

Evaluation of Lemon Varieties on Australian Bigarade Rootstock

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Abstract

An experiment "Evaluation of lemon varieties on Australian Bigarade rootstock in the climatic conditions of Malakand" was conducted at Sub-tropical Germplasm Unit Sherkhana Malakand during 2014. Four lemon varieties i.e., Mesero, Lisbon, Eureka and Foothill eureka were budded on Australian Bigarade (*Citrus aurantium*) rootstock in 2006. Experiment was laid out as single factor Randomized Complete Block Design. There were four replications per treatment (variety), each tree was considered as one replicate. The results revealed that Corona foothill Eureka gained significant vigorous tree growth 4.02 m taller and 4.38 m expanded canopy spread, while trunk circumference/girth was more in Lisbon (75.33 cm), followed by Corona Foothill Eureka (71.67 cm). Statistically, there were no differences in bloom time and the fruit set per twig. However, numbers of flowers per twig were significantly more in Lisbon (35.33) followed by Mesero (27). The highest fruits were set by Corona foothill Eureka and Eureka 23.6 and 22.07%, respectively. Similarly, the lowest fruits were dropped by Corona foothill Eureka and Eureka 25.33 and 25.53%, respectively. The mean significantly high fruit weight (262.23 g), volume (785 cm³), pulp (88.83%), Juice (36.17%), and yield (47.33 kg Tree¹) were found in Mesero lemon. The Mesero lemon also had less number of segments per fruit. The least number of seed per fruit was recorded in Eureka. Corona Foothill Eureka was also good in juice percentage (40.33, fruit volume (685 cm³) and yield (40.07 kg Tree¹). The fruit chemical analysis showed that Lisbon had significantly high Acidity (10.67%) and vitamin C contents (28.33 mg 100 ml⁻¹) followed by Eureka 27. Whereas, there was no significant variation found in juice total soluble solids in rest of the lemon varieties. It can be concluded that Corona Foothill Eureka was better in overall tree growth on Australian Bigarade rootstock, however, the majority of yield components variables including yield were better in Mesero lemon. While fruit chemical quality was better in Lisbon.

INTRODUCTION

Lemon (*Citrus Limon*) belongs to the Family Rutaceae. The true home of lemon is unknown, though some have linked it to northern India. it was reported that lemons

were introduced into Mediterranean region between 1000 and 1150 A.D by Arabs (Chandler, 1958). The total area in Pakistan under citrus cultivation was 194000 ha which produced 2147300 tons of fruit. Whereas, the total area under citrus in Khyber Pakhtunkhwa province was 4100 ha., with production of 32600 tons citrus fruit during the year 2011-12 (Agriculture Statistics of Pakistan, 2011-12). The specific statistical data of area under cultivation and production of lemons in Khyber Pakhtunkhwa (KP) province is not available. However, Lemons are cold-sensitive as compared to oranges and have less ability to cold injury therefore, mild subtropical regions are more congenial for its cultivation. Lemons are used primarily for drinks, fresh juice, flavor and medicinal purposes. In Pakistan, the use of Acid lime (Kaghazi lime) and Limequat (*Chinese lime*) is very popular due its acidic or sour taste, similarly in parts of Pakistan, Sour orange (*Citrus aurantium*) is also used for flavoring salads and Chapli Kababs (spicy meet dish, very common in Pakistan particularly in Khyber Pakhtunkhwa province. However, lemon has its own taste and liked by those people, who know it. There are few very small orchards of lemon in Pakistan but not regular or on a large commercial scale. Although, there are many lemon varieties are under evaluation trials in various agricultural research institutes in Pakistan especially in KP and Punjab provinces and among those varieties two are particularly famous i.e, Lisbon and Eureka. In KP, the traditional commercial rootstock in sour orange for sweet orange, mandarins, lemon, grapefruit etc. but the strain of sour orange use in KP are reported susceptible to Tristiza virus and citrus greening problems (Kharif Report, 2012), therefore a new rootstock namely Australian Bigarade was imported from Australia. The existing four lemon varieties were budded on them. An experiment was designed to evaluate of lemon varieties on Australian Bigarade rootstock in the climatic conditions of Malakand, KP province, Pakistan.

