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Jatropha Curcas: A Pollution-Free Plant with High Biofuel Potential - A Case Study from Bapanpalli Village of Mahabubnagar District.

Dr.G.Ganesh

Lecturer in Botany, Dept.of Botany, MALD Government Degree College, Gadwal Jogulamba Gadwal Dist, T.S, India
Email:ganijaann55@gmail.com.

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A B S T R A C T

Jatropha curcas is widely recognized as a drought-tolerant and pollution-free biofuel plant suitable for cultivation on marginal lands. This study was conducted in Bapanpalli village of Mahabubnagar district to assess its adaptability, growth performance, and biofuel potential under semi-arid conditions. Results showed a seedling survival rate of 88%, demonstrating excellent tolerance to local climatic stresses. After one year of growth, plants attained an average height of 135 cm, reflecting strong vegetative performance even in nutrient-poor red loamy soils. The extracted seeds exhibited an oil content of 34–38%, confirming their suitability for biodiesel production. Biodiesel prepared from the oil met major ASTM standards, highlighting its potential as an eco-friendly alternative to fossil fuels. Overall, the study establishes Jatropha curcas as a promising species for sustainable energy generation and ecological restoration in semi-arid regions such as Mahabubnagar.

Introduction:

Growing concerns over greenhouse gas emissions, fossil fuel dependency, and environmental pollution have accelerated global interest in sustainable biofuel crops. Among several potential species, *Jatropha curcas* stands out due to its high oil content, non-edible nature, resilience to harsh climates, and ability to produce cleaner-burning biodiesel.

Mahabubnagar district, particularly Bapanpalli village, faces semi-arid conditions, erratic rainfall, and degraded soils. These geographical characteristics make the region suitable for assessing the adaptability and biofuel potential of *Jatropha curcas*. This study aims to document its performance, environmental significance, and capacity to generate pollution-free energy in the local ecosystem.

2. Botanical Description of *Jatropha curcas*

- **Family:** Euphorbiaceae
- **Growth Form:** Smooth, erect, branched shrub or small tree up to 2–6 meters
- **Leaves:** Broad, smooth, 3 or 5 lobed and 10 to 18 cm long
- **Flowers:** Greenish-yellow, unisexual with male and female flowers on the same tree
- **Fruit:** Grey-brown capsule up to 4 cm long, it is divided into 3 cells, each containing one seed
- **Seeds:** Black in colour, about 2cm long and 1 cm in thickness, triangular, containing 30–40% oil
- **Root System:** Deep, allowing drought tolerance

These features contribute to the plant's ability to survive and produce oil even in nutrient-poor, drought-prone soils such as those in Bapanpalli.

3. MATERIALS AND METHODS

Study Area:

The study was carried out in Bapanpalli Village, Mahabubnagar district, Telangana. The region has a semi-arid climate, characterized by low rainfall, high temperatures, and red loamy soils. The area is suitable for assessing the adaptability and biofuel potential of Jatropha curcas. Plant Material.

Climatic and Basic Field Data

Table 1. Climatic Data from the Study Area

Parameter	Value (Average)
Annual Rainfall	580 mm
Mean Temperature Range	22–40°C
Soil Type	Red loamy
Soil pH	6.2-7.1

Table 2. Seed Yield and Oil Characteristics

Parameter	Observed Value
Average Seed Yield per Plant	480 g/plant/year
Oil Content	34–38%
Oil Yield	160–180 mL/kg seed
Seed Maturity Period	90–120 days

Figure 1, Jatropha curcas plantation at Bapanpalli Villages, Mahabubnagar district, Telangana.

Plant Material:

Mature seeds of **Jatropha curcas** were collected from healthy mother plants in the study area. Seeds were cleaned, shade-dried, and stored until nursery preparation.

4. Biodiesel Potential of Jatropha

1. Oil Extraction

Oil is extracted from dried seeds through:

- ✓ Mechanical pressing, or
- ✓ Solvent extraction

The oil has high triglyceride content, suitable for biodiesel production.

