
**E-ISSN:** 2618-0618
**P-ISSN:** 2618-060X

www.agronomyjournals.com
2024; 7(5): 244-250
Received: 07-02-2024
Accepted: 20-03-2024

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# Effect of plantation season on growth of different genotypes of *Jatropha curcas* as controlled irrigation and Mycorrhizal association under semi-arid region

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**DOI:** https://doi.org/10.33545/2618060X.2024.v7.i5d.683

**Abstract**
An experiment was conducted at Research and Development farm, Ruchi Biofuel Private Limited Maheshwer (situated between $24^{0}22^{o}12^{/}25^{//}$ N latitude, $75^{0}35^{/}26^{//}$ E longitudes, at an elevation of 600 m above the mean sea level), to study the effect of seed source and best propagation season of *Jatropha curcas*, on germination and growth, which can be used in genetic improvement programme. The five provenances were selected from Madhya Pradesh (Neemuch), Rajasthan (Udaipur), Gujrat (Dahod), and Chhattisgarh (Pendra and Jagdalpur). The germination and related parameters indicate that the seedlings transplanted during rainy season gave the significantly (P=0.05) maximum value for germination percentage as comparison of those planted of winter and summer season. The seedling growth parameters indicated that the provenance of Neemuch exhibited maximum growth, in comparison to other provenance/sources in decreasing order as Dahod, Pendra, Udaipur and Jagdalpur. Authentically overall results exhibited that the seeds collected from Neemuch and Dahod perform consistently in term of germination and growth under semi arid region of Maheshwar after 3 years of plantation.

**Keywords:** Provenances, *Jatropha curcas*, genetic improvement programme and seed germination

## Introduction

*"Countries lacking energy sources require the inclusion of alternative ones, with a high impact on the country's economy. This is the case of renewable energy and biofuels in particular."*

In the recent past, bio-diesel derived from plant species has been a major renewable source of energy. Among various plants *Jatropha curcas* and *Pongamia pinnata* have been chosen as most potential species for varying situations. Between these two species *Jatropha curcas* is considered most potential not only to the growers but also to the processors and end users. To the rural society, the crop can create regular employment opportunities, as it provides never ending marketing potential. Due to potential demand and better marketing opportunities, cultivation of *Jatropha curcas* appears viable. *Jatropha curcas* may not replace other important food crops since it is meant for flood free wastelands and unutilized fallow lands / less productive lands and in turn will not have a major impact on cropping pattern (Tedla *et al*., 2020; Singh *et al*., 2022; Arunyanark *et al*., 2023) [35, 31, 3].

Among the many species, which yield oil as a source of energy in the form of biodiesel, *Jatropha curcas* L. has been identified as most suitable oil seed bearing plant due to its various favourable attributes like hardy nature, short gestation period, adaptability in a wide range agro-climatic conditions, high oil recovery and quality of oil etc. It can be planted on degraded lands through Joint Forest Management (JFM), farmer's field boundaries, road sides, both sides railway track, fallow lands and as agro forestry crop. It grows up to a height of 5 m. and can be maintained to a desired height and shape by trimming and pruning. Planning Commission, Govt. of India has identified two species for mass production of seeds for biodiesel *viz*., J *Jatropha curcas* and *Pongamia*. J *Jatropha curcas* is suitable for upland while *Pongamia* found adaptive for both uplands as well as wetland conditions. Among these two species the following differences made *Jatropha* superior if otherwise the conditions are not unsuitable for it (Sarraf *et al*., 2011; Maftuchaha *et al*., 2020) [29, 21].

In India, the growth and management of *J. curcas* be it on private, public or community lands have been poorly documented with little field experience being shared amongst researchers and farmers. To reduce dependence on crude oil and to achieve energy independence by the year 2012, Jatropha has been promoted under the National Biodiesel Mission in India. The seed oil 'Jatropha oil' can be easily processed to partially or fully replace petroleum-based diesel fuel (Forson, 2004) [9]. Thus, the use of this plant for large-scale biodiesel production is of great interest with regard to solving the energy shortage, reducing carbon emission and increasing the income of farmers (Banerji *et al.,* 1985; Martin and Mayeux, 1985; Gubitz *et al.,* 1999; Keith, 2000; Zhou *et al.,* 2006; Sarraf *et al.,* 2011; Singh et al., 2022) [5, 22, 11, 16, 29, 31]. Recently, the high yield of seeds from the tree (~5 t/ha/yr) and the high oil content of the seeds (~66.4%) attracted global attention for the development of J. curcas as a source of bio-fuel (Keith, 2000, Chen, *et al.,* 2006; Adebowale, *et al.,* 2006; Li, *et al.,* 2007; Muhammad *et al.,* 2020; Adebusuyi *et al*., 2021; Sarraf *et al*., 2011) [16, 7, 1, 19, 24, 2, 29]. The plant can be propagated on a massive scale by direct seedling, planting stem cuttings, stumps and root cuttings. Hot and humid weather is preferred for good germination of seeds and plant growth.