MATERIALS AND METHODS

An experiment "Evaluation of lemon varieties on Australian Bigarade rootstock in the climatic conditions of Malakand, was conducted at Sub-tropical Germplasm Unit Sherkhana Malakand during 2014. Four lemon varieties i.e., Mesero, Lisbon, Eureka and Foothill Eureka were budded on Australian Bigarade (*Citrus aurantium*) rootstock in 2006. Experiment was laid out as single factor Randomized Complete Block Design. There were four replications per treatment (variety), each tree was considered as one replicate. The trees were planted on square layout system with six meters plant to plant and row to row space. The data were recorded on the following study variables;

Tree Height (m): measured tree height from ground surface to the terminal growth of tree and average was calculated.

Canopy Spread (m): Canopy Spread was measured by using measuring tape from all direction and average was calculated.

Trunk Girth (cm): the circumference or the trunk girth was measured with help of measuring tape and average was calculated.

Flowering Date: The date of flowering was recorded when the flower buds were started to appear.

Full Bloom Date: The date of full bloom was recorded from the date of flowering appearance till 80 percent bloom on the twigs with help of visual observation

Days to Fruit Set: When more than 80% flowers shed their petals and the ovaries started swelling then days to fruit set were recorded.

Fruit Maturity Date: Date of fruit maturity was calculated when the fruits rind showed colour break. They were classified as early, mid and late maturing varieties.

Number of Flowers Per Twig: The data were recorded by calculating mean number of flowers from the twig of each variety.

Fruit Set (%): The data were determined by counting the total number of fruit set on selected branches for all varieties and then their mean was calculated.

Fruit Drop (%): The number of fruit drop on selected branches from each variety was noted and percent fruit dropped was calculated.

Yield Tree⁻¹ (kg): Fruit yield was recorded in each variety and mean yield per tree was calculated.

Fruit Weight (g): The weight of ten randomly selected fruit from each treatment was taken and their average was worked out.

Fruit Volume (cm³): Ten fruit from each treatment were randomly selected their volume was determined by water displacement method

Number of Seed Fruit: The data regarding number of seed per fruit was recorded by selecting ten fruits randomly from each treatment. The seed was taken out counted and their average was calculated

Number of Segments Fruit: The total number of segment per fruit was recorded by counted the segment per fruit of ten randomly selected fruit from each treatment and then the average of replicated.

Percent Rind: The weight of ten randomly selected fruits were recorded then the weight of rind/ peels of the same selected fruits were taken and percent peel/rind was calculated.

Pulp Weight: Ten fruit were randomly selected from each variety and their juice was extracted. The remaining pulp was weighed and the mean pulp weight per fruit was calculated.

Pulp (%): percent pulp was determined through dividing pulp weight by Total fruit weight and then multiply by 100.

Rind Colour and Texture: The data of rind colour and texture were recorded on the bases of visual observation.

Chemical Characteristics of Fruit: Chemical characteristics of fruit were studied according to the method and procedure followed by Association of Official Analytical Chemists.

Percent Acidity: Fifty ml of juice was taken and 500 ml volume was made with distilled water in round bottom flask. 10 ml of stock solution was taken in beaker to which few drops of phenolphthalein was added as indicator. The prepared sample was titrated against 0.5N NaOH solution in percents acidity was calculated.

Total Soluble Solids: TSS was determined by placing a drop of juice on clean slab of Brix Refractometer and reading was recorded

Vitamin C: Five ml of sample was taken and volume made up to 100 ml by adding oxalic acid five ml of ths sample was taken and add 10 ml of 4 percent oxalic acid. Then this sample was titrated against dye solution, pink colour was the end-point of vitamin C.

