EFFECT OF ROOT-PROMOTING SUBSTANCES AND DATE OF PLANTING ON ROOTING OF OLIVE CUTTINGS

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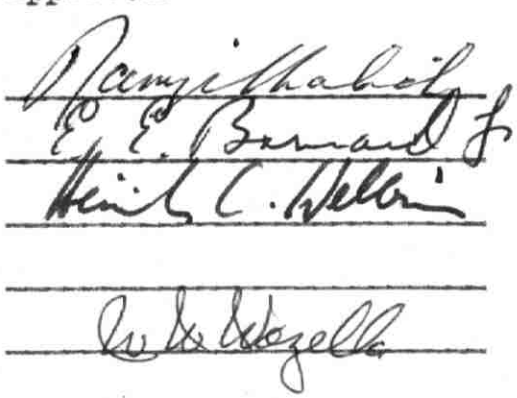

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OLIVE PROPAGATION

KHAN

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ABSTRACT

Rooting of softwood cuttings of the olive variety "Chatawi" was examined at the American University of Beirut. Cuttings were taken at twenty regular fortnightly intervals starting on July 21, 1963. They were treated with solutions of root-promoting substances and were planted in vermiculite and provided with bottom heat at 20 to 22C.

Callusing was retarded but faster and higher percentages of rooting were obtained when the cuttings were taken during the winter and spring months and were treated with solutions of root-promoting substances. Among these substances, IBA at 3000 ppm gave the best results.

Treatment with IBA at 3000 ppm also gave significantly higher percentage of well-rooted cuttings. Cuttings treated with methylene blue at 25 ppm gave the lowest percentage of callusing and rooting.

Mortality of cuttings was high when plantings were made during July or August. Untreated cuttings or cuttings treated with IBA at 3000 ppm had the least mortality as compared with that of the cuttings treated with IBA at 5000 ppm or NAA at 4000 ppm.

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INTRODUCTION

Rooting of olives (Olea europea L.) by cuttings is highly important for the production of clonal scion varieties and uniform stocks for budding or grafting. Cuttings from many olive varieties are, however, difficult to root without any treatment such as the use of a root-promoting substance.

Recently in plant propagation trials in the United States of America and elsewhere a number of growth regulators have been shown to promote rooting of cuttings (7). In addition it appears that cuttings of many olive varieties root fairly well in clean sharp sand, especially with bottom heat and high humidity, provided attention is given to other factors such as proper timing in obtaining the cuttings (16).

Work on similar lines has not been reported so far from the Middle East.

Olives play an important role in the economy of most Middle Eastern countries. In Pakistan, schemes for establishing large scale olive plantations are under government consideration with a view of producing enough olive oil to meet the acute shortage of edible oils and fats in the country (18).

The expected vast expansion in the area under olives in the Middle East warrants the establishment of sound methods for rapid multiplication of improved varieties. The

present investigation has been, therefore, concerned with determining an efficient and economical method for rooting olive cuttings by utilizing the most recent and advanced techniques.

REVIEW OF LITERATURE

Many different types of cuttings have been used for propagating olives but the use of leafy shoot cuttings has been found to be the most promising (7). According to Elant and Perrot (9) 100,000 olive trees are propagated annually by softwood cuttings for the "Beni Amir" (Algeria) irrigation area. In California a large proportion of the olive trees produced each year are propagated by softwood cuttings (13).

A number of synthetic growth regulators aid the rooting of cuttings (11). The two now in common use are Beta-indole-butyric acid (IBA) and Alpha-naphthalene-acetic acid (NAA) either in their acid forms or as salts.

Evenari and Konis (10) treated dormant cuttings of olive, fig and vines with Beta-indole-acetic acid (IAA) in solutions or in lanolin pastes. The effectiveness of the treatments in inducing root formation was shown to depend on the method of application. They found that treatment of the basal portion of the cuttings minimized inhibition of bud development. For leafy cuttings the solution method was superior to the lanolin paste method; the latter, when applied to the base of the cutting, hindered the up-take of water with consequent wilting. In certain cases a better rooting response was obtained by the addition of sugar to the solutions.

The method of application of root-promoting substances used by Hitchcock and Zimmerman and described by Cooper (8) consisted of dipping the bases of the cuttings for a few

seconds in a 50% alcohol solution containing I to 20 mg/ml of the root-promoting substance. This method was found particularly effective with such difficult-to-root species as apple and rhododendron. The large volume of alcohol used in these concentrated solutions made the method helpful in preparing solutions of some of the relatively insoluble compounds such as naphthalene acetamide.

Hartmann (14), working on olive propagation, found that the concentrated-solution-dip method of applying root-promoting substances was almost as satisfactory as the low-concentration-soaking method in rooting softwood olive cuttings. While IBA at 4000 to 5000 ppm gave the best results in the concentrated-solution-dip method almost as good results were obtained in concentrations ranging from 3000 to 7000 ppm. In comparisons made using vitamin B1 as a preplanting treatment, no benefits were obtained from this material with hardwood olive cuttings.

Dipping the bases of softwood cuttings, 9 to 12 cm long, of the olive variety Mission in concentrated solutions of either IBA (2g/l) or a combination of IBA and NAA (each at 0.5g/l) resulted in 14% and 34% rooting respectively, as compared to the untreated controls (4). Additional treatment with ammonium sulphate and sucrose had no beneficial effect.

Hartmann and Hansen (16) tested the Sevillano olive

for its rooting ability under mist. It proved to be relatively easy to root provided attention was given to other factors, such as proper timing in obtaining the cuttings and the use of root-promoting substances. Of the treatments employed, the use of root-promoting substances was the most important.

When cuttings of an olive variety of poor rooting quality were treated with different root-promoting substances, there was no increase in rooting over the water control. However, there was more root growth and number on cuttings treated with NAA (2).

Rooting in eight olive varieties ranged from 3% in Coratina and 3.3% in Leccino to 49.4% in Maurino (19). The treatments were comprised of IBA and IAA each at I0,50 and I00 ppm and vitamin B6 at I0,30 and 60 ppm. With a single exception, the highest rooting percentages (29.4 - 67.I%) were obtained with I00 ppm IBA. The differences in varietal responses to the three substances were considerable. In general, callus formation and shoot growth were not affected by the treatments.

The application of a I:I,000 aqueous solution of methylene blue, for 30 minutes, stimulated the formation of roots and general growth of hop (Humulus lupulus) cuttings (3). The roots of the treated cuttings were four times longer and contained up to 3I% greater substance than the controls.

Hartmann (14) reported that, in rooting softwood cuttings of the olive, the use of sand as a rooting medium resulted in a long, unbranched type of root, whereas several mixtures of other materials gave a more desirable, compact, branching type of root system. A good mixture was found to be one made of vermiculite plus Haydite.

Experiments to show the effect of the rooting media on olive cuttings were made by Blommaert (4) at Stellenbosch. The best results were obtained with sifted sand alone and with a mixture containing two parts of sand to one part of vermiculite. These gave 70% rooting. Vermiculite alone gave almost as good results.

Reduction in rotting and improvement in rooting occurred when vermiculite was used instead of sand for rooting cuttings, treated with root-promoting substances, under constant mist (21).

Olive cuttings of the variety Leccino rooted best in medium-size-grained vermiculite (5). Results were also good with coarse or fine vermiculite and with sphagnum moss or building sand, but fine sea sand was not satisfactory.

Depth of planting cannot properly be considered apart from the length of the cutting. According to Garner's report (11), Casella, working with olives, used short thick hardwood cuttings which were planted either horizontally or vertically 6 to 10 cm below the surface. By slanting the

cutting the depth of planting was adjusted without exposing un-necessary above ground length.

Stcherbakoff (22) discussed the respective merits of propagating olives from seeds or cuttings. He suggested that the one-or two-year old cuttings must be 8 to 9 cm long with 3 to 4 buds, the leaves must be removed from the lower two buds and the cuttings set to a depth of two-thirds of their length, leaving one or two buds above the sand.

According to Garner (11) Knight found that a high water content of the medium favored callusing but reduced rooting in hardwood cuttings. However, he quoted Hunter who reported indications that root formation, as distinct from callusing, took place under fairly wet conditions. Hunter recommended increasing the water supply of the media after callusing.

Hartmann (13,14) observed that in general better results were obtained when bottom heat, controlled at 23C, was used together with high humidity in rooting softwood cuttings of olive.

Success in the application of root-promoting substances to cuttings was found to depend on optimum environmental conditions (20). At 20 to 25C results were much better than at lower temperatures in propagating chrysanthemums by cuttings, treated with the preparation P604. (The chemical compound not stated). Low levels of moisture in the medium induced better rooting than high levels.

Anzilotti (1) was able to root olive cuttings fully in 60 to 90 days, without the removal of any leaves, by keeping the substrate temperature maintained at 22 to 26C and the relative humidity at 60 to 85%. The percentage of success ranged from 70 to 90 in lignified and 30 to 60 in softwood cuttings.