Therefore, keeping the above mentioned fact about the *Jatropha* the present study was sought to determine suitable period and situation specific propagation method and input management method for the cultivation *Jatropha curcas* for seed production in order to maintain genetic purity, uniformity and gainful exploitation of useful variation, and also to meet the required demand for high-quality planting material at commercial scale.

## Materials and Methods

The present study was carried out with five provenances were selected from Madhya Pradesh, Chhattisgarh, Rajasthan and Gujarat, at the research and demonstration farm of Ruchi Bio Fuels Pvt. Ltd. at village Gawla Talab, Maheshwar District-Khargone M.P located between 22º12/25// N latitude, 75⁰35/26// E longitude with an elevation of 600 meter from sea level, The soil texture of the experiment site is sandy clay loam having 54.2, 19.3 and 26.5% of sand, silt and clay, respectively. Soil colour varied from red at the upper part of the experimental site to dark brown at the lower part. Blocking was done perpendicular to the soil gradient and slope and available nitrogen originate inferior (219.3 kg/ha) and available potassium was determined higher (560 kg/ha) side as per requirement of species in soil. Mean annual rain fall ranges from 500 to 650 mm and occurs during a single rainy season extending from June to September. Mean annual temperatures range from 10 ºC to 45 ºC. Sometimes the area experiences frost from December to January (Table 1.)

Homogeneous dimension cuttings about 25 cm long and 5 cm in diameter were collected from five selected provenances of Neemuch (Madhya Pradesh), Pendra and Jagdalpur (Chhattisgarh), Udaipur (Rajasthan) and Dahod (Gujarat) (Table 2). Uniformed sized seedlings of an average height of 45 cm and a root collar diameter of 11 mm are using for the experiment. 150 seedlings were planted in 10 replications inside 30 cm deep and 15 cm diameter pits by using soil mixture of 1:1:1 of soil, sand and FYM. Transplanting of seedlings was done in the season of summer (April-May), rainy (June-July) and winter (November-December) from the nursery to the plantation site. Mycorrhiza @ 2g/plant was also applied in soil at the time of plantation, uniform water intensity level was maintained through drip irrigation by the capacity of 2 lts/hrs. (drip diameter 32 mm) and duration of irrigation was fixed as 4 hrs. per week. Spot weed management practices were done after two months of planting. The total plant density was maintained as1000 sapling/acre in entire plantation side. The planting densities was chosen after Singh *et al*. (2007) [34] and Heller (1996) [12] recommendations that *J. curcas* planting densities for commercial plantations be 2500 stems/ha.

Measurements were done on all the plants in the plots after three month of plantation. Plant survival was determined after three months of planting by using following formula.

$$\text{Total Survival (\%)} = \frac{\text{Plants established-Total plants dead}}{\text{Total plants established}} \times 100$$

Growth in height and root collar diameter was measured after three months after planting, using a height rod and a verneer caliper, respectively. Plant height was measured as the distance in cm. However, in some of the plants, the apical meristem was damaged by herbivores, frost or pathogens. In these cases, branch leader meristems were considered for height measurement (Balderrama and Chazdon, 2005) [4]. The data was statistically analyzed for $3^3$ Factorial Randomized Design and analysis of variance (ANOVA) was done for all trials and simple correlation (r) was calculated following the method of Shnedecor and Cochran (1967) [30].

## Results and Discussion

Survival data showed that saplings established during rainy season (81.42%) outperformed ($p$>0.05) and those planted during winter and summer season exhibited 58.07, and 19.41%, respectively. In turn, *Jatropha curcas* planted during winter season outperformed ($p$<0.05) the ones propagated in summer season in terms of survival (Fig 1). This observation is scientifically sensible because the cultivation of seedlings under closely monitored nursery conditions gives them a physiological advantage over plants established by direct planting of either seed or cuttings. The well-developed root system and stem increase the potential to survive water and other stresses. Although the cultivated seedlings were observed to initially lose leaves due to transplantation shock, the roots and stem organs enabled them to quickly develop new leaves thereby increasing chances of survival. Thus, pre-cultivated seedlings easily adapted to the harsh, less controlled field environment than non-rooted cuttings and seed. However, during winter, plants established by planting pre-cultivated seedlings were the most affected, losing their apical meristems to frost, forcing the plants to develop some shoots in response tothe loss of apical dominance. This is consistent with observations by Wini *et al*. (2006) [36] and Singh *et al*. (2007) [34] that *J. curcas* cannot withstand frost. The mortality was mainly attributed to frost which attacked the saplings' shoots during winter (Wini *et al.,* 2006; Singh *et al.,* 2007) [36, 34] and defoliation by mammals, rodents and locusts (Heller, 1992; Muhammad *et al.,* 2020; Adebusuyi *et al*., 2021; Sarraf *et al*., 2011; Singh *et al*., 2024) [11, 24, 29, 2, 32].

