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Using the Grafting for Propagation of the Jackfruit and Producing the Rootstocks for the Grafting

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Abstract: Two field experiments were carried out on jackfruit plants (*Artocarpus heterophyllus* lam.) under Giza governorate conditions during 2004/2005 and 2005/2006 seasons and took some observations until 2007 year. The first one aimed to the seedlings production to use as a rootstock or an selected trees in the future for further evaluations, the seedlings produced by using either the intact seeds or the decoated seeds (without outer leathery coat) treated by some chemical treatments (GA_3 at 0.5 ppm for 12 hrs. or 10 ppm for 10 minutes and kinetin at 10 ppm for 6 hrs. or 100 ppm for 5 minutes); and some physical treatments (soaking in the tap water for 12 or 24 hrs, growing under the shade of mango, red cellophane sheets and the sunlight (control)), as an individual or mixed treatments. The second experiment aimed to the possibility of using the top-cleft and saddle grafting methods to benefit of the characters of the grafting in propagating the jackfruit, the apical growth of the current shoots of the old trees in Egypt that native to "kapa" jackfruit or the apical growth of the seedlings produced in this trial used as a sources of the scions, make the girdling under the graft union and covering the scion and the graft union with transparent or black polyethylene bags or without cover. Also, the histological study have done on the graft union region to detect the anatomical reasons of the compatibility or incompatibility between the scion and the rootstock and correlated with the morphological results. The results revealed that the differences between the seasons, in all cases were insignificant. Treatment of soaking in tap water for 12 hrs. + 10 ppm GA_3 for 10 minutes + 100 ppm kinetin for 7 minutes + shade of mango hasten the germination and gave the higher germination percentages in the general average (75.6%), in average of the intact seed (66.1%) and in average of the decoated seed (85.1%) compared to the control (25.1%), also, the seed germination % increased by increasing the time after the sowing date. On the other hand, the seedlings grown under the red cellophane sheets achieved the highest percentage of the seedlings with deeply lobed leaves (56.5%), the highest significant survival seedlings (61.7%) and the height (29.6 cm), but they recorded the least significant stem thickness (2.9 mm); the seedlings grown under the shade conditions recorded the highest significant number of leaves / seedling (5.7) and the leaf area (7.6 cm^2), while, the seedlings grown under the sunlight (control) had the highest significant stem thickness (4.9 mm). The seedlings age of 6 months had the higher significant height of the vegetative growth (23 cm) and the stem thickness (4.3 mm), but the seedlings age of 3 months had the highest significant survival seedlings (51.8%). It seems to be that the seed germination and the seedling's growth were significantly affected by the light conditions, where they enhanced and hastened under the shade of mango and the red cellophane sheets. Considering the grafting, data showed that the rootstocks at age of 9 months achieved the higher significant grafting success (37.5%), the time required for obtaining the maximum scion bud sprouting (35.8 day), number of the sprouted buds/scion (1.7), length of the new shoots (2.9 cm), number of the leaves/scion (4.6) and length of the scion (12.5 cm). The treatment of using the top-cleft grafting, the seedlings as a source of the scions, the girdling under the graft union region and the black polyethylene bags as a cover for the graft union area, recorded the higher significant success grafts (75%), number of the sprouted buds/scion (3.6), length of the new shoots (6.6 cm), number of the leaves/scion (8.2) and length of the scion (16.6 cm) and it gave the least significant time required for obtaining the maximum scion bud sprouting (22.5 day). The histological studies illustrated that the anatomical features were varied according to the grafting types and the compatibility between the scions and the rootstocks that correlated with the grafting success percentage. Also, the latex resinous materials secreted by the secratory canals of the scion and the rootstock, were acted as an adhesive materials "Cement" between the scion and the rootstock. It is recommended by staying the ties of grafting union region until beginning the growth of scion and thickened the rootstock's bark under the grafting union region. The transverse sections of the success top-cleft grafting were devoid of the collapsed cells, the necrotic layers and the separation zones on the whole grafting margins; forming an

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regular disposition condensed and uniformly callus tissue originated only from the xylem ray cells of both the scion and the rootstock at the opposite positions of the vessels of both the scion and the rootstock in the grafting union region, also, the new vascular elements initiated in this callus. Besides, scattered condensed callus groups initiated from the rootstock pith, so, the translocation between the scion and the rootstock of jackfruit top-cleft grafted seedlings can take place through both the callus bridges and the new vascular elements formed in the grafting union region and consequently the scion continued alive and had a good growth. The opposite anatomical features had shown in the transverse sections of the saddle grafting union region.

Key words: Jackfruit plants . *Artocarpus heterophylls* . grafting . rootstock . histology

INTRODUCTION

The jackfruit tree (*Artocarpus heterophylls* lam. 2n=56 (tetraploid)) belongs to the family moraceae; it is monoecious evergreen latex-producing tree, up to 20 m in height, with dark green entire leaves. The fruits are pear or barrel-shaped borne on a 5-10cm stalk, the thick skin has short protuberances, fleshy, golden yellow, edible perianth that surrounds the seed (the fruit have up to 500 seed) and the seed surrounded by a horny endocarp and sub gelatinous exocarp. Ripe kackfruits are divided into two types, based upon edible pulp. The first type (Barka) has small fruits, thin, fibrous, soft edible flesh, acid to very sweet with a strong aroma and broken open with the hands. The other type (kapa) has thick, firm to crisp flesh, high quality with less aroma and cut open with a knife. Fruits are eaten unripe and peeled at 25-50% of full size as a vegetable or ripe as a fruit.

The fruit is a good source of carbohydrates, vitamin A and a fair protein source [1]. The seeds boiled or roasted or preserved in syrup like chestnuts, canned in brine. Flesh of the unripe fruit has been canned, made into ice cream, jam, jelly and paste. Tender leaves and young flower clusters coocked or eaten by cattle. The latex serves as bird lime or household cement. Jack wood resembles mahogany and it is superior to take for furniture. The seeds and bulbs consider tonic and nutritious or overcoming the influence of alcohol; the roots is a remedy for skin diseases. The bark have 3.3% tannins made into cloth and cordage [2]. In Egypt, jackfruit tree could be cultivate on the roads beside an irrigation canals or irrigate them to profit by the previous uses, which return on Egypt by many benefits, whether in the local consumption field or in the exportation field, as in Egypt, the main crop of the jackfruit (it carry fruits during the year), ripen on May-to-July, as it could be getting an easiness early market, which extend during an ordinary fruit market period. To spread the jackfruit's plantation in Egypt, it must be produce an sufficient number of plants by using a successful propagation methods producing a large number of a good plants under conditions of Egypt (Egypt have a few trees as a source of propagation's materials), where a lack of propagation's materials are found. So, we must be use a seed (one fruit contains 100-500 seeds), to produce the seedlings or the rootstocks for grafting a good exported cultivars or grafting a good scions of the mother plants having a good characters; or use the tissue cultures as a pronounced technique producing a numerous number of the diseases free plants. The two previous propagation methods suited for Egypt conditions, because the other propagation methods have many troubles as follows: concerning the cuttings, Kamaluddin *et al*. [3] decided that leafy tip cuttings of jackfruit seedlings were rooted by treating them with 0.8% IBA solution. Also, Rahman and Blacke [4] mentioned that rooting success of the jackfruit's cuttings depend on ringing the shoots used for preparing the cuttings and/or etiolating for 20 days before the detachment of the cuttings and dipping the cuttings for 2 minutes in a solution of IBA at 750 ppm. before insertion in a 1:1 compost : vermiculite mixture. Also, the jackfruit tree could be bearing fruits twice yearly [5] and hence give an economic crop.

From the previous opinions, the propagation by the cuttings face many difficulties, beside that the plant produce by the cutting have surface adventitious weak roots, which are not suite to the nature of the jackfruit tree as Jamaludheen *et al*. [6] said that most of the physiologically active roots of the jackfruit tree were concentrated within a radius of 30-75 cm depth. Also, the preparation of the cuttings needs more plant materials which are not available in Egypt.

