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Performance of Jatropha curcas: A biofuel crop in wasteland of Madhya Pradesh, India

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Abstract
In India vast tracts of land (20.17% of total geographical area) exists as wastelands accounting for about 63.85 million hectares. Wastelands are degraded lands that lack their life sustaining potential as a result of inherent or imposed disabilities such as by location, environment, chemical and physical properties of the soil or financial or management constraints. In recent years, the central government and many of the state governments have expressed their support for bringing wastelands, under cultivation. Jatropha curcas has been found most promising for this purpose due to the use of its seed oil as biodiesel and other favorable attributes like hardy nature, short gestation period and adaptability in a wide range of agro-climatic conditions etc. Jatropha plantation helps in restoration of vast stretches of wastelands into green oil fields and can address major issues of developing countries like energy security, environmental amelioration, rural employment generation and conservation of foreign exchange reserves. With the objective to evaluate the performance of Jatropha plants in wasteland conditions, Tropical Forest Research Institute, Jabalpur has initiated a study in 2006. Progeny trial was laid out in Barha (Jabalpur) locality comprising of 20 superior genotypes of Jatropha. Among them, Gessani Shivpuri 3, Gessani Shivpuri 2, Bilara Pohiri Shivpuri 2, Parsoria Damoh Sagar, Bizouli Janarpura Gwalior 3, Bizouli Janarpura Gwalior 2 and Dewari Sagar 1 genotype are performing better as compared to other genotypes. This information will be helpful in assessing of the potential of locally adapted accessions and provide baseline information for future Jatropha plantation and wasteland reclammation programmes.

Keywords: Jatropha curcas, performance, restoration, superior genotypes, wasteland.

1. Introduction

Land, a vital non-renewable resource, is essential to all primary production system and is the basis for existence of mankind. The demand for food, energy and other human requirements depends upon the preservation and improvement of the productivity of land. The increasing human and animal population has reduced the availability of land over the decades. In many developing countries land is subjected to varying degrees and forms of degradation. In India, the per capita availability of land has declined from 0.89 hectare in 1951 to 0.37 hectare in 1991 and is projected to slide down to 0.20 hectare in 2035. As far as agricultural land is concerned the per capita availability of land has declined from 0.48 hectare in 1951 to 0.16 hectare in 1991 and is likely to decline further to 0.08 hectare in 2035 [1]. In India, 63.85 million hectare of land exists as wastelands, accounting about 20.17 % of total geographical area [2]. Wastelands are degraded lands that lack their life sustaining potential as a result of inherent or imposed disabilities such as by location, environment, chemical and physical properties of the soil or financial or management constraints. It has a direct bearing on the productivity of soil, its vulnerability to rainfall variations, scarcity of drinking water, fodder and fuel wood. They are in urgent need of attention and have to be accorded the highest priority for reclamation programmes.

India is one of the fastest growing petroleum oil consumers in the world. Due to stagnating domestic crude oil production, country meets over 72 percent of its crude oil and petroleum products (diesel, aviation fuel, etc.) requirement through imports. Petroleum product consumption has gone up from 100 million tons in Indian fiscal year (IFY) 2001/02 (April/March) to 134 million tons in IFY 2008/09. Energy demand by the transport sector is expected to grow by 6-8 percent per year during the 11th five-year plan [3].The Indian economy is expected to grow at a rate of over 6% per annum and the petroleum imports are projected to rise to 166 MT by 2019 and 622 MT by 2047 [4]. Figure 1 provides the oil production and consumption scenario in India [5]. There is a growing need for energy security as any disturbance in the supply of petroleum fuels or increase in petroleum prices can have negative impact on the growth of Indian economy. Indigenously produced biofuels are considered as one of the options to partially substitute petroleum fuels and reduce dependence on imported oil.