RESULTS AND DISCUSSION

The study was carried out to evaluate the different lemon varieties grown under the agro climatic condition of sub-tropical Fruit Germplasm unit Malakend

Tree Height (m)

There was a highly significant mean difference in plant height among different varieties of lemon. It is obvious from the data in Table 1 that maximum height (4.02 m) was attained by Corona Foothill Eureka while Eureka gained the minimum height (2.73 m). Rootstocks have significant effects on the scion growth i.e., tree height and trunk cross section (William *et al.*, 2010). Similarly, it was reported that sweet orange had vigorous growth on Karna Khatta rootstock (Ghosh *et al.* (2012).

Trunk Girth (cm)

Tree trunk girth showed significant variation among the four varieties of lemon. The maximum trunk girth was recorded in Lisbon which gained 75.33 cm) trunk girth, followed by Corona Foothill Eureka (71.67 cm). Whereas, Mesero had (64.0 cm) and Eureka got (52.67 cm) tree trunk girth. The genetic variation of different scion varieties may be one of the reason and rootstocks have also affects on the tree height and trunk cross section (William *et al.*, 2010). There is a compatibility response of scion to rootstock (Mustafa and Reddy, 1990, and Ghosh *et al.*, 2012)

Tree Canopy Spread (m)

There were significant variations in the mean tree canopy spread among different varieties of lemon (Table 1). The maximum spread was observed in variety Corona Foothill Eureka (4.38 m) and least was recorded in Lisbon (3.58 m). Mesero and Eureka had 4.34 and 3.85 m canopy spread. It could be the genetic variation and the rootstock effect on scion (Mustafa and Reddy, 1990; William *et al.*, 2010 and Ghosh *et al.*, 2012).

Table 1: Tree growth performance of different varieties of lemon in the malakand region.

Variety	Tree growth		
	Tree height (m)	Canopy spread (m)	Trunk girth (cm)
Mesero	3.67b	4.34b	64ab
Lisbon	3.48c	3.58d	75.33a
Eureka	2.73d	3.85c	52.67b
Corona foothill eureka	4.02a	4.38a	71.67a
LSD ^a value at 0.05	0.0692	0.0321	14.17

Mean showing a common letter are not significantly different at $P \leq 0.05$ (Fisher LSD test)

^a Least Significant Differences

Day to Full Bloom

Statistically there was non-significant difference in days to full bloom in different varieties (Table 2). However, Mesero took more days (6.7) followed by Eureka (6.0) and Corona Foothill Eureka (5.33) and Lisbon (4.3 days). The almost equal response of lemon varieties may be due to similar climatic conditions i.e. temperature and relative humidity. So, the flowering and bloom dates were not varied.

Days to Fruit Set

There were also non-significant variations in days taken to fruit set among different varieties of lemon. There was only three days difference in the time taken to set

the fruits among the varieties. Mesero took 13 days, Lisbon (11 days), Eureka (10.33 days) and Corona Foothill Eureka (10 days).

Number of Flowers Twig⁻¹

All the lemon varieties were significant different with respect to number of flower per twig (Table 2). The mean values for higher number of flower per twig show that the highest number of flower per twig was counted in Lisbon (35.33) than in Mesero (27) and Eureka (24), while the minimum flowers per twig (16) was counted in Corona Foothill Eureka. This may be the variation in genetic behavior or tree previous year growth, some time alternate or biennial bearing habits of tree can cause variation in flowers numbers.

Fruit Set (%)

Different varieties had significant differences in percent fruit set. The high percentage of fruit set was recorded in Corona Foothill Eureka (23.6), followed by Eureka (22.07). Fruit set percentage in Lisbon was 18.70, while poor fruits were set in Mesero (16.17%). The variation may be attributed to the extent of suitability of agro- ecological conditions of Malakand to different varieties and the genetic variations among them. Similar, Anwar *et al.* (2004b) observed maximum number of fruit and fruit set in Pineapple sweet orange variety on Sour orange rootstock in Peshawar.

