Male 4) & Jatoi (Male 5). All male characters, such as plant height (feet), trunk diameter (feet), frond length (feet), number of leaflets frond^{-1}, leaf size (inch), number of spines frond^{-1}, size of spines (inch), number of spathe plant^{-1}, spathe length (feet), spathe width (inch), weight of single spathe (kg), net weight of pollen powder spathe^{-1} (g), number of strands spathe^{-1}, size of male strand (inch), number of flowers spathe^{-1} were recorded. For further studies of their pollen effect, two female date palm varieties Gajar and Aseel having twenty years of age were selected at Date Palm Research Institute (DPRI), Shah Abdul Latif University Khairpur, during the year 2018 and 2019. The experiment was conducted in completely randomized design based on three replications. The investigations were carried out on four stages of fruit development (Kimri (early), Khalal (mid), Rutab (mature), and Tamar (flesh). Following data was recorded. Number of bunches plant^{-1}, weight of single bunch (kg), number of strands bunch^{-1}, number of fruits strand^{-1}, weight of single fruit (g), fruit length (cm), fruit diameter (cm), seed stone weight (g), seed stone length (cm), yield plant^{-1} (kg).

Statistical analysis

All traits were analyzed statistically with the application of Statistix version 8.1 (2006). To compare the treatment differences (LSD) was used at alpha 0.05.

Results and Discussions

Effect of male types on different fruit development stages

Results presented in (Table 1a) revealed that maximum 3.41 g and 2.54 g single fruit weight at early fruit development stage was observed in Gajar and Aseel varieties respectively with the application of M4. These findings indicated that early stage of fruit development associated with pollen vigour because due to pollen viability cell multiplication occurred properly and resultantly fruit weight increased in both varieties. These results are in harmony with the findings of Iqbal, 2007, who also reported that pollen affected cell number in the development of early fruit. In the mid fruit development stage, maximum 11.36 g and 7.61 g single fruit weight was observed in Gajar and Aseel varieties with the application of M4 and M5, respectively. These finding are generally in agreement with the study of Mansour, 2005, who recorded 23.80 g in Samany and 11.06g fruit weight in Bent-Aisha cultivars during mid-stage. The maximum 16.03 g single fruit weight was observed in Gajar and 13.15 g by Aseel with application of M4 at mature stage. However, maximum 10.50 g in Aseel and 10.03 g fruit weight was observed in Gajar at flesh stage with M1. Among fruit development stages varied performance of different males were observed due to their diverse sources and might be due to the physiological and metabolic conditions that favored fruit set. These results are supported by the findings of Helail and Hassan, 2001, which also found that pollen source has a significant effect on flesh weight of date fruits. Similar results were reported by Al-Ghamdi et al., 1988 that pollen grains play significant role in fruit pulp development.

Regarding the fruit length maximum 2.27 cm length was recorded with M5 in Gajar and 1.44 cm in Aseel with M4 at early stage. At mid stage, highest length 4.10 cm was recorded with M4 in Gajar and 3.60 cm with M5 in Aseel. The observance of variation in fruit length mainly due to genetic character and partially due to environmental factors they caused competition for food partitioning during early fruit development stages. According to previous studies even after successful pollination carpels not progress into full fruit (Djerbi, 2000). At mature stage, maximum 4.68 and 3.79 cm

Table. 1a. Date palm varieties as affected by male types at different fruit development stages