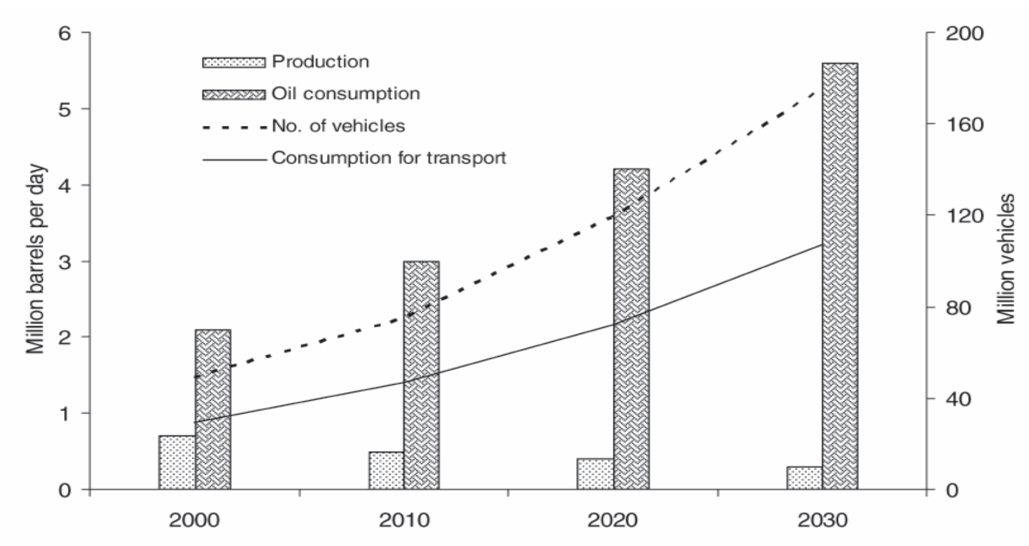

Figure 1. Forecast of oil production, number of vehicles and oil consumption in India
Source: International Energy Agency (2002)

The Government of India (GOI) is also looking at ways to promote production and use of bio-fuels to mitigate the current and future energy needs of the country. Consequently, the GOI has developed an ambitious National Biodiesel Mission for contributing to energy security and addressing major issues like environmental protection and climate change. 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. In recent years, the central government and many of state governments has expressed their support for bringing wastelands, under cultivation (physical reclamation). The country has 63 million ha of wastelands out of which about 40 million ha area have potential to be exploited and developed by undertaking Jatropha plantations. The plant can be grown in all categories of wastelands with minimum care and it should be a major thrust area in reclaiming wastelands along with making country independent in fuel and energy sector.

National Bureau of Soil Survey and Land Use Planning (NBSS&LUP) has identified agro-ecological regions and sub-regions suitable for Jatropha cultivation on the basis of soil, climate and physiographic parameters. The area (Figure 2) is classified in three classes namely high, moderate and poor [6]. The Government of Madhya Pradesh is also keen to promote Jatropha cultivation at a substantial scale in the state. For the purpose the Government has identified about 2000 hectares of land in various clusters across the state.

