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HYDROPONIC SYSTEM FOR MASS PROPAGATION OF *FICUS ELASTICA* VAR. *DECORA*

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ABSTRACT: Terminal and sub-terminal cuttings of *Ficus elastica* var. *decora* were cultured in peat moss (after dipping in 4000 ppm IBA) or hydroponic units contained: water, quarter Hoagland strength, half Hoagland strength, full Hoagland strength and 10 or 20 ppm IBA solutions. Using of sub-terminal cutting and/or different hydroponic solutions were more promising than terminal cutting and/or peat moss, respectively. Among the different hydroponic solution treatments, IBA solution at low concentration (10 ppm) had the best results, since it produced high values of rooting percentage, number of roots/cutting, number of sprouted buds/cutting, survival percentage, root fresh weight and initiated the first root during short time.

Key words: *Ficus elastica* var. *decora*, hydroponic, propagation, Hoagland solution, indolebutyric acid (IBA).

INTRODUCTION

Ficus elastica var. *decora* is a popular ornamental tree grown around the world. It is grown both indoors and outdoors in warmer tropical climates where it grows to a spectacular large spreading tree with attractive large glossy leaves (Dehgan, 1998). This plant can be propagated by cutting. The alternative method is air-layering which is costly and need to a higher hand labor (Brickel and Zuk, 1997). Efforts have been done to develop hydroponic and aeroponic systems for using in propagation by cutting (Hershey and Merritt, 1986; Bertram, 1988; Soffer and Burger, 1989; Bertram, 1991; Tawfik, 2001). These techniques have many advantages Vis availability of high oxygen concentration which stimulate root initiation and development; facilitating of water influx to the cutting; simplicity and low cost. Most of previous studies devoted particular attention to compare hydroponic and aeroponic systems with solid medium during propagation by cutting. The objectives of this study were, therefore, to investigate the effect of using different concentrations of IBA, different levels of nutrients in hydroponic solutions and two different types of cutting (terminal and sub-terminal) on root initiation and development as well as to compare our *de novo* hydroponic system (which comparable to nutrient film technique) with the common rooting medium (peat moss).

MATERIALS AND METHODS

This experiment was conducted in Horticulture Department, Faculty of Agriculture, Zagazig University during the two successive seasons, 2005 and 2006.

Plant Material: Uniform shoots with about 150 cm length were collected from 15 years old tree of *Ficus elastica* var. *decora* grown in Faculty of Agriculture, Zagazig University Farm on April 1^{st}, during both seasons. Terminal cuttings (contained terminal bud) were prepared with about 15 cm length from the terminal parts of these shoots, while the sub-terminal parts of shoots which had about 1.0 cm diameter were used to prepare the sub-terminal cuttings (about 15 cm length and included about 5 nodes). Cuttings bases (5 cm) were dipped in fungicide solution (2 g l^{-1}) of Rizolex for 2 h. before culturing.

Hydroponic Unit Preparation: Hydroponic units were designed by using plastic pipes (4.0 inches diameter and 4.0 m. length) with upper holes every 20 cm with 12 cm diameter each. Pipes were fixed with a gentle slope 1:100, so that solution could be flowed under the influence of gravity. Solution was accumulated in plastic tank contained 20 liters of solution. Solution was pumped in PVC hose (0.5 inch diameter) from the tank to higher end of pipe by using electrical pump (120 l h^{-1}). Solution was flowed to lower end of pipe and accumulated in the tank with continuous recirculation. Lower end of pipe was closed particularly (4 cm) from the bottom to allow solution to rise and reach to cuttings bases (about 2 cm).

Culture of Cuttings: cutting bases were dipped in 4000 ppm IBA solution (the best treatment for treating *Ficus elastica* var. *decora* cuttings according to Souidan *et al.*, 1995) for one minute before placed in pots (20 cm diameter) contained peat moss (one cutting each) or placed directly (without IBA treatment) in plastic pipe containing one of the following solutions: distillated water, full Hoagland strength (prepared according to Hoagland and Amron, 1950), half Hoagland strength, quarter Hoagland strength, and 10 or 20 ppm IBA. Cuttings were fastened in plastic pipes by using adhesive tape. Thirty cuttings were cultured in each treatment. Three cuttings were placed in each hole. Cuttings were incubated in greenhouse at about 25 °C.