On the other hand, the propagation by layering (mound or air layering) have more difficulties, such as the higher survival and regeneration of roots in layering of jackfruit producing by treatment of IBA+NAA at 5000 ppm [7]. Also, the best root growth, development and survival rate was observed in air layers of jackfruit following etiolation of stems and treatment with IBA at 5000 ppm [8]; while Alila *et al*. [9] reported that treatment of IBA at 4500 ppm, ringing the bark and covering the medium-sized stools or shoots by the soil for one month are necessary for obtaining the best results in the mound layering of jackfruit. In the same trend, Mahabir *et al*. [10] decided that treatment of IBA + NAA at 12000-16000 ppm are need to obtain the successful air layers of jackfruit. From the previous concerning the layering, it could be noticed that the layering need more efforts beside they are difficult procedures, take more time, few produced plants and hinder the horticultural procedures. On the other side, the tissue culture technique could be used in jackfruit for propagation, specially for producing the large number of the plants or in a special purposes (genetic engineering, …); also, the facilities of this technique must be found by Roy *et al*. [11].

Finally, the grafting methods are suggesting as a pronounced traditional method for propagating the jackfruit (maintain a good characters, easy and cheap procedure, produce a free diseases plant, speed fruiting, it needs a few plant materials and less treatments than the other methods) such as in many cultivation areas, the seed is the major mean of propagation and could be serve in the rootstocks production.

As for the anatomical study, there are not any report talked about the anatomical structure in the grafting union of the jackfruit but we try to review or survey some opinions in the near tropical fruit trees species which put the light on some facts help in this study.

Retaining all or some of the leaves on the rootstock at grafting patch bud of jackfruit and keeping plants in a greenhouse, in open sunlight or in partial or complete shade after grafting had no effect on bud break or survival. Also, tying with single polyethylene strips was recommended [12].

The newly formed cambial layer in the callus bridge begins typical cambial activity, laying down new secondary xylem to word the inside and phloem toward the outside, thus permits the vascular connection between the scion and the rootstock. This process be completed before much new leaf development arises from buds on the scion [13]. Soule [14] described four stages in formation of mango bud union as follows: Pre-callus, where 4 days after budding only a wound periderm was present; callus, where 8 days after budding proliferation from tissues mainly near the cambium resulted in firm attachment of the components; cambial bridge, where 12 days after budding cambial layers from stock and scion formed a bridge and vascular tissues were differentiated within 36-48 days and the healed union, where after 6-8 months several cylinders of new tissues were present and the lateral shift of the scion to align with the stock had begun.

This investigation was undertaken to obtain the jackfruit's seedlings by the optimum available procedures under Egypt conditions. These seedlings can be use as rootstocks or as cultivated fruit trees. The second aim is using easy practical types of the grafting as new vegetative propagation method of the jackfruit, characterized by highly success percentages in the most plant species, to obtain abundant grafted seedlings having a good and different characters in parallel with morphological and anatomical studies of the compatibility between the scion and the rootstock seedlings.

MATERIALS AND METHODS

These studies were carried out in two successive seasons (2004-2005 and 2005-2006) in a special farm at Kerdasa village-Giza governorate. Jackfruit's seedlings were used as rootstocks or as individual trees for further evaluations and estimations in the future, while the individual tree at El-Zohereia botanical garden (Cairo) and other individual trees at the plants garden (Aswan) were used as a selected scions, where these scions produced from either the seedlings or the trees believe that they native or belong to the second type (Kapa). Also, the apical growth of the rootstocks seedlings were used as the scions for permit with further anatomical studies to distinguish many types of the anatomical features which indicate or explain the compatibility or incompatibility and their types in the grafting union region of jackfruit. The trials are made as follows:

The seedlings production: At the first season (2004-2005) on July-August of 2004, the fruits of the individual trees in El-Zohereia garden and plants garden in "Aswan", were fresh collected, selected to be free of diseases and heavy weight, cut open with a knife and extract the seeds according to the following two classes:

- Seeds which the outer thin leathery seed coat have removed and
- Seeds have the outer thin leathery seed coat. Each class were treated by the following treatments:

The physical treatments

Soaking in the tap water for 12 hr. and cultivate under the direct sunlight.
Soaking in the tap water for 24 hr. and cultivate under the direct sunlight.
Cultivating under shade of the mango trees.
Cultivating under red cellophane sheets.

The chemical treatments

- Treatment with GA_3 at 0.5 ppm. for 12 hr. and cultivate under the direct sunlight.
- Treatment with GA_3 at 10 ppm. for 10 minutes and cultivate under the direct sunlight.
- Treatment with kinetin at 100 ppm. for 5 minutes and cultivate under the direct sunlight.
- Treatment with kinetin at 10 ppm. for 6 hrs. and cultivate under the direct sunlight.

The mixed treatments

- Treatment with mix of GA_3 at 10 ppm.+ kin. at 100 ppm. for 7 minutes.
- Treatment with soaking in the tap water for 12 hr. and cultivating under the shade conditions of the mango trees.
- Treatment with soaking in the tap water for 12 hr. and cultivating under red cellophane sheets.
- Treatment with soaking in the tap water for 12 hr, then treatment with mix of GA_3 at 10 ppm. + kin. at 100 ppm. for 7 min. and cultivating under the shade conditions of the mango trees.

Cultivating under the direct sunlight (control)

Two seeds from each class and each treatment were directly cultivated in a perforated black polyethylene bag (25x50 cm) filled with disinfected mixture of soft clay, peatmoss and sand (1:1:2 v:v:v), vitafax capitan solution (1 g/L.) used as a disinfectant. Each treatment of each class = 3 replicates and the replicate = 5 pots (black polyethylene bag) and left for 6 months under the previous conditions mentioned in the treatments (exposed to the 3 physical treatments "sunlight, shade of mango and red cellophane sheets"), as they were distributed into a three groups with equal numbers. The cultivated pots (seedlings or a grafted seedlings) were distributed in a randomized complete block design, also the seedlings resulted of two cultivated seed's germination were separated into individual pots and received the same horticultural procedures (regular irrigation for individual pot every 3 day up-to the germination and adjust the irrigation to irrigating every week between September-October, then irrigate at one week intervals between November-1st February and irrigate at 3 day intervals between February-August. At 4 month age of seedlings, every seedling received 3g NH_4 NO_3 at fortnightly intervals between January-August; and diseases controlling by sulphur, copper oxychloro and mineral oils. Three weeks after sowing date and at two week-intervals during 1.5 month, the seed germination percentage have taken.

Three and six months after germination (at seedling's age of 3 months at Feb. and 6 months at May), height of the vegetative growth (cm), thickness of the stem (mm), survival percentage of the seedlings, percentage of the seedlings characterized by blade have many parts (partioned leaves or deeply lobed leaves), leaf number/seedling and leaf area (cm^2) (as average of seedlings from each class and each treatment), have estimated and then the grafting test started. A large amount of seeds have germinated by soaking in a tap water for 12 hrs. for complete the sufficient number for the grafting test beside the seedlings produced of the germination treatments.

The grafting test: It has been done under the shade conditions of the mango trees. The apical growth (8-10 cm which have about 3-4 nodes) of the seedlings and the apical growth of twigs from individual old trees were used as the scions, while the homogenous seedlings at different ages were used as the rootstocks. The grafting procedures have been done on the rootstocks at age of 6-9 months and the following design were applied as illustrate in diagram (A). Also, the grafting union region was completely tied with a single transparent polyethylene tapes and the grafted seedlings were subjected to the usual procedures as mentioned before (irrigation, fertilization, suckering, etc.). After 3-4 weeks from the scion sprouting, the covering bag was removed. After 1.5 months (until the scions stopped or finished their sprouting) of the grafting, data have taken as averages of a number of the sprouted scions and calculated as survival or successful grafts percentages, the time (day) required for maximum sprouting of the scion, length (cm) of the new shoots (sprouts) on the scion, number of the sprouted buds per scion, leaf area (cm^2), leaves number per scion and length (cm) of the scion. Each treatment has three replicates and each replicate has two grafted rootstocks. The grafted rootstocks were distributed in a randomized complete block design and subjected to a variant treatments.