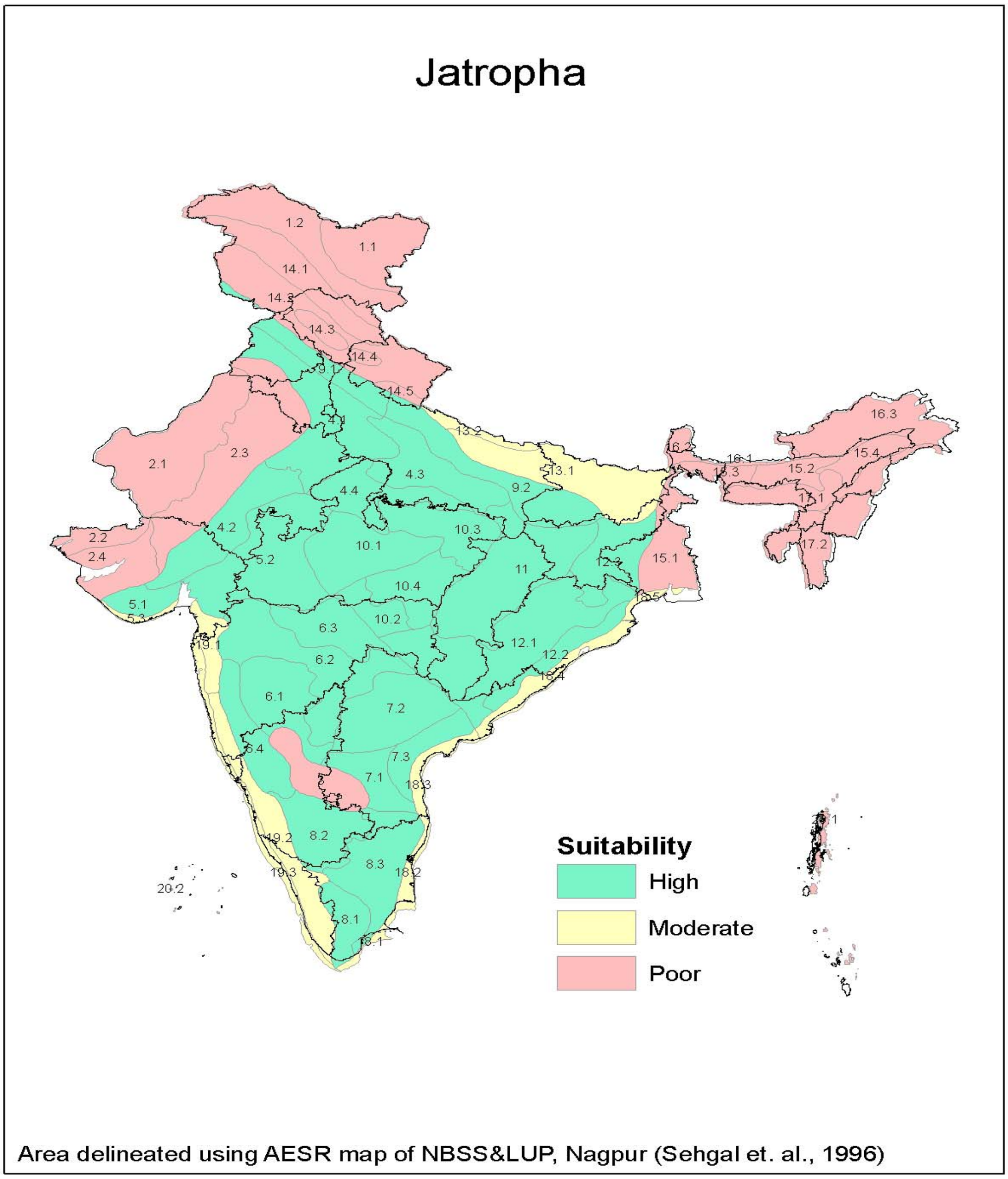

Figure 2. Suitability of area for Jatropha cultivation in India

Jatropha curcas, a hardy, drought-tolerant wild oilseed plant of tropics is credited as a most promising bio-fuel and as an alternative and renewable energy source. Jatropha curcas (Gk: Jatros – physician and trophe –food; common name physic nut or purging nut) belonging to the family Euphorbiaceae, is a low growing tree native to America and now thrives throughout Africa and Asia. It is a succulent plant that shed its leaves during the dry season and attains a height of about 3 meters in 3 years [7]. Preparations of various parts of the plant have been used in traditional medicine and as pest repellents. The most important uses of Jatropha are erosion control and oil production. It finds traditional use principally as a living fence, protecting cropland from freely ranging cattle, sheep and goats in tropical countries. Being drought tolerant, it can be used to reclaim degraded areas. It is adapted to higher temperatures and grows well in well drained soils receiving an average rainfall of 300 to 1000 mm. It can however tolerate slight frosts, droughts and is well adapted to marginal soils with low nutrient content [8, 9, 10]. Yields vary from 0.5 to 12 t/yr /ha based on soil and rainfall conditions. If only poor soils with low nutrient contents are considered, a yield of about 0.5- 0.75 tonnes could be expected per hectare per year. It often starts fruiting from the first year onwards. However, adequate yields are obtained from plants that are about 3-5 years old. The productive age of Jatropha is over 30 years. Jatropha seeds contain more than 30% non edible oil that is suitable for conversion into bio-diesel. Jatropha oil is an environmentally safe, cost effective, renewable source of non-conventional energy and a potential substitute of petroleum diesel. It

is an economically important species and can contribute significantly to the capital stock of the country by sustainable generation of income and employment.
Despite of lot of research on Jatropha, sufficient information is lacking on realistic figures related to growth and potential of this plant on wasteland. With the objective of evaluating the performance of Jatropha genotypes in wasteland under tropical climate of Madhya Pradesh, Tropical Forest Research Institute has initiated a study in 2006. The study was carried out under the national network programme of National Oilseeds and Vegetable Oils Development (NOVOD) Board, Govt of India, Ministry of Agriculture, on integrated development of J.curcas. The paper provides a brief account on the performance of progenies of different J. curcas genotypes in wasteland that will be helpful in the identification of potential Jatropha genotypes ideally suited for wasteland reclammation programmes in Madhya Pradesh, India.

