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Growth of certain tree species in fly ash amended soil

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ABSTRACT

The study reports on the use of fly ash on the growth of five tree species namely Subabul (Leucaena leucocephala), Chakundi (Cassia siamea) Black siris (Albizia lebbek), Shisham (Dalbergia sissoo) and Gamhar (Gmelina arborea). Out of five species, the former four are nitrogen fixers belonging to the family Leguminsae and the last one viz. Gamhar is an excellent fast growing timber tree species belonging to the family Verbenaceae. The experiment was conducted in cement pots for one year (August 1993 to August 1994) in completely randomised design (CRD) with five treatments and four replications to record the growth parameters viz. collar diameter, height, number of leaves and leaf area at 30 days interval. The five treatments were : T_0 (No fly ash, only 20 kg soil), T_1 (Soil + 5% Fly ash), T_2 (Soil + 10% fly ash), T_3 (Soil + 20% fly ash) and T_4 (Soil + 50% fly ash). Results reveal that collar diameter, height, number of leaves and leaf area of all the five tree species increased progressively up to 20% Fly ash addition to acid soils of Chotanagpur region. It was also observed that 50% fly ash addition on soil was superior to control (no fly ash, only soil) in respect of all growth parameters except number of leaves and leaf area of Black siris, Subabul and Gamhar, and collar diameter of Chakundi and Gamhar. In general, fly ash addition to soil had a beneficial impact on the growth of the above mentioned tree species. These tree species are recommended for afforestation and reforestation of waste lands at 20% fly ash (w/w) levels.

INTRODUCTION

Fly ash constitutes about 70% of the total amount of residue generated in coal-fired power plants equipped with electrostatic precipitators or bay filters. Land application appears to be a favourable practice for ash disposal provided there is no adverse effect on environmental quality. A few tree species are successfully growing in fly ash areas. The present study was, therefore, undertaken to study growth behaviour, biomass production and nutrient cycling of five important tree species.

MATERIALS AND METHODS

The study included four leguminous tree species viz. Subabul (Leucaena leucocephala), Shisham (Dalbergia sissoo), Black siris (Albizia lebbek), Chakundi

(Cassia siamea) and one timber species viz. Gamhar (Gmelina arborea) of the four leguminous species, Leucaena leucocephala is an excellent firewood and fodder tree, Dalbergia sissoo in an excellent timber tree, Albizia lebbek is an excellent timber and fodder tree and Cassia siamea is a fast growing firewood and timber tree.

Three month old nursery grown polybag plants of Sababul, Shisham, Black Siris, Chakundi and Gamhar were transplanted to cement pots in green house. Bokaro flyash supplied by SAIL was added in different proportions and the five treatments were as follows :

1) Control (No fly ash, only 20 kg soil)
2) Soil + 5% fly ash
3) Soil + 10% fly ash
4) Soil + 20% fly ash, and
5) Soil + 50% fly ash

Four replicates of 20 kg of each mixture of soil and flyash were prepared, filled up in cement pots and one seedling was transplanted to each pot in August, 1993. The pots were arranged in a completely randomized design. The following growth parameters were recorded at 30 days intervals- 1. Collar diameter, 2. Height, 3. No. of leaves, 4. Leaf area.

RESULTS AND DISCUSSION

Observations on various growth parameter viz. collar diameter, height, number of leaflets/leaves and leaf area were recorded for one year (360 days) at 1 month (30 days) interval and the results for five tree species are presented from tables 1 to 5.

Collar Diameter

Addition of fly ash to soils produced continuous increase in collar diameter of all the five species up to 20% fly ash (w/w) levels (Table-1 to 5). Although those was decrease in collar diameter at 50% fly ash (w/w) levels (T_4) in all the five tree species as compared to 20% level (T_3) but there was increase in comparison to control (T_0) and 5% level (T_1) in Subabul (up to 300 days) more than control (T_0) in other three leguminous species viz. Shisham, Chakundi, Black Siris and less than control (T_0) in Gamhar.