Growth of field plantation of *Jatropha* as influenced by different plantation season and mycorrhizal status is determined in table 3. Perusals of data are revealed that the in terms of height, saplings propagated in rainy season designated significant differences ($p$<0.01) and obtained average maximum growth (77.97 cm) among those planted to summer (74.97 cm) and winter (74.65 cm) season. The different scenario was observed with mean basal girth, recording significant differences ($p$<0.05) among saplings which were planted in various season.

Maximum growth in mean basal diameter were observed in those cutting were transplanted during the winter season (23.83 cm), closely followed by summer (21.26 cm) and winter (20.14 cm). Saplings were transplanted in different season exhibiting significantly impact ($p<0.05$) on growth in height, while, in phrase of basal girth it revealed non-significantly effect ($p>0.05$). The growth of seedlings were effected by different seed source the analysis of data revealed that for growth parameters (mean of all season) of seedling was observed significantly ($p<0.05$) higher of Neemuch (height; 97.12 cm basal diameter; 26.26 cm) than Dahod (height; 93.79 cm basal diameter; 24.19 cm) and Pendra (height; 91.22 cm basal diameter; 24.01 cm), while, the minimum growth found in those seeds were collected from Jadalpur (height; 67.389 cm basal diameter; 14.72 cm) with mycorrhizal association in irrigated condition and same trends in growth was trace in rainfed condition. The maximum growth was achieved with mycorrhizal association in height 4.64 cm and basal diameter 2.06 cm more than no mycorrhiza applied in irrigated condition and same tendency in growth was recorded in rainfed condition also. The lack of significant differences in growth in height and basal diameter responses of seedlings and direct seeding could be explained by environmental and physiological factors. The loss of the physiological advantage associated with saplings established through pre-cultivated seedlings could be explained by transplanting shock as well as the harsh climatic and edaphic conditions on the field. Transplanting seedlings from the closely monitored nursery to the field, characterized mainly by episodes of moisture deficiency could have significantly lowered the plants' external water potential which could have caused a decrease in cellular growths (Sakurai and Kuraishi, 1988; Singh *et al*., 2024) [27, 32] and thus impacted on shoot length and basal diameter resulting in the lack of significant difference between *J. curcas* established by pre-cultivated seedlings and seedlings. It may be possible that the effect of the transplanting shock was prolonged enough to overshadow the established root system and shoot advantage characteristic of pre-cultivated seedlings (Singh *et al*., 2024) [32].

Mean annual increment in height and basal diameter growth of three year old plant has represented in fig 2. Significant ($p<0.05$) different were noticed for height and basal diameter in all provinces studied but there was no significant ($p>0.05$) different was found in growth characters of various sources while were planted in different season. However maximum growth was found in Neemuch, followed by Dahod and Pendra, whereas, the minimum growth found in Udaipur and Jadalpur provinces with mycorrhizal association in irrigated condition and in non-mycorrhizal application of rainfed condition as well. This might be because of unlike pre-cultivated seedlings, directly planted seed need to germinate and survive the critical, early stages of growth and development which occurs in an unpredictable natural environment characterized by harsh weather conditions and pests and diseases. This partly explains the high mortality observed on *J. curcas* established by direct seeding. Similar results were observed elsewhere (Kobilke, 1989; Heller, 1992; Kureel, 2006; Feike *et al.*, 2007; Singh *et al*., 2024) [17, 11, 8 32]. Salisbury and Ross (1992) [28] explained that the period from germination to the time the seedling becomes established as an independent organism constitute the most critical phase in the life history of the plant. During this period, the plant is most susceptible to injury by a wide range of insect pests and parasitic fungi and water stress can prove to be fatal. Direct field observations from this study attributed the high mortality to pests and diseases chief of which were damping off (Heller, 1992; Singh, 1983) [11, 33], defoliation by millipedes (Heller, 1992) [11], locusts (Heller, 1996) [12], termites and rodents (Kar and Das, 1988; Meshram and Joshi, 1994; Biswas *et al.*, 2006; Rao, 2006; Adebusuyi *et al*., 2021; Sarraf *et al*., 2011) [15, 23, 6, 26, 2, 29]. The high incidence of pests and diseases explains the high vulnerability of the tender, post germinated juvenile plants.