2. Methodology

2.1 Establishment of progeny trial

In order to evaluate the performance of J.curcas in wasteland under tropical climate, progeny trial was established in July 2006 by Tropical Forest Research Institute, Jabalpur. The experiment was laid out at Barha (Jabalpur) locality and the material for the study consisted of seeds of 20 superior genotypes of J.curcas (Table1) collected from various location of Madhya Pradesh.

Table 1. Jatropha curcas genotypes collected from various locations of Madhya Pradesh, India

S.no	Genotype code	Genotype sources
1	T1	Dewari Sagar 1
2	T2	Dewari Sagar 2
3	T3	Samaria Depot Sagar 1
4	T4	Samaria Depot Sagar 2
5	T5	Bizouli Janarpura Gwalior 1
6	T6	Bizouli Janarpura Gwalior 2
7	T7	Bizouli Janarpura Gwalior 3
8	T8	Bizouli Janarpura Gwalior 4
9	T9	Bizouli Janarpura Gwalior 5
10	T10	Gessani Shivpuri 1
11	T11	Gessani Shivpuri 2
12	T12	Gessani Shivpuri 3
13	T13	Parsoria Damoh Sagar
14	T14	Bilara Pohiri road Shivpuri 1
15	T15	Bilara Pohiri road Shivpuri 2
16	T16	Bilara Pohiri road Shivpuri 3
17	T17	Muraina Shivpuri 1
18	T18	Muraina Shivpuri 2
19	T19	Muraina Shivpuri 3
20	T20	Muraina Shivpuri 4

2.2 Nursery practices

Seeds were sown in nursery in the first week of March in polyethene bags filled with soil, sand, Farm Yard Manure (FYM) in the ratio of 1:1:1. Germination was observed within 10-15 days. The seedlings were given regular irrigation at nursery stage.

2.3 Layout and designing

The experimental field was divided into 20 equal size blocks and 60 plants were planted in each block at the spacing of 3 x 3 meter. The pits were dug and filled with the soil and FYM (2:1) before plantation. However, experimental site has very poor soil texture (stony) with low nutrient status and low water holding capacity. Four month old seedlings were planted in July 2006 in Randomized Block Design in three replications as per agro techniques developed by Pandey and Mandal [11].

2.4 Observation and data recording

Regular observation were taken for growth parameters like height, collar diameter, branch number, canopy diameter and data was recorded. A comparative study was done to find out the best performing genotype on the basis of observed growth data. Flowering has been observed in some genotypes (T19, T12, T11, T7 and T1) but fruit formation was not observed.

2.5 Data analysis

The data were subjected to statistical analysis using mean values, ANOVA, simple correlation and summary statistic using Statistix PS DOS Version 2.0, NH Analytical software. Individual mean were used to compute ANOVA while provenance means were used to show correlation [12].

3. Results and discussion

Morphological growth characteristics of different Jatropha genotype after three years of growth are presented in Table 2.

Table 2. Growth characteristics of different genotypes of Jatropha curcas

Genotype code	Plant height (cm)	Collar diameter (cm)	Total no. of branches	Canopy dia (cm)
T1	103.80	4.38	10.25	85.95
T2	82.66	3.57	7.00	53.99
T3	74.90	3.02	4.35	59.12
T4	80.35	3.43	5.66	42.33
T5	106.24	4.26	9.28	84.66
T6	111.80	4.47	15.75	86.45
T7	97.50	4.49	19.47	88.41
T8	82.66	3.06	7.00	53.99
T9	63.06	3.06	6.15	47.04
T10	76.46	3.07	7.58	60.99
T11	121.16	4.66	12.70	94.69
T12	111.98	5.01	13.91	93.03
T13	107.00	4.41	12.91	86.24
T14	81.85	3.67	7.57	57.83
T15	107.51	4.47	15.32	100.58
T16	76.15	3.41	6.62	63.40
T17	101.70	4.06	8.81	59.53
T18	102.70	4.41	7.25	53.41
T19	97.60	3.82	10.08	82.12
T20	74.36	3.71	7.30	56.41
Mean	**93.08**	**3.92**	**9.75**	**70.53**
SD	**18.59**	**0.71**	**4.45**	**22.62**

