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Changes in Soil Properties under Plantation of Multipurpose Trees Species in different Ecosystems of Jharkhand, India

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Abstract   A study was carried out in soil properties of the plantation area under different Multipurpose Tree species (MPTs) namely *Acacia auriculiformis* A.cum (ex Benth), *Cassia siamea* lam and *Eucalyptus hybrid* in three different agro climatic zone of Jharkhand state of India during 2007-2011 to check the quality of soil improvement and enrichment of soil under multipurpose tree species plantation. Soil samples were collected from different location *i.e.* Deoghar district in sub zone IV (Central North Eastern Plateau), Ranchi district in sub zone V (Western Plateau) and East Singhbhum district in sub zone VI (South Eastern Plateau) of Jharkhand, India. The soils of the experimental area were acidic in nature, low organic carbon; light textured having low water and nutrient capacity. The seedling was planted during July 2007 at a spacing of 1mx1m. The soil samples were collected initially before the plantation and also after plantation when plantation reached the age of four years. On the basis of results obtained maximum pH was observed in the field of *Acacia auriculiformis* (5.78) followed by *Cassia siamea* and *Eucalyptus hybrid*. Among the agro-climatic zones highest pH was observed in sub zone V as compared to other two zones. Organic Carbon content (%) found maximum in the field of *Cassia siamea* (0.53%) followed by *Acacia auriculiformis* and *Eucalyptus hybrid*. Available nitrogen was found maximum in the field of *Cassia siamea* (307.44kg/ha) followed by *Acacia auriculiformis* and *Eucalyptus hybrid*, whereas maximum available Phosphorus and potassium were observed in the field of *Acacia auriculiformis* (17.27 and 162.97 kg/ha) followed by *Eucalyptus hybrid* and *Cassia siamea*. The value of available nitrogen in soil was in the order *Eucalyptus hybrid> Acacia auriculiformis> Cassia siamea* whereas available phosphorus and Potassium in soil were in the order of *Eucalyptus hybrid> Cassia siamea> Acacia auriculiformis*.

Keywords: *soil properties, organic carbon, available nitrogen, available phosphorus, biomass production, available potassium, Acacia auriculiformis, Cassia siamea, Eucalyptus hybrid, energy plantation*

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1. Introduction

Recently energy plantation has got much boost in India since biomass energy is the largest source of renewable energy and accounts for 10.4% of total global energy supply and 77.4% of global renewable energy supply [1]. Government of India has already started many plants for afforestation of large areas of the wasteland. The species selected for energy plantations are multipurpose tree viz, *Acacia auriculiformis*, *Cassia siamea, Eucalyptus spp.* and *Leucaena leucocephala* on poor soil to produce fuel wood and also enrich fertility of the soil. In the state of Jharkhand, India a sizeable area is also used for energy plantation with different trees. Majority of the soil of entire Jharkhand is acidic in nature. The textural characteristic is sandy loam and murom soil, well drained poor consistency and low water holding capacity. An

attempt was made to evaluate the fertility status of soil with energy plantation in different agro-climatic zones of Jharkhand, India.

2. Materials and Methods

The present studies was conducted on three multipurpose tree species namely *Acacia auriculiformis, Cassia siamea* and *Eucalyptus hybrid* in three different sub zones viz, IV, V and VI of Jharkhand state of India which comes under agro-climatic zone VII (Eastern plateau hill region) (Figure 1). The observation and analysis of the soil samples were taken in the year 2011 when the plantation reached of 4 years old. The soil of the experimental sites is acidic in nature and low organic carbon content (0.36%). The available nutrient status was 252.10, 16.10 and 162.20 of N, P_2O_5, and K_2O kg ha^{-1} respectively. The seedlings of Multi Purpose Trees (MPTs)