The time at which cuttings are to be taken, is apparently, related to the condition of the plant and to the climate rather than to the calender. In England's temperate climate hardwood cuttings are prepared and planted in September and October, whereas in parts of North America they are collected in the autumn, stored during the winter and planted in the spring (11).

Tukey and Brase (23), working in New York with apple found that those taken in autumn and stored until spring rooted better than cuttings taken and planted in the spring.

Untreated olive cuttings formed roots more readily when taken in the fall and winter months than in late spring (13). When root-promoting substances were used very good results were obtained with cuttings taken in the spring.

MATERIALS AND METHODS

Rooting of cuttings of the olive variety "Chatawi" was examined using softwood cuttings taken at different times of the year and treated with root-promoting substances before planting. Cuttings were obtained from six bearing trees growing on the campus of the American University of Beirut that received pruning, fertilizer and one summer irrigation. The terminal 12 to 15 cm leafy shoots were removed from the harvested branch and discarded and cuttings approximately 10 cm long and 1 to 1.5 cm thick were made of the remaining material with a sharp pruning secateur. Only mature wood of the latest growth (Fig. 1A) was employed. The cuttings were wrapped in a moist towel during their handling to keep them from desiccation.

Before planting, all leaves from the cuttings, except the uppermost two, were removed. The cuttings were treated with a number of root-promoting substances in different concentrations. The treatments were applied using the concentrated-solution-dip method as described by Cooper (8).

Planting was carried out in flats of vermiculite. The cuttings were set 6 cm deep and 2.5 cm from one another, in rows 4 cm apart. In all, twenty plantings were made at regular fortnightly intervals starting on July 21, 1963.

During the winter and spring months from the 18th of October 1963 to the 15th of June 1964 the flats were placed in a thermostatically controlled electric heated bed with a bottom temperature ranging from 20 to 24C. During the rest of the period the flats were kept outside the hot bed.

Water was sprinkled over the cuttings as and when required. The cuttings remained in the flats for a period of 90 days after which the experiment was terminated.

The experiment was laid out on a randomized block system in which there were eight treatments (root-promoting substances) and twenty blocks (planting dates). The treatments were as follows:

1. Control
2. 2,4-Dichlorophenoxy acetic acid (2,4-D).....200 ppm.
3. 3-Indole butyric acid (IBA).....3000 ppm.
4. 3-Indole butyric acid (IBA).....5000 ppm.
5. Nutrient solution consisting of:

   Water ..... 1000 CC.
   Sucrose..... 5000 ppm.
   Urea..... 1000 ppm.
   Thiamin..... 25 ppm.
   Nicotinic acid..... 25 ppm.

6. Nutrient solution plus IBA at 3000 ppm.
7. Tetra methylthionin chloride (Methylene blue).... 25 ppm.
8. -Naphthalene acetic acid (NAA).....4000 ppm.

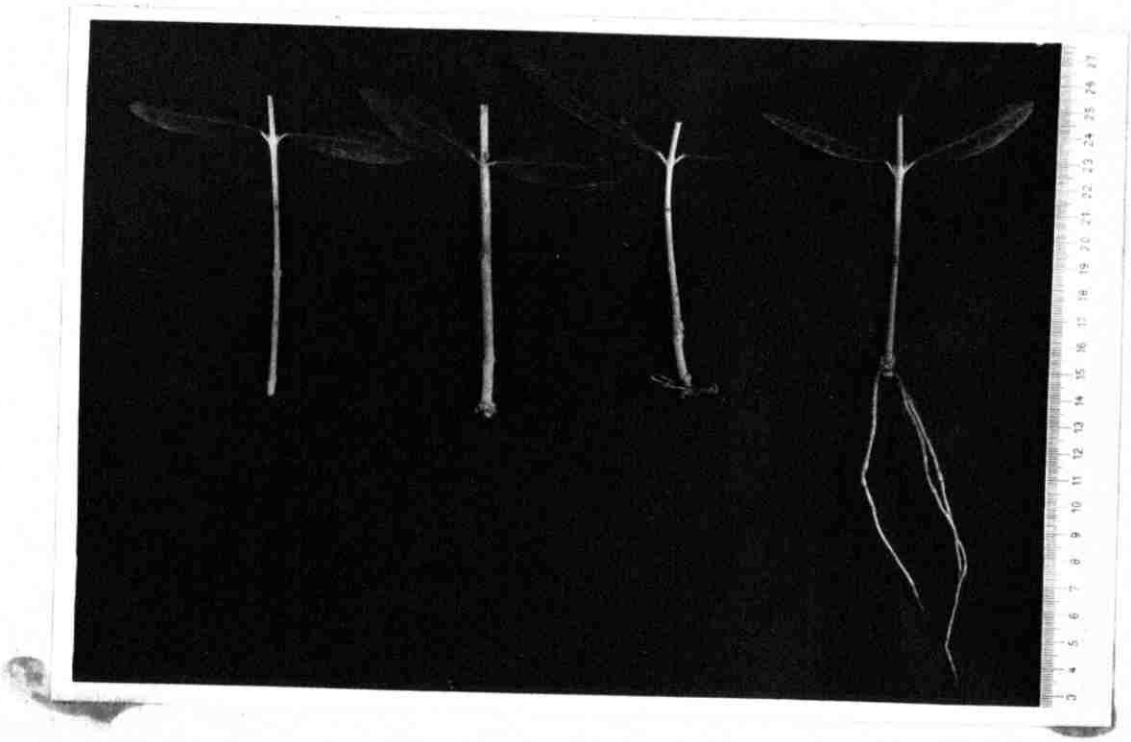
Each treatment consisted of 20 cuttings.

The twenty planting dates were as follows:

1. July 21, 1963
2. August 6, 1963
3. August 21, 1963
4. September 6, 1963
5. September 21, 1963
6. October 6, 1963
7. October 21, 1963
8. November 6, 1963
9. November 21, 1963
10. December 6, 1963
11. December 21, 1963
12. January 6, 1964
13. January 21, 1964
14. February 6, 1964
15. February 21, 1964
16. March 6, 1964
17. March 21, 1964
18. April 6, 1964
19. April 21, 1964
20. May 6, 1964.

Treatments 2 and 7 were dropped from the experiment as of March 6, 1964 on account of shortage of cuttings and the relatively poor performance of these treatments.

The cuttings were examined 30, 45, 60, 75 and 90 days after being placed in the rooting medium for callusing, rooting and survival. Cuttings were considered as callused when callus formation was observable (Fig. 1 B). Rooted cuttings were classified as well-rooted or poorly-rooted according to the number of roots formed and the length attained by them. Only the cuttings that formed at least three roots five centimeters long were classed as well-rooted (Fig. 1 C & D). After every observation the cuttings were replanted discarding the well-rooted and dead cuttings.



A B C D

Fig. 1. Softwood olive cuttings before planting (A), after callusing (B), poorly-rooted (C) and well-rooted (D).

EXPERIMENTAL RESULTS

The results obtained from the rooting of softwood leafy cuttings of olives are reported in tables 1 to 20. The analysis of variance for each character studied is given in the appendix in tables 22 to 25. The experimental findings are reported in three sections, namely callusing, rooting and mortality.

Callusing:

Both time required for callusing and percentage of cuttings callused were affected by planting dates and growth regulators. As seen in tables 1 to 5 callusing started earlier on cuttings planted in mid-summer (July and August) and early spring (February). The above cuttings had the highest amount of callusing 45 days after planting. As rooting time advanced differences in percentage of callusing due to planting dates gradually decreased. After a period of 90 days the highest mean percentages of callusing (30.0 to 33.33% - Table 5) due to planting dates were found on winter and early spring (December 21 to February 21) planted cuttings.

All growth regulators except methylene blue produced faster and higher callusing than the control throughout the period under observation.

Of the growth regulators IBA at 3000ppm and 5000ppm and IBA at 3000ppm with nutrient solution produced faster and higher callusing than the rest of the growth regulators.

The highest percentage of callusing (29.5%) resulted from

the 3000 ppm IBA treatment followed by IBA at 3000 ppm plus nutrient solution (18.25%) and IBA at 5000 ppm (17.0%). Two of the chemicals, 2,2,4-D and methylene blue, produced significantly lower callusing percentages than the rest of the growth regulators. The mean percentage of callusing obtained with 2,4-D in 90 days was 10% and with methylene blue only 3% which was appreciably less than the control (5.0%). With this in view these two treatments were discontinued as of March 6, 1964 when the supply of cuttings ran short.

Rooting:

As shown in tables 6 to 10 there was no rooting during the first 30 days after planting the cuttings, irrespective of the planting dates and treatment with growth regulators.

