The Effect of Different Rootstocks and Superphosphate Fertilizer on Growth and Leaf Phosphorus in Young 'Lisbon' Lemon Trees.

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ABSTRACT

Plants of 'Prior Lisbon' lemon budded on four different rootstocks were set in the field in a randomized block experiment. All trees were maintained under a uniform N and K fertilizer ratio with five different levels of P. By the end of the third growing season in the field, the different P level treatments showed no response in trunk area or in leaf phosphorus percentage of the lemon scions. The mean percentage of leaf phosphorus in trees which received no superphosphate fertilizer during the three-year period after setting in the field was 0.151, being within the known optimum range. These practically invariable results were probably due to the beneficial effects of mixing organic matter with the soil in preparing the holes before transplanting. Meanwhile, the different rootstocks influenced significantly the tree growth and the phosphorus concentration of the lemon leaves. On the average, measurements of stem cross-sectional area showed that tops on rough lemon or on 'Rangpur' lime were more vigorous than on sour orange, while 'Cleopatra' mandarin was slow in growth. The latter supplied more phosphorus to the leaves of lemon scions than sour orange, rough lemon and 'Rangpur' lime being intermediary in this effect.

INTRODUCTION

Under normal growing conditions, phosphorus deficiency or excess *per se*, is not commonly encountered in the world of citriculture. However, it is used to some extent in various forms, in most citrus areas.

Critical reports are lacking to evaluate the status of soil supply of phosphorus to citrus trees growing in the western coastal plain of Libya, where citrus culture prevails. Meanwhile, it is realized that the use of an annual plant as an indicator crop for phosphorus needs of a citrus tree is not a sound approach to the question (1,6).

This investigation was initiated to obtain some basic information with regard to the reaction of young lemon trees to phosphorus in the soil. The effect of four different citrus rootstocks on leaf phosphorus of the same lemon cultivar were compared. In addition, scion growth measurements were recorded for rootstock adaptability evaluation under existing conditions in Libya.

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MATERIALS AND METHODS

The 'Prior Lisbon' lemon *Citrus limon* (L.) Burm.f. was used in this study. It was budded on seedlings of four different citrus rootstocks; namely, the sour orange *Citrus aurantium* L., rough lemon *C. jambhiri* Lush., Rangpur lime *C. limonia* Osbeck, and 'Cleopatra' mandarin *C. reshni*. Hort. ex. Tan. The nursery-grown budlings were transplanted to the field and set in holes, 60 cm in diameter and about 75 cm in depth, made by a tractor-driven auger. The holes were back filled with a thoroughly mixed compost of nearly 1:1 cow manure and soil. During the first three years in the field, each plant received a total of 150 grams, 210 grams and 400 grams pure nitrogen, split in five applications during each growing season respectively. The amounts used of super-phosphate (18% P_2O_5) and potassium sulfate (50% K_2O) were all applied at one time by the beginning of the second and third growing seasons. While the potash (K_2O) ratio was kept constant at half the amount of nitrogen applied in any one year to all the scion/rootstock combinations, the nitrogen to phosphorus pentoxide (P_2O_5) ratios were 1:0, 0.25, 0.5, 0.75, and 1.0. These applications represent ratios of 1N:0, 0.11, 0.22, 0.33, and 0.44 P:0.42 K, respectively.

The trees were spaced seven meters apart on a square system of planting. Each scion/stock combination consisted of 18 tree-plots made of 6 rows, each of 3 trees. The soil is calcareous with a pH of about 7.9 and known to be of low native fertility.

The five levels of phosphorus were applied to each of the four different scion/stock combinations, making a total of 20 treatments. Each combination was represented by three trees, replicated twice in a randomized block design.

At the end of the third growing season in the field, composite leaf samples were collected from 7-month-old, spring cycle growth. Each sample was represented by the 3-tree-subplot. Sample preparation for chemical analysis and phosphorus determination were done on dry-ashed leaves as given by Chapman and Pratt (2). Growth evaluation was based on the calculated stem cross-sectional area from scion diameter measurements at 5 cm above the bud-union.

RESULTS AND DISCUSSION

The initial results of this long term basic experiment on growth responses and percentages of leaf phosphorus in 'Prior Lisbon' lemon trees growing on different rootstocks, and fertilized with various levels of phosphorus, are summarized in Tables 1 and 2.

Growth response

The data in Table 1 show no growth response in stem cross-sectional area of the lemon trees due to any of the phosphorus levels of fertilization. It is premature at this early stage of the experiment to make any inferences in this regard. Meanwhile, it is obvious that by the end of the third growing season in the field, 'Cleopatra' mandarin induced less vigour in the lemon top than the rough lemon or the 'Rangpur' lime. The two latter rootstocks are known to perform well on light sandy soils (8). The lemon gave better growth on sour orange than on 'Cleopatra' mandarin rootstock by the end of its third year in the field.

Table 1 Effect of rootstock and superphosphate fertilizer on growth and leaf phosphorus in young 'Prior Lisbon' lemon trees, at the end of the third growing season in the field

Main effect	Mean values of scion cultivar: Stem cross-sectional area[a] in cm²	Per cent P in dry leaves
Rootstock		
Sour orange	39.1b[b]	0.148a
Rough lemon	49.1d	0.157ab
'Rangpur' lime	44.5c	0.156ab
'Cleopatra' mandarin	29.1a	0.168b
N:P:K ratio in fertilizer		
1:0:0.42	40.9a	0.151a
1:0.11:0.42	39.7a	0.157a
1:0.22:0.42	40.0a	0.157a
1:0.33:0.42	38.6a	0.166a
1:0.44:0.42	43.1a	0.155a

[a]Stem measurements taken at 5 cm above bud-union.
[b]Values within each column followed by the same letter are not significantly different at P = 0.01 according to Duncan's Multiple Range Test.