The selected genotypes showed significant difference for the studied parameter and are discussed below-

3.1 Plant height

Significant increase in plant height has been observed. Plant height was recorded maximum in T11 (121.13 cm) followed by T12 (111.98 cm). The height was recorded lowest in T9 (63.06 cm) followed by T20 (74.36 cm). The plant height ranged 63.06 – 121.16 cm with a mean value of 93.08 ± 18.59. Graphical representation of variation in height in different genotypes is presented in Figure 3.

3.2 Collar diameter

The average collar diameter was recorded maximum in T12 (5.01 cm) followed by T11 (4.66cm) and minimum in T3 (3.02 cm) followed by T8 and T9 (3.06 cm). The collar diameter ranged 3.02 – 4.49cm with a mean value of 3.92 ± 0.71. Figure 4 represent graphical variations in collar diameter of different genotypes.

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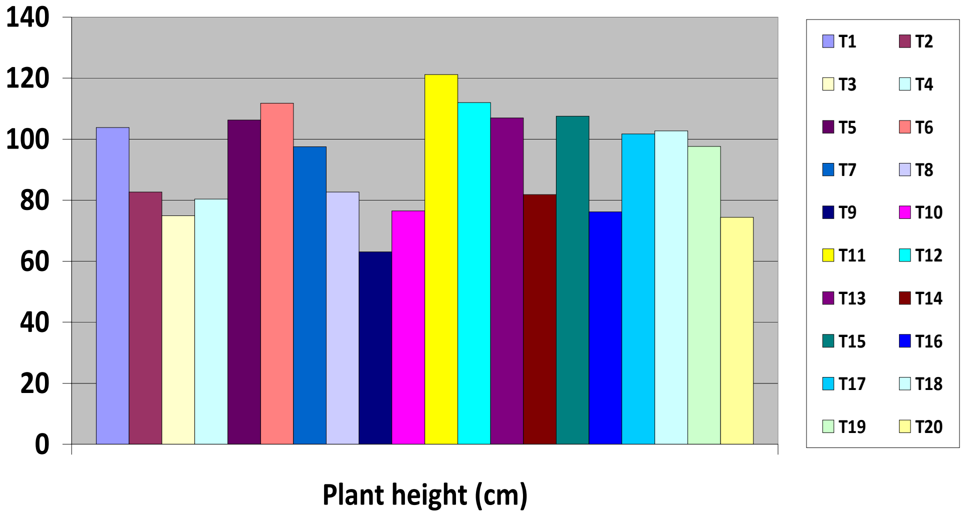

