GROWTH RESPONSES OF 'ROUGH LEMON' (C*itrus limon* L.) ROOTSTOCK SEEDLINGS TO DIFFERENT CONTAINER SIZES AND NITROGEN LEVELS

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Abstract

Studies were carried out at Maseno University, Kenya to find out the effect of different container volumes (1.7litres, 2.7litres and 4.5litres and N fertilizer levels at 0.06kgN/ha, 0.12kgN/ha, 0.18kgN/ha and 0.24kgN/ha; 0.3kgN/ha, 0.6kgN/ha, 0.9kgN/ha, 1.2kgN/ha and 0.5kgN/ha, 1kgN/ha, 1.5kgN/ha and 2.0kgN/ha respectively for the pot sizes of 1.7, 2.7 and 4.5litres on growth of young 'rough lemon' (C. limon L.) seedlings. The fertilizer applied was C. A. N. (Calcium Ammonium Nitrate). The soil used had a dry weight of 4.2kg. The experimental design used was a 3 X 3 factorial laid out in a completely randomized arrangement with three replications. The media placed in the pots was sand and soil at a ratio of 1.1 by volume. Increasing container volumes significantly ($P \leq 0.05$) increased the dry weights of whole plants, number of leaves, heights of plants, heights of canopy, stem diameter, dry weights of roots and shoots and vice versa for small volumes. However, increasing nitrogen fertilizer levels did not affect the number of leaves, stem diameter but linearly and quadratically increased heights of plants, weight of roots and shoots. The interaction between container volume and nitrogen fertilizer levels was significant for weight of roots and shoots and whole plants, height of canopy and height of plants but not the number of leaves and stem diameter. Therefore, increasing nitrogen fertilizer levels increased the growth parameters as the container volumes increased.

Key words: Nursery production, rootstocks, nitrogen, fertilizer.

INTRODUCTION

Commercial nursery producers are usually faced with two options, namely: planting of liners directly into market size containers or transplanting them into market size containers and later transferring them into market size containers (upcanning).

Upcanning is more labour intensive, it requires less space, provides more rapid shading of the container that cools the growth medium resulting in less crop failure (Ingram, 1981). In addition to the above, nursery owners are usually faced with the choice of various container sizes to use for their tree seedling production.

Increased container size has been reported to cause increased canopy growth (Gillium *et al*, 1984; Biran and Eliassaf, 1980), in pears *(Pyrus calleryana*), Pecan (*Carya illinoensis*, Japanese euonymus (*Eunymus japonica* Thumb) and other ornamental species respectively. Generally growing seedlings in small containers results in root restriction which reduce canopy growth (Hanson, *et al*, 1987; Richards and Rowe, 1977) reduced plant growth expressed as shoot length, fresh weight and dry accumulation and leaf area (Vizzotto *et al*, 1993), exhibited less expansion and caliper development of plants, reduced the number of primary shoots, total combined length of secondary shoots and total length of all shoots (Alvarez and Caula, 1993), reduced CO_2 assimilation and leaf conductance (Rieger and Marra, 1993), leaf nutrient levels except N (Rieger and Marra, 1993), reduced dry weights of root, stem, leaves and fruit (Bar-Tal and Pressman, 1996). Root restriction reduces dry matter production but this has not been attributed to nutrient deficiency (Peterson *et al*, 1991a, Peterson and Krizeki, 1992, Ruff *et al*, 1987). Conversely Bar-Tal *et al*, (1995) reported that root restriction reduced both dry matter production and K concentration in plant organs indicating a possible K concentration in plant organs, including the roots. It has been reasoned that reduction in plant growth under conditions of root restriction is not caused by nutrient deficiency but probably due to hormone synthesis and metabolism in the root system (Peterson *et al*, 1991b; Richards and Rowe, 1977).

Supra optimal root zone temperatures also slow down the growth of containerized plants (Gravesk, 1991; Martin and Ingram, 1991a). The main source of thermal energy that cause supra optimal rooting medium temperature is solar radiation striking container walls (Martin and Ingram, 1992). One of the most efficient cultural management to correct high root zone temperatures is by using different container dimensions (Ingram, 1981; Laiche, 1985; Martin and Ingram, 1991b).

The effect of container volume on the growth of 'rough lemon' rootstocks, which is the main rootstock used by nursery owners in Kenya appears not to have been investigated. Further, there seems to be no information on how varying container sizes interact with different N fertilizer levels to influence the growth of young citrus rootstock seedlings.

The objectives of the present study were, therefore, to investigate the effect of different container sizes and N fertilizer on the growth of young 'rough lemon' citrus seedlings.

