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GROWTH RESPONSE OF JOJOBA , *SIMMONDSIA CHINENSIS* (LINK.) SCHNEID. TO DIFFERENT IRRIGATION TECHNIQUES IN CHOLISTAN DESERT OF BAHAWALPUR, PAKISTAN

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ABSTRACT

Among a number of arid zone plant species, Jojoba, *Simmondsia chinensis* (Link.) Schneid., being an evergreen, perennial multistemmic and multipurpose plant has attracted attention due to its economical value, potential by products and ability to withstand the desert environment. The oil extracted from jojoba seeds usually called as "Liquid gold" is the alternative of sperm-whale fish's oil. As this plant was originated from the USA and was introduced in the country on trial basis, thus most of the farmers and even some of the scientists are not familiar with its cultivation. Realizing the situation, a pioneer study was conducted on the sand dunes of Cholistan desert under typical desert conditions. Six irrigation techniques i.e. PVC pipe**,** plastic bags pitchers, pits, furrows and drip irrigation were included in this study. The maximum plant height of 47.4 cm was recorded in plants raised in pits, followed by PVC pipe (47.4 cm) and drip irrigation (45.1 cm). The maximum crown diameter of 44.5 cm was observed in pits followed by PVC pipe (39.3 cm) and drip irrigation treatment (35.0 cm). The maximum number of branches (22.8) was found in plants raised in pits followed by PVC pipe (17.6) and drip irrigation (17.3). The root behavior varied among different treatments.

Key-words: Jojoba , *Simmondsia Chinensis* (Link.) Schneid., growth, irrigation, desert, Cholistan. Pakistan

INTRODUCTION

Hot sandy deserts pose many problems to the newly introduced plants mainly because of scarcity of soil moisture (precipitation in such areas seldom exceeds 300 mm *per annum*). Sandy soils have poor water holding capacity and inadequate plant nutrients. Drought and extremes in temperatures are common features of these areas. The ecological degradation in such areas due to natural and man-made causes and consequent decline in productivity are the main threats to human and animal life. Since desert vegetation is mostly slow growing and hardly meets the ever increasing pressure of overgrazing and exploitation, introduction and establishment of ecologically suitable and economically productive plant species becomes imperative. To restore the ecological balance of a desert like Cholistan through re-vegetation efforts, where water is most precious and scarcest commodity, it is necessary to evaluate various irrigation techniques, which are not only effective and economical but also have wide acceptance among people for adoption at a massive scale (El and Montasser 1995 and Nelson and Palzkill 1993).

Among a number of arid zone plant species, Jojoba *{Simmondsia chinensis),* being an evergreen, perennial, multi-stemmed and multipurpose plant has attracted wide attention due to its economical value, potential by-products and ability to withstand vagaries of desert environment (Wilson & Witcombe, 1985). It is unique plant whose species widely distributed in arid and semi arid regions of Arizona, California and Baja California (USA) over an area of $2.6x10^8$ km^2 between latitude 25 and 31° N (Yermanos, 1979).

Jojoba seed contains 40 to 50% oil, which is, used in cosmetics e.g., lotions, moisturizers, massage oil, smoothing creams, shampoos, gels, lipsticks and nail polishes. There are many potential uses of Jojoba oil in pharmaceutical, plastic, printing and lubricant industries. Chemical composition of jojoba oil resembles that of whale fish oil. As a ban has been imposed on the hunting of whale at the international level, an increased attention is being paid since 1970's to the alternate source of oil (i.e. Jojoba oil) on a commercial scale. There is, however, a vital need to introduce this plant at a larger scale and make good use of its fruit/seed and the other by-products, which has largely been ignored in the past (Nechiporenko, 1989).

Realizing the importance of this plant, a pioneer study was initiated to investigate the growth response of Jojoba to various irrigation techniques in the Cholistan desert. The main objective of this study was "to find out the most effective and easy-to-use irrigation technique (s) for cultivation of jojoba on sand dunes and marginal lands".

