American-Eurasian J. Agric. & Environ. Sci., 7 (5): 535-541, 2010
ISSN 1818-6769

Improving Seed Germination and Seedling Growth of Some Mango Rootstocks

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Abstract: This experiment was conducted during 2007, 2008 and 2009 years at the nursery of Faculty of Agriculture, Cairo University, Egypt to study the effect of seed husking and soaking in GA_3 on germination and vegetative growth parameters of Zebda, Sukkary, Sabre and "13-1"polyembryonic mango rootstocks under nursery conditions. Germination percentage and number of seedlings per seed increased with seed husking and soaking in GA_3 at 100 or 200 ppm concentrations for 48 hours. The highest germination percentage and number of seedlings were recorded by Sabre rootstock meanwhile, the lowest was recorded by Sukkary rootstock. Seedling length, seedling diameter, number of leaves per seedling, leaf area and root length of the studied rootstocks were increased with seed husking and GA_3 treatments. The highest values of seedling length, diameter, leaf area and number of leaves per seedling were observed by Zebda and the lowest was by "13-1". Zebda, Sukkary and Sabre rootstocks recorded higher values of growth parameters than "13-1" rootstock. Husking mango seeds and soaking them in GA_3 prior to sowing improved germination and seedling growth.

Key words: Mango (*Mangifera indica* L.) · Rootstocks · Husking · GA_3 · Seed germination · Seedling growth

INTRODUCTION

Mango seeds are used in the production of rootstocks for grafting various desired cultivars. These rootstocks resulted from seeds, either monoembryonic or polyembryonic. Sabre and "13-1" are considered suitable for use as polyembryonic rootstocks and both of them produce uniform, vigorous seedlings with good compatibility with other cultivars. In mango growing areas, the selected polyembryonic and monoembryonic mango are grafted onto uniform, nucellar seedling rootstocks [1]. In Egypt, mostly mango seedlings of any type are available and used as rootstocks. However Sukkary and Zebda cvs became wide spread as trusted polyembryonic rootstocks [2]. Moreover, Wahdan [3] and Melouk [4] recommended using Sukkary mango as a salt tolerant rootstock in saline soils. Also, Hamed [5] recommended using Sukkary rootstocks for grafting Keitt and Sediek mango cultivars. So, improving mango seed germination and growth of the polyembryonic rootstocks help in promoting its growth. Germination percentage of mango seeds was improved by husking or removing the hard seed coat [2, 5, 6, 7]. Also, application of GA_3 to mango seeds at 100 or 200 ppm enhanced the growth and vigour of mango seedlings [8-10]. Improving seed germination and enhancing seedling growth of mango rootstocks are very important for producing healthy and good rootstocks in a short period as well as increasing the income of the mango nursery.

Therefore, this experiment was conducted to access the effect of seed husking and soaking in GA_3 on germination and seedling growth of Zebda, Sukkary, Sabre and "13-1" polyembryonic mango rootstocks.

MATERIALS AND METHODS

This investigation was conducted during the years 2007, 2008 and 2009 at the nursery and the laboratory of Pomology Department, Faculty of Agriculture, Cairo University at Giza Governorate, Egypt. Mango fruits of Zebda, Sukkary, Sabre and "13-1" cultivars were collected in August of both 2007 and 2008 seasons from trees planted in a private orchard located in Sharkeia Governorate, Egypt.

Freshly extracted seeds were cleaned with tap water then the healthy and normally weight seeds were selected. Seeds of each tested cultivar were received one of the following treatments:

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- Unhusked seeds (intact seeds) with soaking in tap water for 48 hr (control).
- Unhusked seeds with soaking in GA_3 at 100 ppm concentration for 48 hr.
- Unhusked seeds with soaking in GA_3 at 200 concentration ppm for 48 hr.
- Husked seeds (removing seed coat) with soaking in tap water for 48 hr.
- Husked seeds with soaking in GA_3 at 100 ppm concentration for 48 hr.
- Husked seeds with soaking in GA_3 at 200 ppm concentration for 48 hr.