Rooting started earlier with cuttings planted in late winter (January 21) and early spring (February 21). Percentage of rooting increased under all treatments as time advanced. As shown from the means of planting dates in table 10 the highest rooting percentages (29.16 to 14.16%) were obtained in 90 days after planting during the period from December 21, 1963 to April 6, 1964.

In general, all growth regulators produced faster and higher percentages of rooting than the control. IBA at 3000 ppm

Table 1. Effect of Planting Dates and Growth Regulators on Callusing Percentage of Softwood Olive Cuttings, 30 Days after Planting.

Planting Dates	Growth Regulators						Mean of Planting Date
	Control	IBA 3000ppm	IBA 5000ppm	Nutrient Solution	Nutrient Plus IBA 3000ppm	NAA 4000ppm	
21.7.63	0	25	5	5	20	0	9.16
6.8.63	5	25	10	5	15	5	10.83
21.8.63	0	25	15	5	25	15	14.16
6.9.63	0	0	0	0	0	0	0
21.9.63	0	0	0	0	0	0	0
6.10.63	0	0	0	0	0	0	0
21.10.63	0	0	0	0	0	0	0
6.11.63	0	0	0	0	0	0	0
21.11.63	0	0	0	0	0	0	0
6.12.63	0	0	0	0	0	0	0
21.12.63	0	0	0	0	0	0	0
6.1. 64	0	0	0	0	0	0	0
21.1. 64	0	0	0	0	0	0	0
6.2.64	0	10	5	0	0	5	3.33
21.2.64	0	25	20	0	0	0	7.50
6.3.64	0	0	0	0	0	0	0
21.3.64	0	0	0	0	0	0	0
6.4.64	0	0	0	0	0	0	0
21.4.64	0	0	0	0	0	0	0
6.5.64	0	0	0	0	0	0	0
Mean of Growth Regulator	0.25	5.50	2.75	0.75	3.00	1.25	

Mean of Growth Regulators	5.5	3.0	2.75	1.25	0.75	0.25
Mean of Planting Dates	14.16	10.83	9.16	7.50	3.33	0

N.B. Means underlined by the same line do not differ significantly at the 5% level.

Table 2. Effect of Planting Dates and Growth Regulators on Callusing Percentage of Softwood Olive Cuttings, 45 Days after Planting.

Planting Dates	Growth Regulators						Mean of Planting Date
	Control	IBA 3000ppm	IBA 5000ppm	Nutrient Solution	Nutrient Plus IBA 3000ppm	NAA 4000ppm	
21.7.63	0	25	5	5	20	0	9.16
6.8.63	5	25	15	10	20	15	15.00
21.8.63	0	25	15	5	25	15	14.16
6.9.63	0	0	0	0	0	5	0.83
21.9.63	0	0	0	0	0	0	0
6.10.63	0	0	0	0	0	0	0
21.10.63	0	0	0	0	0	0	0
6.11.63	0	0	0	0	0	0	0
21.11.63	0	0	0	0	0	0	0
6.12.63	0	0	0	0	0	0	0
21.12.63	0	0	0	0	0	0	0
6.1.64	0	0	0	0	0	0	0
21.1.64	10	55	35	15	0	5	20.00
6.2.64	0	15	5	0	0	5	4.16
21.2.64	0	40	40	10	5	10	17.50
6.3.64	0	5	0	0	0	5	1.66
21.3.64	0	20	0	0	10	0	5.00
6.4.64	5	20	5	0	15	25	11.66
21.4.64	0	0	0	0	10	0	1.66
6.5.64	0	0	0	0	0	0	0
Mean of Growth Regulator	1.00	11.50	6.00	2.25	5.25	4.25	

Mean of Growth Regulators: 11.5, 6.0, 5.25, 4.25, 2.25, 1.0

Mean of Planting Dates: 20.0, 17.5, 15.0, 14.16, 11.66, 9.16, 5.0, 4.16, 1.66, 0.83, 0

N.B. Means underlined by the same line do not differ significantly at the 5% level.

Table 3. Effect of Planting Dates and Growth Regulators on Callusing Percentage of Softwood Olive Cuttings, 60 Days after Planting.

Planting Dates	Growth Regulators						Mean of Planting Date
	Control	IBA 3000ppm	IBA 5000ppm	Nutrient Solution	Nutrient Plus IBA 3000ppm	NAA 4000ppm	
21.7.63	0	25	5	10	20	0	10.00
6.8.63	5	25	15	10	20	15	15.00
21.8.63	0	25	15	5	25	15	14.16
6.9.63	0	0	0	0	0	5	0.83
21.9.63	0	0	0	0	0	0	0
6.10.63	10	70	40	0	15	5	23.33
21.10.63	0	40	25	0	0	0	10.83
6.11.63	0	0	0	0	0	0	0
21.11.63	0	0	0	0	0	0	0
6.12.63	0	0	0	0	0	0	0
21.12.63	0	0	0	0	0	0	0
6.1.64	0	45	30	0	30	30	22.50
21.1.64	15	75	35	25	0	5	25.83
6.2.64	0	30	10	0	0	15	9.16
21.2.64	0	50	40	15	25	40	28.33
6.3.64	0	25	5	0	0	20	8.33
21.3.64	5	30	25	15	20	25	20.00
6.4.64	5	25	5	0	30	35	16.66
21.4.64	0	0	0	0	10	0	1.66
6.5.64	0	0	0	0	0	0	0
Mean of Growth Regulator	2.00	23.25	12.50	4.00	9.75	10.50	

Mean of Growth Regulators 23.25 12.5 10.5 9.75 4.0 2.0

Mean of Planting Dates 28.33 25.83 23.33 22.5 20.0 16.66 15.0 14.16 10.83 10.0 9.16 8.33 1.66 0.83 0

N.B. Means underlined by the same line do not differ significantly at the 5% level.

Table 4. Effect of Planting Dates and Growth Regulators on Callusing Percentage of Softwood Olive Cuttings, 75 Days after Planting.

Planting Dates	Growth Regulators						Mean of Planting Date
	Control	IBA 3000ppm	IBA 5000ppm	Nutrient Solution	Nutrient Plus IBA 3000ppm	NAA 4000ppm	
21.7.63	0	25	5	10	20	0	10.00
6.8.63	5	25	15	10	20	15	15.00
21.8.63	0	25	15	5	25	15	14.16
6.9.63	0	0	0	0	0	5	0.83
21.9.63	0	5	0	0	10	0	2.50
6.10.63	10	70	40	0	15	5	23.33
21.10.63	0	40	25	0	0	0	10.83
6.11.63	0	0	5	0	0	0	0.83
21.11.63	0	20	15	0	0	5	6.66
6.12.63	0	0	0	0	0	0	0
21.12.63	15	55	45	0	10	10	22.50
6.1.64	0	45	30	15	60	30	30.00
21.1.64	15	75	35	25	0	5	25.83
6.2.64	0	30	20	0	15	15	13.33
21.2.64	0	50	40	20	25	45	30.00
6.3.64	0	25	5	20	25	35	18.33
21.3.64	5	30	25	15	20	25	20.00
6.4.64	5	25	5	0	30	35	16.66
21.4.64	0	10	0	5	20	0	5.83
6.5.64	0	0	0	0	0	0	0
Mean of Growth Regulator	2.75	27.75	16.25	6.25	14.75	12.25	

Mean of Growth Regulators: 27.75 | 16.25 14.75 12.25 | 6.25 2.75

Mean of Planting Dates: 30.0 25.83 23.33 22.5 20.0 18.33 16.66 15.0 14.16 13.33 10.83 10.0 6.6 5.83 2.5 0.83 0

N.B. Means underlined by the same line do not differ significantly at the 5% level.

Table 5. Effect of Planting Dates and Growth Regulators on Callusing Percentage of Softwood Olive Cuttings, 90 Days after Planting.

Planting Dates	Growth Regulators						Mean of Planting Date
	Control	IBA 3000ppm	IBA 5000ppm	Nutrient Solution	Nutrient Plus IBA 3000ppm	NAA 4000ppm	
21.7.63	5	25	5	10	30	0	12.50
6.8.63	5	25	15	10	25	15	15.83
21.8.63	0	25	15	5	40	25	18.33
6.9.63	0	0	0	0	0	5	0.83
21.9.63	0	5	0	0	10	0	2.50
6.10.63	10	70	40	0	15	5	23.33
21.10.63	5	45	20	0	0	0	11.66
6.11.63	0	0	5	0	0	0	0.83
21.11.63	0	20	15	0	0	5	6.66
6.12.63	0	5	10	0	0	0	2.50
21.12.63	15	55	50	0	30	35	30.83
6.1.64	0	45	30	15	60	30	30.00
21.1.64	35	80	40	25	15	5	33.33
6.2.64	0	30	20	0	15	15	13.33
21.2.64	10	50	40	20	25	55	33.33
6.3.64	0	25	5	20	25	35	18.33
21.3.64	5	30	25	15	20	25	20.00
6.4.64	10	35	5	0	35	40	20.83
21.4.64	0	20	0	10	20	0	8.33
6.5.64	0	0	0	0	0	0	0
Mean of Growth Regulator	5.00	29.50	17.0	6.50	18.25	14.75	

Mean of Growth Regulators 29.5 18.25 17.0 14.75 6.5 5.0

Mean of Planting Dates 33.33 30.83 30.0 23.33 20.83 20.0 18.33 15.83 13.33 12.5 11.66 8.33 6.66 2.5 0.83 0

N.B. Means underlined by the same line do not differ significantly at the 5% level.

gave the highest rooting percentage (16.5%) in 90 days which was significantly different from the rooting percentages (11.5 to 4.25%) obtained with the rest of the growth regulators. The control produced the lowest (2.25%) percentage of rooted cuttings.