Histological study: After two months of the grafting date, as the final results of the successful grafts have taken, samples of the grafting union region-for each grafting method-which containing approximately 2 cm of the scion and 2 cm of the stock were took, killed and fixed in 70% FAA (formalin + acetic acid + 95% ethyl alcohol at ratio of 5:5:90, v/v/v), stored in 70% ethyl alcohol, softened a minimum of 2 weeks in glycerol-alcohol solution (glycerol + 50% ethyl alcohol at ratio of 1:1).

Transverse sections were taken at the grafting union region at 25 and 50μ using a hand-fed sliding

Methods:

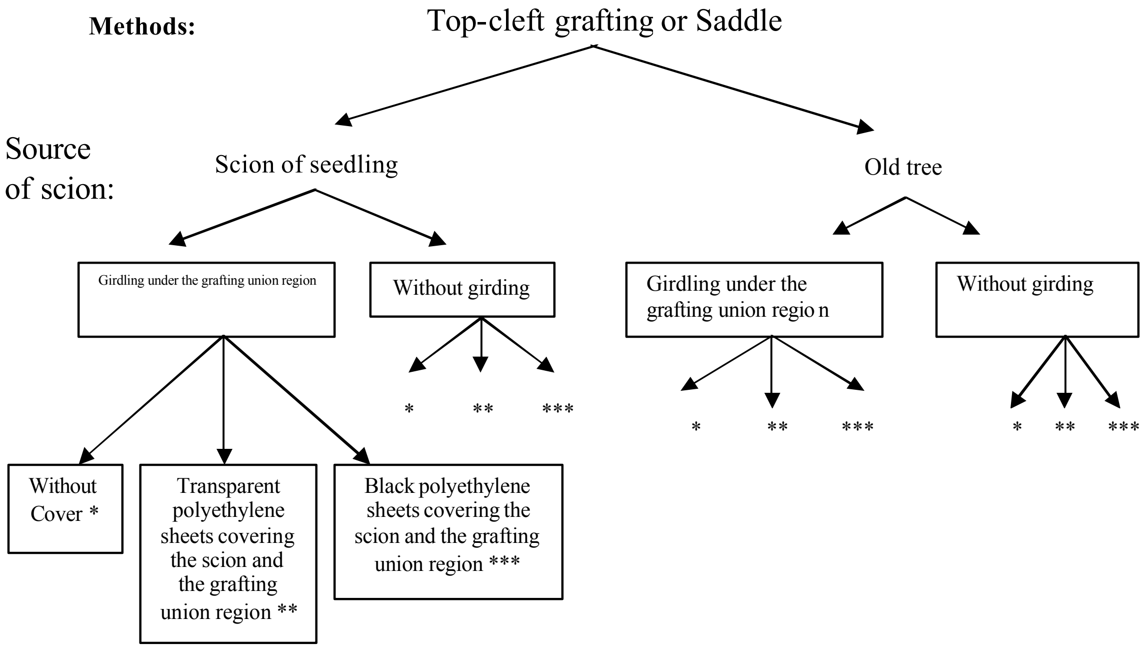

Diagram (A)

microtome. The most clearness samples, double stained with safranine-fast green, mounted in Canada Balsam [15, 16] microscopically examined and photographed on Kodak-colour film, investigation and discuss the histological reasons of the compatibility or incompatibility in the grafts.

Statistical analysis: The obtained data were statistically analyzed according to Least Significant Difference (L.S.D.) to compare between means as described by Snedecor and Cochran [17].

RESULTS AND DISCUSSIONS

Observations: On the winter of the studied growing seasons, many of the grafted plants started to become yellow, then their leaves tumbled and the scion's dieback happened, while, the rootstocks of the grafted plants stayed a life and had regeneration ability to regrow and produce a new vegetative growth, in spite of the scion's death. On the other hand, the rootstock's seedlings seems to be more tolerance to the winter weather than the grafted plants, even though, the yellowness and dry of some leaves.

These phenomena may be due to the insufficient fusion between the rootstocks and the scions, as shown in the histological studies, which lead to a weak movement of the nutrients and the water from the rootstocks to the scions during the growing seasons, hence weaken the scion's growth. Besides, during the winter the absorption of the water and the nutrients was very little and the movement of these needs between the rootstocks and the scions was very weakness or stopped, consequently the scions injured and died. Also, many of the seedlings and the grafted plants infected with Egyptian powdery bugs, but without any significant effects on their growth. The seedlings and the grafted "jackfruit" plants seems to be more tolerate to the dry than the flood, besides, they grow well under the shade of mango and the grape on the spring and the summer, as they seems to be burn under the direct sun rays. This good grow under the shade may be due to that the shade stimulate the buds and the branching of jackfruit, where this plant haven't tolerance against either the direct sun rays or the cold. The seedlings with the portioned leaves seems to be more infected with the rust's diseases, due to their thin soft weak skin with less hairs, as this traits lead to less tolerance against the diseases, but these seedlings were more speed growth and branching than the normal seedlings. Besides, either the seedlings or the grafted plants suffered by the dieback which may reach to the death or many regeneration cycles. This dieback caused by unsuitable climate or the powdery mildew that may be infected the jackfruit plants by the grapevines carried and infected with this disease.

The grafted seedlings and the rootstocks are seems to be greatly influenced by the winter conditions of "Giza", where the current shoot tips and even all of the green shoots have injured by the winter, specially at the temperature below 10^{o}C; the new shoot tips were firstly burned and dried, then the others parts of the shoots burned and dried, followed by the vegetative growth died and subsequently, the scions died or the upper

Table 1: Effect of the physical and chemical treatments, type of the seed, time from the sowing date and the seasons on the germinated seed percentages of jackfruit on 2004/2005 (S_1) and 2005/2006 (S_2) seasons

Type of the seed	Intact seed									Seed without outer thin leathery coat									
Time from the sowing date (week)	3		5		7		9			3		5		7		9			General
Treatments* Seasons	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	Avs.	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	Avs.	Avs.
1-Soak in tap water for 12 hrs. + sunlight	33	37	37	37	40	43	43	47	39.6	40	43	47	50	53	57	57	60	50.9	45.2
2-Soaking in tap water for 24 hrs. + Sun light	30	33	40	43	47	47	47	50	42.1	43	47	50	53	60	57	63	67	55	48.5
3-Shade of mango	13	13	20	23	33	37	33	37	26.1	20	23	27	23	33	33	40	43	30.2	28.1
4-Red cellophane sheets	30	33	37	40	40	43	47	50	40..0	40	43	47	50	53	50	53	57	49.1	44.5
5-GA_3 at 0.5 ppm. for 12 hrs. + Sun light	13	17	23	23	30	33	33	37	26.1	27	23	40	43	40	47	47	50	39.6	32.8
6-GA_3 at 10 ppm. for 10 min. + Sun light	10	10	17	20	23	23	27	30	20	20	23	40	43	40	43	40	43	36.5	28.2
7-Kinetin at 100 ppm. for 5 min. + sun light	20	17	27	30	33	37	33	37	29.2	30	33	43	47	50	53	50	53	44.9	37.1
8-Kinetin at 10 ppm for 6 hrs. + sun light	27	30	37	33	47	47	47	50	39.7	40	43	53	53	57	60	63	67	54.5	47.1
9-GA_3 at 10 ppm and kinetin at 100 ppm for 7 min.	23	27	30	33	37	37	43	47	34.6	37	40	40	40	53	53	60	63	48.2	41.4
10-Soaking in tap water for 12 hrs. + shade of mango	17	20	23	27	27	30	27	30	25.1	30	33	33	37	40	40	43	47	37.9	31.5
11-Soaking in tap water for 12 hrs. + red cellophane sheets	47	50	67	70	70	73	70	73	65	67	70	77	80	77	80	77	80	76	70.5
12-Soaking in tap water for 12 hrs. + GA_3 at 10 ppm and kinetin at 100 ppm for 7 min. + shade of mango	53	57	60	63	73	73	73	77	66.1	73	77	87	90	87	90	87	90	85.1	75.6
13-Control (sunlight)	10	10	20	23	23	23	30	33	21.5	17	17	30	33	30	33	33	37	28.7	25.1
Avs.	25.1	27.2	33.7	35.8	40.2	42	42.5	46	36.6	37.2	39.6	47.2	49.4	51.8	53.5	54.8	58.2	49	42.8
General Avs.	26.1		34.7		41.1		44.2		-	38.4		48.3		52.6		56.5		-	-
LSD (0.05)																			
Treatments (Trs.)	17.315	17.916	19.016	20.962	22.671	23.153	19.516	16.966	18.019	18.319	19.263	18.751	18.512	19.668	18.617	16.951	17.130	18.933	19.809
Type of seeds (Ts.)										5.469									
Seasons (S.)	3.958		4.512		3.694		4.295		-	3.770		3.859		4.086		5.398		-	-
Time from sowing date (Tfsd.)					13.990									16.349					
Trs. × Tfsd.×S.					22.458									20.903					
Trs. × Tfsd. ×S. × Ts.										22.893									