Female varieties	Male types	Fruit Weight (g) at different stages				Fruit Length (cm) at different stages				Fruit Diameter (cm) at different stages				Seed Stone Weight (g) at different stages			
		Early	Mid	Mature	Flesh	Early	Mid	Mature	Flesh	Early	Mid	Mature	Flesh	Early	Mid	Mature	Flesh
Gajjar	M 1	3.27B	10.54B	16.03A	10.03B	1.97D	4.03A	4.68A	4.35A	1.28E	1.74F	2.32A	1.99AB	0.56C	0.91C	1.74A	1.34A
	M 2	2.70D	7.96D	7.20H	6.35G	2.16B	3.24E	3.79D	3.41F	1.30D	2.03E	2.00C	1.73D	0.60B	0.88D	1.34E	1.37A
	M 3	2.70D	8.16C	9.85G	7.37E	2.06C	3.50D	3.72E	3.24H	1.34B	2.60A	1.84E	1.76D	0.47D	0.83F	1.32F	1.22B
	M4	3.41A	11.36A	13.98B	10.03B	2.26A	4.10A	4.27B	4.27B	1.38A	2.03E	2.14B	1.92C	0.60B	0.99B	1.43C	1.16C
	M 5	3.05C	7.86E	11.44F	7.19F	2.27A	3.69B	4.00C	3.97D	1.32C	1.80F	1.80F	1.94BC	0.65A	1.37A	1.66B	1.18BC
Aseel	M 1	2.29G	7.57G	12.17D	10.5A	1.37F	3.49D	3.79D	4.00C	1.33BC	2.15D	1.89D	1.99AB	0.35F	0.85E	1.37D	0.80D
	M 2	1.15H	3.49I	4.03J	1.49H	1.10I	2.23H	2.95G	2.57I	1.19G	2.03E	1.58G	1.28F	0.00G	0.00G	0.00I	0.00F
	M 3	1.06I	2.55J	4.13I	1.41I	1.26G	2.35G	2.83H	2.39J	1.27E	2.32C	1.52H	1.40E	0.00G	0.00G	0.00I	0.00F
	M4	2.54E	6.29H	13.15C	9.03C	1.44E	3.15F	3.56F	3.34G	1.21F	2.30C	1.80F	2.00A	0.38E	0.91C	0.85H	0.75DE
	M 5	2.37F	7.61F	11.58E	8.21D	1.19H	3.60C	3.73E	3.65E	1.33BC	2.50B	2.15B	2.03A	0.39E	0.87D	0.94G	0.70E
SE		0.03	8.56	0.02	0.02	0.02	0.03	7.96	7.96	8.43	0.04	7.95	0.02	7.69	6.72	7.50	0.02
LSD		0.06	0.01	0.05	0.05	0.05	0.08	0.01	0.01	0.01	0.09	0.01	0.06	0.01	0.01	0.01	0.05

The data represent mean values characterize the homogenous subsets analyzed in Duncan post hoc Test at significance level p = 0.05

Table. 1b. Date palm varieties as affected by male types at different fruit development stages

	Male types	Seed Stone length (cm) at different stages			
		Early	Mid	Mature	Flesh
Gajjar	M 1	1.74D	2.48A	3.03A	1.22H
	M 2	1.81A	2.03E	2.62D	2.47B
	M 3	1.78B	2.02E	2.71C	2.32D
	M4	1.76C	2.23C	2.34E	2.37C
	M 5	1.75CD	2.35B	2.96B	2.49A
Aseel	M 1	1.37E	1.97F	2.13F	1.88E
	M 2	0.00G	0.00H	0.00H	0.00I
	M 3	0.00G	0.00H	0.00H	0.00I
	M4	1.36E	1.81G	1.96G	1.72F
	M 5	1.08F	2.12D	1.97G	1.61G
SE		7.55	7.50	0.01	6.885
LSD		0.01	0.01	0.03	0.0145

single fruit length was observed in Gajar and Aseel respectively with the application of M1. Similarly by the application of same male, maximum 4.35 and 4.00 cm length was recorded in Gajar and Aseel respectively at flesh stage. These results confirm the findings of Shahid et al., 2017 they also reported that specific pollens had a significant effect on the fruit length.

In relation to fruit diameter the significant effect of M4 was observed in Gajar variety at early fruit developmental stage, the maximum 1.38cm fruit diameter was recorded with M4 in Gajar. However, 1.33 cm diameter was noted in Aseel with M5 and M1. At the mid fruit developmental stage, maximum 2.60 cm fruit diameter was recorded with M3 in Gajar and 2.50 cm in Aseel with M5. While at mature stage, the maximum 2.32 cm diameter was recorded with M1 in Gajar and 2.15 cmin Aseel with M5. At flesh stage, maximum 2.03 cm diameter was recorded with M5 in Aseel variety, however 1.99 cm diameter was noted in the Gajar with application of M1. The varied performance of male types in fruit stages showed the competency and receptivity of female flower as well as source variability and amount of pollen grains. Our studies also established the findings of Nesiem et al., 2016 they reported that male source has direct effect on date fruit quality characters and pollen viability from one cultivar to another. These results are confirmed with the findings of El-Merghany and El-Daen, 2014 they evaluated 3.13 cm of Sukkary and 1.69 cm fruit diameter of Balady cultivar.