Correlation (r) between character studied and geographical factors of the *Jatropha curcas* are exhibited in table 4, negative correlation ($p<0.05$) were shown for seedling growth in height with elevation of those seedling were transplanted during summer (-0.60) and winter (-0.59) under irrigated condition with micorrhizal association. Latitude is playing significant ($p<0.05$) role to increasing plant height during rainy (0.67) and winter (0.64) season under irrigated condition without mycorrhiza application, incessantly basal diameter is also influencing with latitudinal factor as it shows positive correlation ($p<0.05$) in summer (0.66), winter (0.67) and winter (0.58) season under rainfed condition while it observed highly significant ($p<0.01$) in rainy (0.73) and winter (0.70) under rainfed and irrigated condition, respectively. Longitude is also effecting highly significantly ($p<0.01$) on basal diameter during rainy and winter season under rainfed-non mycorrhizal condition and it is not inspiring on height growth. Climatic condition as rainfall and temperature is playing negligible impact on growth of Jatropha seeding in different season with the association of mycorrhiza under irrigated and rainfed condition.

Correlation (r) between characters studied with edaphic condition of experimental area revealed no impact on growth of Jatropha seeding under Maheshwar condition, only amount of per hector nitrogen and phosphorus are exhibited a smaller amount of part in growth of Jatropha seedlings as its shows negative correlation ($p<0.05$) in rainy season in height (-0.57 and -0.51 respectively) with mycorrhiza application under irrigation condition and during winter its effecting basal diameter growth (-0.56 and-0.57 respectively) under rainfed condition with mycorrhizal association. Surprisely growth of seedling propagated during rainy season are influencing negatively ($p<0.01$) by nitrogen and phosphorus under rainfed condition without application of mycorrhiza (Table 5). For the correlation matrix it is observed that there are certain trials like collar diameter and shoot length which have influencing to weight of the seedling and significant correlation ($p<0.05$) were obtained shoot weight and root weight with collar diameter. This incidence that the differences observed for morphological trials pertaining to seeds may very well be influenced by seasonal variation of respective sources spread over an immense geographical area, experiencing varied environmental conditions. Since the experiment was conducted under a uniform condition where the environmental deviations are negligible, therefore the observed phenotype value will be equivalent to the genotype value. With this assumption the differences observed for grown seedling trials could be genetic in nature. Similar observations were also made by Ginwal *et al.* (1996) [10] for *Acacia nilotica*. Neelu *et al.,* (2000) [25], Iverson *et al.,* (2002) [14] and Hossain *et al.,* (2004) [13] are also opined that considerable variation occurs in germination capacity of seeds of *Pongamia pinnata* from different places under different conditions (Muhammad *et al*., 2020; Sarraf *et al*., 2011) [24, 29].

**Table 1:** Certain Soil Characteristics of experimental plot of Maheshwar

| Sl. No. | Parameters | Values |
|---|---|---|
| | **Edaphic characteristics (Average of three depth 0-10; 10-20 and 20-30 cm)** | |
| 1 | Soil structure | Sandy clay loam |
| 2 | Texture | |
| | Sand (0.05-2.0 mm) (% of <2 mm) | 54.2 ±4.51 |
| | Silt (0.02-0.05 mm) (% of <2 mm) | 19.3 ±2.25 |
| | Clay (<0.02 mm) (% of <2 mm) | 26.5 ±3.01 |
| 3 | Bulk density ($mgm^{-3}$) | 1.9 ±0.75 |
| 4 | Soil pH (1:2) | 7.7 ±0.26 |
| 5 | Electric conductivity (1:2) (dsm-1) | 0.2 ±0.09 |
| 6 | Organic Carbon (%) | 0.6 ±0.05 |
| 7 | Nitrogen (kg ha-1) | 219.3 ±13.25 |
| 8 | Phosphorus (kg ha-1) | 13.4 ±3.86 |
| 9 | Potassium (kg ha-1) | 560.0 ±106.67 |
| | **Geographical characters** | |
| 10 | Latitude (°N) | $22^{0}12^{/}25^{//}$ |
| 11 | Longitude (°E) | $75^{0}35^{/}26^{//}$ |
| 12 | Elevation (m) | 600 |
| 13 | Rainfall (mm) | 650 |
| 14 | Temperature (Mini.–Maxi.) (°C) | 10-45$^{0}$C |