*The physical trs. are 1-4 trs., the chemical trs. are 5-8 trs. and the mixed trs. are 9-12 trs

Table 2: Effect of the light treatments, seedling's age (month) and the seasons on percentage of the seedlings characterized by deeply lobed leaves, leaf number/seedlings and leaf area (cm^2) of jackfruit during 2004/2005 (S_1) and 2005/2006 (S_2) seasons

		Traits								
Age of the seedlings (month) (AS.)		Seedlings with deeply lobed leaves % (A) *		Number of the leaves / seedling (B)		Leaf area (cm^2) (C)		General Avs.		
Treatments (Trs.)	Seasons (S.)	3	6	3	6	3	6	A	B	C
Shade of mango	S_1	40	40	4.8	6.3	6.3	9.5	36.5	5.7	7.6
	S_2	33	33	5.2	6.5	6.0	8.7			
Red cellophane sheets	S_1	60	60	3.2	5.6	5.6	8.3	56.5	4.5	7.0
	S_2	53	53	3.5	5.9	5.4	8.8			
Control (sunlight)	S_1	13	13	3.3	4.2	5.2	8.4	10.0	3.9	6.7
	S_2	7	7	3.6	4.5	4.9	8.5			
AVS.	S_1	37.70	37.70	3.8	5.4	5.7	8.7	-	-	-
	S_2	31.00	31.00	4.10	5.6	5.4	8.7			
General Avs.		34.30	34.30	4.00	5.50	5.50	8.70	34.30	4.7	7.1
LSD (0.05)	Trs.×S. or Trs.**	24.110	24.110	1.395	1.079	0.802	0.985	21.390**	1.027**	0.836**
	As.	0.001		1.292		2.332			-	
	S.	8.188	8.188	0.501	0.403	0.539	0.001		-	
	Trs. ×As.×s.	24.292		1.153		0.837			-	

*This phenomenon was also observed in the new growth of the normal seedlings damaged their apical growth by the cold of winter

vegetative growth of both the grafted seedlings and the rootstock were died. At the following summer, the basal buds began to growth formed a new shoots that died on the winter. These injuries caused the failure of jack's cultivation under "Giza" conditions, so, it is recommended by the covered cultivation in the winter for 2 years at least. The most dead seedlings during the two years after the grafting, were the saddle grafted seedlings. This may be due to some incompatibility that illustrated in the incomplete anatomical union between the scions and the rootstocks.

The seedlings production: Data represented in Table 1 revealed that the percentages of jackfruit seed germination were significantly affected by the treatments, type of the seed and the time from the sowing date, while the differences between the seasons in all cases were insignificant. Concerning the treatments, treatment of soaking in tap water for 12 hrs. + 10 ppm. GA_3 for 10 minutes + 100 ppm. kinetin for 7 minutes + shade of mango gave the higher germination %, in general (75.6%), for the intact seed (66.1%) and for the seed without outer thin leathery coat (85.1%) and hasten the germination, followed by and without significant difference the treatment of soaking in tap water for 12 hrs. + red cellophane sheets (70.5, 65 and 76% for the general average, intact seed and decoated seed, respectively). The control (sunlight) treatment gave the lowest values (25.1%, 21.5 and 28.7% for the general average, intact seed and decoated seed, respectively) compared to the other treatments. The difference between the intact seed germination (36.6%) and decoated seed (49%) was significant.

Table 3: Effect of the light treatments, seedling's age and the seasons on the survival seedlings percentage, height of the vegetative growth (cm) and the stem thickness (mm) of jackfruit during 2004/2005 (S_1) and 2005/2006 (S_2) seasons

		Traits								
Age of the seedlings (month) (AS.)		Survival seedlings % (A) *		Height of the vegetative growth (cm) (B)		Stem thickness (mm) (C)		General Avs.		
Treatments (Trs.)	Seasons (S.)	3	6	3	6	3	6	A	B	C
Shade of mango	S_1	47	40	18.9	20.5	2.9	3.9	45	20	3.4
	S_2	50	43	19.3	21.3	2.8	4.2			
Red cellophane sheets	S_1	67	57	26.5	30.6	2.1	3.5	61.7	29.6	2.9
	S_2	70	53	29.8	31.7	2.3	3.7			
Control (sunlight)	S_1	37	30	14.2	16.7	4.6	5.3	35	15.5	4.9
	S_2	40	33	13.8	17.2	4.2	5.4			
AVS.	S_1	50.3	42.3	19.9	22.6	3.2	4.2	-	-	-
	S_2	53.3	43.0	21.0	23.4	3.1	4.4			
General Avs.		51.8	42.60	20.40	23.00	3.10	4.30	47.20	21.70	3.70
LSD (0.05)	Trs.×S. or Trs. **	17.618	12.362	4.932	3.991	1.898	1.005	8.390**	8.887**	0.953**
	As.	7.579		2.092		1.059			-	
	S.	4.395	3.055	2.390	1.803	0.303	0.563		-	
	Trs. ×As.× s.	15.635		4.332		1.579			-	

Fig. 1: A photograph of *Artocarpus heterophyllus* lam. showing to the left a seedling with normal leaves and to the right a seedling with a deeply lobed leaves (3 month old)

Concerning the time from the sowing date, the seed germination % increased by increasing the time from the sowing date, where time of 9 weeks resulted in the highest significant values (44.2% for intact seed and 56.5% for decoated seed), followed by the time of 7 weeks, 5 weeks and 3 weeks.

The interactions effect of the treatments, time from the sowing date and season or that of the treatments, time from the sowing date, season and type of the seed, confirmed the above results and took the same trends. It could be recommended with using the treatment of soaking in tap water for 12 hrs. + 10 ppm GA_3 + 100 ppm. kinetin + shade for the decoated seed of jackfruit and take the results after 9 weeks for obtaining the highest seed germination in jackfruit.

It seems to be the jackfruit seeds are sensitive seed to the light, where their germination highly significant affected by the studied light conditions. Also, the intact seeds did not responsed to the treatments and it seems to be the outer leathery coat prevent or decrease the effect of the treatments and act as a non-permeable coat and hence decrease the germination.