In Dates minimum seed stone weight is considered quality character of fruit. In this study, minimum 0.35 seed stone weight at early stage was recorded in Aseel with the application of M1. While at mid stage 0.83 seed stone weight was observed in Gajar with application of M3. The minimum 0.85 seed stone weight was noted in Aseel at mature stage with application of M4. However at flesh stage minimum

0.70 seed stone weight was observed in Aseel with application of M5. The variation in seed stone weight in earlier and at the flesh stage of fruit might be due to pollen variation and female acceptability rate. Jalal and Ghnaim, 2006 reported that seed weight significantly affected due to different pollen sources. Parallel results also reported by Rahemi, 1998. In the case of seed stone length (Table 1b) data revealed that at the early stage, minimum1.74cm seed stone length was noted in Gajar with M1 and 1.08cm length was recorded in Aseel with M5. At mid stage, minimum length was recorded 2.02 cm with M3 in Gajar and 1.81 cm with M4 in Aseel. At mature stage, minimum 2.34 cm length was recorded with M4 in Gajar and 1.96 cm with same male in Aseel. At flesh stage, minimum 1.22 cm length was recorded with M1 in Gajar and 1.61cm with M5 in Aseel. These results are confirmed with the findings of Khaled et al., 2017 who reported that, tallest 5.0 cm fruits were gained from Masoud date palm trees when compared to Amhat and Zaghloul cultivars.

Yield Parameters

Findings of this study for yield contributing parameters revealed that, highest 15.21 number of bunches per plant was recorded by Gajar and fewer 11.77 were noted by Aseel (Table 4). The number of bunch is considered major yield contributing parameter. High and low number of bunch totally depends on the varietal character, age of the plant and management practices. But the weight of bunch directly link with healthy fruit and that depends on source of viable pollen and fertilization. In our studies, the maximum 9.12 kg weight bunch^{-1} was recorded with M5 in Gajar and 7.78 kg with M1 in Aseel (Table 3). Similar results were also recorded by El-Salhy et al., 2010 they reported that there was a positive correlation between fruit set percentage and bunch weight. Marzouk et al., 2002 also reported significant relationship between fruit set percentage and bunch weight. Results regarding the number of fruits strand^{-1} showed that maximum 15.99 fruits were observed in Gajar with M1 and minimum 8.88 with M3.

The maximum 39.62 kg yield plant^{-1} was recorded with M1 in Gajar and 37.35 with M1 in Aseel. Results indicated that the effect of M1 recorded more yield due to maximum fruit setting, fruit weight, size, and less fruit dropping. This variation may occur also due to pollen source, female–male compatibility, temperature, fertilization, irrigation, and soil characters (Salomon et al., 2017. These results are in agreement with the findings of Omaima et al., 2014 who reported

Table. 2. Morphological Characters of male types

Male types	Plant height (feet)	Frond length (feet)	Number of leaflets frond^{-1}	Number of spines frond^{-1}	Number of spathe plant^{-1}	Spathe length (feet)	Weight of single spathe (kg)	Number of strands spathe^{-1}
M 1	18.130B	10.290D	162.60B	23.210A	6.100E	2.3500A	1.6200C	165.10C
M 2	31.200A	11.150B	152.60D	20.250B	17.990B	2.7100A	2.2100A	173.23B
M 3	16.700C	9.420E	143.56E	14.210E	13.100C	3.8567A	0.8100E	147.50E
M 4	12.500D	11.290A	177.43A	14.730D	19.550A	3.0300A	1.8800B	192.00A
M 5	12.630D	10.450C	155.36C	19.140C	11.327D	2.1000A	1.0300D	164.20D
SE	0.0581	7.303	0.1531	8.944	8.028	1.0541	8.944	0.2239
LSD	0.1341	0.0168	0.3532	0.0206	0.0185	2.4308	0.0206	0.5163