The experiment was arranged in a randomized complete blocks design. Each treatment was comprised three replicates, each of 50 seeds. After that, seeds of each treatment were immediately sown in black polyethylene bags containing a mixture of clay and clean sand. Number of germinated seeds and total number of germinated seedlings per seed was counted after two months from sowing the seeds. The germination (%) was calculated by the following equation:

$$\text{Germination (\%)} = \frac{\text{Number of germinated seeds}}{\text{Total number of seeds}} \text{ X } 100$$

After eight months from seed germination (April 2008 and 2009 seasons), seedling length (cm), seedling diameter (cm), number of leaves per seedling, leaf area (cm^2) and root length (cm) were measured. The current study followed a randomized complete blocks design in factorial analysis, with three factors (A: rootstocks, B: husking and C: GA_3). The obtained data were tabulated and statistically analyzed according to Snedecor and Cochran [11] and mean values were compared by Duncan's multiple range test at 5% level of probability [12].

RESULTS

Germination Percentage: Effects of seed husking and soaking in GA_3 on germination percentage of Zebda, Sukkary, Sabre and "13-1" mango rootstocks are presented in Table 1. It is obvious that, husked seeds gave higher significant germination percentage than unhusked ones. Also, soaking both husked and unhusked seeds in GA_3 (at 100 or 200 ppm) significantly improved germination percentage as compared with the control. However, seed husking was more effective in improving germination percentage than GA_3 applications. Regardless of seed treatments, the germination percentage varied significantly between the studied rootstocks where the highest value was recorded with Sabre followed by Zebda and "13-1" rootstocks respectively. On the contrary, seeds of Sukkary rootstock recorded the least germination percentage. Regarding the interaction effect between rootstocks and seed treatments, the highest germination percentage resulted from soaking husked Zebda seeds in GA_3 at 200 ppm. Meanwhile, the lowest germination percentage resulted from unhusked Sukkary seeds without any of GA_3 treatments.

Number of Germinated Seedlings per Seed: Data presented in Table 2 showed that husked seeds produced a higher significant number of germinated seedlings than the unhusked ones. Soaking seeds in GA_3 at 200 ppm significantly increased number of germinated seedlings however, GA_3 at 100 ppm had no significant effect on this number of both husked and unhusked seeds. Regardless of seed treatments, Sabre rootstock produced the highest significant number of seedlings. On the other hand, there were no significant differences between the other three tested rootstocks regarding the number of germinated seedlings. Considering the interaction effect between rootstocks and seed treatments, the highest number of germinated seedlings per seed resulted from Sabre seeds which were husked and dipped in GA_3 at 200 ppm. On the contrary, the lowest number was resulted from unhusked seeds of both Sukkary and "13-1" without any of GA_3 treatments.

Seedling Length: Seedling length was significantly longer for husked seeds than the unhusked ones (Table, 3). Soaking in GA_3 produced longer seedling for both husked and unhusked seeds than soaking in tap water. Regardless of seed treatments, Zebda rootstock produced the longest seedling followed by Sabre and Sukkary rootstocks. Meanwhile, the shortest seedling was detected with "13-1" rootstock. Interaction indicated that seed husking and soaking them in GA_3 at 200 ppm produced the maximum seedling length for all the studied rootstocks and the highest values were observed with Zebda. On the other hand, the shortest seedling was resulted from unhusked seeds without application of GA_3 and the lowest value was detected with "13-1" rootstock.

Table 1: Germination percentage of some mango rootstocks after treatments with seed husking and soaking in GA_3 during 2007/2008 and 2008/2009 seasons

