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Propagation of Lime by Stem Cuttings

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Abstract: An experiment was conducted during three consecutive years (2002, 2003 and 2004) to study the effects of season of the year, girdling and planting interval after girdling on rooting of stem cuttings of "Baladi" lime {*Citrus aurantifolia* (Christm.) Swing.}. Three types of stem cutting were used; namely, non-girdled and girdled apical and basal cuttings. All cuttings were collected from a single lime tree during the summer, autumn and winter seasons of each year from non-girdled and girdled branches at intervals of 2, 4, 6, 8 and 10 weeks after girdling. Cuttings were planted in sand soil in plastic trays and were kept under a plastic tent in a lath house. Cuttings planted during autumn and winter gave significantly higher percentage of rooted cuttings than the summer planted ones. Also, girdled apical cuttings gave significantly high rooting percentage compared to the girdled basal cuttings. On the other hand, no significant differences were obtained between planting intervals of 2, 4, 6, and 8 weeks after girdling, while cuttings taken 10 weeks after girdling gave significantly higher rooting percentage than the other intervals. It seems that temperature, relative humidity and the accumulative increase in quantity and quality of carbohydrates, root promoters and inhibitors play an important role, among other factors, in the rooting of lime stem cuttings.

Key words: Lime (*Citrus aurantifolia*); propagation; stem cuttings; own-rooted trees

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INTRODUCTION

Lime {*Citrus aurantifolia* (Christm.) Swing.} is a member of the family Rutaceae. It is extensively cultivated in hot tropical and semi- and sub-tropical regions of the world for its fresh juice and as flavouring for many foods. Lime trees can survive on poor soils and are thus widely grown in schools, hospitals, houses and other governmental premises in Sudan.

Most citrus cultivars can be propagated by seeds. Seedling citrus trees are found in many tropical countries on small scale plantings, but large scale plantations generally use budded trees. The budded seedling method is usually the most widely used and most practical method for the vegetative propagation of large number of trees for commercial citrus plantation. An unusual practice of horticultural interest used in the culture of lime, however, is the use of seedling trees rather than budded trees in establishing large scale plantations. Being a very distinct species, not closely related to other *Citrus* spp., no satisfactory rootstock is known for lime, and there has been only limited experience with lime on different rootstocks showing signs of incompatibility with other citrus species and citrus relatives (Purseglove 1984). The budding method for clonal propagation has proved to be impractical for lime.

Many *Citrus* spp. can be propagated by rooting of cuttings (Platt and Opitz 1973; Sabbah *et al.* 1991), known as own-rooted citrus trees. More recently, interest in own-rooted fruit trees has increased for its effectiveness in rapid and economic propagation of large number of plants, and attaining planting size eight months after rooting compared with the two to three years required for budded trees. Cuttings also provide a rapid means of obtaining uniform rootstock material for budding, especially of selections of short seed supply or varieties producing seeds having low viability or a low percentage of nucellar seedlings (Platt and Opitz 1973).
The objective of this research was to develop an easy, quick and simple method for the clonal propagation of lime by rooting of stem cuttings.

MATERIALS AND METHODS

Experiments were conducted during summer (April-July), autumn (August-November) and winter (December-March) seasons of the years 2002, 2003 and 2004 using cuttings collected from a 10-year-old "Baladi" lime tree growing in the orchard of the School of Gardening and Nutrition of the Ministry of Education, El-Dammar (Latitude $15^0$1'N; Longitude $36^0$4'E), Sudan.

Selected branches with uniform thickness were girdled (ringed) at the appropriate season of each year. Branches were cut for all experimentation above the girdle at two weeks interval (2, 4, 6, 8, and 10 weeks) after girdling. Stem cuttings of 7 cm length containing 1-2 lateral buds were used as planting material. The basal end of all cuttings was dipped for few seconds in the commercial rooting formulation (Seradix II) powder just prior to planting - a practice commonly used by nurserymen for rooting of semi-hard wood shoot cuttings of various ornamental plant species.

The cuttings were then planted in sand soil in 27x24x7 cm plastic trays with nine drainage holes at the bottom. The planted cuttings were kept under plastic covered frames (tents) in a lath house. The plastic covered frames were made of wood with dimensions of 300x150x23 cm and covered with white transparent plastic to maintain high relative humidity around the cuttings. Watering was done once every day by spraying.

The treatments consisted of three types of stem cuttings, viz, basal cuttings consisting of the part of the girdled shoot proximal to the girdle, apical cuttings representing the portion of the girdled shoot distal to the girdle and a control from non-girdled shoots. A completely randomized block design was used, and the experiments were terminated after 30 weeks from planting.