**Table 2:** Accession sources of Jatropha curcas and their geographical locations

| SN. | Location | Latitude (°N) | Longitude (°E) | Elevation (m) | Rainfall (mm) | Temperature (Mini.–Maxi.) (°C) |
|---|---|---|---|---|---|---|
| 1 | Pendra (Chhattisgarh) | 22.76 | 81.95 | 591 | 1060 | 9.5-40.3 |
| 2 | Neemuch (MP) | 24.27 | 74.52 | 452 | 950 | 12.5-40.5 |
| 3 | Udaipur (Rajasthan) | 28.11 | 70.25 | 600 | 665 | 08.0-46.2 |
| 4 | Dahod (Gujarat) | 22.53 | 74.19 | 313 | 680 | 15.0-45.0 |
| 5 | Jagdalpur (Chhattisgarh) | 19.07 | 82.03 | 552 | 860 | 10.0-41.5 |

***Source***: www.mustseeindia.com

**Table 3:** Plant growth (cm±SD) as influence by irrigation and mycorrhizal association in different session of plantation of *Jatropha curcas*.

| Sources | Irrigation condition | Mycorrhizal Status | Summer | | Rainy | | Winter | |
|---|---|---|---|---|---|---|---|---|
| | | | Height (cm) | Diameter (cm) | Height (cm) | Diameter (cm) | Height (cm) | Diameter (cm) |
| Pendra | Irrigated | M | 87.21 ±21.41 | 24.60 ±09.54 | 81.23 ±35.54 | 26.54 ±10.54 | 105.22 ±44.50 | 20.91 ±15.21 |
| | | N | 80.21 ±25.47 | 23.78 ±11.32 | 82.22 ±21.27 | 25.86 ±17.67 | 97.20 ±36.63 | 18.61 ±12.21 |
| | Non Irrigated | M | 79.28 ±13.44 | 18.78 ±08.75 | 70.52 ±19.07 | 18.37 ±12.23 | 80.35 ±18.97 | 19.65 ±11.54 |
| | | N | 74.78 ±15.25 | 17.36 ±08.45 | 72.49 ±21.54 | 18.28 ±10.25 | 75.33 ±21.67 | 16.54 ±14.50 |
| Neemuch | Irrigated | M | 96.84 ±16.20 | 26.32 ±07.91 | 83.18 ±17.98 | 29.61 ±10.75 | 111.34 ±25.67 | 22.85 ±11.06 |
| | | N | 75.22 ±20.42 | 25.01 ±11.62 | 82.73 ±23.31 | 27.17 ±12.67 | 103.85 ±21.11 | 18.69 ±13.00 |
| | Non Irrigated | M | 76.58 ±19.38 | 21.31 ±10.78 | 70.38 ±37.54 | 24.52 ±15.54 | 93.85 ±19.21 | 20.85 ±11.09 |
| | | N | 67.20 ±12.98 | 19.22 ±15.23 | 76.50 ±34.45 | 18.30 ±13.37 | 84.26 ±21.04 | 17.01 ±10.27 |
| Udaipur | Irrigated | M | 74.50 ±19.70 | 19.40 ±04.67 | 76.56 ±42.21 | 21.85 ±15.55 | 82.92 ±15.55 | 19.43 ±16.67 |
| | | N | 71.97 ±10.66 | 17.32 ±11.09 | 80.41 ±12.34 | 21.60 ±16.78 | 75.46 ±11.23 | 18.16 ±15.21 |
| | Non Irrigated | M | 70.92 ±15.68 | 16.50 ±13.63 | 70.49 ±16.87 | 19.51 ±13.25 | 69.12 ±14.45 | 19.65 ±17.25 |
| | | N | 62.90 ±17.62 | 14.67 ±10.25 | 75.25 ±12.65 | 18.88 ±15.67 | 67.25 ±13.23 | 15.40 ±10.50 |
| Dahod | Irrigated | M | 92.00 ±12.62 | 23.24 ±12.39 | 80.59 ±15.67 | 28.38 ±16.87 | 108.78 ±28.75 | 20.95 ±14.21 |
| | | N | 79.79 ±24.18 | 24.48 ±11.35 | 86.80 ±13.65 | 27.20 ±19.90 | 106.20 ±42.21 | 17.36 ±09.87 |
| | Non Irrigated | M | 73.96 ±26.63 | 20.93 ±8.76 | 74.56 ±17.98 | 23.58 ±17.55 | 94.83 ±25.54 | 19.78 ±07.97 |
| | | N | 71.60 ±29.42 | 19.35 ±13.45 | 76.82 ±20.21 | 20.52 ±13.29 | 88.65 ±31.33 | 18.72 ±20.21 |
| Jagdalpur | Irrigated | M | 65.94 ±16.26 | 13.20 ±16.23 | 62.61 ±10.21 | 19.57 ±10.88 | 75.04 ±22.21 | 11.41 ±08.89 |
| | | N | 52.87 ±16.75 | 10.06 ±10.54 | 50.41 ±17.39 | 15.81 ±09.64 | 69.32 ±10.67 | 9.91 ±03.65 |
| | Non Irrigated | M | 62.99 ±14.21 | 9.09 ±07.56 | 45.50 ±16.21 | 11.59 ±07.54 | 68.77 ±12.39 | 9.12 ±07.67 |
| | | N | 44.69 ±21.54 | 8.67 ±10.88 | 40.37 ±10.41 | 11.32 ±07.42 | 54.25 ±17.67 | 6.05 ±05.37 |
| C.D. (5%) | | | 4.29* | 2.37 | 15.32** | 4.67* | 2.25 | 3.91* |