Fruit Drop (%)

There were highly significance differences in percent fruit drop among different varieties of lemon (Table 2). The mean value for percent fruit drop show that maximum fruit drop occurred in Mesero (58.23%) followed by Lisbon (36.67%), while minimum percentage of fruit drop was recorded in Corona Foothill Eureka and Eureka (25.53 and 25.33), respectively. It may be presumed that the soil fertility could be the possible factor affecting retention of fruit on the tree beside genetic variations. Sharma (1999) and Mann *et al.* (2009) also found that fruit drop percentages are different in citrus scion varieties on different rootstocks.

Table 2: Reproductive growth performance of different varieties of lemon in the malakand region.

Variety	Reproductive growth variables				
	Days to full bloom	Days to fruit set	No. of flowers twig ⁻¹	Fruit set (%)	Fruit drop (%)
Mesero	6.67	13.0	27b	16.17c	58.23a
Lisbon	4.33	11.0	35.33a	18.70bc	36.67b
Eureka	6.0	10.33	24c	22.07ab	25.33c
Corona foothill eureka	5.33	10.0	16d	23.60a	25.53c
LSD ^b value at 0.05	NS ^a	NS	0.5767	4.3701	6.7078

Mean showing a common letter are not significantly different at $P \leq 0.05$ (Fisher LSD test)

^a = not significant, ^b = Least Significant Differences

Fruit Weight (g)

The fruit weight showed in Table 3 had highly significant difference among the four varieties of lemon. The mean values show that Mesero had the maximum fruit

weight (262.23 g), while minimum fruit weight was recorded in variety Eureka (59.90 g). there non-significant variation in fruit weight between Corona Foothill Eureka (159.13 g) and Lisbon (150.67 g). These results are in the agreement with Ghosh *et al.* (2012) that Musambi sweet orange gained maximum fruit weight on Kamquat rootstock. The variation in fruit weight may also be attributed to genetic differences among varieties and extent of suitability of agro-climatic conditions to any variety.

Fruit Volume (cm³)

The different varieties are significantly different in fruit volume (Table 3). The mean value from fruit volume indicates that the maximum fruit volume was recorded in Mesero lemon (785 cm³) followed by Corona Foothill Eureka and Lisbon (685 and 700 cm³) respectively. Eureka bore fruit with less volume (655 cm³). These variations may be due to the varietal behaviors and their performance in the specific region. The findings are in the agreement of Kusuma *et al.* (2005) and Ghosh *et al.* (2012).

Fruit Yield Tree⁻¹ (Kg)

The maximum fruit yield per tree (47.33 kg) was recorded in Mesero, while minimum yield was recorded in Eureka (13.40 kg). Corona Foothill Eureka and Lisbon produced 40.07 and 28.67 kg fruit per tree. Variation in fruit yield may be the genetic potential of the variety and the suitable scion and rootstock compatibility. The same trends were found and reported by Mehrotra *et al.* (2002).

Fruit Pulp (%)

There were significant variations in pulp percentage of different lemon varieties (Table 3). Mesero had the highest pulp percentage (88.83), whereas, least pulp (20.47%) was recorded in Eureka. However, Lisbon and Corona Foothill Eureka had non-significant variation in pulp percentage i.e., 44.13 and 43.67, respectively. The pulp quantity of the fruit may be related to genetic potential of the variety. Similar results were reported by Kusuma *et al.* (2005).

Rind (%)

It is revealed from Table 3 that there were significant variations in rind percentage of different lemons. There was high and non-significant variation in Lisbon, Mesero, and Corona Foothill Eureka varieties which are 24.93, 23.80 and 23.33%, respectively, whereas, the lowest rind percentage (12.0) was recorded in Eureka lemon. These variations are may be due to varietal variations. These results are agreement with Saleem (1988) who reported maximum rind in Dancy mandarin.

Juice (%)

There were significant variations in Juice percentage of different lemons (Table 3). The highest Juice was found in Corona Foothill Eureka (40.33%), followed by Mesero (36.17%), and Lisbon (33.33%), respectively, whereas, the lowest Juice percentage (23.13) was recorded in Eureka. Similar findings were reported by Rehman *et al.* (1982) who stated that sweet oranges were different in their juice contents.

