

Planting Time Impact on Growth of Saplings/Plantlets from Promising Strains of Jojoba (*Simmondsia chinensis*)

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Abstract: Jojoba saplings established through rooted cuttings from female plants of promising six strains (PKJ-1, PKJ-2, PKJ-3, PKJ-4, PKJ-5 and PKJ-6) were transplanted in the field of Jojoba Research Station, Bahawalpur, in October and March during 2003-2005. The saplings planted in October, resulted in higher survival, increased plant height, higher number of branches and leaves per branch than that planted in March. Saplings of PKJ-3 strain had the highest survival, maximum plant height, number of branches and number of leaves per branch. The interactions between time of planting and strains were non-significant for all parameters except plant height. The saplings of PKJ-3 planted in October, attained the maximum plant height. Another study showed that the survival of tissue-cultured plantlets in field conditions was independent of the time of planting and jojoba strains.

Key words: Clones, cuttings, genotypes, growth, jojoba, plantlets, saplings, *Simmondsia chinensis*.

Jojoba (*Simmondsia chinensis* Link. Schneider) is an evergreen multi-stemmed 0.6 to 2.0 m tall woody shrub. It has 15-25 m deep tap root that may extract water from deep in the soil profile to tolerate drought. Under desert conditions (annual rainfall <100 mm), the plants persist as small stunted bushes and survive temperature of 45°C. Optimum temperature for its vegetative growth is 27-33°C. Under more favorable conditions the plants thrive best with life span exceeding 100 years. The plant is dioecious and wind pollinated. The seeds contain 50% by weight a liquid wax or oil. Estimated annual world production of this oil is 3,500 tons and demand is between 64,000 and 200,000 tons (Forster and Wright, 2002). Jojoba plantations are established through seeds, seedlings, rooted cuttings, or tissue-cultured plantlets. Plant vigor and rapid growth at early stage are important features for better establishment and survival. The best time for transplanting potted jojoba plants to the field in southern California is December or early January. However, in Pakistan, planting in these coldest months is not suitable because the small plants are susceptible to frost. So, it is necessary to wait until the March for transplanting. Planting of jojoba at Safford, Tucson, and Marana (Arizona) had failed because of low winter temperatures (Palzkill and Hogan, 1983). In Arizona, growers plant female cuttings of jojoba in September or March/April with over 90% survival (National Research Council of USA, 1985). One- and two-year-old cuttings and one-year-old

seedlings of jojoba proved suitable for planting in March-May when the soil moisture and humidity was adequate (Reina and Giorgio, 1985). Direct planting of rooted jojoba cuttings in the field failed because of hostile climatic conditions and in adequate soil moisture in arid regions (Harsh *et al.*, 1987). Palzkill (1988) reported that the root system of cutting-propagated plants might be somewhat different from direct-seeded plants and cuttage plants can be successfully established under irrigated conditions. Zhou (2002) reported 75 to 95% survival of jojoba cuttings after transplanting.

In Pakistan, jojoba was formally introduced in mid 1980s and Jojoba Research Station was established at Bahawalpur (Anonymous, 1994). The research station has a potential germplasm for vegetative propagation, yet the growth and survival of clonally multiplied material in field conditions has not been studied properly. The present study was undertaken to find out promising jojoba strains, their growth and survival in the field under arid and semi-arid conditions.

Materials and Methods

The fifteen-year-old female plants of promising jojoba strains i.e., PKJ-1, PKJ-2, PKJ-3, PKJ-4, PKJ-5 and PKJ-6, as characterized in Table 1, were selected and attempts were made to propagate female plants of these strains through cuttings (Bashir *et al.*, 2007) and tissue culture (Bashir *et al.*, 2008). Potted saplings were established after hardening of rooted

cuttings in clay pots for about six months i.e., April to September (Bashir *et al.*, 2007). These saplings were planted at the Experimental Farm of Jojoba Research Station, Bahawalpur, in the months of October and March during 2003-2005 in pits filled with the mixture of sand + silt + leaf mold (1:1:1 by volume) at plant to plant and row to row distance of 2 m. The saplings were irrigated twice a week during summer once a week during winter months. Chlorpyrifos @ 2 ml L⁻¹ of water was applied in the pits to control termites at fortnightly interval during September-October and February-March. Weeds around the saplings were removed once in a month by manual hoeing.