were planted during July 2007 at a spacing 1m x 1m. The initial and final (after 4 years of plantations) soil samples were collected, processed and analyzed for pH using standard procedure as outlined by Jackson [2].
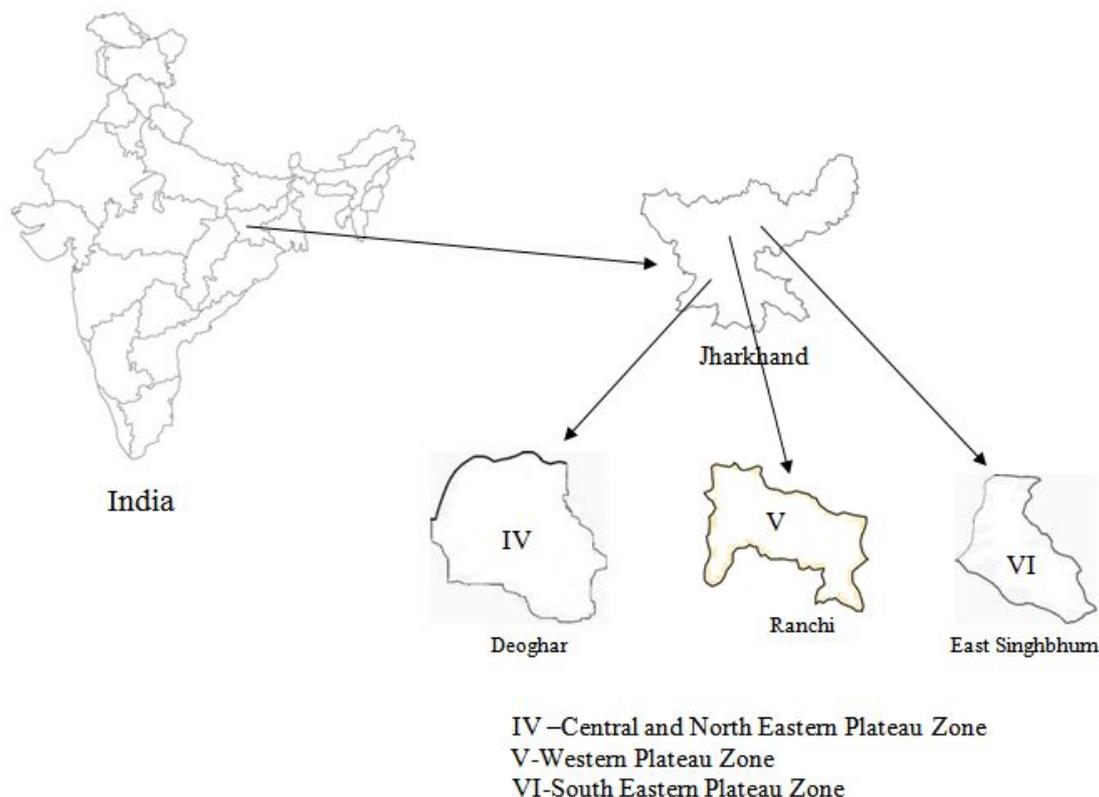

Figure 1. Location map of the study area

Available nitrogen was determined by alkaline permanganate method of following [3]. Available phosphorus determined by Bray's method and estimated by colorimeter using ascorbic acid method as described by Tandon [4]. Available potassium was determined by flame photometer in soil solution prepared in extraction solution of normal ammonium acetate (pH 7.0) in ratio of 1:5 (w/v) and Organic carbon was determined by Walkley and Black's rapid titration method as described by Tandon [4].

3. Results and Discussion

Soil Properties

3.1. pH

The pH of soil at 0-15cm and 15-30 cm depth of the plantation area of three tree species *viz. Acacia auriculiformis, Cassia siamea* and *Eucalyptus hybrid* in three different sub zones IV, V and VI of Agroclimatic zone VII of Jharkhand is presented in Table 1. Perusal of soil at sub surface (0-15 cm) data has indicated that *Acacia auriculiformis* was obtained maximum pH of soil (5.78) followed by *Cassia siamea* (5.44) whereas the minimum pH of soil obtained by *Eucalyptus hybrid* (5.39). Among the sub zones, the maximum pH of soil was found in sub zone V (5.64) whereas sub Zone IV and Zone VI has minimum pH i.e. 5.48. Statistical analysis revealed that among species *Acacia auriculiformis* has highly statistically significant than other two species whereas *Cassia siamea* has significant than *Eucalyptus hybrid.* Among zones, sub zone V has highly significant from other two zones whereas sub zone IV and VI are at par. Further, it was observed that there is an increase of 5.35% of pH in the four year's old *Acacia auriculiformis* plantation over control in zone V at top soil. The soil under trees showed a trend of improvement in pH [5].

Table 1. pH of soil under plantation in different agro-climatic zone

Soil depth / Species	0-15 cm					15-30 cm			
	IV	V	VI	Mean		IV	V	VI	Mean
Acacia auriculiformis	5.63	5.90	5.80	5.78		5.69	5.98	5.90	5.86
Cassia siamea	5.46	5.51	5.34	5.44		5.50	5.56	5.38	5.48
Eucalyptus hybrid	5.35	5.52	5.32	5.39		5.39	5.56	5.37	5.44
Mean	5.48	5.64	5.48	5.54		5.53	5.70	5.55	5.59
Initial	5.60	5.60	5.60			5.60	5.50	5.70	
	(S.Em (±))		CD 5%			(S.Em (±))		CD 5%	
Tree specie	0.021		0.044			0.021		0.044	
Agro climatic zone	0.021		0.044			0.021		0.044	
Tree species X Agro climatic zone	0.036		0.077			0.036		0.076	
CV%	1.137					1.114			