Quality of Rooting:

As shown in tables 11 to 15 quality of rooting was more affected by planting dates than by growth regulators. Plantings on January 21 and February 21, 1964 produced significantly higher percentages of well-rooted cuttings than the rest of the planting dates.

Cuttings treated with growth regulators produced good quality roots faster than control cuttings. However after 90 days there were no differences among them as the non treated cuttings had the same quality roots as those treated.

IBA at 3000 ppm, however, was found to differ significantly from the control in inducing better root quality.

Mortality:

As is evident from tables 16 to 20 survival of the cuttings was affected by planting dates. High mortality was observed during the first 45 days after planting but it decreased as time advanced so that negligible numbers of cuttings died during the period 75 to 90 days after planting.

Table 6. Effect of Planting Dates and Growth Regulators on Rooting Percentage of Softwood Olive Cuttings, 30 Days after Planting.

Planting Dates	Growth Regulators						Mean of Planting Date
	Control	IBA 3000ppm	IBA 5000ppm	Nutrient Solution	Nutrient Plus IBA 3000ppm	NAA 4000ppm	
21.7.63	0	0	0	0	0	0	0
6.8.63	0	0	0	0	0	0	0
21.8.63	0	5	0	0	0	0	0.83
6.9.63	0	0	0	0	0	0	0
21.9.63	0	0	0	0	0	0	0
6.10.63	0	0	0	0	0	0	0
21.10.63	0	0	0	0	0	0	0
6.11.63	0	0	0	0	0	0	0
21.11.63	0	0	0	0	0	0	0
6.12.63	0	0	0	0	0	0	0
21.12.63	0	0	0	0	0	0	0
6.1.64	0	0	0	0	0	0	0
21.1.64	0	0	0	0	0	0	0
6.2.64	0	0	0	0	0	0	0
21.2.64	0	0	0	0	0	0	0
6.3.64	0	0	0	0	0	0	0
21.3.64	0	0	0	0	0	0	0
6.4.64	0	0	0	0	0	0	0
21.4.64	0	0	0	0	0	0	0
6.5.64	0	0	0	0	0	0	0
Mean of Growth Regulator	0	0.25	0	0	0	0	

Growth Regulators : Non Significant

Planting Dates : Non Significant

Table 7. Effect of Planting Dates and Growth Regulators on Rooting Percentage of Softwood Olive Cuttings, 45 Days after Planting.

Planting Dates	Growth Regulators						Mean of Planting Date
	Control	IBA 3000ppm	IBA 5000ppm	Nutrient Solution	Nutrient Plus IBA 3000ppm	NAA 4000ppm	
21.7.63	0	0	0	0	0	0	0
6.8.63	0	0	0	0	0	0	0
21.8.63	0	5	0	0	10	0	2.50
6.9.63	0	0	0	0	0	0	0
21.9.63	0	0	0	0	0	0	0
6.10.63	0	0	0	0	0	0	0
21.10.63	0	0	0	0	0	0	0
6.11.63	0	0	0	0	0	0	0
21.11.63	0	0	0	0	0	0	0
6.12.63	0	0	0	0	0	0	0
21.12.63	0	0	0	0	0	0	0
6.1.64	0	0	0	0	0	0	0
21.1.64	0	25	25	5	0	5	10.00
6.2.64	0	0	0	0	0	0	0
21.2.64	0	10	5	0	0	0	2.50
6.3.64	0	0	0	0	0	0	0
21.3.64	0	0	0	0	0	0	0
6.4.64	0	5	0	0	0	0	0.83
21.4.64	0	0	0	0	0	0	0
6.5.64	0	0	0	0	0	0	0
Mean of Growth Regulator	0	2.25	1.50	0.25	0.50	0.25	

Mean of Growth Regulators : Non Significant

Mean of Planting Dates : 10.0 2.50 0.83 0

N.B. Means underlined by the same line do not differ significantly at the 5% level.

Table 8. Effect of Planting Dates and Growth Regulators on Rooting Percentage of Softwood Olive Cuttings, 60 Days after Planting.

Planting Dates	Growth Regulators						Mean of Planting Date
	Control	IBA 3000ppm	IBA 5000ppm	Nutrient Solution	Nutrient Plus IBA 3000ppm	NAA 4000ppm	
21.7.63	0	0	0	0	0	0	0
6.8.63	0	0	0	0	0	0	0
21.8.63	0	5	0	0	5	0	1.66
6.9.63	0	0	0	0	0	0	0
21.9.63	0	0	0	0	0	0	0
6.10.63	0	10	20	0	5	0	5.83
21.10.63	0	10	5	0	0	0	2.50
6.11.63	0	0	0	0	0	0	0
21.11.63	0	0	0	0	0	0	0
6.12.63	0	0	0	0	0	0	0
21.12.63	0	0	0	0	0	0	0
6.1.64	0	15	10	0	0	5	5.00
21.1.64	0	65	30	15	0	5	19.16
6.2.64	0	5	0	0	0	5	1.66
21.2.64	0	25	20	10	10	15	13.33
6.3.64	0	0	0	0	0	10	1.66
21.3.64	0	20	0	5	10	15	8.33
6.4.64	5	15	5	0	20	30	12.50
21.4.64	0	0	0	0	0	0	0
6.5.64	0	0	0	0	0	0	0
Mean of Growth Regulator	0.25	8.50	4.50	1.50	2.50	4.25	

Mean of Growth Regulators : 8.5 4.5 4.25 2.5 1.5 0.25

Mean of Planting Dates : 19.16 13.33 12.5 8.33 5.83 5.0 2.5 1.66 0

N.B. Means underlined by the same line do not differ significantly at the 5% level.

Table 9. Effect of Planting Dates and Growth Regulators on Rooting Percentage of Softwood Olive Cuttings, 75 Days after Planting.

Planting Dates	Growth Regulators						Mean of Planting Date
	Control	IBA 3000ppm	IBA 5000ppm	Nutrient Solution	Nutrient Plus IBA 3000ppm	NAA 4000ppm	
21.7.63	0	0	0	0	0	0	0
6.8.63	0	0	0	0	0	0	0
21.8.63	0	5	0	0	15	5	4.16
6.9.63	0	0	0	0	0	0	0
21.9.63	0	0	0	0	0	0	0
6.10.63	0	10	20	0	5	0	5.83
21.10.63	0	10	5	0	0	0	2.50
6.11.63	0	0	0	0	0	0	0
21.11.63	0	10	10	0	0	5	4.16
6.12.63	0	0	0	0	0	0	0
21.12.63	15	20	15	0	0	0	8.33
6.1.64	0	30	10	5	50	20	19.16
21.1.64	0	65	30	15	0	5	19.16
6.2.64	0	10	15	0	5	5	5.83
21.2.64	0	40	20	15	20	25	20.00
6.3.64	0	20	0	0	10	20	8.33
21.3.64	5	20	10	15	20	20	15.00
6.4.64	5	15	5	0	20	30	12.50
21.4.64	0	5	0	0	15	0	3.33
6.5.64	0	0	0	0	0	0	0
Mean of Growth Regulator	1.25	13.00	7.00	2.50	8.00	6.75	

Mean of Growth Regulators : 13.0 8.0 7.0 6.75 2.5 1.25

Mean of Planting Dates : 20.0 19.16 15.0 12.5 8.33 5.83 4.16 3.33 2.5 0

N.B. Means underlined by the same line do not differ significantly at the 5% level.

Table 10. Effect of Planting Dates and Growth Regulators on Rooting Percentage of Softwood Olive Cuttings, 90 Days after Planting.