Each year 180 saplings were transplanted; 90 saplings in October 2003 and 90 in March 2004. Similarly 90 saplings in October, 2004 and 90 in March 2005 were transplanted in the field. The layout of the experiment was RCBD with 2 factors and 3 replications. The first factor was time of planting i.e., October and March. The second factor was six jojoba strains. Each time, 5 saplings of each strain were planted in one replication. The data were recorded for survival percentage, plant height and number of branches six months after the transplanting. The number of leaves per branch was recorded from randomly selected branches of each sapling. The survival percentage of saplings was also recorded.

The data were analyzed using Fisher's Analysis of Variance technique. The data in percentage were subjected to arcsin transformation prior to statistical analysis. The treatment means were compared employing Duncan's Multiple Range test at $\alpha = 5\%$ (Steel and Torrie, 1984).

Results and Discussion

The pooled analysis revealed the survival percentage was affected significantly by both the time of planting and the strains (Table 2). The

higher survival (50.6%) was recorded from October planting than that from March planting (42.3%). PKJ-3 had the highest survival (62.5%) and was followed by PKJ-6 (54.1%). Both the strains were statistically at par with each other. PKJ-2 had the lowest survival (33.3%) and was statistically similar to that of PKJ-5 (39.5%).

It is apparent from the data that the time of planting had significant effect on plant height (Table 3). Planting in October resulted in increased plant height (23.1 cm) than that in March (13.3 cm). The saplings of PKJ-3 grew fastest attaining a height of 25.5 cm while saplings of PKJ-2 were slowest (11.4 cm). The interaction between time of planting and the strains was statistically significant for this parameter (Table 3). The saplings of PKJ-3 attained the maximum plant height (31.0 cm) from October planting, while that of PKJ-2 had the minimum one (8.5 cm) from March planting.

The effect of both time of planting and the strains on branch number was statistically significant (Table 4). The saplings planted in October produced more branches (6.7) than that planted in March (5.8 branches). As far as the strains are concerned, PKJ-3 produced maximum branches (7.3), and was statistically at par with PKJ-6 (7.1) and PKJ-4 (6.8), while PKJ-2 produced minimum branches (4.7). The interaction was non-significant.

As plant height and number of branches increased in October planting, it also encouraged number of leaves per branch (7.6) over March planting (6.9). The strains also differed significantly for number of leaves per branch. The branches of PKJ-3 had maximum number of leaves (8.3) and behaved statistically alike with that of PKJ-6 (7.9). Minimum number of leaves per branch (6.0) was on PKJ-2 and it remained statistically at par with that of PKJ-5 (6.5). The interaction between two factors was non-significant (Table 5).

Table 1. Source origin, oil content and yield of six promising jojoba strains

Jojoba strains	Source origin	Seed oil content (%)	Seed yield (4 year avg.) (kg plant ⁻¹)	Potential yield (kg plant ⁻¹)
PKJ-1	California	47.2	3.12	4.00
PKJ-2	Arizona	50.4	2.83	3.10
PKJ-3	Arizona	49.4	2.71	3.10
PKJ-4	Arizona Upland	42.7	2.42	2.80
PKJ-5	California	49.4	2.20	3.10
PKJ-6	California	44.5	2.15	2.65

Source: Anonymous (2000-2006).

Table 2. Survival percentage affected by time of planting and jojoba strains

Strains	Time of planting		
	October	March	Average
PKJ-1	45.83a*	41.67a	43.75c
PKJ-2	37.50a	29.17a	33.33d
PKJ-3	66.67a	58.33a	62.50a
PKJ-4	50.00a	41.67a	45.83bc
PKJ-5	45.83a	33.33a	39.58cd
PKJ-6	58.33a	50.00a	54.17ab
Average	50.69a	42.36b	

*Means sharing similar letters in a group are non-significant at $\alpha = 5\%$ (DMR test).