Recorded Data: Cuttings in each treatment were checked for root appearance every two days to determine the number of day to first root appearance on each cutting. Cuttings which initiate root in peat moss were marked and did not check again to prevent interruption of root growth. After 30 days from culturing the cuttings, the following Data were recorded: rooting %, No. of main roots/cutting, root length (cm), root fresh weight (g), No. of sprouted buds/cutting. Also survival (%) was recorded after 30 days from transplanting rooted cuttings to pots (20 cm diameter, each pot contained one rooted cutting) contained peat moss medium.

Statistical Layout of Experiment: The statistical layout of this experiment was factorial system included two factors; i.e., rooting media and cutting type in a completely randomized design. The recoded data were statistically analyzed, and the means were compared using Duncan multiple range test according to Little and Hills (1978).

RESULTS

Effect of Different Hydroponic Solutions, Peat moss and Cutting Type on Rooting Percentage of *Ficus elastica* var. *decora* Cutting

Data in Table 1 show that all hydroponic treatments were more effective in enhancing rooting percentage than solid medium since it resulted in 66.66 – 83.33% during the two seasons against 15.00 – 16.66 % for solid medium (peat moss). Also, sub-terminal cutting showed higher rooting percentage (81.28 – 84.42 % during two the seasons) than terminal cutting which produced 45.71 – 49.99 % during the two seasons.

The interaction between medium treatments and cutting type indicate that 10 or 20 ppm IBA with sub-terminal cutting gave the highest rooting percentage (90.00 – 96.66 %).

Effect of Different Hydroponic Solutions, Peat moss and Cutting Type on Number of Days to First Root Appearance of *Ficus elastica* var. *decora* Cutting

Table 2 shows that sub-terminal cutting produced first root faster than terminal cutting (11.54 and 13.04 day against 15.20 and 15.10 day, respectively) during two the seasons. Also, the main effect indicates that hydroponic solutions of IBA at 20 ppm resulted in the least number of day to first root appearance (10.72 and 9.90 days) during the first and second seasons, respectively.

The interaction effect indicates that using of water or IBA at 10 or 20 ppm with sub-terminal cutting produced roots earlier than other treatments.

Effect of Different Hydroponic Solutions, Peat moss and Cutting Type on Number of Main Roots/Cutting of *Ficus elastica* var. *decora*

Data in Table 3 indicate that sub-terminal cutting produced higher number of main roots /cutting than

Table 1. Effect of different hydroponic solutions, peat moss and cutting type on rooting percentage of *Ficus elastica* var. *decora* cutting during two seasons after 30 days

Medium treatments	Cutting type					
	First season			Second season		
	STC*	TC**	Mean	STC*	TC**	Mean
Peat moss	33.33	0.00	16.66	30.00	0.0	15.00
Water	93.33	60.00	76.66	90.00	53.33	71.66
Quarter Hoagland	93.33	50.00	71.66	93.33	53.33	73.33
Half Hoagland	90.00	50.00	70.00	86.66	46.66	66.66
Full Hoagland	86.66	53.33	69.99	86.66	50.00	71.66
10 ppm IBA	96.66	66.66	81.66	90.00	56.66	73.33
20 ppm IBA	96.66	70.00	83.33	93.33	60.00	76.66
Mean	84.28	49.99		81.42	45.71	

*Sub-terminal cutting
** Terminal cutting

Table 2. Effect of different hydroponic solutions, peat moss and cutting type on number of days to first root appearance on *Ficus elastica* var. *decora* cutting during two seasons

Medium treatments	Cutting type					
	First season			Second season		
	STC*	TC**	Mean	STC*	TC**	Mean
Peat moss	18.0 e	----	18.00 D	20.0 f	----	20.00 E
Water	9.0 a	16.1 d	12.55 B	10.0 ab	14.1 cd	12.05 B
Quarter Hoagland	9.5 a	15.5 cd	12.50 B	11.9 bc	16.9 e	14.40 C
Half Hoagland	12.4 b	17.3 de	14.85 C	14.9 d	18.5 f	16.70 D
Full Hoagland	14.2 c	16.1 d	15.15 C	14.9 d	17.0 ef	15.95 D
10 ppm IBA	8.1 a	14.3 c	11.20 A	10.6 b	13.3 c	11.95 B
20 ppm IBA	9.6 a	11.9 b	10.72 A	9.0 a	10.8 b	9.90 A
Mean	11.54 A	15.20 B		13.04 A	15.10 B	