Planting Dates	Growth Regulators						Mean of Planting Date
	Control	IBA 3000ppm	IBA 5000ppm	Nutrient Solution	Nutrient Plus IBA 3000ppm	NAA 4000ppm	
21.7.63	0	0	0	5	0	0	0.83
6.8.63	0	0	0	0	0	0	0
21.8.63	0	15	0	0	20	20	9.16
6.9.63	0	0	0	0	0	0	0
21.9.63	0	0	0	0	0	0	0
6.10.63	0	10	20	0	5	0	5.83
21.10.63	0	35	10	0	0	0	7.50
6.11.63	0	0	0	0	0	0	0
21.11.63	0	10	10	0	0	5	4.16
6.12.63	0	0	0	0	0	0	0
21.12.63	15	25	35	0	20	20	19.16
6.1.64	0	30	10	5	50	20	19.16
21.1.64	20	75	35	25	5	5	27.50
6.2.64	0	10	15	0	15	5	7.50
21.2.64	0	45	40	15	25	50	29.16
6.3.64	0	25	0	15	25	35	16.66
21.3.64	5	20	10	15	20	20	15.00
6.4.64	5	20	5	0	25	30	14.16
21.4.64	0	10	0	5	20	0	5.83
6.5.64	0	0	0	0	0	0	0
Mean of Growth Regulator	2.25	16.50	9.50	4.25	11.50	10.50	

Mean of Growth Regulators : 16.5 11.5 10.5 9.5 4.25 2.25

Mean of Planting Dates : 29.16 27.5 19.16 16.66 15.0 14.16 9.16 7.5 5.83 4.16 0.83 0

N.B. Means underlined by the same line do not differ significantly at the 5% level.

Table 11. Effect of Planting Dates and Growth Regulators on Quality of Rooting of Softwood Olive Cuttings, 30 Days after Planting.

Planting Dates	Growth Regulators												Mean of Planting Date	
	Control		IBA 3000ppm		IBA 5000ppm		Nutrient Solution		Nutrient Plus IBA 3000ppm		NAA 4000ppm			
	WR	PR	WR	PR	WR	PR	WR	PR	WR	PR	WR	PR	WR	PR
21.7.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.8.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21.8.63	0	0	0	5	0	0	0	0	0	0	0	0	0	0.83
6.9.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21.9.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.10.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21.10.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.11.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21.11.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.12.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21.12.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.1.64	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21.1.64	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.2.64	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21.2.64	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.3.64	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21.3.64	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.4.64	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21.4.64	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.5.64	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean of Growth Regulator	0	0	0	0.25	0	0	0	0	0	0	0	0		

Mean of Growth Regulators : Non Significant

Mean of Planting Dates : Non Significant

WR : Well-rooted

PR : Poorly-rooted

Table 12. Effect of Planting Dates and Growth Regulators on Quality of Rooting of Softwood Olive Cuttings, 45 Days after Planting.

Planting Dates	Growth Regulators												Mean of Planting Date	
	Control		IBA 3000ppm		IBA 5000ppm		Nutrient Solution		Nutrient Plus IBA 3000ppm		NAA 4000ppm			
	WR	PR	WR	PR	WR	PR	WR	PR	WR	PR	WR	PR	WR	PR
21.7.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.8.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21.8.63	0	0	5	0	0	0	0	0	5	5	0	0	1.66	0.83
6.9.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21.9.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.10.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21.10.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.11.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21.11.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.12.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21.12.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.1.64	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21.1.64	0	0	20	5	15	10	5	0	0	0	5	0	7.50	2.50
6.2.64	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21.2.64	0	0	0	10	0	5	0	0	0	0	0	0	0	2.50
6.3.64	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21.3.64	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.4.64	0	0	0	5	0	0	0	0	0	0	0	0	0	0.83
21.4.64	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.5.64	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean of Growth Regulator	0	0	1.25	1.0	0.75	0.75	0.25	0	0.25	0.25	0.25	0		

Mean of Growth Regulators : Non Significant

Mean of Planting Dates :

(WR)	7.5	1.66	0
(PR)	2.5	0.83	0

WR : Well-rooted

PR : Poorly-rooted

N.B. Means underlined by the same line do not differ significantly at the 5% level.

Table 13. Effect of Planting Dates and Growth Regulators on Quality of Rooting of Softwood Olive Cuttings, 60 Days after Planting.

Planting Dates	Growth Regulators												Mean of Planting Date	
	Control		IBA 3000ppm		IBA 5000ppm		Nutrient Solution		Nutrient Plus IBA 3000ppm		NAA 4000ppm			
	WR	PR	WR	PR	WR	PR	WR	PR	WR	PR	WR	PR	WR	PR
21.7.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.8.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21.8.63	0	0	5	0	0	0	0	0	0	5	0	0	0.83	0.83
6.9.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21.9.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.10.63	0	0	10	0	15	5	0	0	5	0	0	0	5.00	0.83
21.10.63	0	0	5	5	5	0	0	0	0	0	0	0	1.66	0.83
6.11.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21.11.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.12.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21.12.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.1.64	0	0	5	10	0	10	0	0	0	0	5	0	1.66	3.33
21.1.64	0	0	60	5	30	0	15	0	0	0	5	0	18.33	0.83
6.2.64	0	0	0	5	0	0	0	0	0	0	0	5	0	1.66
21.2.64	0	0	10	15	0	20	5	5	0	10	5	10	3.33	10.00
6.3.64	0	0	0	0	0	0	0	0	0	0	0	10	0	1.66
21.3.64	0	0	10	10	0	0	0	5	0	10	0	15	1.66	6.66
6.4.64	5	0	10	5	5	0	0	0	15	5	20	10	9.16	3.33
21.4.64	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.5.64	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean of Growth Regulator	0.25	0	5.75	2.75	2.75	1.75	1.0	0.5	1.0	1.5	1.75	2.5		

Mean of Growth Regulators (WR) : 5.75 2.75 1.75 1.0 0.25

(PR) : Non Significant

Mean of Planting Dates (WR) : 18.33 9.16 5.0 3.33 1.66 0.83 0

(PR) : 10.0 6.66 3.33 1.66 0.83 0

WR : Well-rooted
PR : Poorly-rooted

N.B. Means underlined by the same line do not differ significantly at the 5% level.

Table 14. Effect of Planting Dates and Growth Regulators on Quality of Rooting of Softwood Olive Cuttings, 75 Days after Planting.

Planting Date	Growth Regulators												Mean of Planting Date	
	Control		IBA 3000ppm		IBA 5000ppm		Nutrient Solution		Nutrient Plus IBA 3000ppm		NAA 4000ppm			
	WR	PR	WR	PR	WR	PR	WR	PR	WR	PR	WR	PR	WR	PR
21.7.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.8.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21.8.63	0	0	5	0	0	0	0	0	15	0	5	0	4.16	0
6.9.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21.9.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.10.63	0	0	10	0	15	5	0	0	5	0	0	0	5	0.83
21.10.63	0	0	5	5	5	0	0	0	0	0	0	0	1.66	0.83
6.11.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21.11.63	0	0	10	0	10	0	0	0	0	0	5	0	4.16	0
6.12.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21.12.63	15	0	10	10	10	5	0	0	0	0	0	0	5.83	2.50
6.1.64	0	0	25	5	10	0	5	0	40	10	20	0	16.66	2.50
21.1.64	0	0	60	5	30	0	15	0	0	0	5	0	18.33	0.83
6.2.64	0	0	10	0	15	0	0	0	5	0	0	5	5.00	0.83
21.2.64	0	0	35	5	15	5	15	0	15	5	20	5	16.66	3.33
6.3.64	0	0	10	10	0	0	0	0	0	10	10	10	3.33	5.00
21.3.64	5	0	20	0	10	0	15	0	20	0	20	0	15.00	0
6.4.64	5	0	10	5	5	0	0	0	15	5	20	10	9.25	3.33
21.4.64	0	0	0	5	0	0	0	0	10	5	0	0	1.66	1.66
6.5.64	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean of Growth Regulator	1.25	0	10.5	2.5	6.25	0.75	2.5	0	6.25	1.75	5.25	1.5		

Mean of Growth Regulators (WR) : 10.5 6.25 5.25 2.5 1.25

(PR) : 2.5 1.75 1.5 0.75 0

Mean of Planting Dates (WR) : 18.33 16.66 15.0 9.25 5.83 5.0 4.16 3.33 1.66 0

(PR) : 5.0 3.33 2.5 1.66 0.83 0

WR : Well-rooted
PR : Poorly-rooted

N.B. Means underlined by the same line do not differ significantly at the 5% level.

Table 15. Effect of Planting Dates and Growth Regulators on Quality of Rooting of Softwood Olive Cuttings, 90 Days after Planting.