	Seed treatments (husking and soaking in GA_3)								
	Unhusked seed				Husked seed				
	GA_3 concentrations (ppm)				GA_3 concentrations (ppm)				
Cultivars (Rootstocks)	0	100	200	Mean	0	100	200	Mean	Average
	2007/2008 season								
Zebda	52.6m	64.6ij	72.0h	63.1E	85.3def	90.0bcd	94.0ab	89.7A	76.4B
Sukkary	46.6n	54.0lm	61.3jk	53.9G	72.0h	80.0fg	82.0fg	78.0C	65.9D
Sabre	54.0lm	69.3hi	78.0g	67.1D	88.0cde	93.3abc	97.3a	92.8A	79.9A
"13-1"	46.6n	56.0klm	61.3jk	54.9F	82.0fg	82.6fg	85.3def	83.3B	69.1C
Mean	*49.9F*	*61.0E*	*68.1D*	59.9B	*81.8C*	*86.4B*	*89.6A*	85.9A	
	2008/2009 season								
Zebda	53.3lm	65.3j	72.0ghi	63.5E	87.3c	92.0b	93.3b	90.8B	77.2B
Sukkary	48.0n	53.3lm	65.3j	55.5F	70.0hi	78.5ef	83.3cd	77.2C	66.4C
Sabre	56.0klm	68.6ij	76.0fg	66.8D	92.0b	96.0ab	98.0a	95.3A	81.1A
"13-1"	52.6m	57.3kl	60.0k	56.6F	74.0gh	80.0def	82.0de	78.6C	67.6C
Mean	*52.4F*	*61.1E*	*68.3D*	60.6B	*80.8C*	*86.6B*	*89.1A*	85.5A	

Values followed by the same letter (s) are not significantly different at 0.05 level of probability

Table 2: Number of germinated seedlings per seed of some mango rootstocks after treatments with seed husking and soaking in GA_3 during 2007/2008 and 2008/2009 seasons

	Seed treatments (husking and soaking in GA_3)								
	Unhusked seed				Husked seed				
	GA_3 concentrations (ppm)				GA_3 concentrations (ppm)				
Cultivars (Rootstocks)	0	100	200	Mean	0	100	200	Mean	Average
	2007/2008 season								
Zebda	1.3 ef	1.4 ef	1.6 ef	1.43 C	2.8 cd	3.0 bcd	3.1 bcd	2.96 B	2.20 B
Sukkary	1.2 ef	1.3 ef	1.2 f	1.23 C	2.7 d	2.8 cd	2.9 cd	2.80 B	2.01 B
Sabre	1.3 ef	1.4 ef	1.7 e	1.46 C	3.2 abc	3.4 ab	3.6 a	3.40 A	2.43 A
"13-1"	1.2 f	1.3 ef	1.3 ef	1.26 C	2.8 cd	3.0 bcd	3.0 bcd	2.93 B	2.10 B
Mean	*1.25 C*	*1.35 C*	*1.45 C*	1.35 B	*2.87 B*	*3.05 AB*	*3.15 A*	3.02 A	
	2008/2009 season								
Zebda	1.2 fg	1.4 efg	1.6 ef	1.40 CD	2.8 cd	2.9 bcd	3.2 abc	2.96 B	2.18 B
Sukkary	1.1 g	1.3 fg	1.4 efg	1.26 D	2.7 d	2.7 d	3.0 abcd	2.80 B	2.03 B
Sabre	1.4 efg	1.5 efg	1.8 e	1.56 C	3.0 abcd	3.3 ab	3.4 a	3.23 A	2.40 A
"13-1"	1.1 g	1.3 fg	1.5 efg	1.30 D	2.8 cd	2.8 cd	3.0 abcd	2.86 B	2.08 B
Mean	*1.20 D*	*1.37 D*	*1.57 C*	1.38 B	*2.82 B*	*2.92 B*	*3.15 A*	2.96 A	

Values followed by the same letter (s) are not significantly different at 0.05 level of probability

Table 3: Seedling length (cm) of some mango rootstocks after treatments with seed husking and soaking in GA_3 during 2007/2008 and 2008/2009 seasons