2. Biodiesel Production Process

Transesterification of Jatropha oil with methanol and an alkaline catalyst yields:

- Biodiesel (methyl esters)
- Glycerol (by-product)

3. Advantages of Jatropha Biodiesel

- Low sulphur emissions
- Biodegradable
- High flash point
- Reduced carbon monoxide
- Reduced particulate matter
- Cleaner engine performance

This makes it a **pollution-free, renewable, and eco-friendly biofuel**.

RESULTS AND DISCUSSION:

Growth Performance of Jatropha curcas:

In the present study conducted at Bapanpalli village, Jatropha curcas showed strong adaptability to semi-arid conditions, with a survival rate of 88% during the first year. Plants attained an average height of 135 cm, and developed 6–8 branches per plant, indicating vigorous vegetative growth. These findings are in line with earlier studies from Rajasthan and Maharashtra, where survival rates of 80–90% were recorded under similar rainfed conditions (Singh et al., 2007). The slightly higher survival rate in Bapanpalli may be attributed to moderate soil pH (6.2–7.1) and better initial seedling care.

Seed Yield and Oil Content:

The average seed yield was 480 g/plant/year, and the seed oil content ranged from 34–38%. These results are comparable to findings from Karnataka and Tamil Nadu, where seed yields varied between 450–600 g/plant and oil content ranged from 30–40% (Achten et al., 2008; Kaushik et al., 2007).

While yield values were similar, the oil content observed in Bapanpalli was slightly higher, possibly due to differences in genetic stock and soil micronutrient availability.

Soil Influence on Plant Growth:

The red loamy soils of the study area, although low in nitrogen and organic carbon, supported good plant growth. This aligns with previous studies in drought-prone regions of Gujarat, which reported that Jatropha performs well in nutrient-poor, degraded, or marginal soils (Tiwari et al., 2007).

The ability of plants in Bapanpalli to grow without fertilizer inputs further supports their suitability for wasteland reclamation.

Biodiesel Quality in Comparison to Literature:

The biodiesel produced from Bapanpalli seeds met ASTM standards for:

Density (0.86 g/cm³)

Viscosity (4.2 cSt)

Flash point (165°C)

Calorific value (38 MJ/kg)

These values match closely with those reported by Pramanik (2003) and Banerjee & Chakraborty (2009), who found that Jatropha-based biodiesel typically exhibits viscosity between 4.0–5.5 cSt and flash point above 130°C. Thus, biodiesel from Bapanpalli falls within the high-quality range reported globally.

Environmental and Regional Comparison:

The environmental performance of Jatropha curcas in Bapanpalli was comparable to plantations in semi-arid regions of Africa and Southeast Asia, where the species is used widely for:

- ➢ reducing soil erosion
- ➢ increasing vegetation cover
- ➢ providing rural energy security

This strengthens the case for promoting Jatropha as a pollution-free, sustainable biofuel crop in the Mahabubnagar district and similar agro-climatic zones of India.

Overall Interpretation:

The combined results confirm the high adaptability, moderate seed yield, and excellent biodiesel properties of Jatropha curcas grown in Bapanpalli. Comparative analysis also shows that the performance of the species in this region is equal to or better than that observed in several other Indian states and international locations.

These findings reinforce the potential of Jatropha curcas as a viable bioenergy crop for semi-arid areas, contributing both to environmental restoration and rural livelihoods.

8. Challenges in Bapanpalli

Despite its advantages, several challenges exist:

- Variation in seed yield due to climate
- Water scarcity during the establishment stage
- Need for improved high-yielding varieties
- Lack of structured markets for Jatropha products
- Systematic collection of Jatropha in the centre of origin
- Investigation of the taxonomic status of existing plantations
- Influence of pruning on seed yield
- Economic analysis of the fertilizer value of the seed cake
- Economic analysis of seed oil production in rural areas for diesel fuel and soap production

Addressing these issues can significantly enhance productivity and adoption.

9. Conclusion

The study conducted in Bapanpalli village of Mahabubnagar district demonstrates that *Jatropha curcas* is a resilient, eco-friendly, and efficient biofuel crop capable of contributing significantly to pollution reduction and sustainable energy generation. Its adaptability to semi-arid conditions, high oil content, and extensive environmental benefits make it an appropriate crop for degraded and marginal lands. With proper management practices, improved varieties, and local processing facilities, Jatropha can become a valuable renewable energy resource for rural communities and contribute to greener, cleaner development.

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