MATERIALS AND METHODS

STUDY SITE

The study was carried out at the experimental farm of Arid Zone Research Institute of PARC, located in the Cholistan desert (Pakistan) at 71° 28 E and 28° 54 N latitudes 100 km south of Bahawalpur city at an elevation of

120 m above sea level. The study site is a typical desert area comprising of sand dunes and inter-dunal flats representing the unique Cholistan environment (Dasti and Agrew, 1994).

Planting techniques

The jojoba nursery plants of the age of six months, having approximately equal heights were planted using six different watering treatments i.e.; PVC pipe, plastic bags, pitchers, pits, furrows and drip irrigation techniques on the sand dunes. There were thirty-six plants in each treatment. The plant-to-plant distance was kept as 1.22 m and row-to-row distance was kept as 3.96 m. Each plant received 14 liters of water except furrow treatment throughout the study period. The irrigation was carried out on weekly basis for the first six months and then on fortnightly intervals throughout study period except furrows where irrigation was applied through flood irrigation on monthly basis. Some details of the irrigation techniques used in this study are given below.

1. Through PVC pipe

In this treatment, 45 cm deep pits were dug and 15 cm depth (bottom) of the pits was filled with loose sand. Jojoba plant was placed on the top of the loose sand and a 45 cm long PVC pipe (6 cm dia.) was erected near the roots of the plant in such a way that one end of the pipe remained outside the pit. Pipe was inserted in a slanting position. After erecting the pipe and placing the plant, the pit was completely filled with the soil. The open end of the pipe was covered with a cap to avoid water losses. The watering to the plant was carried out through the open end of the PVC pipe. Losses of water due to transpiration are minimized in this technique. The water directly goes to the roots and is efficiently used by the plant.

Fig.1. A view of growth response of Jojoba to different irrigation techniques on sand dunes at Cholistan experimental station of Arid Zone Research Institute, Bahawalpur.

2. Through Plastic bag

In this case, 0.9 m long common degradable laundry plastic bags having a diameter of 0.6 m were placed in pits. The plastic bags were then filled with sand and jojoba seedlings were planted in the bags. No holes were made at the bottom of the bags to avoid escape of moisture into the underneath soil.

3. Through Pitchers

In this case, 60 cm deep pits having a diameter of 50 cm were dug. Common earthen pitchers having 30 cm height and a mid-point diameter of 30 cm were placed inside the pits. The pits were refilled with sand in such a way that only opening of the pitchers was kept outside the pits. A single jojoba plant along side the pitchers was planted at a distance of 25 cm from the pitchers. Plants alongside pitchers were planted in a manner so as to receive the seepage water coming out of the pitchers (Fig. 2). Less losses of water were recorded in this method. The measured quantity of water was filled in the pitchers. The plant roots extracted water from soil nearby the pitchers. In this manner, leaching and transpiration losses of water were minimized and vegetables were also grown around the pitchers.

Fig.2. A view of growth response of Jojoba to pitcher irrigation technique on sand dunes at Cholistan experimental station of Arid Zone Researcvh Institute, Bahawalpur.

4. Through Pits

In order to have a control treatment, traditional simple pit method was included in the trial. Pits of 45 cm depth, with a diameter of 0.5 m were dug and Jojoba was planted.

5. Through Furrows

Furrows having 30 cm depth and 45 cm width were made using tractor mounted ditcher. Plants were then planted on the top of the furrows by making planting holes.

6. Through Drip irrigation

For drip irrigation, a drum measuring 220 liters of water was connected with a plastic pipe having an inner diameter of 1.27 cm. The pipe passed touching each plant, in a row. The plants were planted in 45 cm deep pits. At each plant, a spiral emitter was inserted in the main pipe in such a way that flow of water to the plant was in the form of drops. In order to have a uniform pressure, the drum was placed on a dune top. A uniform water pressure (10 psi) was maintained in this treatment.