Figure 3. Variation in height of different genotypes

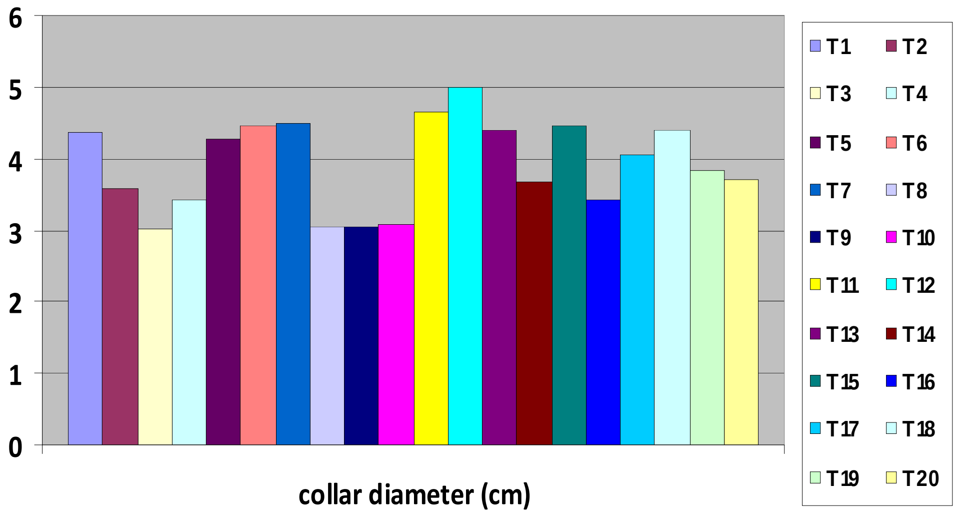

Figure 4. Variation in collar diameter of different genotypes

3.3 Number of branches

Maximum no. of branches were recorded in T7 (19.47) followed by T 6 (15.72) and minimum in T3 (4.35) followed by T4 (5.66). The no. of branches ranged 4.35 – 19.47 with a mean value of 9.75 ± 4.45. Variation in no. of branches among different genotypes is presented graphically in Figure 5.

3.4 Canopy diameter

Highest canopy diameter was recorded in T15 (100.58 cm) followed by T11 (94.69 cm) and minimum in T4 (42.33cm) followed by T9 (47.04 cm). The canopy diameter ranged 42.33-100.58cm with a mean value of 70.53 ± 22.62. Figure 6 depicts the variation in canopy diameter among different genotypes.