Significant at P=0.05*; P= 0.01**

M=Mycorhiza applied (@ 2 gram/plant); N= Mycorhiza not applied

**Table 4:** Simple correlation (r) between character studied and the geographical factors of the provinces of *Jatropha curcas.*

| Plant Characters | Season of plantation | Irrigation | Mycorhiza Status | Geographical factors | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Latitude (°N) | Longitude (°E) | Elevation (m) | Rainfall (mm) | Temperature (°C) |
| Height | Summer | Irrigated | M | 0.21 | -0.25 | -0.60* | 0.25 | 0.32 |
| | | | N | 0.49 | -0.26 | -0.34 | 0.07 | 0.33 |
| | | Non Irrigated | M | 0.39 | -0.13 | -0.17 | 0.42 | 0.01 |
| | | | N | 0.44 | -0.26 | -0.29 | 0.16 | 0.25 |
| | Rainy | Irrigated | M | 0.39 | -0.26 | -0.36 | 0.61* | 0.15 |
| | | | N | 0.67* | 0.49 | -0.51 | 0.44 | -0.02 |
| | | Non Irrigated | M | 0.47 | -0.46 | -0.52 | 0.05 | 0.41 |
| | | | N | 0.42 | -0.44 | -0.45 | 0.06 | 0.42 |
| | Winter | Irrigated | M | 0.11 | -0.13 | -0.59* | 0.31 | 0.29 |
| | | | N | 0.64* | -0.48 | 0.40 | 0.18 | -0.29 |
| | | Non Irrigated | M | -0.02 | -0.20 | -0.43 | 0.10 | 0.51 |
| | | | N | 0.27 | -0.40 | -0.52 | -0.10 | 0.56* |
| Collar diameter | Summer | Irrigated | M | 0.16 | -0.21 | -0.63** | 0.65* | 0.33 |
| | | | N | 0.36 | -0.33 | -0.38 | 0.15 | 0.36 |
| | | Non Irrigated | M | 0.51 | -0.43 | -0.51 | -0.14 | 0.55* |
| | | | N | 0.66* | -0.64** | -0.42 | -0.24 | 0.54* |
| | Rainy | Irrigated | M | 0.55* | -0.47 | -0.34 | 0.15 | 0.26 |
| | | | N | 0.44 | -0.56* | -0.37 | -0.09 | 0.42 |
| | | Non Irrigated | M | 0.67* | -0.59* | -0.36 | -0.14 | 0.44 |
| | | | N | 0.73** | -0.64** | -0.31 | -0.12 | 0.40 |
| | Winter | Irrigated | M | 0.50 | -0.49 | -0.34 | 0.09 | 0.27 |
| | | | N | 0.70** | -0.33 | -0.14 | 0.05 | 0.18 |
| | | Non Irrigated | M | 0.52 | -0.49 | -0.26 | -0.02 | 0.30 |
| | | | N | 0.58* | -0.54* | -0.44 | -0.08 | 0.46 |