*Sub-terminal cutting
** Terminal cutting
---- No root was formed so it did not include in statistical analysis
Data with the same letter vertically are not significant according to Duncan's multiple range test at 5% level

Table 3. Effect of different hydroponic solutions, peat moss and cutting type on number of main roots/cutting and root length of *Ficus elastica* var. *decora* during two seasons after 30 days

Medium treatments	No. of main roots/cutting						Average root length (cm)					
	Cutting type						Cutting type					
	First season			Second season			First season			Second season		
	STC*	TC**	Mean	STC	TC	Mean	STC	TC	Mean	STC	TC	Mean
Peat moss	2.0 b	0.0 a	1.0 A	3.1 bc	0.0 a	1.55 A	3.18 d	0.0 a	1.59 B	2.93 d	0.00 a	1.46 B
Water	3.2 c	1.9 b	2.55 B	2.5 b	1.2 ab	1.85 A	25.0 i	14.5 h	19.75 F	23.11 k	10.92 h	16.56 F
Quarter Hoagland	5.5 d	2.5 bc	4.00 C	5.2 c	3.3 bc	4.25 B	14.47 h	7.37 f	10.92 F	15.7 j	8.20 g	11.95 E
Half Hoagland	8.4 e	6.3 d	7.35 D	7.9 d	7.1 cd	7.5 C	9.45 g	6.48 ef	7.96 D	11.74 i	5.51 f	8.62 D
Full Hoagland	10.0 f	8.1 e	9.05 E	8.0 d	7.3 cd	7.65 C	7.24 f	5.80 e	6.52 C	8.33 g	4.81 e	6.57 C
10 ppm IBA	30.9 i	24.8 g	27.85 F	30.5 e	28.1 e	29.3 D	1.8 c	2.42 cd	2.11 B	1.18 c	1.71 c	1.44 B
20 ppm IBA	38.7 j	29.0 h	33.85 G	40.3 g	34.8 f	37.4 E	0.81 b	0.59 ab	0.70 A	0.54 b	0.61 b	0.57A
Mean	14.1 B	10.37 A		13.92 B	11.68 A		8.85 B	5.3 A		9.07 B	4.4 A	

* Sub-terminal cutting
** Terminal cutting

Data with the same letter vertically are not significant according to Duncan's multiple range test at 5% level

terminal cutting, while the main effect of culture medium clears the efficiency of hydroponic culture in increasing number of main roots/cutting comparing with solid medium (peat moss). Moreover, IBA hydroponic solutions (10 and 20 ppm) were more effective in this regard than all Hoagland strength solutions. Higher IBA concentration (20 ppm) produced the highest number of main roots/cutting.

The interaction effect between cutting type and culture medium clears that, sub-terminal cutting significantly surpassed terminal cutting in any culture medium. The highest number of main roots/cutting (38.7 and 40.3 roots/cutting during two seasons) was obtained with sub-terminal cutting cultured in 20 ppm IBA solution against 29.0 and 34.8 roots/ cutting during the two seasons (Fig. 1).

Effect of Different Hydroponic Solutions, Peat moss and Cutting Type on Average Root Length and Root Fresh Weight/ Cutting of *Ficus elastica* var. *decora*

Tables 3 and 4 show clearly that. sub-terminal cutting significantly surpassed terminal one concerning root length and fresh weight of roots. Also, hydroponic culture solutions of water and different Hoagland strengths resulted in higher root length and fresh weight of root/cutting than peat moss medium. On the other side, addition of IBA in hydroponic solution at 10 or 20 ppm resulted in the least length although it produced the highest fresh weight of roots.

The interaction between cutting type and culture medium indicate that the highest root length and root fresh weight/cutting were obtained by sub-terminal cutting in hydroponic water culture (Fig. 1).

The herein results declared that the less nutrient levels (quarter strength of Hoagland solution) was more effective in enhancing root length but showed less number of root comparing to high concentrations (full and half strength of Hoagland solution).