	Seed treatments (husking and soaking in GA_3)								
	Unhusked seeds				Husked seeds				
	GA_3 concentrations (ppm)				GA_3 concentrations (ppm)				
Cultivars (Rootstocks)	0	100	200	Mean	0	100	200	Mean	Average
	2007/2008 season								
Zebda	56.5 fg	60.4 de	64.2 c	60.3 C	65.2 c	70.3 ab	73.4 a	69.6 A	65.0 A
Sukkary	45.2 j	48.0 ij	53.2 gh	48.8 E	53.5 gh	58.2 ef	64.6 c	58.7 C	53.7 C
Sabre	49.0 i	51.3 hi	54.1 gh	51.4 D	62.4 cd	64.2 c	69.1 b	65.2 B	58.3 B
"13-1"	32.2 l	37.5 k	38.5 k	36.1 G	39.1 k	40.3 k	45.2 j	41.5 F	38.8 CD
Mean	*45.72 F*	*49.30 E*	*52.50 D*	49.1 B	*55.0 C*	*58.2 B*	*63.1 A*	58.7 A	
	2008/2009 season								
Zebda	48.6 ij	58.2 efg	63.1 bcde	56.6 C	64.2 bc	66.3 ab	70.4 a	66.96 A	61.8 A
Sukkary	46.3 j	47.3 ij	52.0 hi	48.5 D	58.6 defg	60.1 cdef	62.3 bcde	60.33 B	54.4 C
Sabre	47.3 ij	52.1 hi	54.3 gh	51.2 D	55.6 fgh	63.6 bcd	67.3 ab	62.16 B	56.7 B
"13-1"	34.1 l	36.4 kl	38.2 kl	36.2 F	39.7 k	40.8 k	40.2 k	40.23 E	38.2 D
Mean	*44.1 E*	*48.5 D*	*51.9 C*	48.1 B	*54.52 B*	*57.70 A*	*60.05 A*	57.42 A	

Values followed by the same letter (s) are not significantly differed at 0.05 level of probability

Table 4: Seedling diameter (cm) of some mango rootstocks after treatments with seed husking and soaking in GA_3 during 2007/2008 and 2008/2009 seasons

	Seed treatments (husking and soaking in GA_3)								
	Unhusked seed				Husked seed				
	GA_3 concentrations (ppm)				GA_3 concentrations (ppm)				
Cultivars (Rootstocks)	0	100	200	Mean	0	100	200	Mean	Average
	2007/2008 season								
Zebda	0.52 def	0.54 cd	0.64 ab	0.56 AB	0.55 cd	0.59 abc	0.66 a	0.60 A	0.58 A
Sukkary	0.54 cd	0.52 def	0.63 ab	0.56 AB	0.54 cd	0.58 bcd	0.65 ab	0.59 A	0.57 A
Sabre	0.45 fg	0.51 def	0.52 def	0.49 C	0.53 cde	0.54 cd	0.54 cd	0.53 B	0.51 B
"13-1"	0.41 g	0.43 g	0.45 efg	0.43 D	0.42 g	0.52 def	0.52 def	0.48 C	0.46 C
Mean	*0.48 B*	*0.50 B*	*0.56 A*	0.51 B	*0.51 B*	*0.56 A*	*0.59 A*	0.55 A	
	2008/2009 season								
Zebda	0.54 b-e	0.65 a	0.65 a	0.61 A	0.56 a-e	0.57 a-e	0.62 ab	0.58 AB	0.59 A
Sukkary	0.52 def	0.63 abc	0.64 ab	0.59 A	0.56 a-e	0.63 abc	0.64 ab	0.61 A	0.60 A
Sabre	0.50 ef	0.52 def	0.53 cde	0.51 CD	0.53 cde	0.53 cde	0.64 ab	0.56 ABC	0.54 B
"13-1"	0.42 f	0.51 ef	0.52 def	0.48 D	0.52 def	0.53 cde	0.54 b-e	0.53 BCD	0.50 B
Mean	*0.49 C*	*0.57 AB*	*0.58 AB*	0.55 A	*0.54 BC*	*0.56 AB*	*0.61 A*	0.56 A	

Values followed by the same letter (s) are not significantly different at 0.05 level of probability

Table 5: Number of leaves per seedling of some mango rootstocks after treatments with seed husking and soaking in GA_3 during 2007/2008 and 2008/2009 seasons