Significant at P=0.05*; P= 0.01**

**Table 5:** Simple correlation (r) between character studied and the edaphic factors of the provinces of *Jatropha curcas.*

| Plant Characters | Season of plantation | Irrigation | Mycorrhizal Status | Edaphic factors | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Soil pH (1:2) | EC (1:2) (dsm$^{-1}$) | Organic Carbon (%) | Nitrogen (kg ha$^{-1}$) | Phosphorus (kg ha$^{-1}$) | Potassium (kg ha$^{-1}$) |
| Height | Summer | Irrigated | M | 0.12 | 0.45 | -0.47 | -0.39 | -0.50 | -0.43 |
| | | | N | -0.11 | 0.50 | -0.52 | -0.46 | -0.25 | -0.38 |
| | | Non Irrigated | M | -0.28 | 0.18 | -0.42 | -0.51 | -0.49 | -0.19 |
| | | | N | -0.19 | 0.32 | -0.40 | -0.40 | -0.33 | -0.49 |
| | Rainy | Irrigated | M | 0.11 | 0.40 | -0.39 | -0.57* | -0.51* | -0.27 |
| | | | N | -0.26 | 0.32 | 0.17 | 0.38 | -0.45 | -0.38 |
| | | Non Irrigated | M | 0.14 | 0.37 | -0.47 | -0.69** | -0.72** | -0.40 |
| | | | N | 0.49 | 0.23 | -0.36 | -0.44 | -0.31 | -0.45 |
| | Winter | Irrigated | M | -0.42 | 0.33 | -0.46 | -0.38 | -0.59 | -0.17 |
| | | | N | 0.50 | 0.49 | -0.42 | -0.58 | 0.14 | 0.49 |
| | | Non Irrigated | M | 0.39 | 0.42 | -0.37 | -0.32 | -0.48 | -0.51 |
| | | | N | 0.27 | 0.32 | -0.32 | -0.51 | -0.32 | -0.47 |
| Collar diameter | Summer | Irrigated | M | 0.18 | 0.42 | -0.41 | -0.27 | -0.35 | -0.44 |
| | | | N | 0.43 | 0.29 | -0.38 | -0.46 | -0.39 | -0.35 |
| | | Non Irrigated | M | 0.37 | 0.52 | -0.48 | -0.44 | -0.37 | -0.23 |
| | | | N | 0.46 | 0.13 | -0.51 | -0.39 | 0.25 | -0.38 |
| | Rainy | Irrigated | M | 0.13 | 0.34 | -0.46 | -0.37 | -0.41 | -0.39 |
| | | | N | 0.48 | 0.19 | -0.36 | -0.41 | -0.36 | -0.21 |
| | | Non Irrigated | M | 0.50 | 0.17 | -0.45 | -0.70** | -0.67** | -0.15 |
| | | | N | 0.25 | 0.28 | -0.53 | -0.32 | 0.22 | -0.12 |
| | Winter | Irrigated | M | 0.21 | 0.40 | -0.42 | -0.25 | -0.21 | -0.33 |
| | | | N | 0.18 | 0.29 | -0.39 | -0.42 | -0.50 | -0.19 |
| | | Non Irrigated | M | 0.21 | 0.32 | -0.39 | -0.56* | -0.57* | -0.18 |
| | | | N | 0.46 | 0.20 | -0.45 | -0.47 | -0.51 | -0.26 |