Segments Fruit⁻¹

Table 3 is showing that Eureka had significantly higher numbers of segments (13), fruit⁻¹ as compared to the rest of lemon varieties. Whereas, the least mean number of segments (9.67) were recorded in Lisbon. Corona Foothill Eureka and Mesero had 11.67 and 11.0 mean number of segments per fruit, respectively. Different varieties had their specific varietal range/ potential of number of segments per fruit. Khalid *et al.* (2015) also found different number of segments in the fruits sweet orange varieties.

Seed Fruit¹

It is evident from Table 3 that differences among the cultivars for seed per fruit were highly significant. The maximum number of seeds per fruit (25.33) were observed Corona Foothill Eureka followed by Mesero (18.33) and Lisbon (17.33). While minimum seed number (5.67) per fruit was recorded in Eureka. The differences in the number of seed per fruit is due to varietal differences.

Table 3: Fruit morphology of different varieties of lemon in the malakand region.

Variety	Fruit weight (g)	Volume (cm ³)	Yield (Kg tree ⁻¹)	Pulp (%)	Rind (%)	Juice	Segments fruit ⁻¹	Seed fruit ⁻¹
Mesero	262.23 a	785a	47.33 a	88.83 a	23.80 a	36.17 a	11.0b	18.33 a
Lisbon	150.67 b	700ab	28.67 c	44.13 b	24.93 a	33.33 a	9.67c	17.33 a
Eureka	59.90c	655b	13.40 d	20.47 c	12.0b	23.13 b	13.0a	5.67b
Corona foothill eureka	159.13 b	685ab	40.07 b	43.67 b	23.33 a	40.33 a	11.67b	25.33 a
LSD ^a value at 0.05	60.713	124.33	0.638 8	21.58 0	7.257 2	8.724 1	0.881	8.456 7

Mean showing a common letter are not significantly different at $P \leq 0.05$ (Fisher LSD test)

^a = Least Significant Differences

Total Soluble Solids (°Brix)

The data in Table 4 show that there was statistically non-significant variation in the mean values of total soluble solids (TSS). Which were 7.67, 7.0, 7.0, and 6.0°Brix in Mesero, Lisbon, Corona Foothill eureka and Eureka, respectively. These results are in contrast with findings reported by Farooqi (1985) who reported 12.16°TSS in variety Kinnow. The reason may be very close maturity times in lemons varieties.

Acidity (%)

The data regarding the acidity percentage of juice (Table 4), the maximum acidity (10.67%) was found in Lisbon, followed by Corona Foothill Eureka (8.0%), and Eureka (7.67%), while the minimum acidity percentage of 6.80 was found in Mesero lemon. These results also with agreement of Anwar *et al.* (2004b).

Vitamin C (mg/100 ml)

It is revealed from Table 4 that Lisbon variety had the maximum Vitamin C (28.33 mg/100 ml) content. followed by Eureka (27.0 mg/100 ml). While, minimum vitamin C were found in Mesero and Corona Foothill Eureka (26.67 mg/100 ml each). The results are in agreement with work of Rehman *et al.* (1982), who reported 22.5 to 56.17 mg/100 ml Vitamin C in different mandarin varieties.

Table 4: Fruit bio-chemical quality of different varieties of lemon in the malakand region.

Variety	Bio-chemical quality		
	TTS	Acidity	Vit. C (mg 100 ml ⁻¹)
Mesero	7.67	6.80b	26.67b
Lisbon	7.0	10.67a	28.33a
Eurika	6.0	7.67ab	27.0ab
Corona foothil eureka	7.0	8.0ab	26.67b
LSD ^a value at 0.05	NS ^b	3.25	1.3729

Mean showing a common letter are not significantly different at $P \leq 0.05$ (Fisher LSD test)

^a = not significant, ^b = Least Significant Differences

CONCLUSION

It can be concluded that Corona Foothil Eureka was better in overall tree growth on Australian Bigarade rootstock, however, majority of yield components variables including yield were better in Mesero lemon. While fruit chemical quality was better in Lisbon

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