Data collection and analysis

For collection of data, 10 plants from each treatment were selected randomly. Data on plant survival, plant height, crown diameter and number of branches per plant were recorded regularly on four-month intervals. The data was analyzed by using RCBD treating each plant as independent replication. The mean values separated using Duncan's Multiple Range Test.

Root behavior

In order to examine the response of jojoba roots to different irrigation treatments, one plant from each of the six irrigation treatments were sampled destructively at 18-months age. For this purpose, roots of each plant under each treatment were exposed carefully, washed and photographed and measurements of root length, roots spread, height of above ground plant portion and crown diameter were recorded.

The growth data of the plant was analyzed statistically.

RESULTS AND DISCUSSION

A. Plant height

The maximum plant height (47.4 cm) was recorded in plants raised in simple pits followed by PVC (47.4 cm) and drip (45.1 cm) irrigation treatments. Plant height among these three treatments did not differ significantly

(P<0.05). Pitchers and furrow irrigation treatments produced 33.3 and 30 cm plant heights, respectively and did not differ significantly The lowest plant height (19.1 cm) was recorded in case of plastic bag treatments, which did not differ significantly from furrow irrigation (Table 1). These findings are similar to those reported by Nerd and Benzioni (1988).

B. Crown Diameter

Likewise, maximum crown diameter of jojoba plants was recorded in case of pits (44.5 cm) followed by PVC pipe (39.3 cm) and drip (35.0 cm) irrigation treatments. Plants raised alongside pitchers attained 21.4 cm crown diameter that was not significantly different from that gained under furrows (13.6 cm) or plastic bag (7.2 cm) treatments (Table 1). These results are completely in agreement with those of Chilkara and Kumari (1991) and Roundy and Dobrenz, (1989).

C. Number of Branches:

Plants produced maximum number of branches raised under pits (22.8) followed by PVC pipe (17.6) and drip (17.3) irrigation treatments and these did not differ significantly. The lowest number of branches was observed in plants raised under plastic bag treatments (3.5), which did not differ significantly from the plants raised under furrow irrigation treatment (8.6). Just like plant height and crown diameter, the pitcher irrigation treatment remained intermediate in terms of number of branches (11.0) among all the treatments (Table 1). Similar results have been reported by of Kohorn (1994) and Benzioni and Ventura (1996).

D. Root Behavior:

The distribution and development of root system varied amongst plants grown with different cultivation techniques. Roots of jojoba raised under PVC pipe treatment attained a maximum depth of 50 cm and were spread over an area of about 60 cm^2. All the fibrous and taproots were found evenly distributed in the soil. Such uniform distribution of roots resulted in the development of a well-developed conical-shaped crown that attained almost 70 cm height and 50 cm diameter (Fig. 3-A). These results are in favour of Benzioni and Ventura (1998). These plants were female and were in flowering stage. In plastic bags treatment, although the tap-roots attained a length of about 70 cm but fibrous roots were either absent or very weak. The roots did spread in a horizontal fashion and penetrated vertically deep into the soil. The crown of the plant was, however, erect with few branches and diameter of 40 cm (Fig. 3-B) (Kumari and Chilkara, 1992).