Effect of Different Hydroponic Solutions, Peat moss and Cutting Type on Number of Sprouted Buds/ Cutting of *Ficus elastica* var. *decora*

Data in Table 4 show that when sub-terminal cutting cultured in half or full Hoagland solutions it gave more sprouted bud/cutting compared with terminal cutting. The least number of sprouted buds/cutting was belonging to cuttings which dipped in 4000 ppm and cultured in peat moss (Fig. 1).

Effect of Different Hydroponic Solutions, Peat moss and Cutting Type on Survival Percentage of *Ficus elastica* var. *decora* Rooted Cutting

Rooted cuttings which had sprouted bud and rooted in hydroponic culture were transplanted to peat moss growing medium (in 20 cm diameter pot) and its survival

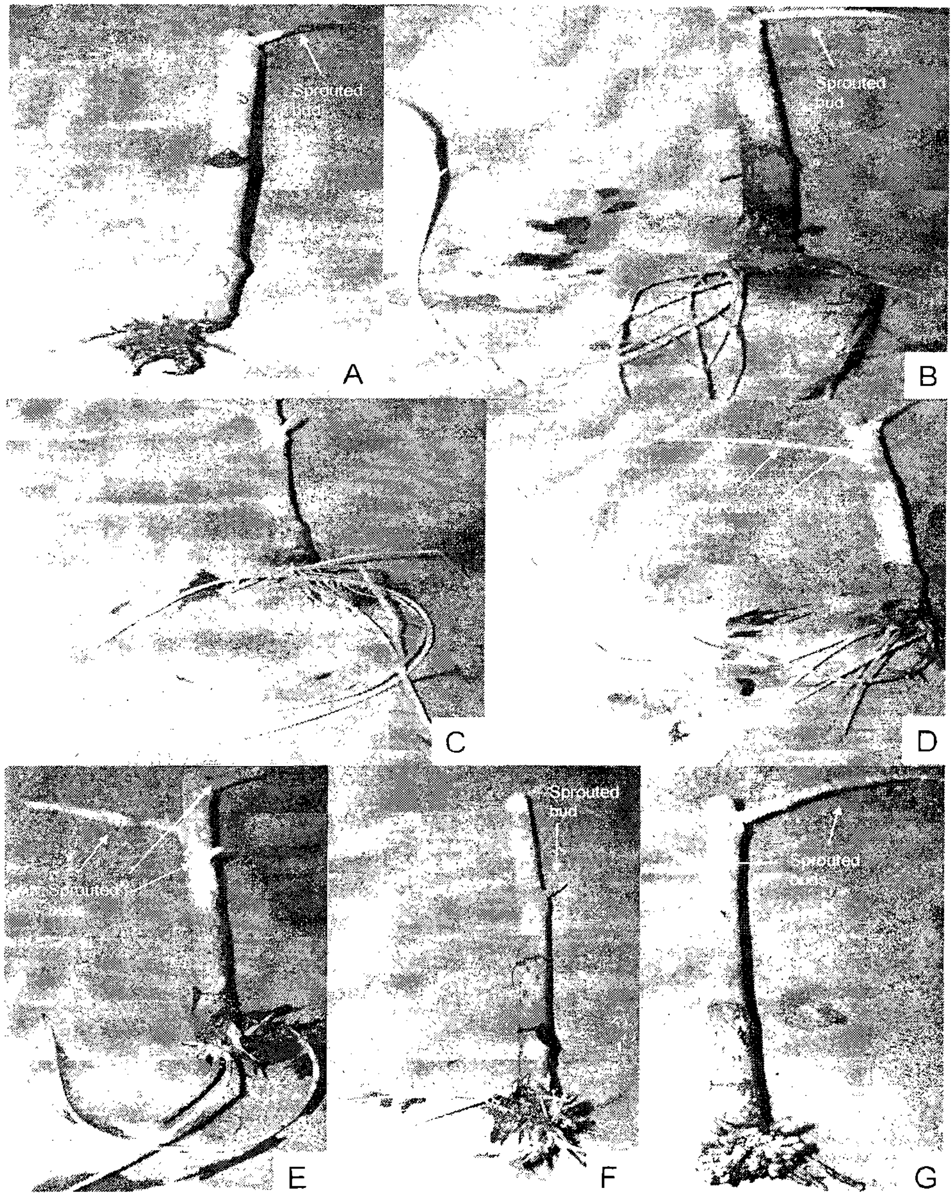

Fig. 1. Sub-terminal rooted cuttings of *Ficus elastica* var. *decora* after 30 day from placing them in peat moss (A) or different hydroponic solutions; water (B), quarter Hoagland strength (C), half Hoagland strength (D), full Hoagland strength (E), 10 ppm IBA (F) and 20 ppm IBA (G)