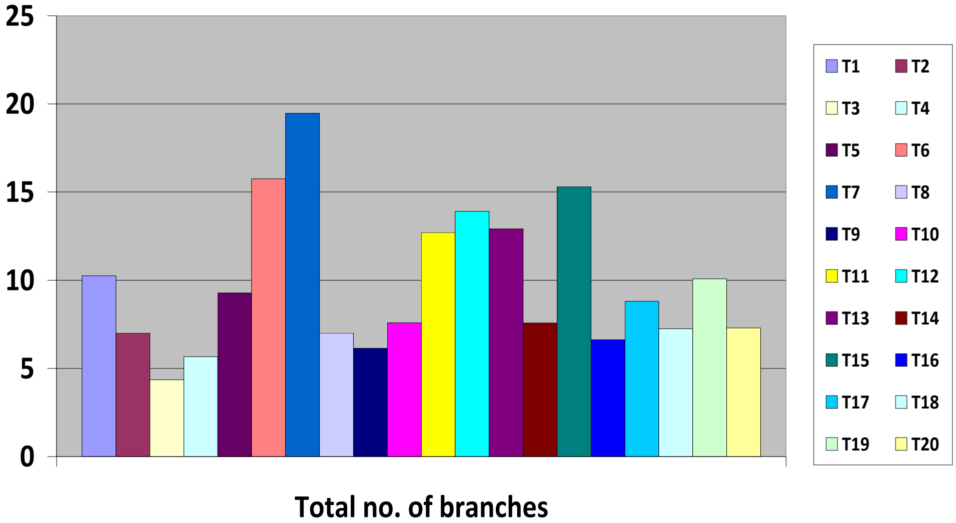

Figure 5. Variation in total no. of branches in different genotypes

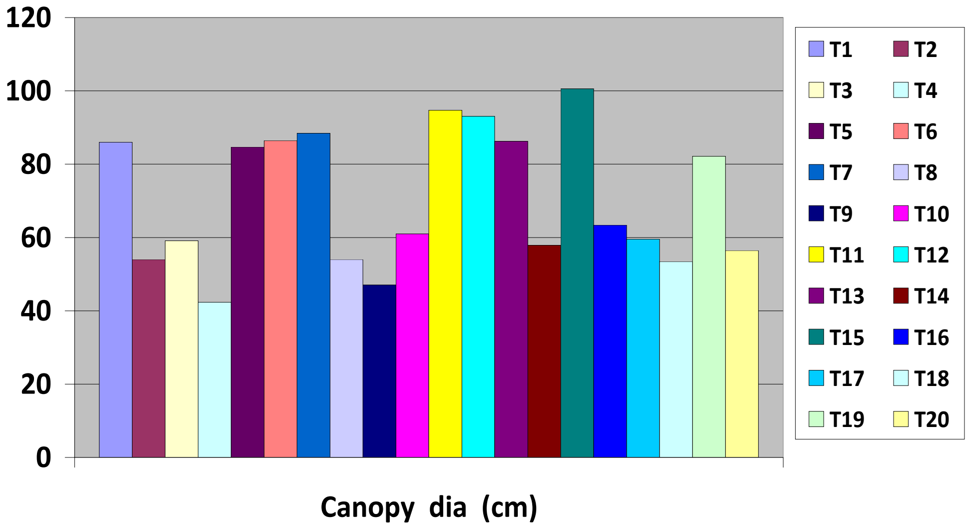

Figure 6. Variation in canopy diameter of different genotypes

Descriptive statistical analysis and correlations with respect to morphological growth characteristics are presented in Table 3 and Table 4. The data revealed that some genotypes are performing well among other genotypes in wasteland. Better performing genotypes with respect to growth attributes are presented in Table 5. The analysis also revealed that growth parameters i.e. plant height, collar diameter, number of branches and canopy diameter of selected genotypes are significant and positively associated with each other. Similarly Pandey et.al. [13] and Sakia et al. [14] also reported variations in growth performance of different accession/genotypes.

Table 3. Analysis of variance for different growth parameters in Jatropha curcas

Parameters	Df	SS	MS	SE	F Value	C.D.
Height (cm)	19	15197	799.82	9.407	6.02	19.04
Collar Diameter (cm)	19	21.68	1.1413	0.382	5.21	0.773
Branches (no.)	19	906.02	47.68	2.041	7.63	4.132
Canopy diameter(cm)	19	18744	986.53	14.08	3.32	28.50

Table 4. Correlations of different growth parameters in Jatropha curcas

Parameters	**Height (cm)**	**Collar dia. (cm)**	**Branches (no)**	**Canopy dia. (cm)**
Height (cm)	1.0000			
Collar dia. (cm)	0.7837	1.0000		
Branches(no)	0.6797	0.6738	1.0000	
Canopy dia. (cm)	0.6489	0.6465	0.6501	1.0000

Table 5. List of best performing genotypes on the basis of growth parameters

S.no	**Growth parameter**	**Genotype**	
		Genotype code	**Genotype source**
1.	Height (cm)	T 11	Gessani Shivpuri 2
		T 12	Gessani Shivpuri 3
		T 6	Bizouli Janarpura Gwalior 2
		T 15	Bilara Pohiri Shivpuri 1
		T 13	Parsoria Damoh Sagar
		T 5	Bizouli Janarpura Gwalior 1
		T 1	Dewari Sagar 1
2.	Collar diameter (cm)	T 12	Gessani Shivpuri 3
		T 11	Gessani Shivpuri 2
		T 7	Bizouli Janarpura Gwalior 3
		T 6	Bizouli Janarpura Gwalior 2
		T 15	Bilara Pohiri Shivpuri 1
		T 18	Muraina Shivpuri 2
		T 1	Dewari Sagar 1
3.	Number of branches	T 7	Bizouli Janarpura Gwalior 3
		T 12	Gessani Shivpuri 3
		T 6	Bizouli Janarpura Gwalior 2
		T 15	Bilara Pohiri Shivpuri 2
		T 13	Parsoria Damoh Sagar
		T 11	Gessani Shivpuri 2
		T 1	Dewari Sagar 1
4.	Canopy diameter (cm)	T 15	Bilara Pohiri Shivpuri 2
		T 11	Gessani Shivpuri 2
		T 12	Gessani Shivpuri 3
		T 7	Bizouli Janarpura Gwalior 3
		T 6	Bizouli Janarpura Gwalior 2
		T 13	Parsoria Damoh Sagar
		T 1	Dewari Sagar 1

4. Conclusion

In the present study, all the selected genotypes are growing well in wasteland of Madhya Pradesh, India. However, T15, T13, T12, T11, T7, T6 and T1 are performing better among all genotypes. The study will be helpful for assessment of the potential of locally adapted accessions and provide baseline information for future Jatropha plantation and wasteland restoration programmes. The production of bio- diesel from Jatropha plantations set up on wastelands is highly relevant for developing countries like India, with large tracts of land already degraded or under the threat of degradation. These plantations can also address other major issues of developing countries like energy security, environmental amelioration, rural employment generation and conservation of foreign exchange reserves.

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