	Seed treatments (husking and soaking in GA_3)								
	Unhusked seed				Husked seed				
	GA_3 concentrations (ppm)				GA_3 concentrations (ppm)				
Cultivars (Rootstocks)	0	100	200	Mean	0	100	200	Mean	Average
	2007/2008 season								
Zebda	25.2 ghi	26.5 f-i	32.4 bcd	28.0 C	32.8 bc	40.2 a	44.5 a	39.1 A	33.6 A
Sukkary	23.1 hij	24.2 g-j	27.4 e-h	24.9 D	25.6 f-i	27.2 e-i	31.6 b-e	28.1 C	26.5 C
Sabre	26.4 f-i	28.2 c-g	28.1 d-g	27.5 CD	30.2 b-f	33.1 b	34.6 b	32.6 B	30.1 B
"13-1"	18.2 k	20.2 jk	22.7 ijk	20.4 E	23.4 hij	25.3 ghi	26.2 f-i	24.9 D	22.6 D
Mean	*23.2 D*	*24.7 D*	*27.6 C*	25.2 B	*28.0 C*	*31.4 B*	*34.2 A*	31.2 A	
	2008/2009 season								
Zebda	24.1 efg	25.3 d-g	27.5 c-f	25.6 CDE	31.3 bc	32.7 b	43.2 a	35.7 A	30.6 A
Sukkary	23.2 fgh	24.2 efg	26.3 def	24.5 DE	26.0 d-g	28.2 b-e	29.3 bcd	27.7 BC	26.1 C
Sabre	25.6 d-g	27.6 c-f	28.2 b-e	27.1 BCD	27.1 c-f	29.1 bcd	32.5 b	29.5 B	28.3 B
"13-1"	18.1 i	18.9 hi	21.4 ghi	19.4 F	23.7 efg	24.6 d-g	24.3 efg	24.2 E	21.8 D
Mean	*22.7 E*	*24.0 DE*	*25.8 CD*	24.2 B	*27.0 BC*	*28.6 B*	*32.3 A*	29.3 A	

Values followed by the same letter (s) are not significantly different at 0.05 level of probability

Table 6: Leaf area (cm^2) of some mango rootstocks after treatments with seed husking and soaking in GA_3 during 2007/2008 and 2008/2009 seasons

	Seed treatments (husking and soaking in GA_3)								
	Unhusked seed				Husked seed				
	GA_3 concentrations (ppm)				GA_3 concentrations (ppm)				
Cultivars (Rootstocks)	0	100	200	Mean	0	100	200	Mean	Average
	2007/2008 season								
Zebda	38.6 m	44.3 jk	46.0 jk	42.9 F	39.8 lm	48.0 ij	52.1 hi	46.6 E	44.8 D
Sukkary	70.7 e	83.7 c	89.2 b	81.2 B	79.2 d	94.3 a	96.2 a	89.9 A	85.5 A
Sabre	39.0 m	45.1 jk	46.6 jk	43.6 F	44.1 jk	57.4 fg	59.2 f	53.5 D	48.5 C
"13-1"	43.6 kl	54.5 gh	59.8 f	52.6 D	46.3 jk	60.3 f	67.2 e	57.9 C	49.6 C
Mean	*48.0 F*	*56.9 D*	*60.4 C*	55.1 B	*52.3 E*	*65.0 B*	*68.6 A*	61.9 A	55.2 B
	2008/2009 season								
Zebda	41.2 k	45.0 ijk	47.6 hij	44.6 G	41.9 k	49.2 ghi	54.0 fg	48.3 EF	46.4 D
Sukkary	73.1 c	81.6 b	86.2 b	80.3 B	82.2 b	92.3 a	95.1 a	89.8 A	85.1 A
Sabre	42.1 jk	46.8 ijk	49.5 ghi	46.1 FG	43.2 jk	56.2 ef	60.3 de	53.2 D	49.6 C
"13-1"	45.1 ijk	52.8 fgh	56.7 ef	51.5 DE	49.1 ghi	61.2 de	63.4 d	57.9 C	54.7 B
Mean	*50.3 E*	*56.5 D*	*60.0 C*	55.6 B	*54.1 D*	*64.7 B*	*68.2 A*	62.3 A	

Values followed by the same letter (s) are not significantly different at 0.05 level of probability

Table 7: Root length (cm) of some mango rootstocks after treatments with seed husking and soaking in GA_3 during 2007/2008 and 2008/2009 seasons