Significant at P=0.05*; P= 0.01**

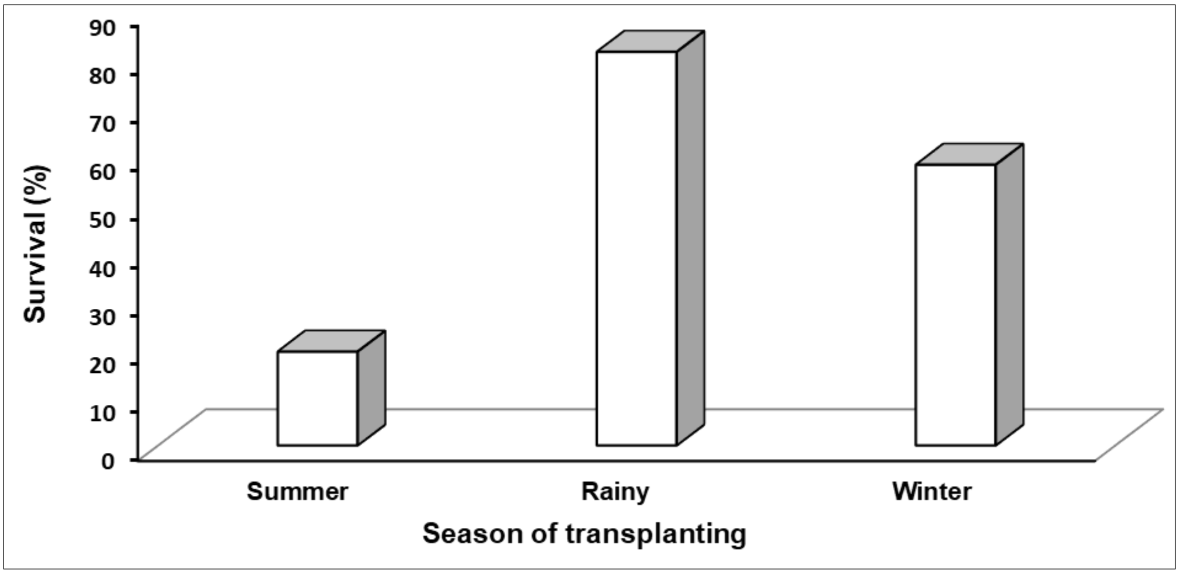


**Fig 1:** Sapling establishment in the experimental field were transplanted in different seasons

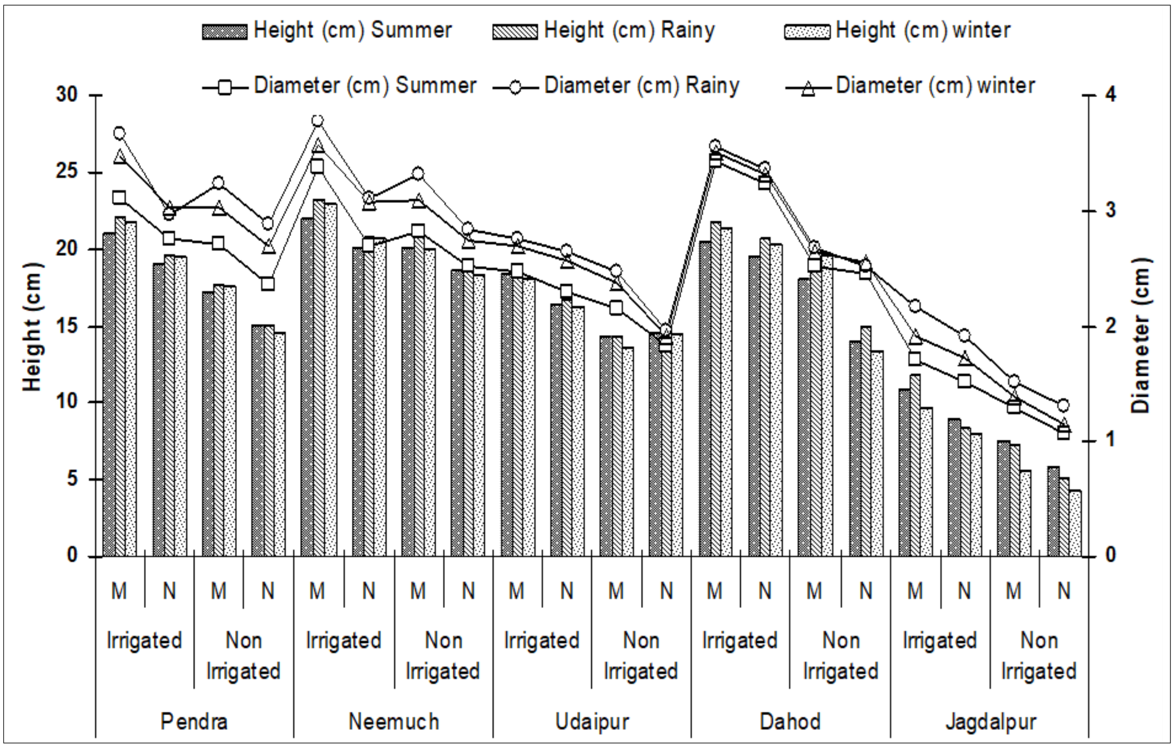


**Fig 2:** Mean annual increment (MAI) in stem growth (cm) of various provinces of *Jatropha curcas*

## Conclusion

The results of the present study determined that the seeds were collected from the source of Neemuch performed well again to other sources under nursery condition of Maheshware. Dahod and pendra collection is also being valuable for the conservation of genetic variation, prospects of improvement and assessment of the potential of the locally adapted accession source. Transplant was done during the rainy season exhibited best survival and growth with mycorrhizal association. The apparent variability in growth performance during rainy season with mycorrhiza application indicates that economic benefits may be obtained. These sources can safely be used for large-scale reforestation programmes in the region for high seed yield and vegetative growth. Germplasm used in afforestation programmes in India and other countries, generally utilizes only locally available material. Thus opportunities for using materials with higher yield potential or with more desirable characteristics might have been missed. This work will facilitate selection of promising accessions for multi-location evaluation and will also hasten the process of utilization of germplasm. It further gives a direction to the effect and practice studies for genetic improvement of this species.

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