Table. 3. Different parameters as affected by different male types

Female varieties	Male types	Weight of single bunch plant^{-1}	Number of fruits strand^{-1}	Yield plant^{-1} (kg)
Gajjar	M 1	8.5500B	15.990A	39.620A
	M 2	7.1000E	11.770G	30.300E
	M 3	7.0333F	13.210C	29.880F
	M4	7.4800D	15.330B	38.967B
	M 5	9.1200A	11.880F	38.810B
Aseel	M 1	7.7800C	11.770G	37.350C
	M 2	6.5000J	12.660D	21.540G
	M 3	6.6200H	8.880I	21.473G
	M4	6.9100G	12.210E	35.430D
	M 5	6.5600I	10.530H	35.230D
SE		0.0280	8.607	0.1351
LSD		0.0588	0.0181	0.2839

that fruit yield was affected by various pollen sources. Due to the significant effect of pollen source on fruit characteristics, various studies have been conducted to identify the suitable male Outghouliast et al., 2020.

Table. 4. Number of bunch plant^{-1}

Female varieties	Number of bunch plant^{-1}
Gajjar	15.210A
Aseel	11.770B
SE	0.0115
LSD	0.0497

Morphological Characters of male types

The recorded morphological traits of different male types were significantly different. The highest plant height 31.2 feet was recorded in M2 and lowest 12.50 in M4 (Table 2). The variation in plant height might be due to genetic character, an ideal location, availability of irrigation water and fertilizer due to intercropping. These results are in agreement with Keramat et al., 2007 who assessed average trunk height 10.32 meters. The maximum 11.29 inch frond length was recorded in M4 and minimum 9.42 in M3. The maximum 177.43 number of leaflets frond^{-1} was recorded in M4 and minimum 143.56 with M3. The maximum 23.21 number of spines frond^{-1}was recorded in M1 and minimum 14.21 in M3. The highest trunk diameter of lower plant portion was observed 6.03 by M2, middle 5.70 by M4 and upper 5.43 feet by M4. (Table 5). For collection of data regarding the leaf size, each frond was divided horizontally in three equal portions, such as lower, mid and upper. From the lower portion maximum 19.81 inch size of leaf was recorded in M3 while minimum 15.84 inch was recorded in M5. The maximum 24.13 inch size of leaf of middle portion was noted in M3 and minimum 16.00 inches was recorded in M1. The highest 17.33 inch size of leaf in the upper region was observed in M3 and lowest sized 8.98 inch was recorded in M5. The highest 4.99 inch size of spines frond^{-1} (lower region) was recorded in M4, While, lowest size of spines frond^{-1} 2.16 inch noted in M1.The maximum 5.83 inch size of spines frond^{-1} was recorded in M3 at middle portion, while lowest 3.72 inch size of spines frond^{-1} was recorded in M1. The highest 7.49 inch size of spines frond^{-1} was recorded in M2 while lowest 4.88 inch size of spines frond^{-1} was recorded in M3 at the upper part of frond. Our findings are in agreement with the results of Metwally et al., 2019 they reported the longest spine length of 17.24 cm.

Reproductive characters of male types

According to this study maximum 19.55 number of spathe plant^{-1} was recorded by M4 and minimum 6.10 spathe number was recorded by M1 (Table 2). The highest 3.85 feet spathe length was measured by M3 and lowest 2.10 feet with M5. The reason behind the difference in reproductive characteristics of male palm was noted due to varied origin (Al-Khalifah, 2006). These results are also