	Seed treatments (husking and soaking in GA_3)								
	Unhusked seed				Husked seed				
	GA_3 concentrations (ppm)				GA_3 concentrations (ppm)				
Cultivars (Rootstocks)	0	100	200	Mean	0	100	200	Mean	Average
	2007/2008 season								
Zebda	42.8 efg	43.2 ef	44.0 def	43.3 C	51.3 abc	52.3 ab	53.6 a	52.4 A	47.8 A
Sukkary	30.2 kl	35.4 ij	41.5 fgh	35.7 D	43.2 ef	44.0 def	47.2 cde	44.8 BC	40.2 B
Sabre	33.6 ijk	38.3 ghi	38.2 ghi	36.7 D	46.2 def	47.5 b-e	48.3 bcd	47.3 B	42.0 B
"13-1"	21.2 m	26.1 l	27.2 l	24.8 F	27.1 l	33.2 jk	37.0 hij	32.4 E	28.6 C
Mean	*31.9 D*	*35.7 C*	*37.7 C*	35.1 B	*41.9 B*	*44.2 AB*	*46.5 A*	44.2 A	
	2008/2009 season								
Zebda	35.5 i-l	42.4 fgh	43.9 c-g	40.6 C	48.2 a-d	49.3 ab	50.6 a	49.3 A	44.9 A
Sukkary	33.1 l	35.0 jkl	39.2 g-j	35.7 D	44.0 c-g	48.7 abc	45.0 b-f	45.9 B	40.8 B
Sabre	32.2 l	38.2 h-k	40.1 f-i	36.8 D	43.0 e-h	43.2 d-h	47.6 a-e	44.6 B	40.7 B
"13-1"	25.2 n	26.0 n	26.7 mn	25.9 F	31.6 lm	32.0 l	33.2 kl	32.2 E	29.0 C
Mean	*31.5 C*	*35.4 B*	*37.4 B*	34.7 B	*41.7 A*	*43.3 A*	*44.1 A*	43.0 A	

Values followed by the same letter (s) are not significantly different at 0.05 level of probability

Seedling Diameter: Data presented in Table 4 showed a higher seedling diameter with the husked seeds than unhusked ones but the differences were significant in the first season only. Soaking seeds in GA_3 at 200 ppm recorded higher values of seedling diameter than 100 ppm or the untreated seeds, this was noticed with both husked and unhusked seeds. Regardless of seed treatments, the seedling diameter varied between rootstocks where Zebda and Sukkary recorded the highest values while the lowest seedling diameter was found with "13-1" rootstock. Interaction effect between seed treatments and rootstocks showed that the highest seedling diameter was observed with seed husking and soaking in GA_3 at 200 ppm. On the other hand, the lowest seedling diameter was achieved with unhusked seeds without any of GA_3 treatments.

Number of Leaves per Seedling: Seed husking increased number of leaves per seedling significantly comparing with the unhusked ones (Table 5). Soaking seed in GA_3 at 100 or 200 ppm increased the number of leaves per seedling for husked and unhusked seeds. Regardless of seed treatments, Zebda seedling recorded the highest significant number followed by Sabre and Sukkary rootstocks. On the contrary, the lowest number of leaves was observed with "13-1" rootstock. Regarding the interaction effect between seed treatments and rootstocks, seed husking and soaking in GA_3 at 200 ppm increased this number and the highest values were recorded with Zebda rootstock. On the other hand, unhusked seeds without GA_3 treatments decreased this number and the lowest values were recorded with "13-1" rootstock.

Leaf Area: Seedling leaf area of all studied rootstocks was significantly higher with husked seed than unhusked ones (Table 6). Seed treatments with GA_3 at 100 or 200 ppm recorded a significant increase in leaf area for both husked and unhusked seeds. Regardless of seed treatments, leaf area varied significantly between the studied rootstocks where the highest values were recorded with Sukkary followed by "13-1" rootstock and Sabre. Meanwhile, the lowest leaf area was detected with Zebda rootstock. Interaction between seed treatments and rootstocks recorded the highest leaf area with soaking husked seeds of Sukkary in GA_3 at 200 ppm. On the other hand, the lowest leaf area was detected with unhusked seed of Zebda without any of GA_3 treatments.

