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Short communication

Germination and growth of rough lemon (*Citrus jambhiri* Lush.) seedlings under protected environment

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ABSTRACT

Production of disease-free plants is necessary for a healthy future for the citrus industry. Therefore, a study was designed to compare growth of direct-sown and transplanted rough lemon seedlings under controlled conditions. Rough lemon rootstock seedlings were grown under screen-house, shade-net house, glasshouse, and open field conditions. Seeds were planted in seed beds, propagation trays and black polythene bags. Germination was significantly higher (94.30%) in propagation trays under shade-net house except that in screen-house. Minimum germination (62.45%) was recorded in open-field seed-beds. Seedling height, stem diameter, leaf number and leaf area was found to be maximum (i.e., 55.26cm, 0.63cm, 33.43 and 24.75cm^2 respectively) in direct-sown seeds in polybags under screen-house which were transferred to glasshouse during winter. Minimum values observed were 41.33cm, 0.44cm, 18.29 and 15.47cm^2, respectively, in conventionally raised seedlings. On the basis of our study, it is concluded that rough lemon nursery is best raised in polybags under screen-house or glasshouse conditions.

Key words: Screen-house, g lasshouse, shade-net house, rough lemon

The most important commercial citrus species grown in India include mandarin (*Citrus reticulata* Blanco), sweet orange (*Citrus sinensis* Osbeck.) and acid lime (*Citrus aurantifolia* Swingle). Citrus industry in India is the third largest fruit industry covering 0.99 million ha with annual production of 9.64 million tonnes (http://data.gov.in/dataset/all-india-and-state-wise-area-and-production-fruits). India is the sixth largest citrus producing country in the world, contributing 4.69% of world citrus production. In Punjab, citrus fruits rank first, over an area of 44.724 thousand ha and annual production of 9.005 lakh tonnes (http://data.gov.in/dataset/all-india-and-state-wise-area-and-production-fruits). Kinnow is the leading citrus fruit under an area of 31.788 thousand ha and annual production of 5.913 lakh tonnes. Area under kinnow is increasing rapidly due to its precocious bearing habit and very high economic returns to growers. The major problem raising citrus in Punjab and surrounding states is non-availability of quality planting material. Nursery is one of the basic inputs in citrus industry, and attention should be focused on large scale, rapid multiplication of true-to-type, healthy planting material. Therefore, production of disease-free plant material is a pre-requisite for a bright future for the citrus industry. For raising healthy plant material of citrus, a thorough understanding of mother rootstock plant selection, seed sowing, raising seedlings, transplanting seedlings and budwood selection is essential. To raise quality planting material of kinnow, the most important step is to produce healthy and vigorous seedlings of rough lemon for propagation in the shortest possible time. Therefore, the present study was planned to compare growth performance of direct-sown and transplanted rough lemon seedlings.

The present investigation was carried out during 2006-07 in College Orchard, Department of Horticulture, Punjab Agricultural University, Ludhiana. Rough lemon seeds were extracted from healthy fruits collected from single-tree source and treated with Ridomil MZ 72 WP. These were sown in seed beds, propagation trays and black polythene bags filled with sterilized farm soil + FYM (2:1) in the second fortnight of August. After seed sowing, the polythene bags and propagation trays were divided into three sets. Of these, one set was placed under screenhouse, the second in shade-net house and the third under open field conditions. Seed-beds and propagation trays could not support larger seedlings. Therefore, seedlings from seed-beds were transplanted into nursery beds and in polythene bags when these attained a height of 10cm. Seedlings from propagation

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trays were also transferred to polybags. In mid-November, polythene bags from each treatment were divided into three sets. One set of each treatment was transferred to polyhouse, the second to glasshouse up to the end of February, while, the third remained in place. In the first week of March, the polythene bags placed in glasshouse and polyhouse were again shifted to their original place for further growth until seedlings reached the buddable stage. Observations were recorded on seed germination in the second fortnight of September, before transplanting. Data on seedling height, seedling diameter, number of leaves and leaf area were recorded at the time of budding during May. Germination data were recorded one month after sowing and per cent germination was calculated as under:

$$\text{Per cent germination} = \frac{\text{No. of germinated seeds}}{\text{Total number of seeds sown}} \times 100$$

Height of the seedlings was measured from soil surface to the plant tip in centimeters with a meter scale, while diameter was intimated with Vernier calipers at 5 cm-above ground at the time of budding. Fully developed green leaves were counted starting from the base of the stem at the time of budding, and leaf size was calculated using a graph sheet. There were three replications per treatment, with 50 seedlings constituting a replication. Data were analyzed in this completely randomized block design (Singh *et al,* 1998).