Planting Dates	Growth Regulators												Mean of Planting Date	
	Control		IBA 3000ppm		IBA 5000ppm		Nutrient Solution		Nutrient Plus IBA 3000ppm		NAA 4000ppm			
	WR	PR	WR	PR	WR	PR	WR	PR	WR	PR	WR	PR	WR	PR
21.7.63	0	0	0	0	0	0	0	5	0	0	0	0	0	0.83
6.8.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21.8.63	0	0	10	5	0	0	0	0	15	5	15	5	6.66	2.50
6.9.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21.9.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.10.63	0	0	10	0	15	5	0	0	5	0	0	0	5.00	0.83
21.10.63	0	0	35	0	10	0	0	0	0	0	0	0	7.50	0
6.11.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21.11.63	0	0	10	0	10	0	0	0	0	0	5	0	4.16	0
6.12.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21.12.63	15	0	25	0	35	0	0	0	15	5	20	0	18.33	0.83
6.1.64	0	0	25	5	10	0	5	0	40	10	20	0	16.66	2.50
21.1.64	10	10	75	0	35	0	25	0	5	0	5	0	25.83	1.66
6.2.64	0	0	10	0	15	0	0	0	15	0	0	5	6.66	0.83
21.2.64	0	0	45	0	40	0	15	0	25	0	45	5	28.33	0.83
6.3.64	0	0	20	5	0	0	15	0	25	0	35	0	15.83	0.83
21.3.64	5	0	20	0	10	0	15	0	20	0	20	0	15.00	0
6.4.64	5	0	15	5	5	0	0	0	15	10	25	5	10.83	3.33
21.4.64	0	0	5	5	0	0	0	5	15	5	0	0	3.33	2.50
6.5.64	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean of Growth Regulator	1.75	0.5	15.25	1.25	9.25	0.25	3.75	0.5	9.75	1.75	9.5	1.0		

Mean of Growth Regulators (WR): 15.25 9.75 9.5 9.25 3.75 1.75
(PR): Non Significant

Mean of Planting Dates (WR): 28.33 25.83 18.33 16.66 15.83 15.0 10.83 7.5 6.66 5.0 4.16 3.33 0
(PR): Non Significant

WR : Well-rooted
PR : Poorly-rooted

N.B. Means underlined by the same line do not differ significantly at the 5% level.

The highest mortality percentage was recorded for the cuttings planted on July 21 (59.16%) and August 6 (45.0%) and the least (Maximum of 8.33%) for the winter and spring plantings (January 6 to May 6, excepting, March 6). It was observed that cuttings started dying earlier when planted in summer (July and August) and winter (December) as compared with cuttings planted in spring (February to April).

The growth regulator treatments employed in this study did not show significant effects on the percentage of mortality. The final mortality percentage recorded 90 days after planting was appreciably less (13.75%) with the control cuttings, cuttings treated with IBA at 3000 ppm (11.25%) or cuttings treated with IBA at 3000 ppm plus nutrients (12.0%) as compared with data recorded for the cuttings treated with IBA at 5000 ppm (17.75%), nutrients solution (17.25%) or NAA (19.5%).

Table 16. Effect of Planting Dates and Growth Regulators on Percentage Dead Softwood Olive Cuttings, 30 Days after Planting.

Planting Dates	Growth Regulators						Mean of Planting Date
	Control	IBA 3000ppm	IBA 5000ppm	Nutrient Solution	Nutrient Plus IBA 3000ppm	NAA 4000ppm	
21.7.63	30	25	45	30	5	55	31.66
6.8.63	5	0	0	0	5	0	1.66
21.8.63	0	5	5	0	0	0	1.66
6.9.63	0	0	0	0	0	0	0
21.9.63	0	0	0	0	0	0	0
6.10.63	0	0	0	0	0	0	0
21.10.63	0	0	0	0	0	0	0
6.11.63	0	0	0	0	0	0	0
21.11.63	0	0	0	0	0	0	0
6.12.63	0	0	0	0	0	0	0
21.12.63	0	0	0	0	0	0	0
6.1.64	0	0	0	0	0	0	0
21.1.64	0	0	0	0	0	0	0
6.2.64	0	0	0	0	0	0	0
21.2.64	0	0	0	0	0	0	0
6.3.64	0	0	0	0	0	0	0
21.3.64	0	0	0	0	0	0	0
6.4.64	0	0	0	0	0	0	0
21.4.64	0	0	0	0	0	0	0
6.5.64	0	0	0	0	0	0	0
Mean of Growth Regulator	1.75	1.50	2.50	1.50	0.50	2.75	

Growth Regulators : Non Significant

Mean of Planting Dates: 31.66 1.66 0

N.B. Means underlined by the same line do not differ significantly at the 5% level.

Table 17. Effect of Planting Dates and Growth Regulators on Percentage of Dead Softwood Olive Cuttings, 45 Days after Planting.

Planting Dates	Growth Regulators						Mean of Planting Date
	Control	IBA 3000ppm	IBA 5000ppm	Nutrient Solution	Nutrient Plus IBA 3000ppm	NAA 4000ppm	
21.7.63	30	25	45	30	5	55	31.66
6.8.63	45	30	30	10	5	5	20.83
21.8.63	0	5	10	0	0	0	2.50
6.9.63	0	0	0	0	0	0	0
21.9.63	0	0	0	0	0	0	0
6.10.63	0	0	0	0	0	0	0
21.10.63	0	0	0	0	0	0	0
6.11.63	0	0	0	0	0	0	0
21.11.63	0	0	0	0	0	0	0
6.12.63	20	55	15	40	35	50	35.83
21.12.63	5	0	5	5	10	15	6.66
6.1.64	0	0	0	0	0	0	0
21.1.64	5	0	0	5	5	5	3.33
6.2.64	0	0	0	0	0	0	0
21.2.64	0	0	0	0	0	0	0
6.3.64	0	0	0	0	0	0	0
21.3.64	0	0	0	0	0	0	0
6.4.64	0	0	10	5	0	0	2.50
21.4.64	5	5	10	5	0	5	5.00
6.5.64	0	0	0	0	0	0	0
Mean of Growth Regulator	5.50	6.0	6.25	5.0	3.0	6.75	

Growth Regulators : Non Significant

Mean of Planting Dates : 35.83 31.66 20.83 6.66 5.0 3.33 2.5 0

N.B. Means underlined by the same line do not differ significantly at the 5% level.

Table 18. Effect of Planting Dates and Growth Regulators on Percentage of Dead Softwood Olive Cuttings, 60 Days after Planting.

Planting Dates	Growth Regulators						Mean of Planting Date
	Control	IBA 3000ppm	IBA 5000ppm	Nutrient Solution	Nutrient Plus IBA 3000ppm	NAA 4000ppm	
21.7.63	50	70	80	45	40	70	59.16
6.8.63	45	30	30	10	5	5	20.83
21.8.63	0	5	10	0	0	0	2.50
6.9.63	0	0	5	5	0	10	3.33
21.9.63	0	0	0	0	0	0	0
6.10.63	0	0	0	0	0	0	0
21.10.63	5	0	0	0	0	0	0.83
6.11.63	0	0	0	0	0	0	0
21.11.63	0	0	0	0	0	0	0
6.12.63	20	55	15	40	35	50	35.83
21.12.63	5	0	5	5	10	15	6.66
6.1.64	10	0	10	15	0	0	5.83
21.1.64	5	0	0	5	5	5	3.33
6.2.64	0	0	0	0	0	0	0
21.2.64	0	0	0	10	15	0	4.16
6.3.64	0	0	0	0	0	0	0
21.3.64	0	0	0	10	5	0	2.50
6.4.64	0	0	10	5	5	0	3.33
21.4.64	5	5	10	5	0	5	5.00
6.5.64	0	0	0	0	0	0	0
Mean of Growth Regulator	7.25	8.25	8.75	7.75	6.00	8.00	

Growth Regulators : Non Significant

Mean of Planting Dates : 59.16 35.83 20.83 6.66 5.83 5.0 4.16 3.33 2.50 0.83 0

N.B. Means underlined by the same line do not differ significantly at the 5% level.

Table 19. Effect of Planting Dates and Growth Regulators on Percentage of Dead Softwood Olive Cuttings, 75 Days after Planting.

Planting Dates	Growth Regulators						Mean of Planting Date
	Control	IBA 3000ppm	IBA 5000ppm	Nutrient Solution	Nutrient Plus IBA 3000ppm	NAA 4000ppm	
21.7.63	50	70	80	45	40	70	59.16
6.8.63	45	30	30	10	5	5	20.83
21.8.63	5	5	45	0	15	0	11.66
6.9.63	0	0	5	5	0	10	3.33
21.9.63	0	0	0	0	0	0	0
6.10.63	0	0	10	0	0	45	9.16
21.10.63	5	0	0	0	0	0	0.83
6.11.63	10	5	15	25	10	55	20.00
21.11.63	40	15	25	55	25	55	35.83
6.12.63	20	55	15	40	35	50	35.83
21.12.63	10	5	10	15	10	15	10.83
6.1.64	10	0	10	15	0	0	5.83
21.1.64	5	0	0	5	5	5	3.33
6.2.64	0	0	0	5	0	0	0.83
21.2.64	0	0	0	15	15	0	5.00
6.3.64	15	0	15	0	0	0	5.00
21.3.64	10	0	15	10	10	0	7.50
6.4.64	0	0	10	5	5	0	3.33
21.4.64	5	5	10	5	0	5	5.00
6.5.64	0	0	0	0	0	0	0
Mean of Growth Regulator	11.50	9.50	14.75	12.75	8.75	15.75	

Growth Regulators : Non Significant

Mean of Planting Dates : 59.16 35.83 <u>20.83 20.0 11.66 10.83 9.16 7.5 5.83 5.0 3.33 0.83</u> 0

N.B. Means underlined by the same line do not differ significantly at the 5% level.