MATERIALS AND METHODS

Location of research site:
The study was conducted at the Maseno University's Department of Horticulture nurseries, Kenya. The nurseries are located at 1515m above level and are at a longitude of 34^0, 36^0 East and latitude of 0^0. The soils used in this study was collected from a nearby site within the University farm. The soils in this farm comprise a complex of somewhat excessively drained, shallow and rocky soils of varying colour, consistence and texture (dystric regosols with ferralic cambisols, lithic phase and rock outcrops). The area receives an annual rainfall of 1853mm (Jaetzold and Smidt, 1983).

Experimental materials and their preparation, Land preparation, fertilization, planting and subsequent care:
'Rough lemon' (*citrus limon* L.) fruits were obtained from a citrus orchard near Kisumu town, Kenya. Recommended practices of weeding, irrigation, fertilization, crop protection had been undertaken on the citrus trees before harvesting. The fruits were subsequently transferred to Maseno University's department of Horticulture laboratories where they were stored in the refrigerator for 2 days at a temperature of 5^0C. The fruits were then washed and graded for uniformity of mass and freedom from blemishes. The fruits were then cut in half and seeds extracted in warm water then air dried briefly for two days in trays in readiness for planting.
Nursery beds measuring 25 metres by 1.5 metres were well prepared to a fine tilth using hoes and machetes and well mixed with 2.3tonnes per hectare of Farm yard manure (FYM) and 18kg N per hectare of DAP fertilizer. The seeds were then planted on the nursery beds on 15^{th} May, 2004 at a spacing of 40cm by 15cm and a layer of grass mulch placed between the holes. For cut worms, Aldrin (1, 2, 3, 4, 10, - hexachloro- 1, 4, 8, 8a – hexahydro 1, 4, - endoexo – 5 dimethanonaphthalene) 40% EC at a rate of 1 litre in 500 litres of water per hectare was sprayed at 2 weeks interval to control other insect pests. Diseases were controlled by Benomyl (Methyl N – (1-butyl carbomoyl) phosphorothiolothionate) 40% EC at a rate of 20mg per 200litres of water. Beds were watered daily at 0800 hours and 1600 hours to saturation with 16mm interval diameter hose and breaker nozzle watering cans.

Transplanting of seedlings, treatments and experimental design:
After four months in the nursery the seedlings were transplanted into three sizes of white plastic pots and one seedling planted per container according to the treatments to be applied, which were V1 (1.7litres), V2 (2.7litres), and V3 (4.5litres). The N fertilizer treatment levels were 0, 6, 12, 18 and 24gm per pot or 0.06kgN/ha, 0.12kgN/ha, 0.18kgN/ha and 0.24kgN/ha; 0.3kgN/ha, 0.6kgN/ha, 0.9kgN/ha, 1.2kgN/ha and 0.5kgN/ha, 1kgN/ha, 1.5kgN/ha and 2.0kgN/ha of C.A.N. (Calcium Ammonium Nitrate, 26%N, Kenya Farmers Association) respectively for the pot sizes 1.7, 2.7 and 4.5litres. The experimental design was a 3 X 3 factorial design laid out in a completely randomized arrangement with three replications. The media in the pots were sand and soil at a ratio of 1:1 by volume in a 30 percent shade structure made of timber and covered with grass. The sizes of the shade structure was approximately 40m in length, 40m in width and 10m in heights. Pest and diseases were controlled as described above for seedlings while weeds were manually removed by hand. Watering was done by watering cans using 16mm interval diameter hose and breaker nozzle.

Plant Parameters measured and statistical analysis:
The plants were uprooted 7 months after transplanting from the containers after moistening the media in the containers to soften it. The plants were washed free of soil, weighed using a Mettler PE Electronic scale and weight expressed in kilograms per pot and dried at 70% for 48 hours in an oven. Whole plants were weighed and roots separated and weighed. Other weighings were for leaves and stem. Heights of canopy and plants were measured using a tape measure. Four plants per replication were used for each measurement. Statistical analysis was done using SAS package (SAS Institute, Cary, N. C, 1988).

RESULTS AND DISCUSSION

The number of leaves increased with increasing container volumes but Nitrogen fertilizer levels had no effect. The interaction between Nitrogen and container volume did not cause any significant ($P \leq 0.05$) effect on the number of leaves. Heights of plants were increased by the container volumes then decreased at the largest container volumes. In contrast, increasing Nitrogen fertilizer levels consistently increased the height of plants (Table 1). The increases in heights of plants were linear (Fig. 1). The interaction between container volume and Nitrogen fertilizer was significant $P \leq 0.05$).
Container volumes increased the height of canopy and stem diameter up to the volume of 2.7litres but decreased at 4.5litres volume (Table 1). In contrast only the height of canopy was increased by increased container volumes. Stem diameter was unaffected by the increasing Nitrogen fertilizer levels. Nitrogen fertilizer linearly and quadratically increased the height of canopy and interacted significantly with container volume (Table 1, Fig. 2). The weight of whole plants and the weight of the roots increased quadratically as the container volumes increased (Fig. 3). The difference between the weights of whole plants in 1.7litres one was far much bigger compared to between 2.7litres and 4.5litres (Table 1). The interactions between the two factors above were significant for weights of whole plants but not weight of roots. The weight of roots

increased then decreased at the biggest container volume (Fig. 3). Similarly Nitrogen fertilizer increased the weight of shoots up to the second highest Nitrogen levels then decreased (Fig. 4). Container volume interacted significantly with Nitrogen fertilizer levels.