The parameter measured in all experiments was the percentage of rooted cuttings. All observations were based on 20 stem cuttings per treatment. Data were recorded at the end of each experiment, and mean separation was performed using Duncan's multiple range test at 5% level.

RESULTS

The results of the effects of season, planting interval and girdling on the percentage of rooted lime stem cuttings are shown in Table 1. Data of the summer season indicated no significant differences between the different types of cutting. No significant difference was obtained in percentage of rooting among cuttings taken 2, 4, 6 and 8 weeks after girdling. However, a highly significant difference was found between these planting intervals and the 10-weeks planting interval where the percentage of rooting was 34.4%.

In autumn, however, no significant differences were obtained in rooting percentage between the different cutting types and in percentage of rooted cuttings among cuttings taken at the different planting intervals.

The data of the winter season, however, showed significant differences between apical cuttings and the other two types of cutting. Although there was no significant difference between the rooting of non-girdled and basal cuttings, the rooting percentage of non-girdled cuttings was doubled. There was no significant difference in percentage of rooting among cuttings taken at different planting intervals (Table1).

The effect of season on percentage of rooted lime stem cuttings is shown in Fig. 1. Cuttings collected during summer showed significantly less rooting percentage than those collected in autumn or winter. Autumn cuttings gave the highest percentage of rooted cuttings (47.0%) followed by winter (44.8%) and only 10.3% for the summer collected cuttings.

Table 1. Effect of season, sowing interval and type of cutting on the percentage of rooted lime stem cuttings

Season	Planting interval (W)	Non-girdled cuttings (%)	Basal cuttings (%)	Apical cuttings (%)	Mean (%)
Summer	2	5.50	5.50	0.00	3.66[b]
	4	0.00	0.00	0.00	0.00[b]
	6	0.00	0.00	0.00	0.00[b]
	8	2.70	39.80	0.00	14.17[b]
	10	45.00	23.30	34.90	34.40[a]
	Mean	10.64[a]	13.72[a]	6.98[a]	10.39[b]
Autumn	2	39.80	34.20	60.20	44.73[a]
	4	50.00	5.50	34.90	30.30[a]
	6	65.10	44.80	61.00	56.96[a]
	8	14.60	65.80	55.00	45.13[a]
	10	40.00	65.10	70.50	58.53[a]
	Mean	41.90[a]	43.08[a]	56.32[a]	47.09[a]
Winter	2	34.90	19.00	50.00	34.63[a]
	4	34.90	50.00	55.30	46.73[a]
	6	45.00	20.00	65.10	43.36[a]
	8	60.20	19.00	81.00	53.40[a]
	10	65.10	11.60	61.00	45.90[a]
	Mean	48.02[b]	23.92[b]	62.48[a]	44.80[a]

W= Weeks

Means followed by the same letter are not significantly different at P=0.05, according to Duncan's multiple range test.

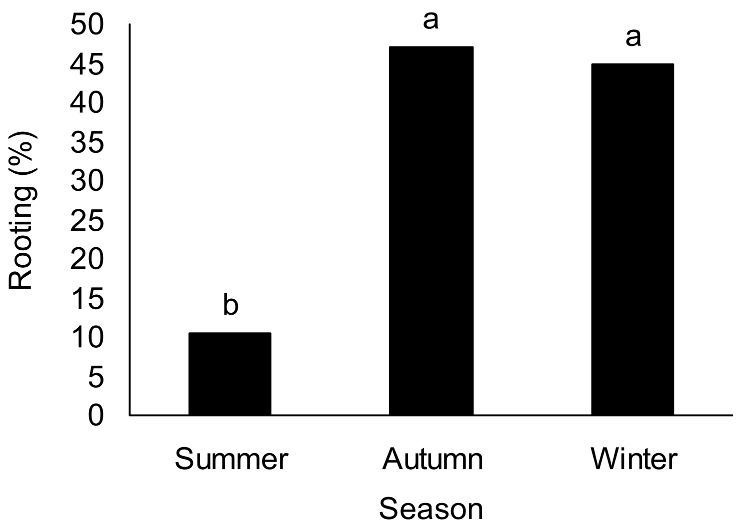

Fig. 1. Effect of season on percentage of rooted lime stem cuttings

The data displayed in Table 2 indicated that basal cuttings had significantly less percentages of rooted cuttings than apical and non-girdled cuttings. The highest percentage of rooted cuttings was obtained with apical cuttings (35.0%) followed by non-girdled cuttings (28.7%). Non-significant differences in percentage of rooted cuttings were found among cuttings taken 2, 4, and 8 weeks after girdling and also among 2, 4, and 6 weeks after girdling. However, cuttings taken 10 weeks after girdling were significantly different from all other planting intervals (Fig. 2). The highest percentage of rooted cuttings (45.6%) was obtained with 10-weeks planting interval after girdling followed by 8-(32.0%), 6-(25.2%), 2-(23.4%) and 4-weeks (18.0 %) planting intervals after girdling. (Table 2 and Fig. 2).