Table 20. Effect of Planting Dates and Growth Regulators on Percentage of Dead Softwood Olive Cuttings, 90 Days after Planting.

Planting Dates	Growth Regulators						Mean of Planting Date
	Control	IBA 3000ppm	IBA 5000ppm	Nutrient Solution	Nutrient Plus IBA 3000ppm	NAA 4000ppm	
21.7.63	50	70	80	45	40	70	59.16
6.8.63	60	35	50	40	40	45	45.00
21.8.63	5	5	45	0	15	0	11.66
6.9.63	0	0	5	5	0	10	0.33
21.9.63	20	5	5	0	10	25	10.83
6.10.63	0	0	10	0	0	45	9.16
21.10.63	5	5	25	5	0	5	7.50
6.11.63	10	5	15	25	10	55	20.00
21.11.63	40	15	25	55	25	55	35.83
6.12.63	20	55	15	70	35	50	40.83
21.12.63	10	5	10	15	10	15	10.83
6.1.64	10	0	10	15	0	0	5.83
21.1.64	5	0	0	5	5	5	3.33
6.2.64	0	0	0	5	0	0	0.83
21.2.64	10	0	0	25	15	0	8.33
6.3.64	15	20	25	15	20	5	16.66
21.3.64	10	0	15	10	10	0	7.50
6.4.64	0	0	10	5	5	0	3.33
21.4.64	5	5	10	5	0	5	5.00
6.5.64	0	0	0	0	0	0	0
Mean of Growth Regulator	13.75	11.25	17.75	17.25	12.00	19.50	

Growth Regulators : Non Significant

Mean of Planting Dates: 59.16 <u>45.0 40.83 35.83</u> 20.0 16.66 11.66 10.83 9.16 8.33 7.50 5.83 5.0 3.33 0.83 0

N.B. Means underlined by the same line do not differ significantly at the 5% level.

DISCUSSION OF RESULTS

Planting dates and growth regulators produced a marked effect on callusing, rooting, rooting quality and survival of the cuttings.

Callusing started earlier in the mid-summer and early spring plantings than in the autumn and winter plantings but rooting was not enhanced. Callusing was retarded but earlier and higher rooting percentages were obtained when the cuttings were planted during the winter and spring months, from December 21, 1963 to April 6, 1964.

Early callusing during the mid-summer period seems to be due to the relatively high temperature (32.63 C — Table 21) occurring during this period. Such high temperatures are known to produce fast and soft callus tissue but not necessarily fast root formation. On the other hand the temperature during the winter and spring months when callusing was retarded was controlled at 20 — 22 C, which seemed to be lower than that required for early callusing. However, the temperature of 20 - 22 C was favorable for root formation and appears to be responsible possible for the earlier and higher rooting percentages obtained during the winter and spring months. Root formation was delayed in mid-summer despite early callusing. This is probably due to the higher temperature prevailing during this period which induced above ground vegetative activity thus interfering with root formation. During winter and spring the cuttings ttings were provided with an optimum soil temperature for

callusing, while the above ground parts were kept from growing; this produced an ideal situation for root formation. Anzilotti (1) also found that olive cuttings will root in 60 to 90 days if the substrate temperature is maintained at 22 to 26 C. Hartmann (13, 14) observed that in general better results were obtained when bottom heat at 23C was used together with high humidity in rooting softwood cuttings of olives.

Early rooting in the winter and spring months also appears to be due to the presence of sufficient reserves of carbohydrates that accumulated in the cuttings during this period of no vegetative activity. It has been established by many investigators (11, 17, 18) that by the onset of the winter period large amounts of carbohydrates accumulate in the shoots and that a high carbohydrate content in cuttings is essential for root formation. According to Garner (11) Starring, Knight and Hatcher all found that a high carbohydrate content of softwood cuttings with low soluble nitrogen favored rooting. Trials of Jacoboni (17) showed that an efficient and rapid method of propagating olives included the use of mist aided by previously ringing the shoots to be used as cuttings. Khan (18) found that olive cuttings taken from normal shoots did not root at all, however, 10% rooting was obtained when cuttings were taken from shoots preconditioned by lifting a two inches wide ring of bark during the summer months. Since olives continue their vegetative growth till late autumn, he suggested that the success

with ringing was probably due to the accumulation of carbohydrates.

Plantings made during winter and spring produced a higher percentage of well-rooted cuttings. This seems to be due to the early rooting of these cuttings which gave the roots a relatively longer time to develop.

Percentage of dead cuttings was high when plantings were made during the summer months. This appears to be due to the high maximum and minimum temperatures (32.63 and 25.17C respectively - Table 21) with a comparatively low relative humidity (71.4%) that prevailed during this time. The above situation induced rapid desiccation and death of the tissues. During the summer months the trees were growing fast and there was fruit on them. Therefore, cuttings taken during this period were low in carbohydrate content which also seems to be responsible for the high mortality of the cuttings.

Untreated cuttings formed roots more readily when planted in the late winter and spring months. This finding is in accordance with the findings of Hartmann (13). He reported more rooting of olives to occur when the cuttings were taken during the fall and winter months as compared to late spring.

Preplanting application of growth regulators to the cuttings enhanced callusing and rooting and increased the rooting percentage of cuttings. The benefits obtained from the use of certain synthetic compounds in rooting cuttings of different plant species have been reported by many investigators

(10, 11, 12, 19, 24, 25, 26). It is believed that auxin is necessary for root growth (7), and that this material translocates down from the apex of the shoot. Supplying the bases of cuttings with additional auxin or with some of the synthetic auxin-like compounds such as IBA or NAA will increase the rooting of cuttings. According to Loreti (19), however, callus formation was not affected when cuttings of a number of olive varieties were treated with different synthetic compounds. He, therefore, concluded that varieties responded differently to synthetic growth regulators. The early callusing obtained with treated cuttings of the olive variety "Chatawi", in this experiment indicates that this variety responds to the use of synthetic growth regulators.

Of the treatments, methylene blue at 25 ppm resulted in the lowest percentage of rooted cuttings. Blattny and Robek (3) reported that the application of 1:1000 solution of methylene blue for 30 minutes stimulated the formation of roots on hop cuttings. The ineffectiveness of this chemical on olive cuttings may be due to the relatively low concentration used or because olives do not respond to this chemical.

2,4-D at 200 ppm also gave poor results as compared to the rest of the growth regulators. The reason for this appears to be the use of too high a concentration (200 ppm) as is indicated by the high mortality percentage (22.6%) of cuttings treated with this compound. Further, 2,4-D might not be

effective in inducing rooting of leafy cuttings of olives.

Cuttings treated with IBA at 3000 ppm gave the highest rooting percentage. According to Garner (11), Hooker found IBA useful in stimulating root formation in cuttings of mango which does not root easily without treatment. Hartmann (14) also obtained the highest rooting percentage of softwood olive cuttings by using IBA solutions at 3000 to 7000 ppm.

Treatment with IBA at 3000 ppm resulted in significantly higher rooting percentage than IBA at 3000 ppm plus nutrient solution (Table 10). This finding is contrary to that of Cajlahjan (6) who observed synergism when IAA, IBA or NAA was applied with one of the vitamins which by themselves had no significant effect on root growth. Graham (12), however, found that adenine inhibited rooting of Prunus cerasifera cuttings when used alone and retarded rooting when used with IBA. It, therefore, appears that the nutrient solution and IBA may be antagonistic to one another, or combined do not have any apparent effect on olive cuttings.

SUMMARY AND CONCLUSIONS

This study was conducted during the year 1963-64 at the American University of Beirut to determine the effect of twenty planting dates and of seven growth regulators on rooting of softwood stem cuttings of the olive variety "Chatawi". The planting dates were 21 st of July, 6th and 21 st of each of the months of August, September, October, November and December 1963, 6th and 21 st of January, February, March and April and the 6th of May 1964. The growth regulators consisted of 2,4-D at 200 ppm, IBA at 3000 ppm and at 5000 ppm, nutrient solution, nutrient solution plus IBA at 3000 ppm, methylene blue at 25 ppm and NAA at 4000 ppm.

Before planting all leaves from the cuttings except the uppermost two were removed and the cuttings treated with the growth regulators using the concentrated-solution-dip method. Cuttings were planted in flats of vermiculite where they remained for a period of 90 days. During the winter and spring months from October 18, 1963 to June 15, 1964 the flats were provided with bottom heat maintained at 20 - 22 C.

