Can we use *Jatropha curcas* L. as bioenergy producer plant for land reclamation?

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***Abstract** - The present study tested the hypotheses that Jatropha curcas L. bioenergy producer plant has potentiality to restore degraded land. In this study, the parameters organic C, total N and microbial biomass are used as soil fertility indicator. The level of soil microbial biomass C and N differed significantly between the two land-use types for all three seasons. The same trend was observed in C/N ratio (ranges 9.4 to 14.6). Compared with the control, the levels of soil microbial biomass C and N were 16% and 40% higher respectively in Jatropha plantation plot. Since the rate of N mineralisation is regulated by the microbial biomass C/N ratio and C input, greater the microbial C/N ratio in control plot may also support higher rates of immobilisation relative to Jatropha plantation. Microbial biomass C/N ratio has been suggested as the indicator of ecosystem recovery, since lower the ratio, shorter will be the time required for build-up of the microbial population and its activity. Between the both land uses types investigated, the microbial biomass C/N ratio was lower in the Jatropha plantation than control. Based on high soil microbial biomass and faster recovery rates, it is suggested that Jatropha plantation could be adopted as the major strategy for restoration of degraded lands in the dry tropics.*

Key Words: **C/N ratio, degradation, ecosystem recovery, land restoration, microbial biomass.**

1. INTRODUCTION

Bioenergy from biomass is attracting great attention over the world as an alternative to fossil fuels. In several crops, *Jatropha curcas* L. (*J. curcas*), belong to family *Euphorbiaceae*, has been identified as the most suitable energy crop in tropical regions (1). As it has broader ecological amplitude, can grow in very dry condition, complete germination is achieved within 9-15 days, easily propagated by cuttings, self-compatible, no regular need of ploughing, planting and pesticides and life expectancy of approximately 35-40 years, making this plant suitable for restoration programme. According to United Nations (1997), it has been estimated that about 1.9 billion hectares of land worldwide are affected by land degradation. The problem is especially serious in the heavily populated, under-developed, and ecologically fragile areas of India. Today, remediation and management of soil resources is major issue and as a result, the 68th UN General Assembly has declared the year 2015 as the 'International Year of Soil' in order to create a solidarity for combating soil degradation and fostering the importance of soil conservation and management at global scale

So, the present study tested the hypotheses that *J. curcas* bioenergy producer plant has potentiality to restore degraded land. I have taken the parameters organic C, total N and microbial biomass as soil fertility indicator.

2. MATERIALS AND METHODS

Two study sites have chosen, one control site where no *J. curcas* plants and another with *J. curcas*a plantation. The study sites were situated at Rajeev Gandhi South Campus, Banaras Hindu University, Barakachha, at Mirzapur, Uttar Pradesh, India. Both sites were far for about 1 km^2 area. The study was conducted from January 2011 to April 2012. The sites are at 25.15'N, 82.58'E, and ~81m above mean sea level. The climate is dry tropical monsoonal with marked seasonality. The annual average rainfall is ~1800mm, 95% of which falls during the rainy season. Both sites soil were residual Ultisol, sandy to sandy-loam in texture, and reddish to reddish-brown in colour (2). Temperature ranged from minimum 25 to maximum 46^{0}C. *Jatropha* plantation was started since 2006, approximately 10 years ago in a 100-ha area at Rajeev Gandhi South Campus, Mirzapur. *J. Curcas* was planted in rows, with an inter-row distance of 2m and interplant distance 2m. No supplementary irrigation and manure or pesticides were provided at sites.

Three study sites from control and three from planted were chosen for soil sampling. Each study site was further divided into six sub-sites of 100m x 100m. From each site, three soil samples were taken from sub-site, and mixed to represent the single composite sample of a study site, this way total six soil samples were collected from each study site. Soil samples were collected during the rainy (July), winter (November) and summer (April) seasons at upper 10 cm of soil layer.

Soil temperature was determined by digital thermometer, moisture content by oven drying the soil at 105ºC. Bulk density (dry weight per unit volume of soil) was determined by inserting a metallic tube (of known internal volume) at upper 10 cm of soil depths, and oven drying the enclosed soil core, Water holding capacity by the brass cup method described by Piper (3). As indicator of soil fertility, organic C (4), total N by micro-kjeldahl method (5) and microbial biomass C and N (6, 7) were measured during study period. Data were analyzed using SPSS package (version 16; SPSS). All the values are expressed as mean standard error. Means were compared using the least square difference (LSD). Significance of difference is indicated as $P < 0.05$, $P < 0.01$ and $P < 0.001$.

2. RESULTS AND DISCUSSION

The level of soil microbial biomass C differed significantly between the two land-use types for all three seasons, ranging from 350 to 650 µg g^{-1}dry soils.

Table -1: Seasonal variation of soil physico-chemical properties in two land-use types; control (without *J. curcas* planted plot) and *J. curcas* planted plot.