Table 2. Effect of planting intervals and type of cuttings on the percentage of rooted lime stem cuttings

Planting interval (W)	Non-girdled cuttings (%)	Basal cuttings (%)	Apical cuttings (%)	Interval means (%)
2	24.8	17.9	28.3	23.4[bc]
4	21.0	11.4	22.4	18.0[c]
6	28.3	15.3	33.3	25.2[bc]
8	21.5	40.8	37.2	32.0[b]
10	50.1	31.6	55.6	45.6[a]
Means of cutting types	28.7[a]	22.5[b]	35.0[a]	

W= Weeks

Means followed by the same letter(s) are not significantly different at P=0.05, according to Duncan's multiple range test.

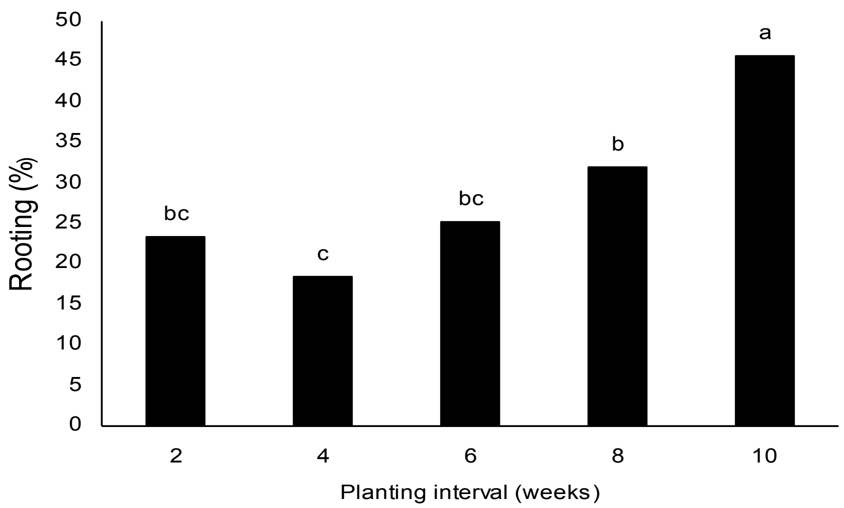

Fig. 2. Effect of planting interval on percentage of rooted lime stem cuttings

DISCUSSION

The season of the year at which lime cuttings were severed and planted greatly influenced their rooting ability. The highest percentage of rooting was obtained in autumn and winter, declining sharply during the summer season in a general agreement with earlier reports on plum (Howard and Nahlawi 1969), peach (Issell and Chalmer 1979) and kiwifruit (Caldwell *et al*. 1988). These findings indicate that the difference in rooting ability of lime cuttings across season is a reflection of their response to the surrounding environmental conditions. The less rooting percentage recorded in the summer season is attributable to the hot, dry desiccating winds that predominate at the time of planting. The gradual decrease in temperature and increase in atmospheric humidity in winter and the rainy season are responsible for the progressive increase in rooting percentage during these two seasons. Both temperature and relative humidity affect rooting through their effects on water loss from the cuttings and/or the planting media, confirming the findings of Juma (1994) who attributed the high rooting percentage of lime cuttings during autumn to the high atmospheric humidity resulting from rainfall.

The ability of cuttings to root is perhaps influenced by the physiological state of the lime tree which varies with the prevailing environmental conditions. The levels of C/N ratio and other rooting promoters in plant tissues vary with season (Cormack and Bate 1976). The lime tree was flowering and setting fruits when the cuttings were collected for the summer plantings. Most food reserves and growth substances in the tissues might have been diverted for flower and fruit formation. Root initiation and growth and development can not compete with the process of transformation of preformed vegetative buds into flower buds and subsequently into fruits. This is in accord with Issell and Chalmer (1979) and Thompson (1986) who attributed the lower rooting percentage of cuttings collected at flowering and fruit set to depletion of food reserves and other rooting cofactors in the tissues of donor plants.