Data of Table 2 and Fig. 1 showed that the differences between the seasons were insignificant in all studied traits. The seedling's age of 6 months were significantly superior to those of 3 months in all studied traits. Also, the seedlings grown under the sunlight (control) gave the worest significant results, while the seedlings grown under red cellophane sheets gave the highest percentage of the seedlings with deeply lobed leaves (56.5), but it notice in this trait that this trait seems to be a genetically trait as it did not affected by the age of seedlings and the degree of its appearance increase when the seedlings grown under the red cellophane sheets (light effect) and decrease under the sunlight. On the other hand, the seedlings grown under the shade conditions achieved the highest significant

Fig. 2: A photograph of *Artocarpus heterophyllus* lam. showing to the left a top-cleft grafted seedling and to the right a saddle grafted seedling at age of six months

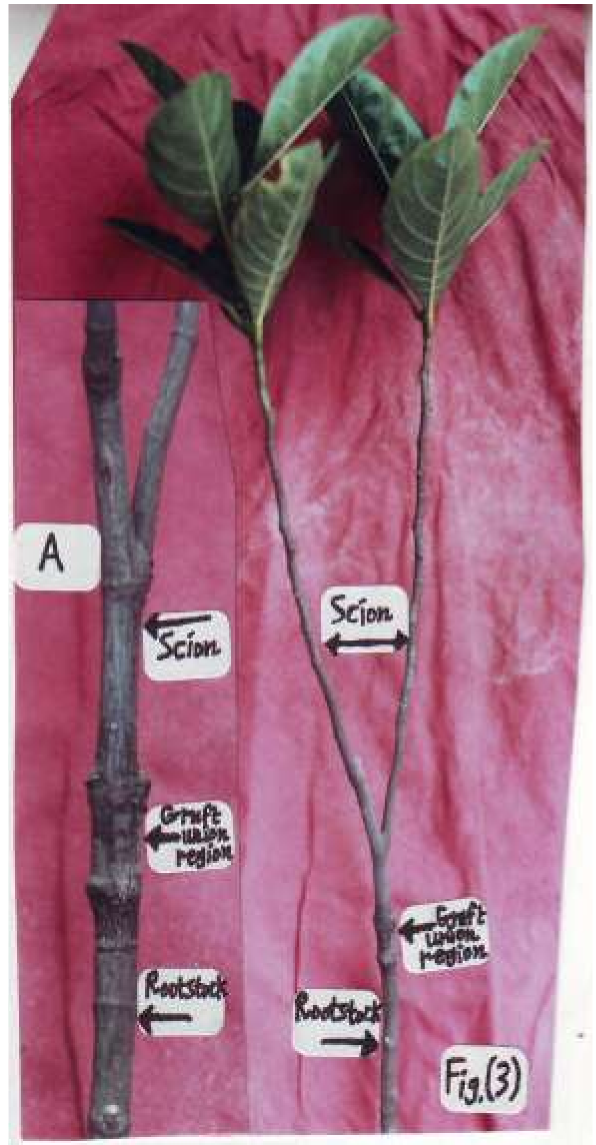

Fig. 3: A photograph of *Artocarpus heterophyllus* lam. showing the success growth of the top-cleft grafted seedling at nine months old and a magnified top-cleft graft region (A)

number of leaves per seedling (5.7) and the leaf area (7.6 cm^2). The effect of the studied interactions go in the same previous trends.

Data of Table 3 indicated that the differences between the seasons were insignificant in all studied traits. The seedling's age of 6 months were significantly superior to those of 3 months, in respect to the height of the vegetative growth (23 cm) and the stem thickness (4.3 mm), but the age of 3 months gave the highest significant survival seedlings (51.8%). Considering the treatments, the seedlings grown under the sunlight (control) gave the least significant survival seedlings (35%) and the height (15 cm) and gave the highest significant stem thickness (4.9 mm), while the seedlings grown under the red cellophane sheets gave the highest significant survival seedlings (61.7%) and the height (29.6 cm), but they recorded the least significant stem thickness (2.9 mm). The effect of the studied interactions took the same previous trends. From the previous results recorded in Table 2 and 3, it seems to be that jackfruit seedling's growth were enhanced and hastened under the red cellophane sheets and the shade conditions and the growth decrease and weak under the direct sunlight.

These results are in lines with those of Chatterjee and Mukherjee [18] who reported that the seed should be planted immediately, the germination is improved by soaking in NAA or GA_3 and the seedlings are best grown under shade.

Table 4: Effect of treatments of the grafting methods (A), source of the scion (B), girdling under the grafting union region (C) and case of covering the scion and the grafting union region (D); age of the rootstock seedling (month); and the season on success grafts % and time required for maximum sprouting the scion (day) of jackfruit during 2004/2005 (s_1) and 2005/2006 (s_2) seasons

Traits				Success grafts (%)							Time required for maximum sprouting the scion						
Age of the rootstock seedlings (month) (Ars.)																	
Treatments (Trs.)				6		9		Avs.		General	6		9		Avs.		General
A	B	C	D Seasons (S.)	S_1	S_2	S_1	S_2	6	9	Avs.	S_1	S_2	S_1	S_2	6	9	Avs.
Top cleft grafting	Seedlings	+	Without cover	33	17	33	33	25.0	33.0	29.0	47	50	41	43	48.5	42	45.2
			Transparent polyethylene	50	50	67	83	50.0	75.0	62.5	35	37	25	23	36.0	24	30.0
			Black polyethylene	50	67	83	100	58.5	91.5	75.0	27	25	18	20	26.0	19	22.5
		-	Without cover	33	50	50	50	41.5	50.0	45.7	60	60	60	58	60.0	59	59.5
			Transparent polyethylene	50	33	67	50	41.5	58.5	50.0	55	52	48	44	53.5	46	49.7
			Black polyethylene	67	50	67	67	58.5	67.0	62.7	41	38	28	30	39.5	29	34.2
		+	Without cover	17	0	17	17	8.5	17.0	12.7	60	-	60	58	30.0	59	44.5
			Transparent polyethylene	17	33	33	50	25.0	41.5	33.2	46	43	42	40	44.5	41	42.7
			Black polyethylene	33	50	67	50	41.5	58.5	50.0	33	35	30	36	34.0	33	33.5
		_	Without cover	0	0	0	0	0.0	0.0	0.0	-	-	-	-	-	-	-
			Transparent polyethylene	17	17	17	33	17.0	25.0	21.0	50	48	46	48	49.0	47	48.0
			Black polyethylene	17	33	50	33	25.0	41.5	33.2	38	40	30	32	39.0	31	35.0
Saddle grafting	Old trees	+	Without cover	17	17	17	33	17.0	25.0	21.0	47	46	43	40	46.5	41.5	44.0
			Transparent polyethylene	50	33	83	83	41.5	83.0	62.2	39	35	32	28	37.0	30	33.5
			Black polyethylene	50	50	67	83	50.0	75.0	62.5	30	27	21	26	28.5	23.5	26.0
		_	Without cover	0	0	0	0	0.0	0.0	0.0	-	-	-	-	-	-	-
			Transparent polyethylene	0	17	17	17	8.5	17.0	12.7	-	60	58	60	30.0	59	44.5
			Black polyethylene	0	17	33	17	8.5	25.0	16.7	-	57	56	58	28.5	57	42.7
		+	Without cover	17	0	17	17	8.5	17.0	12.7	57	-	55	59	28.5	57	42.7
			Transparent polyethylene	17	17	17	33	17.0	25.0	21.0	38	40	36	38	39.0	37	38.0
			Black polyethylene	17	33	50	50	25.0	50.0	37.5	35	37	30	33	36.0	31.5	33.7
		_	Without cover	0	0	0	0	0.0	0.0	0.0	-	-	-	-	-	-	-
			Transparent polyethylene	0	0	0	17	0.0	8.5	4.2	-	-	-	65	-	32.5	16.2
			Black polyethylene	0	17	17	17	8.5	17.0	12.7	-	64	62	60	32.0	61	46.5
Avs.				23	25	36.2	38.9	24.00	37.50	30.7	30.70	33.10	34.20	37.40	31.90	35.8	33.80
LSD (0.05)	Trs.			29.515	31.610	32.511	32.763	30.450	32.661	31.118	18.319	16.536	21.130	17.380	17.673	19.165	19.695
	Ars.					-			9.905	-			-			5.393	-
	S.				2.439		2.740			-		3.008		3.561			-
	Trs.×As. ×S.						31.896			-				17.797			-

Maiti *et al*. [19] decided that jackfruit's seed germination was the highest (98.41%), the time required for maximum seed germination was 15.72 days and the seedling height was the highest (29.57 cm), when soaked the seeds in the water and were sown at 1.25 cm depth under the red cellophane or under the white cellophane concern to the seedling height while, the leaf number did not affected by any treatments.