The cuttings were examined 30, 45, 60, 75 and 90 days after being placed in the rooting medium for callusing, rooting and survival. Rooted cuttings were classified as well-rooted or poorly-rooted. Only the cuttings that formed at least three roots five centimeters long were classed as well-rooted.

Cuttings planted during mid-summer and early spring

started callusing the earliest but the final percentage of callusing (33.33%) and rooting (29.16%) were the highest for the cuttings planted during the period from December 21, 1963 to February 21, 1964.

The percentage of well-rooted cuttings was significantly higher when the cuttings were taken on January 21 or on February 21, 1964.

The highest mortality was observed for the cuttings planted during the months of July and August.

Whereas all growth regulators except methylene blue produced faster and higher callusing than the control, the highest percentages of callusing and rooting were obtained with IBA at 3000 ppm or IBA at 3000 ppm plus nutrient solution.

Quality of rooting was not appreciably affected by growth regulators and the cuttings treated with growth regulators except IBA at 3000 ppm, did not differ significantly from the untreated cuttings in the percentage of well-rooted cuttings. Treatment of the cuttings with IBA at 3000 ppm, however, significantly increased the percentage of well-rooted cuttings as compared with the control.

The percentage of mortality was the least with the untreated cuttings or cuttings treated with IBA at 3000 ppm alone or in combination with the nutrient solution. The highest mortality was observed for the cuttings treated with NAA at 4000 ppm or IBA at 5000 ppm.

The results of the experiment indicate that the best time for rooting softwood cuttings of the olive variety "Chatawi" in Lebanon is during the winter or spring months. Pre-planting treatment of the cuttings with the root-promoting substance, IBA at 3000ppm, will enhance rooting and will improve the percentage of well-rooted cuttings. A good medium for rooting the cuttings was found to be vermiculite. Bottom heat at about 20 to 24C enhanced rooting. The cuttings should be well watered at regular intervals to prevent drying up of leaves. Under such conditions 75% rooting of cuttings was achieved in a period of 90 days.

LITERATURE CITED

1. Anzilotti, F. 1961. Intensive olive growing and mist humidification of cuttings. Ital. Agric. 98:771-84. Hort. Abs. 32 : 1790.

2. Bernardi, J.B., and R. Inforzato. 1958. Rooting of olive softwood cuttings. (English Summary). Bragantia 17 : lx — xlv. Hort. Abs. 30 : 1198.

3. Blattny, C., and A. Robek . 1937. Influence of methylene blue on hop cuttings. (German Summary). Ann. Acad. Tchecosl. Agric. 12: 5883-90 Hort. Abs. 9 : 6.

4. Blommaert, K. L. J. 1953. The rooting of growth-substance treated olive cuttings. Fmg. S. Afri. 28 : 137, 140. Hort. Abs. 23 : 4542.

5. Breviglieri, N., and L. Costal. 1957. Mist propagation of cuttings. Ital. Agric. 94 : 21 - 39. Hort. Abs. 28 : 3971.

6. Cajlahjan, M:H., R.H., Tureckaja and N.S., Klujuskine . 1961. The interaction of physiologically active substances in plant cuttings during the formation and growth of roots and stems. (Russian). Fiziol. Rast. 8 : 601 - 12. Hort. Abs. 32 : 2191.

7. Chandler, W.H. 1958. Evergreen orchards. Lea and Febiger. Philadelphia.

8. Cooper, W.C. 1944. The concentrated-solution-dip method of treating cuttings with growth substances. Proc. Amer. Soc. Hort. Sci. 44 : 533.

9. Elant, H., and J. Perrot. 1952. The propagation of olive trees by cuttings. Rev. Agric. Afri. N. 1711. Hort. Abs. 22 : 3403.

10. Evenari, and E. Konis. 1938. The effect of hetero-auxin on root formation by cuttings. Palestine J. Bot. (Jerusalem). I: 13 - 26. Part II. Ibidem. I : 113-8. Hort. Abs. 9 : 5.

11. Garner, R.J. 1947. Propagation by cuttings and layers. Imperial bureau of Hort. Plantation Crops. Tech. Communication. No : 14.

12. Graham, S.O. 1958. Factors in propagating presumably virus-free prunus understock clones by softwood cuttings. Wash. Agric. Expt. Sta. Bull. 581 : 66.

13. Hartmann, H.T. 1946 . Root promoting substances and olive cuttings. Proc. Amer. Soc. Hort. Sci. 48 : 303.

14. _____. 1952. Further studies on the propagation of the olive by cuttings. Proc. Amer. Soc. Hort. Sci. 59:155.

15. _____. 1962. Olive growing in Australia. Econ. Bot. 16 : 31 - 44.

16. _____; and C.J. Hansen. 1955. Rooting of softwood cuttings under mist. Proc. Amer. Soc. Hort. Sci. 66: 157-67.

17. Jacoboni, N. 1958. The importance of previous ringing for the successful mist propagation of olives. (English Summary). Ann. Sper. Agrar. 12: 1533-56. Hort. Abs. 29 : 2897.

18. Khan, M:S., and I.U. Khan. 1962. Propagation of olives. Agric. Pakistan. xlll. No. 3.

19. Loreti, F. 1962. Studies on the use of root-inducing substances in mist propagation of olives from cuttings. (Italian). Frutticoltura. 24 : 637 - 45. Hort. Abs. 33 : 3898.

20. Riehl, G. 1956. The beneficial or injurious effects of growth substance applications in relation to environmental conditions. Dtsch. Gartenb. 3 : 287 - 91. Hort. Abs. 27 : 1718.

21. Shugert, R. 1955. Out door propagation under constant mist in Missouri. Amer. Nurserym. 101 (2): 13 - 14, 48 - 9. Hort. Abs. 25 : 1955.

22. Stcherbakoff, A.N. 1940. On the vegetative propagation of olives . (Russian). Soviet. Subtropics. No. 9. PP. 36 - 8. Hort. Abs. 11 : 893.

23. Tukey, H.B., and K. Brase. 1935. Random notes on fruit tree propagation. N.Y. St. Agric. Exp. Sta. Bull. 657-26.

24. Tureckaja, R.H. 1960. The role of leaves and buds in the formation of roots on stem cuttings. (Russian). Fiziol. Rast. 7 : 531 - 6. Hort. Abs. 31 : 3635.

25. Zatyko, J. 1959. The rooting of cuttings of fruit tree rootstock and scion varieties with the aid of synthetic growth substances and tissue transplantation. (Russian and German summaries ½ p. each). Kiserl. Kozlem. Sect. C, 52C (2) : 55 - 73. Hort. Abs. 31 : 222.

26. Zheziang Whangyan Citrus Experimental Station. 1958. Quicker and cheaper propagation of citrus nursery stock. Chinese J. Agric. 22 : 38. From Biol. Abs. Sect. D, 36, Abs. 21. Hort. Abs. 31 : 5132.

A P P E N D I X

Table 21. Average Monthly Temperature in Degrees C and Rainfall in m.m. at the American Univ. of Beirut from July 1963 to May 1964.

Month		Mean Max. Temp.	Mean Mini. Temp.	Rainfall	Mean Rel. Humidity %
July,	1963	30.94	24.26	0.00	72.2
August,	1963	32.63	25.17	0.00	71.4
September,	1963	30.40	24.09	22.08	67.5
October,	1963	26.83	20.93	94.65	70.6
November,	1963	22.58	17.36	136.80	70.6
December,	1963	18.34	12.58	137.05	66.6
January,	1964	15.16	10.02	96.30	62.2
February,	1964	16.94	10.79	319.90	73.4
March,	1964	19.40	13.80	91.10	75.7
April,	1964	21.50	15.20	21.10	67.9
May,	1964	23.00	17.00	53.70	72.3

Table 22. Analysis of Variance for Percentage Callusing of Softwood Olive Cuttings, 90 Days after Planting.

Source	D.F.	M.S.	
Planting Dates	19	748.9	xx
Growth Regulators	5	1587.8	xx
Error	95	141.8	

Table 23. Analysis of Variance for Percentage Rooting of Softwood Olive Cuttings, 90 Days after Planting.

Source	D.F.	M.S.	
Planting Dates	19	998.7	xx
Growth Regulators	5	2314.5	xx
Error	95	6.4	

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xx Denotes F values significant at the 1% level.

Table 24. Analysis of Variance for Quality of Rooting of Softwood Olive Cuttings, 90 Days after Planting.

Source	D.F.	M.S. (well-rooted)	M.S.(poorly-rooted)
Planting Dates	19	482.5 xx	6.78
Growth Regulators	5	465.2 xx	6.4
Error	95	88.3	4.4

Table 25. Analysis of Variance for Percentage of Dead Softwood Olive Cuttings, 90 Days after Planting.

Source	D.F.	M.S.
Planting Dates	19	1652.6 xx
Growth Regulators	5	228.5
Error	95	131.0

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xx Denotes F values significant at the 1% level.