Root Length: Table 7 showed that seed husking significantly increased root length of all studied rootstocks than unhusking. Soaking in GA_3 increased root length although the differences between the two concentrations 100 and 200 ppm of GA_3 were insignificant. Regardless of seed treatments Zebda rootstock produced the highest average of root length meanwhile, the lowest root length was observed with "13-1" rootstock. Sukkary and Sabre rootstocks produced intermediate values of root length and the differences between them were insignificant. With respect to the effect of interaction between seed treatments and rootstocks, husking Zebda seeds and soaking them in GA_3 at 200 ppm produced the longest roots. On the other side, the lowest root length was exhibited with unhusked seeds of "13-1" rootstock without any of GA_3 treatments.

DISCUSSION

Results of this study showed that, seed husking and soaking in GA_3 resulted in the highest germination percentage and number of germinated seedlings per seed for all studied polyembryonic rootstocks. The beneficial effect of seed husking towards germination characters could be explained to the barrier effect of hard seed coat on germination of embryos and due to its damage effect on embryos through release from the seeds. Thus, the preferable effect of husking mango seeds just before sowing might be attributed to the supply of oxygen and moisture to the embryos in order to help the seedlings to emerge. Such differences in seed germination of mango cultivars were previously found by Abd El-Zaher [2] and Hamed [5]. Also, the GA_3 application increased the percentage of seed emergence of Annona [13].

The results of the present study also revealed that, the germination percentage and average number of germinated seedlings/seed significantly differed according to the studied rootstocks. Sabre and Zebda rootstocks had the highest values, followed by "13-1" and Sukkary rootstocks. In this concern, Abd El-Zaher [2], Singh *et al.* [14] and Perez *et al.* [15] noticed that polyembryonic mango seeds varied in the number of nucellar seedlings originated from a single seed.

Seed husking and soaking in GA_3 before sowing resulted in seedlings attained the highest significant values of seedling length, diameter, number of leaves, leaf area and root length. Meanwhile, seedlings a raised from unhusked seeds without any GA_3 treatment exhibited the least significant values in all growth parameters. This may be related to enhancement of growth resulted from removing hard seed coat, which helped in increasing the growth parameters. Also, this improvement in seedling growth may be related to the role of GA_3 in inducing growth. Moreover, seed husking might accelerated the absorptions of GA_3 by embryos and this enhanced these embryos to produce better seedling growth than unhusked seeds. The favorable effect of such seed treatments on seedling growth was in agreement with the results of Abdel-Galil [7] who improved mango germination by seed husking. Also, Abd El-Zaher [2] recorded highest growth of mango rootstocks when their seeds were subjected to coat removal or cracking. Also, Venkata and Reddy [8] and Venkata *et al.* [10] reported that application of mango seeds with GA_3 at 100 or 200 ppm enhanced germination and growth of mango seedlings. Moreover andrade *et al.* [16] promoted germination and growth of papaya by application of GA_3 which produced higher emergency and seedling growth. The parameters of mango seedlings as influenced by the studied seed treatments were found to be differed by rootstocks under investigation. This variation between the studied rootstocks in their vegetative growth might due to growth habit of these rootstocks rather than seed treatments. In general, Zebda, Sukkary and Sabre seedlings had the highest values in studied parameters as compared with "13-1" mango rootstocks. In this concern, Srivastava *et al.* [17] showed that, growth potential of different mango rootstocks by observing various vegetative parameters helped in screening of rootstocks at nursery stage. In addition, Abd El-Zaher [2], Venkata and Reddy [9] and Perez *et al.* [15] recorded a variation in vegetative growth measurements of different mango rootstocks. Also, Venkata *et al.* [10] cleared that the application of mango seeds with GA_3 enhanced growth and vigor of mango seedlings. Moreover andrade *et al.* [16] promoted germination and seedling growth of papaya by application of GA_3.

It could be concluded that, seed husking of mango rootstocks and soaking them in GA_3 prior to sowing improved germination and accelerating seedling growth.

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