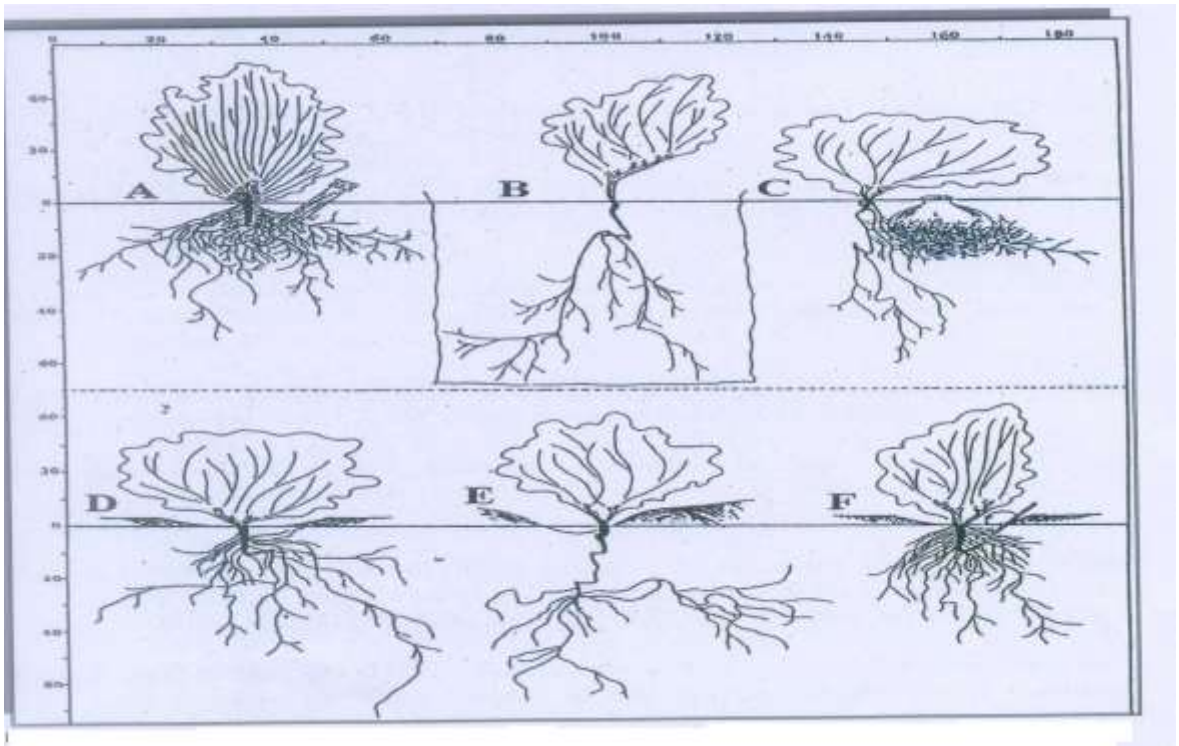

Fig.3. Impact of different irrigation techniques on root behaviour of Jojoba in sandy soils of Cholistan desert
(A) PVC pipes, (B) Plastic bags, (C) Pitchers, (D) Pits, (E) Furrows and (F) Drip irrigation.

A typical behavior of roots was observed in case of pitchers irrigation i.e., a dense mat of fibrous roots almost entirely covered the bottom of pitcher and very few (2-3) tap roots emerged from the plant that penetrated about 60 cm deep into the soil. The crown diameter of the plant in this case was almost 50 cm and the above-ground height was around 40 cm. It was a male plant and in the flowering stage (Fig. 3-C).

A beautiful plant with well-spread root system and vigorous crown was observed in pits irrigation treatment. As found outstanding in all other cases i.e. overall plant height, crown diameter and number of branches among all other treatments, the root system was found very well developed with a fair ratio of fibrous and tap-roots. The maximum penetration of taproot was observed about 80 cm while the overall spread of root system was around 60 cm. The crown was well developed having a diameter of 50 cm and above ground plant height was 55 cm. Similar findings were obtained by Ayerza, (1993). The plant was male and in flowering stage (Fig. 3-D).

In furrows irrigation a strange phenomenon was observed with regard to root development, i.e., the roots started splitting into branches about 30 cm below the soil surface and then covered almost 40 cm area. The roots were weak and a maximum penetration of 70 cm was observed. The crown attained a diameter of 40 cm and above-ground height was 60 cm. The plant was healthy but did not set flowers (Fig. 3-E). Under the drip irrigation treatment, the plant produced massive but comparatively shallow root system. Incidentally, Ash *et. al* (2005) has also reported similar results. The roots attained a depth of about 50 cm with a spread of 25 cm. The crown was conical, healthy and had a diameter of about 25 cm. The observed plant was male and in flowering stage (Fig. 3-F).