Table 4. Effect of different hydroponic solutions, peat moss and cutting type on root fresh weight/cutting and number of sprouted buds/cutting of *Ficus elastica* var. *decora* during two seasons after 30 days

Medium treatments	Root fresh weight/cutting (g)						Number of sprouted buds/cutting					
	Cutting type						Cutting type					
	First season			Second season			First season			Second season		
	STC*	TC**	Mean	STC	TC	Mean	STC	TC	Mean	STC	TC	Mean
Peat moss	0.40 b	0.00 a	0.20 A	0.56 b	0.00 a	0.28 A	1.2 bc	0.0 a	0.60 A	1.0 b	0.0 a	0.50 A
Water	1.36 f	0.98 de	1.17 C	1.17 ef	0.86 d	1.01 C	1.4 c	1.0 b	1.20 B	1.4 c	1.0 b	1.20 B
Quarter Hoagland	1.140 e	0.60 c	0.87 B	1.13 e	0.75 cd	0.94 C	1.9 d	1.0 b	1.45 C	1.8 d	1.0 b	1.40 C
Half Hoagland	0.87 d	0.79 cd	0.83 B	0.96 d	0.72 c	0.84 BC	2.5 e	1.0 b	1.75 D	2.3 e	1.0 b	1.65 D
Full Hoagland	0.91 d	0.74 cd	0.83 B	0.90 d	0.66 bc	0.78 B	2.8 c	1.0 b	1.90 D	2.9 f	1.0 b	1.95 F
10 ppm IBA	1.55 fg	1.42f	1.48 E	1.20 ef	1.30 f	1.25 D	1.3 bc	1.0 b	1.15 B	1.1 bc	1.0 b	1.05 B
20 ppm IBA	1.69 g	0.94 de	1.32 D	1.52 g	0.95 d	1.24 D	1.6 cd	1.0 b	1.30 BC	1.5 cd	1.0 b	1.25 BC
Mean	1.13B	0.78 A		1.06 B	0.75 A		1.81 B	0.857 B		1.714 B	0.857 A	

* Sub-terminal cutting
** Terminal cutting
Data with the same letter vertically are not significant according to Duncan's multiple range test at 5% level

percentage was compared to continuous growing cuttings in peat moss. Obtained results (Table 5) show convenience survival percentages for rooted cuttings ranged between 80.00 – 97.50 % for both cutting type during two seasons comparing to 100% for sub-terminal cutting grown continuously in peat moss.

DISCUSSION

Effect of Hydroponic System Compare to Peat moss Medium on Root Initiation and Development

The present study results clearly demonstrate that hydroponic system offers a new promising method for propagation of plant by cuttings.

All hydroponic solution treatments proved to be more effective than using peat moss medium concerning root initiation and development. In a similar approach to this result, Soffer and Burger (1989) found that rooting percentage, number of roots/cutting and total root length of *Ficus benjamina* was greater in aero-hydroponic system than either solid medium (perlite : vermiculite 1:1 or sand : peat : redwood bark 1:1:1, *V/V*). Also, Tawfik (2001) on some ornamental plants observed that root initiation and development occurred faster in water air-flow system than in peat moss. This enhancing effect of hydroponic system on rooting may be due to that good oxygen dissolving and supply could be achieved by using this system, since it is well known that oxygen is essential for root formation (Soffer and Burger, 1988). Another reason is that the key to successful propagation medium is a good water management (Hartmann *et al.*, 2006) which prevents cutting dehydration during rooting period.