Increasing container volumes increased the plant growth parameters measured in the present study. These were number of leaves, height of plants, height of canopy, stem diameter, weight of whole plants, weight of roots and shoots. These observations can be attributed to the following factors:

1. The large container volumes had reduced root restriction which led to increased dry matter production which increased plant growth rate (Peterson *et al*, 1991b; Richards and Rowe, 1977; Peterson and Krizeki, 1992; Ruff *et al*, 1987 and Vizzotto *et al* 1993).
2. Reduced root restriction in large containers increased soil volume exploited by roots and hence nutrient uptake, hormone synthesis and metabolism in the root system. (Peterson *et al*, 1991b; Richards and Rowe, 1977; Rieger and Marra, 1993).
3. At large volumes of container, there were increased development of primary shoots and their number and total length of all shoots increased (Alvarez and Caula, 1993) which caused increased heights of plants and canopies.
4. The temperatures in the media in the larger containers were cooler due to the greater distance to the container walls (Martin and Ingram, 1993). This ensured that water stayed longer in the larger containers without evaporating. Increased Nitrogen fertilizer levels increased the height of plants, height of canopy, weight of whole plants, weight of roots and shoots but not stem diameter and number of leaves. This increase was more at the larger containers generally. It appears that the beneficial effects of reduced root restriction in larger containers are enhanced at higher N fertilizer levels. It would be interesting to find how different levels of fertilizer such as P and K would behave under the present experimental conditions. Further, D. A. P fertilizer also contains P which is needed for root development so it would be interesting to find how P alone affects the weight of roots before one can conclude that both N and P in the D. A. P fertilizer increased the weight of roots from the present study. It may appear that both N and P in the D. A. P. fertilizer enhanced root development with a possibility of P having more effect. Studies are required to test these factors under conditions of varying container volumes. High N fertilizer application in itself increases plant growth due to increased plant growth promoting processes such as cell division, cell enlargement, metabolic processes etc.

The increased soil volumes increases nutrient uptake which is even more enhanced at higher N fertilizer applications thereby promoting the plant growth processes. Most fertilizer responses were quadratic. This implies that the average optimum rate of 18gm for pot or 0.24kgN/ha, 1.2kgN/ha for the plants has been added and more additions are not beneficial for plant growth.

CONCLUSION

From the results of the present study, it can be concluded that:

1. Increase in container volume increases plant growth parameters such as height of plants, height of canopy, stem diameter, number of leaves, weight of whole plants, shoots and roots.
2. Increasing Nitrogen fertilizer levels from 0.24kgN/ha to 24kgN/ha increases weight of shoots and roots, height of canopy, weight of plants but not stem diameter and number of leaves.
3. Increasing container volumes lead to even higher weight of shoots and roots, height of canopy and plants etc, when N fertilizer levels increase.

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RESULTS

Tab. 1.: Effect of different container volumes and levels of Nitrogen on the plant height, canopy height, stem diameter, whole plants and root weight

Treatment	Number of leaves	Height of plants (cm)	Canopy height (cm)	stem diameter (cm)	Whole plant weight (gm)	Root weight (gm)	Weight of shoots (gm)
Pot size (litres)							
1.7	234	65	64	56	95	42	56
2.7	264	91	72	81	130	48	81
4.5	335	86	52	69	126	54	69

Significance ($P \leq 0.05$)	**	**	**	**	**	**	**
Nitrogen (gm/pot)							
0	166	44	44		47	16	31
6	155	47	47		81	32	48
12	178	56	55		95	46	59
18	184	60	59		117	59	73
24	187	65	62		100	59	68
Significance ($P \leq 0.05$)	**	**	**		**	**	**
Interaction	NS	**	**		**	**	**

Key

** = Significant at ($P < 0.05$)

NS = Not significant

Fig. 1. : Effect of different N fertilizer levels on plant height of ‘rough lemon’ rootstocks grown at Maseno, Kenya in 2004.