Maximum mean seed germination (94.30%) was obtained in treatment T_2, where seeds had been sown in propagation trays under shade net-house. This value was significantly higher than seed germination obtained in all other treatments, except in T_1 93.35%, where seeds were sown in propagation trays under screen-house conditions. This was followed by 89.41% and 85.55% seed germination recorded in T_5 (seeds sown in polybags under shade-net house) and T_4 (seeds sown in polybags under screen-house), respectively. Minimum seed germination (62.45%) was obtained in T_7 (Control), where seeds were sown in seed beds in open-field. This value was significantly lower than in all other treatments (Table 1). Data on seed germination was recorded 30 days after sowing.

It is clear that shade improves germination percentage compared to open-field conditions, and germinations rate increases with increase in shade, i.e., from screen-house to shade-net house.

Optimum temperature range for rough lemon seed germination was recorded as 20-40^{0}C (Rouse and Sherrod, 1996). Present results are in accordance with findings of Dhaliwal and Mehan (2006) who reported 85-90% seed germination in rough lemon (*Citrus jambhiri* Lush.) in seeds sown in black polythene bags/plastic trays under 50% shade-net house with polycarbonate sheet roof, under Ludhiana (Punjab) conditions. Similarly, Singh *et al* (1970) found germination of citrus rootstock seeds (*C. jambhiri, C. pseudolimon, C. limonia, C. magaloxycarpa* and *Poncirus trifoliata*) under alkathene cover (65-85%) to be distinctly superior to that in open-field conditions (25-52%).

Maximum mean seedling height, stem diameter, number of leaves and leaf area of 55.26cm, 0.63cm, 33.43 and 24.75cm^2 were obtained, respectively, in treatment T_{12} where seeds were sown directly in polybags under screenhouse conditions and seedlings were then shifted to glasshouse in winter (November to February). This was significantly higher than seedling height, stem diameter, number of leaves and leaf area obtained in all other treatments, except for stem diameter (0.61cm) obtained in treatment $T_{11,}$ where seeds were sown directly in polybags under screenhouse and were shifted to polyhouse during winter. This was followed by seedling height (54.10cm and 53.46cm) in T_{15} and T_{11}, respectively; for stem diameter, this was followed by T_{11} (0.61cm) and T_3 (0.60cm). In the case of number of leaves, this was followed by T_3 (30.10) where seeds were sown in propagation trays and transplanted to polybags under screen-house and shifted to glasshouse during winter (November to February). In leaf area, this was followed by treatment T_{11} (22.08cm^2), and T_3 (21.33cm^2). Minimum mean seedling height, stem diameter, number of leaves and leaf area of 41.33cm,

Table 1. Effect of sowing method on seed germination in rough lemon (*Citrus jambhiri* Lush.) under modified environment

Treatment	Seed germination (%)
T_1-Seed sowing in PT and transplanting in PB under SH	93.35
T_2-Seed sowing in PT and transplanting in PB under SNH	94.30
T_3-Seed sowing in PT and transplanting in PB under open	69.40
T_4-Seed sowing in PB under SH	85.55
T_5-Seed sowing in PB under SNH	89.41
T_6-Seed sowing in PB under open	65.52
T_7-Seed sowing in seed beds (Control)	62.45
Standard Error of mean (SEm)	5.19
CD (5%)	2.2

PB = Polybag, SH = Screen house, PT = Propagation trays
SNH = Shade-net house

Table 2. Effect of direct-sown and transplanted rough lemon (*Citrus jambhiri* Lush.) seedlings on seedling height, stem diameter, number of leaves and leaf area under modified environmenta