Phosphorus response

Under no condition, including the no-phosphorus treatment, did phosphorus prove to be deficient in the leaves. In fact, it was generally in the upper level of the optimum range as suggested by Embleton *et al.* (4). This could be explained on the basis that the organic matter mixed with the soil, in preparing the holes, before setting the plants in the field accounted for this reaction. It is known that organic matter increases the exchange capacity of the soil which induces the release of the fixed soil phosphorus and renders it available to the growing plants. Pratt *et al.* (7) found a highly significant correlation coefficient of 0.98 between percentage of organic matter and cation-exchange capacity. At this early stage of the experiment, no highly significant differences could be

Table 2 Effect of rootstock and superphosphate fertilizer on percentage of leaf phosphorus in young 'Prior Lisbon' lemon trees, at the end of the third growing season in the field.

Rootstock	Ratios of phosphorus to nitrogen and potassium[a]: 0	0.11	0.22	0.33	0.44
	Mean per cent phosphorus in dry leaves[b]				
Sour orange	0.152	0.144	0.142	0.152	0.148
Rough lemon	0.149	0.149	0.158	0.170	0.158
'Rangpur' lime	0.145	0.156	0.161	0.169	0.151
'Cleopatra' mandarin	0.157	0.179	0.166	0.175	0.165

[a]N and K maintained at a constant ratio of 1:0.42.
To convert P to P_2O_5 multiply by 2.3.
To convert K to K_2O multiply by 1.2.
[b]All values are not significantly different at P = 0.01, according to Duncan's Multiple Range Test.

detected between the various levels of phosphorus applied to any scion/stock combination, as shown in Table 2. The persistent action of the organic matter still effective since planting time cannot be overlooked as a probable explanation to these indifferences. However, there is an indication that the 'Cleopatra' mandarin as a rootstock supplied more phosphorus to the leaves of 'Prior Lisbon' lemon than sour orange, as shown in Table 1; the rough lemon and 'Rangpur' lime being intermediary in this effect. This coincides with the work of Hass (5) who showed that the rough lemon accumulated less phosphorus in the leaves of mature 'Eureka' lemon trees than the 'Cleopatra' mandarin but more than the sour orange rootstock reported in another experiment by Wallace *et al.* (9).

Regardless of the various amounts of phosphorus applied during the three-year period of this investigation, no conclusive results to show any variability in leaf phosphorus contents were evident, as shown in Table 1. However, lemon leaves from plants receiving phosphorus-free fertilizer showed lower phosphorus content at the 0.05 level of probability compared with those from plants receiving a fertilizer ratio of 1N:0.33 P:0.42 K. In the higher phosphorus application, there was a drop in leaf phosphorus concentration similar to the lower levels applied. Embleton *et al.* (3) stated that levels of phosphorus in the leaves normally do not increase in proportion to the phosphorus fertilizer applied to the soil. The first increment of added phosphorus is likely to increase leaf phosphorus more than additional increments.

Further work should elucidate the interactions between rootstocks and levels of phosphorus fertilizers on growth and on phosphorus status in lemon plants growing under Libyan conditions.

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تأثير الاصول المختلفة والتسميد بالسوبر فوسفات علي النمو ونسبة الفوسفور في أوراق أشجار ليمون « لزبون » الصغيرة العمر

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المستخلص

ضمن دراسة طويلة الامد عن تغذية أشجار الحمضيات تحت الظروف المحلية ، أجري هذا البحث لتقييم قدرة أشجار الليمون صنف « لزبون » على الحصول على احتياجاتها من عنصر الفوسفور من التربة في منطقة انتاج الحمضيات بليبيا . هذا بالاضافة إلي دراسة تأثير أربعة أصول مختلفة على قوة نمو الطعم النامى عليها وعلى مستوي الفوسفور في أوراق الليمون الطعم . ولقد تمت التجربة على نباتات مزروعة فيمكانها المستديم منذ ثلاث سنوات تحت نظام تسميد كيماوي موحد لعنصري النيتروجين والبوتاسيوم مع اضافة خمسة معدلات مختلفة من الفوسفور في السماد .

ولقد تبين من التحليل الأحصائي للنتائج المتحصل عليها أن مستويات الفوسفور المختلفة التى استعملت في التسميد لم ينتج عنها استجابة مؤكدة في مساحة مقطع الجذع أو في مستوي عنصر الفوسفور في أوراق الليمون الطعم .

وكان متوسط نسبة عنصر الفوسفور في الاوراق من الاشجار التي لم يضاف هذا العنصر عند تسميدها يقع في حدود المستويات المثالية المعروفة . ولقد تبين أيضا أن للأصول المختلفة تأثير مؤكد على كل من نمـو الاشجار وتركيز الفوسفور في أوراق الليمون الطعم . وبصفـة عامة يمكن القول بأن نمو الطعم صنف « لزبون » على أصل الليمون المخرفش أو « الرانجبور » كان أكثر قوة عنه على أصل النارنج ، بينما ظهر أن النمو كان بطيئا على أصل « كليوباترا » ولو أن الأخير قد أمد أوراق ليمون الطعم بفوسفور أكثر من امداد أصل النارنج لنفس العنصر .

وكان الليمون المخرفش والليمون « رانجبور » متوسطين في هذه الصفة .