Table 1. Growth response of Jojoba (*Simmondsia chinensis*) to different irrigation techniques.

Treatments	Plant height (cm)	Crown Diameter (cm)	No. of Branches/plant
PVC Pipe	47.4 a	39.3 b	17.6 b
Plastic Bags	19.1 c	7.2 f	3.5 e
Picture Irrigation	33.3 b	21.4 d	11.0 c
Pits Irrigation	47.4 a	44.5 a	22.8 a
Furrow Irrigation	30.0 b	13.6 e	8.6 d
Drip Irrigation	45.1 a	35.0 c	17.3 b
CV	7.26%	6.99%	4.91%
$LSD_{p < 0.055}$	3.50	3.41	1.21

REFERENCES

Ash, G. J., A. Albiston and E.J. Cother (2005). Aspects of jojoba agronomy and management. *Advances in Agronomy* (USA), 85: 409-437.

Ayerza, R. (1993). Effect of irrigation on jojoba production under arid Chaco conditions: 11. Seed yield and wax quality. *J. American Oil Chemist's Society*, 70(9): 1225-1228.

Benzioni, A. and M. Ventura (1996). Long-term effect of irrigation with saline water on the development and productivity of jojoba clones. *J. Horticultural Science*, 71(6): 835-846.

Benzioni, A. and R.L. Dunstone (1988). Effect of air and soil temperature on water balance of jojoba growing under controlled conditions. *Physiologacion Plantarum*, 74(1): 35-36.

Chilkara, J. and A. Kumari (1991). Evaluation of jojoba potential under Indian conditions. *Proceedings of the National Academy of Sciences India*, Section B61 (4): 481-485.

Dasti, A. & Agrew, A.D.Q. (1994). The vegetation of Cholistan and Thar deserts, *Pak. J. of Arid Environments*, 27:193-208.

El, T.A.L., A.S. Montasser (1995). Effect of irrigation on mineral contents of jojoba plant. *Annals of Agricultural Science*, 29 (2): 1055-1068.

Kohorn, L. U. (1994). Shoot morphology and reproduction in jojoba: Advantages of sexual dimorphism. *Ecology Tempe*, 75 (8): 2384-2394.

Kumari, A. and J. Chilkara (1992). Variability in *Simmondsia Chinensis* under semiarid conditions. *Indian J. of Genetics and plant breeding*, 51(l):85-88

Nechiporenko, V.N. (1989). Industrial cultivation of new oil-producing plant *Simmondsia chinensis* Link in arid Zone. *Problemy Osvoeniya Pustyn*, (4): 73-75.

Nelson, J. M., and D. A. Palzkill (1993). Irrigation cut-off affects growth, frost damage and yield of jojoba. *Journal of the American Society for Horticultural Science* 118(6): 731-735.

Nerd, A., and A. Benzioni (1988). Effect of water deficit on vegetative growth and fruit development of jojoba, *Journal of the American Society for Horticultural* Science 113(3): 440-444.

Roundy, B.A. and A.K. Dobrenz (1989). Herbivory and plant water status of jojoba in the Sonoran desert of California (USA). *Journal of Arid Environments* 16(3): 283-292.

Wilson, J.M. and J.R. Witcombe (1985). Crops for arid lands. In: *Proceedings of the Kew International Conference on Economics Plants for Arid Lands held in the Jodrell Laboratory*, Royal Botanic Gardens, Drw, England, 23-27.

Yermanos, D.M. (1979). Jojoba, a crop whose time has come. *California Agriculture*. California Agricultural Experiment Station, July-August, 1979, PP: 4-7

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