3.2. Organic Carbon Content (%)

Organic carbon content(%) of soil at surface (0-15cm) has indicated that *Cassia siamea* was obtained maximum organic carbon content of soil (0.53%) followed by *Acacia auriculiformis* (0.51%) whereas the minimum organic carbon content of soil obtained by *Eucalyptus hybrid* (0.48%) as presented in Table 2. Among the sub zone, the maximum organic carbon content of soil was found in sub zone V (0.53%) followed by sub zone VI (0.51%) and least organic carbon content was obtained in sub zone IV

(0.48%). Statistical analysis revealed that among species *Cassia siamea* has highly statistically significant than other two species whereas *Acacia auriculiformis* has significant than *Eucalyptus hybrid.* Among zones, sub zone V has highly significant from other two zone whereas sub zone VI has significant than sub zone IV. At sub-surface (15-30cm) *Cassia siamea* was obtained maximum organic carbon content of soil (0.48%) followed by *Acacia auriculiformis* (0.47%) Among the sub zone, the maximum organic carbon content of soil was observed in sub zone IV (0.48%) followed by sub Zone VI.

Table 2. Organic carbon content (%) of soil under plantation in different agro-climatic zone

Soil depth \ Species	0-15 cm				15-30 cm			
	IV	V	VI	Mean	IV	V	VI	Mean
Acacia auriculiformis	0.49	0.53	0.51	0.51	0.46	0.49	0.47	0.47
Cassia siamea	0.52	0.55	0.53	0.53	0.47	0.50	0.49	0.48
Eucalyptus hybrid	0.43	0.53	0.49	0.48	0.41	0.46	0.45	0.44
Mean	0.48	0.53	0.51	0.51	0.45	0.48	0.47	0.47
Initial	0.39	0.35	0.34		0.34	0.32	0.30	
	(S.Em (±)		CD 5%		(S.Em (±)		CD 5%	
Tree specie	0.005		0.010		0.004		0.009	
Agro climatic zone	0.005		0.010		0.004		0.009	
Tree species X Agro climatic zone	0.008		0.018		0.008		NS	
CV%		2.823				2.797		

So there is an increase of 57.14% of organic carbon in the four year's old *Cassia siamea* plantation over control in zone V at top soil where as in sub-surface maximum increase of 9.57% was observed in zone IV. The soil organic matter content was generally higher in different forest vegetation at high altitude with maximum accumulation in the surface horizon. It decreased with depth but without a definite trend [6].

3.3. Available nitrogen (kg ha^{-1})

At soil surface of (0-15) depth, from 4yrs old plantation of *Cassia siamea* had obtained maximum available nitrogen of soil (307.44 kg ha^{-1}) followed by *Acacia auriculiformis* where as the minimum available nitrogen

of soil obtained by *Eucalyptus hybrid* (289.44 kg ha^{-1}). So there is an increase of 27.21% of available nitrogen in *Cassia siamea* plantation over control in zone V (Table 3). Statistical analysis revealed that among species *Cassia siamea* has highly statistically significant than other two species whereas *Acacia auriculiformis* has significant than *Eucalyptus hybrid*. Among zones, sub zone V has highly significant from other two zone whereas sub zone IV and VI are at par. At sub-surface (15-30 cm), *Cassia siamea* was obtained maximum available nitrogen of soil (277.78 kg ha^{-1}) followed by *Acacia auriculiformis*. This reflects a similar trends in sub surface of the soil also statistically. The soil under trees showed a trend of improvement in fertility enrichment of available nutrient status [5].

Table 3. Available nitrogen (kg ha^{-1}) of soil under plantation in different agro-climatic zone

Soil depth \ Species	0-15 cm				15-30 cm			
	IV	V	VI	Mean	IV	V	VI	Mean
Acacia auriculiformis	283.33	322.67	290.00	298.67	253.33	291.67	258.33	267.78
Cassia siamea	308.33	325.67	288.33	307.44	276.67	295.00	261.67	277.78
Eucalyptus hybrid	270.00	323.33	275.00	289.44	240.00	286.67	254.00	260.22
Mean	287.22	323.89	284.44	298.52	256.67	291.11	258.00	268.59
Initial	250.0	256.0	260.3		235.0	242.00	240.00	
	(S.Em (±)		CD 5%		(S.Em (±)		CD 5%	
Tree specie	2.676		5.673		2.239		4.746	
Agro climatic zone	2.676		5.673		2.239		4.746	
Tree species X Agro climatic zone	4.635		9.826		3.878		8.221	
CV%		2.689				2.501		