The highest and the earliest germination were achieved in the jackfruit seeds from which the outer thin leathery seed coat was removed and which were then soaked in water for 8h, followed by treatment with biotin at 10 ppm. and kinetin at 50 ppm. [20]. Freshly extracted jackfruit seeds had 100% germination, but on day 15, the germination % was zero [21].

On the contrary Chiesotu *et al*. [22] recorded that growth regulator treatments did not affect on the percentage germination, time taken for germination or survival percentage of jackfruit's seedlings in the field. Fresh seeds had a higher percentage germination (66%), more rapid germination (15.1 days) and higher survival percentage in the field (63.9%) than the stored seeds.

The grafting test:

Data recorded in Table 4-6 and Fig. 2-4 illustrated that, in general, the rootstock seedlings at age of 9 months achieved the higher significant success grafts (37.5%), the time required for a maximum scion sprouting (35.8 day), number of the sprouted buds/scion (1.7), length of the new shoots (2.9 cm), number of the leaves/scion (4.6) and length of the scion (12.5 cm) than the seedlings of 6 month old. The differences between the seasons were insignificant in all studied traits. Concerning the treatments, the higher significant values of all traits had obtained by the treatment that using the top-cleft grafting, the seedlings as a source of the scions, the girdling under the graft union region and the black polyethylene bags as a cover for the graft union area. The results confirmed the previous conclusions, where the previous treatment recorded the higher significant success graft (75%), number of the sprouted buds/scion (3.6), length of the new shoots (6.6 cm), number of the leaves/scion (8.2) and length of the scion (16.6 cm) and gave the least significant time required a maximum scion buds sprouting (22.5 day). Also, the treatments devoid of one or more of the previous treatments gave a less significant values reached to zero in all studied traits. The less results of the saddle grafting were not attributed to the treatments only, but also these results attributed to the anatomical causes (as shown in the histological study). The effect of the interaction between the treatments, age of the rootstock seedlings and the seasons was took and confirmed the same trends. These results were in accordance with those obtained by Konhar *et al*. [23] whose said that the highest percentage budding success

Table 5: Effect of treatments of the grafting methods (A), source of the scion (B), girdling under the grafting union region (C) and case of covering the scion and the grafting union region (D); age of the rootstock seedling (month); and the season on n umber of the sprouted buds/scion and length (cm) of the new shoots sprouted on the scion of jackfruit during 2004/2005 (S_1) and 2005/2006 (S_2) seasons

Traits				Number of the sprouted buds / scion							Length (cm) of the new shoots sprouted on the scion						
Age of the rootstock seedlings (month) (Ars.)																	
Treatments (Trs.)				6		9		Avs.		General	6		9		Avs.		General
A	B	C	D Seasons (S.)	S_1	S_2	S_1	S_2	6	9	Avs.	S_1	S_2	S_1	S_2	6	9	Avs.
Top cleft grafting	seedlings	+	Without cover	2.7	2.3	2.5	2.7	2.5	2.6	2.5	5.5	5.2	6.0	5.7	5.3	5.8	5.6
			Transparent polyethylene	3.0	2.5	2.8	3.2	2.7	3.0	2.8	6.4	6.2	6.8	6.7	6.3	6.7	6.5
			Black polyethylene	3.2	2.8	3.7	3.5	3.0	3.6	3.3	6.5	6.3	6.6	7.0	6.4	6.8	6.6
		-	Without cover	1.2	1.3	1.5	1.7	1.2	1.6	1.4	2.5	2.6	2.8	2.3	2.5	2.5	2.5
			Transparent polyethylene	2.0	1.8	2.2	2.3	1.9	2.2	2.0	2.7	2.5	2.3	2.3	2.6	2.3	2.4
			Black polyethylene	2.0	2.0	2.3	2.5	2.0	2.4	2.2	2.2	2.8	2.8	2.2	2.5	2.5	2.5
		+	Without cover	1.0	-	1.0	1.0	0.5	1.0	0.7	2.5	-	2.8	2.5	1.2	2.6	1.9
			Transparent polyethylene	1.2	1.5	1.7	2.0	1.3	1.8	1.6	2.0	2.0	2.0	2.0	2.0	2.0	2.0
			Black polyethylene	1.7	1.8	2.0	2.0	1.7	2.0	1.8	2.0	2.2	2.2	2.3	2.1	2.2	2.2
		_	Without cover	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			Transparent polyethylene	1.0	1.0	1.0	1.2	1.0	1.1	1.0	2.5	2.7	2.8	2.6	2.6	2.7	2.7
			Black polyethylene	1.0	1.2	1.5	1.5	1.1	1.5	1.3	2.0	2.0	2.2	2.5	2.0	2.3	2.1
Saddle grafting	Old trees	+	Without cover	2.3	2.0	2.5	2.7	2.1	2.6	2.4	3.8	3.6	4.8	5.0	3.7	4.9	4.3
			Transparent polyethylene	2.5	2.3	3.2	3.0	2.4	3.1	2.7	4.2	4.0	5.2	5.3	4.1	5.2	4.6
			Black polyethylene	3.0	2.7	3.5	3.3	2.8	3.4	3.1	5.0	4.8	5.4	5.6	4.9	5.5	5.2
		_	Without cover	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			Transparent polyethylene	-	2.0	2.3	2.2	1.0	2.2	1.6	-	2.4	2.5	2.3	1.2	2.4	1.8
			Black polyethylene	-	2.2	2.5	2.5	1.1	2.5	1.8	-	2.7	2.8	3.0	1.3	2.9	2.1
		+	Without cover	1.2	-	1.0	1.2	0.6	1.1	0.8	2.5	-	3.0	2.7	1.2	2.8	2.0
			Transparent polyethylene	1.2	1.5	2.0	2.0	1.3	2.0	1.7	2.0	2.0	2.2	2.0	2.0	2.1	2.0
			Black polyethylene	1.8	1.6	2.0	1.7	1.7	1.8	1.8	2.0	2.0	2.6	2.5	2.0	2.5	2.3
		_	Without cover	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			Transparent polyethylene	-	-	-	1.0	-	0.5	0.2	-	-	-	3.0	-	1.5	0.7
			Black polyethylene	-	1.0	1.0	1.2	0.5	1.1	0.8	-	3.0	2.5	2.5	1.5	2.5	2.0
Avs.				1.30	1.40	1.70	1.80	1.40	1.7	1.50	2.30	2.40	2.90	3.00	2.40	2.90	2.70
LSD (0.05)	Trs.			0.906	0.919	1.219	1.356	0.985	1.461	1.490	2.359	2.516	2.660	2.491	2.617	2.511	2.706
	Ars.					-			0.201	-			-			0.359	-
	S.				0.119		0.116			-		0.215		0.180			-
	Trs.×As. ×S.				1.404					-				2.705			-

Fig. 4: A photograph of *Artocarpus heterophyllus* lam. showing the success growth of the saddle grafted seedling at nine months old and with making the girdling under the union region and a magnified saddle grafted region (A)

(80%) of jackfruit was obtained with patch budding by using defoliated bud sticks at 7 days before the budding to activate the buds and one-year-old seedling rootstocks during the month of July and Aug.

The soft wood grafting of the jackfruit was best carried out in Feb.-March and take 30-60 days after grafting to give the highest success (36.67-40%) [24]. The maximum grafting success of the jackfruit (60%) was recorded with ringing and blanching the basal portion of the scion for 3 days [25]. The percentages of the sprouting and the survival were higher (67-70%) from bud grafts of 9-month-old bud sticks on 9-month-old rootstock, type of rootstock (Kapa or Barka) did significantly influence on the budding success and growth [26]. There was a linear increase in success and growth of patch bud grafting with an increase in the size of polyethylene bags. This was attributed to the better root growth of the rootstock. Budding *in situ* with irrigation produced the highest sprouting (80%), survival (78.6%), mean number of leaves/graft (2.6) and mean length of sprouts/graft (7.3 cm) [27]. Approach grafting of jackfruit gave the better success rate (60.4-90%) than bud grafting (35%) [28].