Treatments	Seedling height (cm)	Stem diameter (cm)	Number of leaves	Leaf area (cm^2)
T_1Seed sowing in PT and transplanting in PB under SH	50.01	0.56	26.03	19.32
T_2-Seed sowing in PT and transplanting in PB under SH + PH	52.49	0.59	27.89	20.35
T_3-Seed sowing in PT and transplanting in PB under SH + GH	53.43	0.60	30.10	21.33
T_4-Seed sowing in PT and transplanting in PB under SNH	47.82	0.55	25.56	17.52
T_5-Seed sowing in PT and transplanting in PB under SNH + PH	49.05	0.56	26.21	18.09
T_6-Seed sowing in PT and transplanting in PB under SNH + GH	49.63	0.57	26.57	19.57
T_7-Seed sowing in PT and transplanting in PB in open	45.28	0.49	24.61	16.59
T_8-Seed sowing in PT and transplanting in PB in open + PH	45.95	0.51	25.34	17.21
T_9-Seed sowing PT and transplanting in PB in open + GH	46.58	0.52	26.64	18.66
T_{10}-Direct sowing of seeds in PB under SH	50.29	0.59	27.36	20.09
T_{11}-Direct sowing of seeds in PB under SH + PH	53.46	0.61	29.56	22.08
T_{12}-Direct sowing of seeds in PB under SH + GH	55.26	0.63	33.43	24.75
T_{13}-Direct sowing of seeds in PB under SNH	49.92	0.56	26.56	18.22
T_{14}-Direct sowing of seeds in PB under SNH + PH	51.85	0.57	26.88	18.91
T_{15}-Direct sowing of seeds in PB under SNH + GH	54.10	0.58	27.95	20.38
T_{16}-Direct sowing of seeds in PB in open	48.28	0.51	25.28	17.23
T_{17}-Direct sowing of seeds in PB in open + PH	49.42	0.53	26.34	18.13
T_{18}-Direct sowing of seeds in PB in open + GH	50.80	0.53	27.76	20.11
T_{19}-Seed sowing in seed beds and transplanting in PB in open	43.69	0.48	20.93	15.62
T_{20}-Seed sowing in seed beds and transplanting in PB in open + PH	45.26	0.49	22.60	16.25
T_{21}-Seed sowing in seed beds and transplanting in PB in open + GH	45.37	0.51	23.55	16.37
T_{22}-Seed sowing in seed beds and transplanting in nursery beds (control)	41.33	0.44	18.29	15.47
Standard Error of mean (SEm)	0.77	0.11	0.69	0.59
CD (5%)	0.95	0.02	0.96	1.08

PB = Polybag, SH = Screen house, PT = Propagation trays, SNH = Shade-net house, GH = Glass house, PH = Poly house

0.44cm, 18.29 and 15.47cm^2 were recorded in T_{22} (Control) respectively, where seeds were sown in seed beds and transplanted to nursery beds in open-field conditions. Maximum seedling height (53.43cm), stem diameter (0.60cm), number of leaves (30.10) and leaf area (21.33cm^2) were obtained when seeds were sown in propagation trays and seedlings then transplanted into polybags under screenhouse, and which were shifted to glasshouse during winter (Nov-Feb) compared to all other similar type of treatments. Greater seedling height, stem diameter, number of leaves and leaf area were recorded in treatments T_3, T_6, T_9, T_{12}, T_{15}, T_{18} and T_{21}, where seedlings were shifted to glasshouse in winter (November to February) compared to treatments where seedlings were transferred to polyhouse (T_2, T_5, T_8, T_{11}, T_{14}, T_{17} and T_{20}) or those that were not shifted from their original place (T_1, T_4, T_7, T_{10}, T_{13}, T_{16} and T_{19}). This might be due to modification in environmental conditions like temperature and humidity, which were favourable for growth of seedlings under screenhouse compared to shade-net house and open field conditions. Also, there is less attack of insect-pests on seedlings under screenhouse. Open-field conditions may have more harmful effects on seedling growth due to high temperature. These findings are in accordance with results of Dhaliwal *et al* (2003a) who recorded significantly higher seedling height, stem diameter and number of leaves under screen house compared to open-field under Ludhiana, Punjab conditions. In another trial, Dhaliwal *et al* (2003b) also recorded maximum seedling height, stem diameter and number of leaves in rough lemon seedlings germinated under glasshouse and placed in screenhouse conditions, compared to those germinated in glasshouse and placed in openfield; germinated and kept in screenhouse or those that were germinated and placed in open-field, under Ludhiana, Punjab conditions. Singh *et al* (1970) also recorded increase in seedling height, stem diameter, number of leaves and leaf area of rough lemon and rangpur lime seedlings under alkathene cover compared to open-field, under Delhi conditions. In the case of seedling height, similar results were reported by Muller (1988) in citrus rootstocks under South African conditions; by Chaturvedi and Bajpai (1999) in *Bridelia retusa* and *Holarrhena antidysenterica* under Madhya Pradesh (India) conditions; West *et al* (2002) in saw tooth oak (*Quercus acutissima*), white oak (*Quercus alba*), green ash (*Fraxinus pennsylvanica*) and flowering dogwood (*Cornus florida*) under Auburn, Alabama, U.S.A,

conditions. Similar results were recorded by Chaturvedi and Bajpai (1999) in *Bridelia retusa* Spieng. and *Holarrhena antidysenterica* Wall. under Madhya Pradesh, India conditions; Kumari *et al* (2001) in Nagpur mandarin under Nagpur, Maharashtra conditions; Singh (2003) in rough lemon under Ludhiana, Punjab conditions; Kumar (2004) in rough lemon under Ludhiana, Punjab conditions and Hazarika *et al* (2005) in seedlings of *Khasi* mandarin under Tinsukia (Assam) conditions in the case of number of leaves.

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