Table. 5. Morphological Characters of male types

Male types	Plant portion	Trunk Diameter (Feet)	Size of Leaf (Inch)	Size of Spine Frond^{-1} (Inch)	Spathe width (Inch)	Size of male strand spathe^{-1}
M1	Lower	5.6000D	16.920E	2.1600J	2.4400I	4.1100F
	Middle	4.6600I	16.000H	3.7200H	4.6700C	3.5700J
	Upper	4.3600K	14.800L	5.7000BC	3.5600F	2.9000K
M2	Lower	6.0300A	15.330J	2.4500I	2.8900H	9.6400A
	Middle	4.9400FG	16.150G	5.1000DE	5.3400A	7.4633B
	Upper	4.4600J	15.240K	7.4900A	3.8900E	5.0367C
M3	Lower	4.6300I	19.810B	4.6667F	2.5167I	3.6900I
	Middle	5.0000F	24.130A	5.8300B	4.2200D	5.0633C
	Upper	3.2100M	17.330D	4.8800EF	3.1100G	3.9000G
M4	Lower	5.8600B	16.400F	4.9900DE	2.8000H	4.6800D
	Middle	5.7000C	18.400C	4.2700G	5.0300B	3.6700I
	Upper	5.4300E	13.510M	5.1600D	3.6800F	3.7800H
M5	Lower	4.8667GH	15.840I	2.4400I	3.1100G	4.3500E
	Middle	4.8000H	16.880E	5.5600C	4.5600C	4.1800F
	Upper	4.1100L	8.987N	5.7200BC	2.7900H	4.3500E
SE		0.0402	0.0380	0.1217	0.0997	0.0364
LSD		0.0823	0.0779	0.2492	0.2043	0.0745

Table. 6. Reproductive characters of male types

Male types	Spathe category	Weight of pollen (powder) spathe^{-1} (g)	Number of flowers spathe^{-1}
M1	Large	4.6900E	2727.2H
	Medium	4.0300H	2840.2G
	Small	3.8200I	2547.1K
M2	Large	4.7100E	3025.0F
	Medium	4.3100FG	2712.4H
	Small	3.2400J	2630.8J
M3	Large	8.5400A	2676.4I
	Medium	5.5700D	2645.0J
	Small	4.1800GH	2676.6I
M4	Large	7.0000B	6417.5A
	Medium	6.1900C	5498.6B
	Small	5.6100D	4620.3D
M5	Large	4.4700F	4762.2C
	Medium	4.1200H	4608.3D
	Small	2.7100K	3815.1E
SE		0.0870	12.169
LSD 0.1783		24.927	

supported by Djerouni et al., 2015 who measured the length of Degla Bida male with (88.00 cm). The highest number 6417.5, 5498.6 and 4620.3 of flowers produced by large, medium, and small spathes respectively from M4.The maximum 2.21 kg weight of single spathe was recorded from M2 and lowest 0.81 kg in M3 (Table 2). The maximum 192.00 number of strands spathe^{-1} was recorded with M4, while minimum 147.5 number of strand spathe^{-1} was recorded by M3 (Table 2). Variation in strand number spathe^{-1} also reported by Hamady, 1982 they stated significant differences in the number of strand spathe^{-1} of each male palm. The highest 3.11, 5.34, 3.89 and lowest 2.44, 4.22, 2.79 inch spathe width of lower, middle, and upper region of spathe was recorded by M5,M2,M1, M3 and M5 respectively (Table 5). These results of our study are not congruent with the findings of Soliman et al., 2013, who reported highest (20.33, 18.67 cm) spathe width of Sallag and Menify male date palm respectively. The maximum size of male strand spathe^{-1} 9.64, 7.46, 5.03 and minimum 3.69, 3.57, 2.90 inch recorded by M2, M3 and M1 respectively with lower, mid and upper portion of spathe (Table 5). These results are in line with the findings of Al-Tahir and Asif, 1983, who reported that male palms differ significantly in the length of strands. The highest 8.54 g net weight of pollen powder from large spathe was collected from M3, however medium and small spathe of M4 recorded more 6.19 and 5.61 g, respectively. The lowest 4.47, 4.03 g and 2.71 g quantity of powder was collected from large, medium and small spathe of M5, M1 and M5 respectively. Generally, the diversity of male pollen in three fruit development stages was observed. It might be due to the genetic dissimilarity among the male palms, therefore every male responded differently according to genetic makeup.

Conclusion

In the light of above study, it is concluded that diversity in morphological and reproductive characters of male types was observed, because of genetical variation and due to the fact that males were originated by seed. Varied response of male types was observed into fruit characters and yield. According to this study M4 and M1 were proved very suitable for pollination in Gajar and Aseel varieties. These findings will be helpful to the researchers/Date palm growers in the selection of suitable male for pollination in future.

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