The physical removal of a ring of the phloem (bark) from a branch or stem blocks the downward movement of photosynthates, hormones and other growth regulators synthesized in leaves. The present data showed that girdling has no effect on rooting percentage of neither basal nor apical stem cuttings during summer or autumn seasons. However, a significant decrease in rooting percentage of basal cuttings was obtained in winter. This is consistent with the findings of Evert and Smittle (1990) and in close agreement with the results of Cormack and Bate (1976) who reported low rooting percentages of stem cuttings of peach and macadamia, respectively, during winter. The lesser rooting percentage recorded with basal than apical or non-girdled cuttings during winter may be attributed to the accumulation of high levels of carbohydrates and other growth promoters to levels that are inhibitory to rooting. The current results deviate from earlier reports (James *et al*. 1970; Basu *et al*. 1972; Debnath *et al*. 1986) which attributed the positive effect of girdling on rooting to a significant buildup of carbohydrates, root promoters and other growth factors above the girdle.

Differences in rooting efficacy across planting intervals may be attributed to the accumulative build-up of rooting promoters with time accounting for the progressive increase in rooting percentage obtained with increasing time intervals between girdling and cutting collection. Again, and in agreement with Marini (1983) and Caldwell *et al*. (1988), higher rooting percentage was obtained with apical cuttings than basal ones. This difference in rooting ability may be associated with the degree of maturity of the tissues of each type of cuttings. Apical cuttings are more juvenile and have high rates of cambial activity than basal cuttings. The gradual decrease in rooting ability with distance from the apex, however, may be due to phase change that progressively occurs along the branches and stems of plants. This is in agreement with the report of Hackett (1985) on adult/juvenile phases in woody plants.

The endogenously produced auxin, indole-3-acetic acid (IAA), is basipetally transported in plant tissues. Thus, the level of this auxin along stems and branches is expected to vary. It might be optimal, sub-optimal or supra-optimal for root production in the different portions of the branches. The high ability of apical cuttings to root may be due to the presence of optimal levels of auxin in their tissues, while basal cuttings contained sub-optimal or supra-optimal levels at the time cuttings were collected and planted. This speculation agrees with the findings of Howard and Nahlawi (1969) who obtained equal rooting percentages of terminal, median and basal cuttings of plum when these cutting types were treated with varying concentrations of auxins.

In conclusion**,** these results indicate that the potential exists for vegetative propagation of lime by rooting of stem cuttings. The procedure developed is inexpensive, simple, repeatable and easier to practice. However, much more research efforts are needed to develop this procedure into a practical, refined means for the propagation of lime.

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تكاثر الليمون بالعقل الساقية

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موجز البحث: أجريت تجربه لثلاث سنوات متتالية (2002 و 2003 و 2004) لدراسة تأثير الموسم والتحليق وفترة الزراعة بعد التحليق على تجذير العقل الساقية لليمون البلدي*(Citrus aurantifolia)* . استخدمت ثلاثة طرز من العقل الساقية هي عقل غير محلقة وعقل محلقة طرفية وقاعدية. جمعت كل العقل من شجرة ليمون بلدي واحدة، أثناء فصول الصيف والخريف والشتاء لكل سنة، من أفرع غير محلقة ومحلقة على فترات: 2 و4 و6 و8 و 10 أسابيع بعد التحليق. زرعت العقل في تربة رملية في صواني بلاستيكية ووضعت تحت خيمة بلاستيكية في بيت خشبي. أعطت العقل المزروعة خلال فصلى الخريف والشتاء نسبا عالية معنويا من العقل المجذرة مقارنة بمثيلاتها الصيفية، وكذلك أعطت العقل الطرفية المحلقة نسبا عالية معنويا من التجذير مقارنة بالعقل القاعدية المحلقة. ومن ناحيه أخرى، لم تكن هناك فروق معنوية بين فترات الزراعة 2 و4 و6 و8 أسابيع بعد التحليق بينما كان الاختلاف معنويا بين فترة الزراعة 10 أسابيع بعد التحليق والفترات الأقل حيث أعطت هذه المعاملة أعلى نسبة نجاح للعقل المجذرة. يستخلص من هذه الدراسة إن الحرارة والرطوبة النسبية والزيادة التراكمية في كمية ونوعية الكربوهيدرات ومحفزات ومثبطات التجذير تلعب دورا مهما، ضمن عوامل أخرى، في تجذير عقل الليمون الساقية.

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