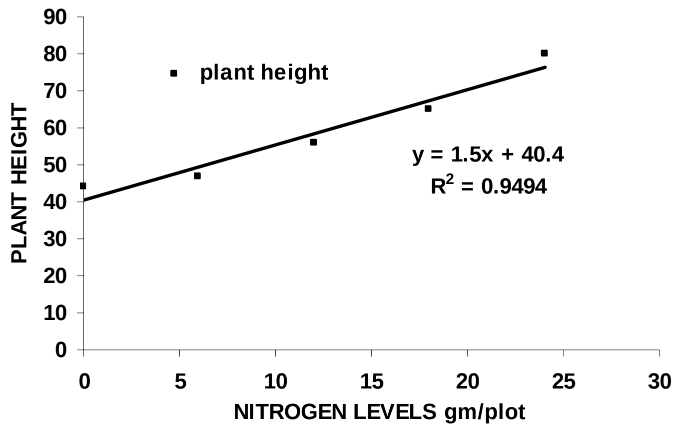


Fig. 2. : Effect of different N fertilizer levels on canopy height of ‘rough lemon’ rootstocks grown at Maseno, Kenya in 2004.

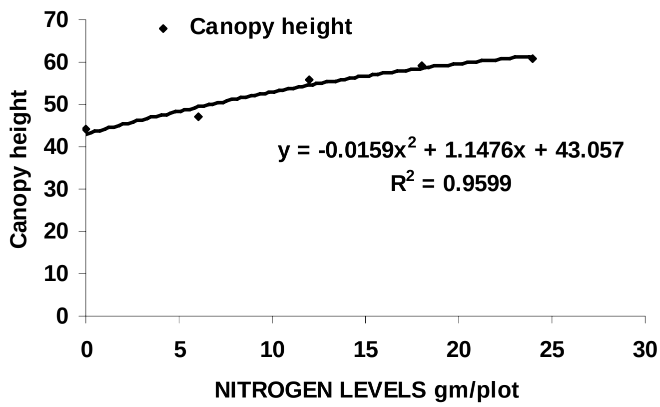


Fig. 3.: Effect of different N fertilizer levels on root weight and whole plant weight of 'rough lemon' rootstocks grown at Maseno, Kenya in 2004.

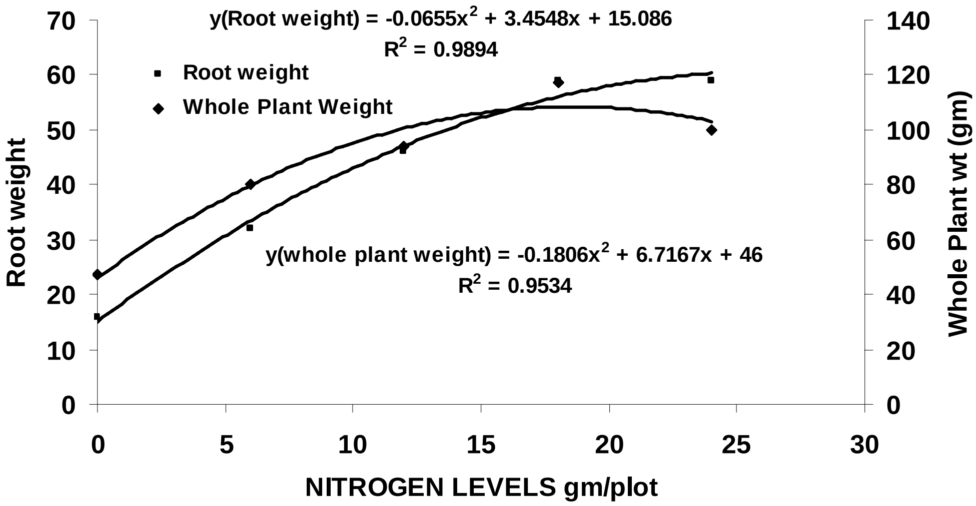
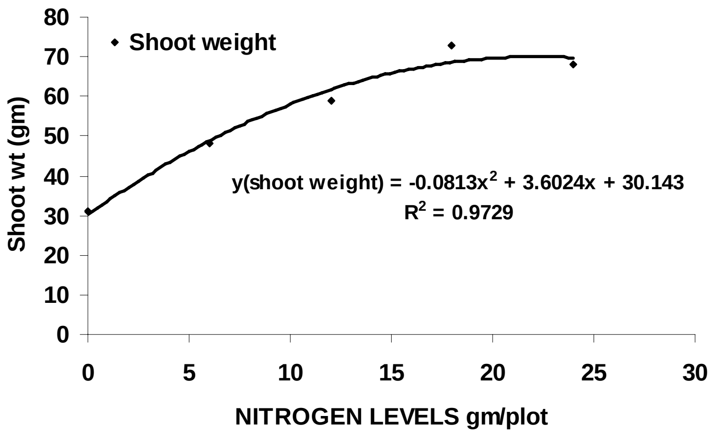


Fig. 4.: Effect of different N fertilizer levels on shoot weight of 'rough lemon' rootstocks grown at Maseno, Kenya in 2004.



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