On the reverse, Kelaskar *et al*. [12] reported that retaining all or some of the leaves on the rootstock at patch bud grafting of the jackfruit had no effect on the graft taken and the survival, keeping the plants in a greenhouse, in an open sunlight or in a partial or a

Table 6: Effect of treatments of the grafting methods (A), source of the scion (B), girdling under the grafting union region (C) and case of covering the scion and the grafting union region (D); ag e of the rootstock seedling (month); and the season on number of the leaves / scion and length (cm) of the scion of jackfruit during 2004/2005 (S_1) and 2005/2006 (S_2) seasons

Traits				Number of the leaves/scion							Length (cm) of the scion						
Age of the rootstock seedlings (month) (Ars.)																	
Treatments (Trs.)				6		9		Avs.		General	6		9		Avs.		General
A	B	C	D Seasons (S.)	S_1	S_2	S_1	S_2	6	9	Avs.	S_1	S_2	S_1	S_2	6	9	Avs.
Top cleft grafting	Seedlings	+	Without cover	7.6	7.6	7.3	7.6	7.6	7.4	7.5	16.0	16.0	16.6	16.5	16.0	16.5	16.2
			Transparent polyethylene	8.0	7.8	7.8	8.3	7.9	8.0	8.0	16.0	16.5	17.0	16.8	16.2	16.9	16.5
			Black polyethylene	8.0	8.0	8.0	8.7	8.0	8.3	8.2	16.5	16.3	16.8	17.0	16.4	16.9	16.6
		-	Without cover	4.8	5.0	5.0	5.2	4.9	5.1	5.0	15.0	14.8	15.0	15.2	14.9	15.1	15.0
			Transparent polyethylene	5.0	5.2	5.5	5.5	5.1	5.5	5.3	15.0	15.0	15.0	15.3	15.0	15.1	15.0
			Black polyethylene	5.5	5.6	6.0	5.8	5.5	5.9	5.7	15.2	15.0	15.2	15.5	15.1	15.3	15.2
		+	Without cover	5.7	-	6.0	5.8	2.8	5.9	4.3	14.0	-	14.0	14.2	7.0	14.1	10.5
			Transparent polyethylene	5.5	5.8	6.0	6.2	5.6	6.1	5.8	14.2	14.0	14.0	14.5	14.1	14.2	14.1
			Black polyethylene	5.8	6.2	6.5	6.5	6.0	6.5	6.2	14.2	14.4	14.6	14.5	14.3	14.5	14.4
		_	Without cover	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			Transparent polyethylene	2.5	2.5	2.7	2.6	2.5	2.6	2.5	13.8	13.4	13.6	14.0	13.6	13.8	13.7
			Black polyethylene	2.8	2.6	2.8	3.0	2.7	2.9	2.8	13.5	14.0	14.0	14.0	13.7	14.0	13.8
Saddle grafting	Old trees	+	Without cover	7.0	7.0	7.2	7.4	7.0	7.3	7.1	15.6	15.5	16.0	16.0	15.5	16.0	15.7
			Transparent polyethylene	7.3	7.0	7.5	7.5	7.1	7.5	7.3	15.5	16.0	16.2	16.4	15.7	16.3	16.0
			Black polyethylene	7.3	7.5	7.6	7.8	7.4	7.7	7.5	16.5	16.5	16.5	16.7	16.5	16.6	16.5
		_	Without cover	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			Transparent polyethylene	-	3.5	3.5	3.6	1.7	3.5	2.6	-	15.0	15.0	15.3	7.5	15.1	11.3
			Black polyethylene	-	4.0	3.8	4.0	2.0	3.9	2.9	-	15.0	15.5	15.5	7.5	15.5	11.5
		+	Without cover	4.6	-	4.4	4.0	2.3	4.2	3.2	12.0	-	12.0	12.5	6.0	12.2	9.1
			Transparent polyethylene	4.0	4.0	4.6	4.2	4.0	4.4	4.2	12.5	12.8	12.8	12.6	12.6	12.7	12.7
			Black polyethylene	4.8	4.7	5.0	4.5	4.7	4.7	4.7	12.6	13.0	13.0	13.0	12.8	13.0	12.9
		_	Without cover	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			Transparent polyethylene	-	-	-	2.8	-	1.4	0.7	-	-	-	11.0	-	5.5	2.7
			Black polyethylene	-	2.5	2.6	2.8	1.2	2.7	1.9	-	11.0	11.3	11.5	5.5	11.4	8.4
Avs.				4.00	4.00	4.60	4.70	4.00	4.60	4.30	10.3	11.0	12.2	12.8	10.7	12.5	11.6
LSD (0.05)	Trs.			2.818	2.751	3.291	3.416	2.850	3.496	3.051	2.063	2.756	3.010	2.907	2.539	3.001	3.211
	Ars.					-			0.458	-			-			1.755	-
	S.				0.001		0.369			-		0.809		0.983			-
	Trs. ×As.× S.					3.209				-				2.396			-

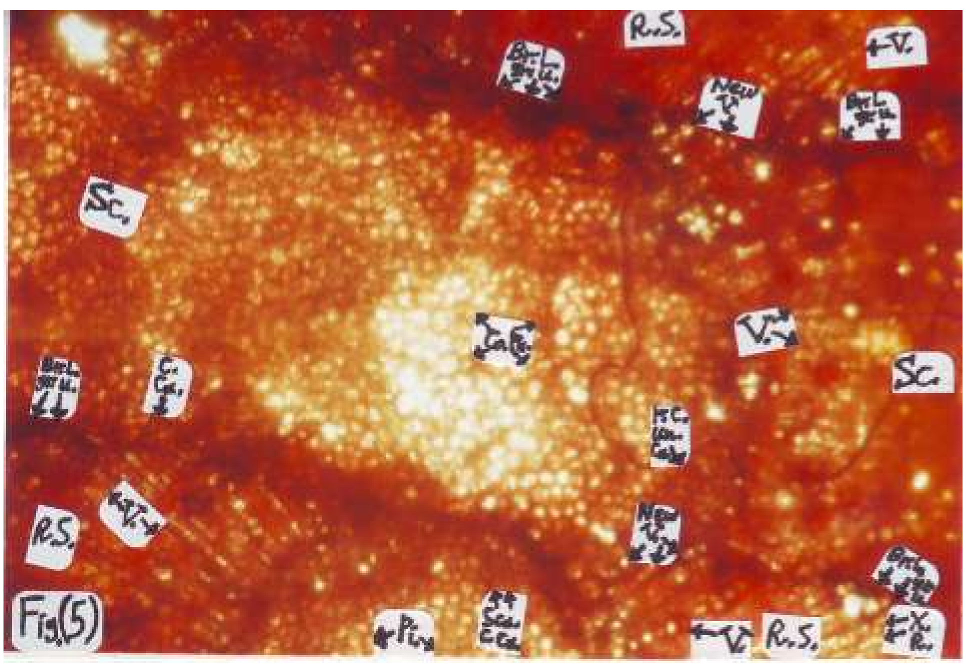

Fig. 5: Transverse section at the graft union of the success top-cleft grafting of jackfruit seedlings at age of 9 months. Notice: the positions of new vessels or vascular connection and the callus bridges

Details: R. S., Rootstock; Sc., Scion; Br. L. gr. U., Brown lines at the grafting union (adhesive materials of latex resinous); New V., New vessels; V., Vessels; C. ca., condensed callus; Pi., Pith; S ca. c. ca., Scattered condensed callus; X. R., Xylem Ray; r. c. un. ca., regular condensed uniformly callus; and co. pa., cortex parenchyma