The better growth in October planting could be attributed to favorable environmental conditions due to optimum temperature and humidity. However, poor growth in March planting may be due to increased temperature and decreased humidity. Moreover, due to hot winds of April, May and June, the saplings also wilted and died. Gradual decrease in maximum average

Table 3. Height of saplings (cm) as affected by time of planting and jojoba strains

Strains	Time of planting		
	October	March	Average
PKJ-1	23.33c*	12.58g	17.96d
PKJ-2	14.29fg	8.58h	11.44f
PKJ-3	31.03a	20.00d	25.51a
PKJ-4	26.32b	13.42g	19.87c
PKJ-5	16.37e	9.58h	12.98e
PKJ-6	27.57b	15.96ef	21.76b
Average	23.15a	13.35b	

*Means sharing similar letters in a group are non-significant at $\alpha = 5\%$ (DMR test).

temperature from 33.2 to 19.6°C (with 13.6°C difference) and high average maximum humidity range (76.6 to 89.7%) increased growth period during the months following October planting. On the other hand immediate increase in average maximum temperature from 32.2 to 43.4°C (with 11.2°C difference) and low average maximum humidity range (56.2 to 82.7%) reduced the growth during the months after March planting (Table 7). These results supported the findings of Sen and Couvillon (1983), who found saplings from October planted cuttings of peach cultivars in the field survived maximum, grew better than did cuttings planted on the other dates. The variation

among the strains in growth parameters may be due to their genetic make up and in case of plant height may be due to differential response of strains to time of planting. All the strains were influenced by stress caused by high temperature and low humidity that prevailed after March planting. Benzioni *et al.* (1999) found considerable variability in yield parameters, chilling requirement and morphological traits among jojoba clones. In another study, the survival rate of jojoba cuttings after transplanting ranged from 75 to 95% (Zhou, 2002). Cutting-propagated plants tend to produce

Table 4. Number of leaves per branch of sapling as affected by time of planting and jojoba strains

Strains	Time of planting		
	October	March	Average
PKJ-1	8.00a*	6.92a	7.46b
PKJ-2	6.17a	5.83a	6.00c
PKJ-3	8.67a	7.95a	8.31a
PKJ-4	7.89a	7.17a	7.53b
PKJ-5	6.83a	6.33a	6.58c
PKJ-6	8.39a	7.53a	7.96ab
Average	23.15a	13.35b	

*Means sharing similar letters in a group are non-significant at $\alpha = 5\%$ (DMR test).

more fibrous root system, which enables to sustain the plants under stress conditions, but they can be successfully established under irrigated conditions (Palzkill, 1988). Earlier Harsh *et al.* (1987) stated that development of rooted cuttings is difficult because of harsh environmental conditions of arid region. According to Palzkill and Feldman (1993), cuttings of jojoba with better root system

Table 5. Number of branches per sapling affected by time of planting and jojoba strains

Strains	Time of planting		
	October	March	Average
PKJ-1	6.50a	5.92a	6.21b
PKJ-2	5.33a	4.25a	4.79d
PKJ-3	7.86a	6.83a	7.35a
PKJ-4	7.42a	6.33a	6.87a
PKJ-5	5.50a	5.08a	5.29c
PKJ-6	7.75a	6.47a	7.11a
Average	6.73a	5.81b	

*Means sharing similar letters in a group are non-significant at $\alpha = 5\%$ (DMR test).

developed as a result of wounding and deeper insertion into the medium, performed better when

Table 6. Survival percentage of tissue-cultured plantlets in field conditions as affected by time of planting and jojoba strains

Strains	Time of planting		
	October	March	Average
PKJ-1	46.67a*	40.00a	43.33a
PKJ-2	40.00a	33.33a	36.67a
PKJ-3	60.00a	53.33a	56.67a
PKJ-4	53.33a	46.67a	50.00a
PKJ-5	40.00a	40.00a	40.00a
PKJ-6	53.33a	46.67a	50.00a
Average	48.89a	43.33a	

*Means sharing similar letters in a group are non-significant at $\alpha = 5\%$ (DMR test).

transplanted to the field. However, Reina and Giorgio (1985) concluded one- and two-year-old cuttings of jojoba to be suitable material for planting in March when the soil moisture was adequate.

The study revealed that survival of tissue-cultured plantlets in field conditions was independent of the plant genotype and the time of planting. The poor survival of plantlets following field transplantation may be due to reduction in leaf size during test tube culture as plantlets with larger and healthy leaves adapt and grow faster in soil after transplanting (Lee, 1988).