3.4. Available Phosphorus (kg ha^{-1})

At soil surface (0-15cm depth) four years old plantation of *Acacia auriculiformis* had obtained maximum available phosphorus (17.27 kg ha^{-1}) followed by *Eucalyptus hybrid* whereas the minimum available phosphorus obtained by *Cassia siamea* (16.09 kg ha^{-1}). So there is an increase of 16.65% of available phosphorus in *Acacia auriculiformis* plantation over control in sub zone V (Table 4). Statistical

analysis revealed that among species *Acacia auriculiformis* has highly statistically significant than other two species whereas *Eucalyptus hybrid* has significant than *Cassia siamea*. Among zones, sub zone V has highly significant from other two zone whereas sub zone IV and VI are at par. At sub-surface (15-30 cm) *Acacia auriculiformis* was obtained maximum available phosphorus of soil (16.12 kg ha^{-1}) followed by *Eucalyptus hybrid*. This reflects a similar trends in sub surface of soil statistically.

Table 4. Available phosphorus (kg ha⁻¹) of soil under plantation in different agro-climatic zone

Soil depth / Species	0-15 cm				15-30 cm			
	IV	V	VI	Mean	IV	V	VI	Mean
Acacia auriculiformis	18.55	23.33	9.93	17.27	16.77	22.33	9.27	16.12
Cassia siamea	15.60	22.37	10.30	16.09	14.63	21.57	9.70	15.30
Eucalyptus hybrid	16.40	22.60	10.90	16.63	14.80	21.43	10.60	15.61
Mean	16.85	22.77	10.38	16.66	15.40	21.78	9.86	15.68
Initial	16.0	20.0	10.30		16.00	20.00	10.30	
	(S.Em (±))		CD 5%		(S.Em (±))		CD 5%	
Tree specie	0.133		0.281		0.092		0.196	
Agro climatic zone	0.133		0.281		0.092		0.196	
Tree species X Agro climatic zone	0.203		0.487		0.160		0.339	
CV%		2.386				1.766		

3.5. Available Potassium (kg ha⁻¹)

At soil surface (0-15 depth) four years old plantation of *Acacia auriculiformis* had obtained maximum available potassium of soil (162.97 kg ha⁻¹) followed by *Eucalyptus hybrid* . Whereas the minimum available potassium of soil obtained by *Cassia siamea* (153.81 kg ha⁻¹). So there is an increase of 9.20% of available potassium in *Acacia auriculiformis* over control in zone V (Table 5). Statistical analysis revealed that among species *Acacia auriculiformis* has highly statistically significant than

other two species whereas *Eucalyptus hybrid* has significant than *Cassia siamea*. Among zones, sub zone V has highly significant from other two zones whereas sub zone IV and VI are at par. At sub-surface (15-30 cm) *Acacia auriculiformis* was obtained maximum available potassium of soil (161.69 kg ha⁻¹) followed by *Eucalyptus hybrid*. This reflects a similar trend in sub surfaces of soil statistically. In ash, the ash element composition of plants obtained under conditions of physical modeling in evolutionary pedogenic process [7] however, the effect of crop rotations leads to an intermittent change in the dynamics of the ash composition of plant tissue [8].

Table 5. Available potassium (kg ha⁻¹) of soil under plantation in different agro-climatic zone

Soil depth / Species	0-15 cm				15-30 cm			
	IV	V	VI	Mean	IV	V	VI	Mean
Acacia auriculiformis	161.47	174.73	152.70	162.97	160.37	173.63	151.07	161.69
Cassia siamea	154.87	161.43	145.13	153.81	153.87	160.50	143.93	152.77
Eucalyptus hybrid	150.87	171.23	148.40	156.83	147.78	169.37	148.21	155.12
Mean	155.73	169.13	148.74	157.87	154.01	167.83	147.74	156.53
Initial	156.0	160.0	148.6		147.00	146.00	144.30	
	(S.Em (±))		CD 5%		(S.Em (±))		CD 5%	
Tree specie	0.698		1.481		1.211		2.568	
Agro climatic zone	0.698		1.481		1.211		2.568	
Tree species X Agro climatic zone	1.210		2.565		2.098		4.447	
CV%		1.327				2.321		

4. Conclusion

Analysis of soil after four years of plantations with *Acacia auriculiformis, Cassia siamea* and *Eucalyptus hybrid* for soil reaction, available N, P and K revealed variation among various types of energy plantation. Among the three sub zones with energy plantation the highest variation was observed for sub zone VI as compared to their respective initial values. From the view points of results of the study revealed that the soil under *Acacia auriculiformis, Cassia siamea* and *Eucalyptus hybrid* showed a trend of improvement in physico-chemical properties viz., pH and fertility enrichment of organic carbon and available nutrient status in different ecosystems.

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