Effect of Nutrient Salt Concentration in Hydroponic Rooting Media on Root Initiation and Development

It has been difficult to quantify the effect of nutrient on root primordial initiation versus root primordial elongation (Hartmann *et al.*, 2006). The promotive effect of increasing nutrient salt concentration in rooting medium on number of initiated root/cutting which observed in this study was previously demonstrated by Bertram (1991) on *Hibiscus rosa-sinensis* cuttings rooted in water culture system. On the other side, the enhancing effect of decreasing nutrient salt level on root development has been reported in some micropropagation studies such as Hasegawa (1980) on rose, Deshpande *et al.* (1998) on *Ficus religiosa* and Kaur and Kant (2000) on *Acacia catechu* and confirmed here.

Effect of IBA Concentration in Hydroponic Rooting Media on Root Initiation and Development

It has been repeatedly confirmed that auxin is required for initiation of adventitious roots on stems, and indeed, it has been shown that divisions of the first root initial cells are dependent upon either applied or

Table 5. Effect of different hydroponic solutions, peat moss and cutting type on survival percentage of *Ficus elastica* var. *decora* rooted cutting during two seasons after 30 days from transplanting

Medium treatments	Cutting type					
	First season			Second season		
	STC*	TC**	Mean	STC*	TC**	Mean
Peat moss	100	----	100.00	100	----	100.00
Water	95	90	92.50	100	90	95.00
Quarter Hoagland	90	100	95.00	90	95	92.50
Half Hoagland	95	95	95.00	95	100	97.50
Full Hoagland	100	95	97.50	95	100	97.50
10 ppm IBA	95	90	92.50	90	95	92.50
20 ppm IBA	85	80	82.5	80	80	80.00
Mean	94.28	91.66		92.85	93.33	

*Sub-terminal cutting
** Terminal cutting
---- No root was formed

endogenous auxin (Hartmann *et al.*, 2006). This fact was also confirmed in this study since addition of IBA to hydroponic solution at both concentrations (10 or 20 ppm) increased the number of roots/cutting, root fresh weight and rooting percentage as well as decreased the number of days to first root appearance compared with control treatment (water without IBA).

The enhancing effect of increasing IBA concentration on number of roots/cutting and number of sprouted buds/cutting in this investigation are in harmony with Khattak *et al.* (2001) on olive (*Olea europaea*) cuttings, Ahmed *et al.* (2003) on peach rootstocks cuttings and Husen and Pal (2003) on teak plant (*Tectona grandis*) cuttings. On the other hand, obtained results revealed that higher concentration of IBA (20 ppm) had a depressive effect on average root length, root fresh weight and survival percentage. This result is in agreement with those obtained by Iqbal *et al.* (1999) on apple cuttings, Ahmed *et al.* (2003) on peach rootstocks cuttings, Habib *et al.* (2003) on *Morus alba* microcuttings, Rahman *et al.* (2004) on *Elaeocarpus robusts* microcuttings and Poudel *et al.* (2005) on *Vitis ficifloia* var. *ganebu* microcuttings. This may be attributed to the toxic effect of high concentration of IBA on cuttings of certain species (Hartmann *et al.*, 2006).

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اكثار اشجار الفيكس ديكورا باستخدام نظام المزارع المائية

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زرعت العقل الساقية الطرفية و نصف الناضجة لاشجار الفيكس ديكورا فى البيت موس (بعد نقعها فى اندول حمض البيوتريك بتركيز ٤٠٠٠ جزء فى المليون) او فى وحدات زراعة مائية تحتوي على الماء او محلول هوجلاند بتركيزات مختلفة (كامل او نصف او ربع تركيزالاملاح) او محلول اندول حمض البيوتريك بتركيز ١٠ او ٢٠ جزء فى المليون، حيث وجد ان استخدام كلا من العقل الساقية نصف الناضجة و/ او المحاليل المختلفة فى المزارع المائية اعطى نتائج افضل من استخدام العقل الطرفية و/ او البيت موس، على الترتيب ، كما ثبت ان استخدام محلول اندول حمض البيوتريك بتركيز ١٠ جزء فى المليون قد اعطى افضل استجابة ، حيث ادى للاسراع بتكوين الجذور على العقل و كذلك الحصول على قيم عالية فيما يتعلق بنسبة التجذير ، و عدد الجذور على العقلة ، و عدد البراعم المتفتحة على العقلة ، والوزن الطازج للجذور ، و نسبة البقاء بعد اعادة الزراعة.