Table 7. Monthly temperature and humidity (RH) average of two years, i.e. 2003-04 and 2004-05

Months	Temperature (°C)		RH (%)	
	Max.	Min.	Max.	Min.
October	33.2	17.6	89.7	48.6
November	30.2	11.7	76.6	37.7
December	24.7	7.6	86.6	38.0
January	19.6	5.8	85.6	60.8
February	23.1	8.8	87.5	50.0
March	32.2	16.0	82.7	28.9
April	41.5	22.1	57.2	18.4
May	41.9	25.0	62.6	27.8
June	43.4	28.9	56.2	31.1
July	39.3	27.4	74.3	36.4
August	38.4	27.5	70.4	37.6
September	36.5	24.4	82.2	44.6

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Physico-chemical Qualities of Solar Dried Fruits of Karonda (*Carisa carandus* L.) as Affected by Blanching and Potassium Metabisulphite

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Abstract: The effect of blanching and potassium metabisulphite on physico-chemical qualities of solar dried fruits of karonda (*Carisa carandus* L.) for obtaining good quality dried produce was studied. Karonda fruits were subjected to different processing treatments viz., blanching, without blanching and potassium metabisulphite (0.5% and 1.0%) and dried in solar drier and their quality assessed. The fruits blanched for 5 minutes and sulphitation with + 0.5% KMS for 15 minutes exhibited maximum dry matter recovery (16.76%), reconstitution ratio (3.93), acidity (0.515%) and ascorbic acid (40.75 mg/100 g). The consumer acceptability of the fruits under this treatment was highest with maximum organoleptic score (8.04).

Key words: Karonda, *Carisa carandus*, blanching, potassium metabisulphite, physico-chemical qualities

Karonda (*Carisa carandus* L.) has remained neglected as far as post-harvest management is concerned. Shelf life of karonda is short because of its soft flesh with high moisture content. Mature green and ripe fruits may be dried and the products like squash, syrup, jam, jelly, pickle and sweet chutney could be prepared from mature green fruits (Pawar, 1998). The main objective of drying is to dehydrate the fruits to the extent where microorganisms do not survive and reproduce. Thus, dehydration controls the biological and chemical reactions, which facilitate the preservation of fruits. Dehydrated fruits and vegetables are more concentrated than those in any other preserved form. They are less costly to produce, involve minimum labor and equipment for processing equipments are limited too. Dried product may be consumed in off-season and transported to remote areas. Sun drying of fruits and vegetables is practiced widely in arid and semi-arid regions, where there is plenty of sunshine and less or no rains during the drying season (Sagar, 1999). Karonda fruits often lose their green color during storage, which can be prevented by blanching and sulphitation. Thus, in the present investigation effectiveness of blanching and potassium metabisulphite independently or in combination on the quality of dried karonda fruits was studied.

Materials and Methods

The experiment was conducted at SKN College of Agriculture (Rajasthan Agricultural University), Jobner, during 2000-01 and 2001-02. Fully matured,

but unripe fruits of karonda were cut into two halves and subjected to blanching and sulphitation treatments (viz., blanching for 5 min., blanching for 5 min. + 0.5% KMS (potassium metabisulphite), without blanching + 0.5% KMS, blanching for 5 min. + 1.0% KMS and without blanching + 1.0% KMS). For blanching, the fruits placed in muslin cloth were dipped into boiling water for 5 minutes and immediately dipped into cold water and given KMS treatment by placing them in 0.5 or 1.0% solution for 15 minutes and maintaining a ratio of 2:1 (fruit:solution). The fruits were dried for 5 days in solar dryer ($35\pm5^{\circ}\text{C}$ and $65\pm5\%$ RH). Dry matter recovery, reconstitution ratio, acidity, vitamin C and organoleptic evaluations were recorded just after drying. The dry matter was calculated on the per cent basis of dried fruits to the fresh fruits. For reconstitution ratio, 10 g fruits were soaked in 100 ml of water at room temperature for 24 hours and surface water was removed with filter paper. Reconstitution ratio was calculated as the ratio of drained rehydrated fruits to initial weight of dried fruits. The acidity and ascorbic acid of fruits were determined following AOAC (1990). The organoleptic evaluation of the fruits was conducted by a panel of 5 judges on the basis of fruit color, texture, aroma and taste using Hedonic rating test (Amerine *et al.*, 1965). The experiment was laid out in CRD with four replications using 2.0 kg fruits per treatment and analysis of variance was done as suggested by Gomez and Gomez (1984).

Results and Discussion

Dry matter recovery and reconstitution ratio were affected significantly by blanching and

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