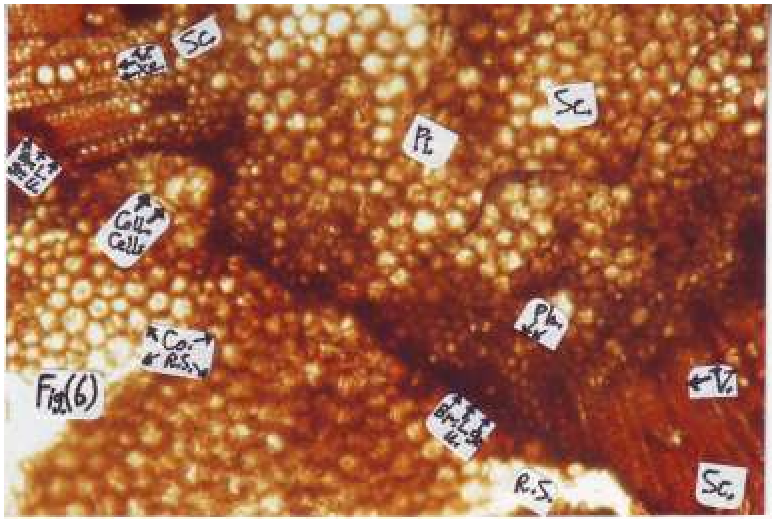

Fig. 6: Transverse section at the graft union of the success saddle grafting of jackfruit seedlings at age of 9 months. Notice: a good adhesion at the grafting union region without formed any callus

Details: Sc., Scion; R. S., Rootstock; Br. L. gr. u., Brown lines of the grafting union (latex resinous materials); Coll. Cells, Collapsed cells; Co. R. S., Cortex of rootstock; V., Vessels; X. R., Xylem Ray; Pi., Pith; and Ph., phloem

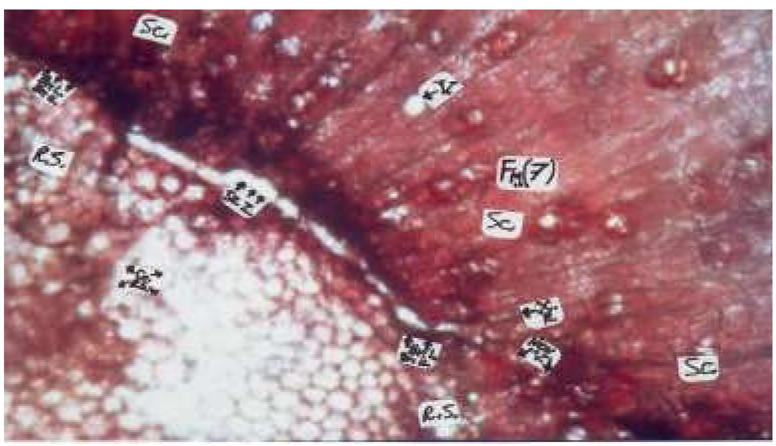

Fig. 7: Transverse section at the graft union of the success saddle grafting of jackfruit seedlings at age of 9 months. Notice: formation of the new vessels and the separation zones (spaces)

Details: Sc., scion; R.S., Rootstock; Br. L. gr. U., Brown lines of the grafting union (latex resinous materials); Se. z., Separation zones; V., Vessels; X. R., Xylem Rays and New V., new Vessels

complete shade after grafting had no effect on the bud break or the survival. Tying with a single polyethylene strips was recommended, as the most economical method.

Finally, jackfruit plants consider a sensitive plants to the environmental conditions of Egypt, especially the cold and the light and it must be take some cares to secure their cultivation success.

Histological study: Transverse sections at the graft union zone of two successful grafting types, i.e., top-cleft (Fig. 5) and saddle grafting (Fig. 6 and 7) illustrated that the anatomical features were varied according to the grafting types and the compatibility between the scions and the rootstocks that correlated with the grafting success percentage. In general, the wounded edges of the original scions and rootstocks were present as brown lines of a necrotic cell layer surrounded, intermingle and interlock with the latex resinous materials secreted by the secretary canals of the scion and the rootstock, where these materials act as a binding or adhesive materials "cement" between the scion and the rootstock of jackfruit, but this firm adhesion in the jackfruit grafts is not indicator of the grafting success continuity or happening of the scion and the rootstock vascular connection, as many scions have dead after the success of grafts, in spite of the continuity of adhesion between the scion and the rootstock without any separation or swell. This phenomenon in jackfruit is almost observed in the saddle grafts after removing the polyethylene strips tied covered the graft union region, so it is recommended by staying these ties for enough time after the grafting (until beginning the growth of scion and thickened the rootstock's bark under the graft union region). These previous brown lines characterize the grafting margins in jackfruit transverses (Fig. 5-7).

Figure 5 showed the anatomical features of an compatible top-cleft graft, which seem in an regular disposition condensed and uniformly callus tissue originated only from the xylem ray cells of both the scion and the rootstock at the opposite positions of the vessels of both the scion and the rootstock in the grafting union region, also, the new vascular elements initiated in this callus with a large degree that reflected a good connection in this grafting type, as shown in the right part of the Fig. 5. On the other hand, the vessels of the rootstock which were not opposite to the vessels of the scion failed to form any new vessels and formed only irregular little amount of callus, as shown in the left part of the section. Besides, scattered condensed callus groups initiated from the rootstock pith, presumably from some parenchyma cells regenerated from some collenchyma or individual parenchyma cells as a result of cutting (wound hormone), while the cortex of the scion with its parenchyma cells failed to form any callus on the whole margin of the grafting, as shown in the middle part of the section. The compatible top-cleft grafting section devoid of any spaces or separated positions in the whole grafting margins that reflected a good adhesion between the two partners by the latex resinous materials.

Also, it is concluded that the homogenous tissues of both scion and rootstock must be put opposite and align with each others for obtaining a good callus and complete vascular connection. In this top-cleft grafting, the translocation between the scion and the rootstock of jackfruit can take place through both the callus bridges and the new vascular elements formed in the grafting union region, hence the scion continued alive and had a good growth. Also, this success top-cleft grafting section devoid of any collapsed cells or even any necrotic positions which reflect the highly compatibility in this grafting type, where the previous anatomical features could be explained the highly success percentages resulted of using this grafting type with jackfruit plants at the studied old.

Figure 6 and 7 showed the anatomical features of the saddle grafts of jackfruit seedlings at age of 9 months (they were more clearness). These transverse sections illustrated some incompatibility between the scion and the rootstock of jackfruit showed in devoid of both the callus and the new vessels bridges at the union region, the line of necrotic layer on the margins of the graft union and existence of the collapsed cells at the union region as shown in Fig. 6.

The other incompatible anatomical features were cleared in Fig. 7 that showed these features which characterized by existence of the separation zones at the grafting union region.

On the contrary, the compatible anatomical features in this figure were initiation of the new vessels in the condensed callus which seem to be originated from the xylem ray cells of the scion, thus translocation can take place through these new vessels and hence the scion continued alive with acceptable growth for some times until forming a large number of the leaves, which loosed a large amount of water and consumed a large amount of nutrients more than the supply by the translocation and finally the scion's growth weak, stopped and the scion died. The previous incompatible anatomical features, greatly, decrease the translocation and shorten the survival scion's life of the saddle grafted seedlings, in spite of existence of a good adhesion between the rootstock and the scion.

The previous results were agreement with those obtained by Abd El-Zaher [29] who decided that histological study at the graft union zone of incompatible grafts (Ewais on Hindy Sinnara and Alphonso on Zebda) revealed presence of necrotic layer on both sides of union zone, scattered callus and numerous free of callus positions that lead to weak or fail connection between two graft partners. The graft union is initially formed by rapidly dividing callus cells, originating from the scion and rootstock, which later differentiate to form the vascular cambium and the associated vascular system. The development of a compatible graft is typically comprised of three major events: adhesion of the rootstock and scion, proliferation of callus cells at the graft interface or callus bridge; and vascular differentiation across the graft interface. [30].

Moore [31] recorded that lethal cellular has resulted in the formation of necrotic layer of collapsed cells that separates the two partners of an incompatible graft. Meanwhile, the compatible grafts, Esau *et al.* [32] recorded that the new parenchyma cells are produced adjacent and internal to the necrotic layer, soon they intermingle and interlock, filling up the spaces between scion and rootstock and development in the healing of a graft union. The cambial activity in the callus has resulted in the production of secondary tissues which have joined the vascular tissues of the stock and scion.

Finally, it could be recommended with using the top-cleft method as a pronounced grafting method in the jackfruit seedlings.

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