	Rainy	Winter	Summer	*LSD*
Soil pH				
Control	7.5±0.03	7.4±0.04	7.3±0.03	*0.10*
J. curcas	7.7±0.08	7.6±0.06	7.5±0.03	*0.19*
Soil moisture (%)				
Control	30.7± 0.48	20.6±0.52	14.0±0.37	*1.37*
J. curcas	35.5±0.26	24.8±0.36	18.4±0.30	*0.94*
Soil temperature (^{0}C)				
Control	30.6±0.24	25.5±0.36	39.8±0.31	*0.93*
J. curcas	27.6±0.37	20.8±0.38	35.5±0.18	*0.98*
Bulk density (g cm^{-3})				
Control	1.40±0.04	1.44±0.03	1.45±0.02	*0.07*
J. curcas	1.37±0.01	1.35±0.01	1.38±0.01	*0.03*
Water holding capacity (%)				
Control	34.5±0.50	32.6±0.30	33.0±0.10	*1.03*
J. curcas	40.6±0.55	38.0±0.58	37.6±0.20	*1.44*
Microbial biomass C (µg g^{-1} dry soil)				
Control	350±3.65	460±9.67	568±4.76	*19.79*
J. curcas	400±6.83	600±5.77	640±5.77	*18.53*
Microbial biomass N (µg g^{-1} dry soil)				
Control	24±0.39	34±0.28	42±0.50	*1.22*
J. curcas	40±0.44	58±0.58	68±0.73	*1.80*
Microbial biomass C/N ratio				
Control	14.6±0.38	13.5±0.20	13.5±0.14	*0.78*
J. curcas	10.0±0.29	10.3±0.10	9.4±0.08	*0.55*

LSD for comparison amongst seasons in two land use types.

The level of soil microbial biomass C was least during rainy season, and increased through winter to the maximum in summer for both the land use types (Table 1). Between the land-use types, the level of soil microbial biomass C was greater (650 µg g^{-1}) in the *Jatropha* plantation during summer season than without *Jatropha* plantation (control) during three seasons, and the minimum (350 µg g^{-1}) in the control in rainy seasons.

The trend for microbial biomass N was similar to that for microbial biomass C under both land-use types and seasons ranged from 22 to 66 µg g^{-1} (Table 1). Microbial biomass N was highest in *Jatropha* plantation during summer, followed in decreasing order by winter and rainy seasons in control. The same trend was observed in C/N ratio in two land use type during three seasons. It was minimum in *Jatropha* plantation during summer season (9.4) and maximum during rainy season in control (14.6).

Table - 2: Correlation coefficients (r) showing relationships between microbial biomass C and N with soil moisture content and soil temperature in two land-use types.

Land use	MBC	MBN
Soil moisture content		
Control	-0.98*	-0.98*
J. curcas	-0.96*	-0.97*
Soil temperature		
Control	0.62*	0.58**
J. curcas	0.19^{NS}	0.48**

*$P < 0.01$; **$P < 0.05$
n = 16 for each parameter of individual land use type

Distinct seasonal variation was observed in soil temperature for all land-use types, with the minimum during winter and maximum during summer (ranges from 20.8 to 39.8). Soil moisture content varied distinctly with season, being maximum during the rainy season and minimum during summer for all land-use types, and ranging between and 14 to 35.5 % in two land use type, soil microbial biomass C and N showed significant, strong negative correlations with soil moisture content, and weak positive correlations with soil temperature for each land-use type (Table 2).

Compared with the control, the levels of soil microbial biomass C and N were 16% and 40% higher respectively in *Jatropha* plantation plot. In other words, rise in soil microbial biomass C and N indicated the trend of restoration of degraded control land with *Jatropha* plantation. *Jatropha* plants generally shed all their nutrient-rich leaves during late winter. These leaves, along with the profusely branched root system limited to upper 20 cm, could have added large amounts of organic matter to the soil, in turn stimulating the microbial biomass.

Since the rate of N mineralisation is regulated by the microbial biomass C/N ratio and C input (8), greater the microbial C/N ratio in control plot may also support higher rates of immobilisation relative to *Jatropha* plantation. Microbial C/N ratio has been suggested as the indicator of ecosystem recovery, since the lower the ratio, the shorter will be the time required for build-up of the microbial population and its activity (9). Between the both land uses types investigated, the microbial biomass C/N ratio was lower in the *Jatropha* plantation than control, indicating that the rate of restoration could be faster in *Jatropha* plantation than the normal land.

Although the land-use types were quite different and this had impact on the amount of soil microbial biomass, the seasonal variations were common to all four sites, indicating that climatic factors played important roles in regulating seasonal variations in the soil microbial biomass. The significant negative correlation coefficient between the level of microbial biomass C or N and moisture content between both land-use types, and the weak positive relationship between microbial biomass C or N and soil temperature indicated that soil moisture content rather than soil temperature could be a better indicator of seasonal variations in soil microbial biomass C and N. In these dry tropics, the availability of soil moisture depends on rainfall. Because variability in rainfall pattern has also been projected by climate change modelling studies for our region (10), any change in the rainfall pattern may have an impact on the soil microbial biomass dynamics, which, in turn, would influence the C and N cycling in the region. Overall, such studies will a greatly assist in designing restoration strategies.

3. CONCLUSIONS

The impact of land-use change on soil microbial biomass C and N was different in both land use types. *Jatropha* plantation, having higher microbial biomass, favoured the restoration of degraded control (Vindhyan) soil towards natural soil. Variations in microbial biomass C/N ratio among the land-use types indicated that it could be used as an index of ecosystem restoration. It is suggested that designing effective restoration strategies for degraded forests, especially in the dry tropics, should be based on holistic, site-specific studies that include not only the upper soil layer but the entire soil profile. Based on high soil microbial biomass and faster recovery rates, it is suggested that *Jatropha* plantation could be adopted as the major strategy for restoration of degraded lands in the dry tropics.

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BIOGRAPHY

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