Height

Height of all the five tree species increased continuously with addition of

Table-1 : Height (cm), Collar diameter (cm), number of leaflets and lef area (cm^2) of Black Siris (Albizia lebbeck) as affected by levels of fly ash addition to soil

Treatments	Parameter	Plant age (days)					
		60	120	160	240	300	360
T_0	Height	35.0	51.7	60.0	64.7	69.1	72.6
	Collar diameter	0.78	1.48	2.40	2.57	2.85	3.21
	Number of leaflets	630	1036	508	576	780	1070
	Leaf area	2649	4145	2286	2619	3433	4494
T_1	Height	41.9	52.6	62.0	67.7	72.3	77.0
	Collar diameter	1.25	2.03	2.78	3.23	3.60	3.54
	Number of leaflets	1145	1181	430	617	866	1278
	Leaf area	4227	4724	1935	2892	3811	5369
T_2	Height	50.2	66.8	75.5	82.7	90.3	95.5
	Collar diameter	1.37	2.32	3.46	3.97	4.61	5.13
	Number of leaflets	1361	1987	700	845	1165	1565
	Leaf area	5047	5949	3150	3549	5127	6499
T_3	Height	54.9	70.0	86.7	93.1	101.3	107.3
	Collar diameter	1.63	22.87	3.74	4.28	4.94	5.47
	Number of leaflets	1557	1805	607	907	1235	1657
	Leaf area	6517	7220	2731	4210	5437	6362
T_4	Height	48.4	63.2	70.5	74.2	79.0	82.9
	Collar diameter	1.17	1.79	2.58	2.91	3.33	3.87
	Number of leaflets	1130	1508	300	484	791	980
	Leaf area	4747	6035	1350	2112	3482	4117

Table-2 : Height (cm), Collar diameter (cm), number of leaflets and leaf area (cm^2) of Chakundi (Cassia siamea) as affected by levels of fly ash addition to soil

Treatments	Parameter	Plant age (days)					
		60	120	180	240	300	360
T_0	Height	32.4	45.3	50.5	53.9	56.9	61.4
	Collar diameter	0.77	1.47	2.05	2.53	2.95	3.26
	Number of leaflets	268	457	290	333	548	750
	Leaf area	2821	4572	2000	3496	4602	8250
T_1	Height	25.9	50.7	52.4	55.0	60.1	64.5
	Collar diameter	1.44	1.87	2.56	3.12	3.61	4.05
	Number of leaflets	259	539	340	433	626	1000
	Leaf area	2640	5397	3400	4462	5264	11000
T_2	Height	36.2	48.8	57.7	64.0	68.5	73.2
	Collar diameter	1.95	2.00	2.55	3.26	3.90	4.49
	Number of leaflets	297	553	425	469	857	1310
	Leaf area	3126	5537	4250	4932	7198	13410
T_3	Height	39.2	60.9	70.0	75.5	80.7	85.7
	Collar diameter	1.90	2.33	3.51	4.21	4.45	5.00
	Number of leaflets	334	574	320	473	934	1421
	Leaf area	4506	5747	3200	4974	7849	15631
T_4	Height	28.1	40.2	50.5	57.3	60.0	64.1
	Collar diameter	1.65	1.71	2.42	2.93	3.25	3.63
	Number of leaflets	239	412	209	258	528	842
	Leaf area	2517	4120	2090	2716	4435	9267

Table-3 : Height (cm), Collar diameter (cm), number of leaflets and leaf area (cm^2) of Gamhar (Gmelina arborea) as affected by levels of fly ash addition to soil

Treatments	Parameter	Plant age (days)					
		60	120	160	240	300	360
T_0	Height	61.6	68.0	75.5	79.8	84.2	88.1
	Collar diameter	0.76	2.36	3.42	3.89	4.26	4.60
	Number of leaflets	67	92	50	45	79	107
	Leaf area	6978	9250	4750	4703	6335	10165
T_1	Height	69.0	82.1	84.0	89.9	95.8	101.1
	Collar diameter	0.81	2.15	2.75	4.21	4.83	4.97
	Number of leaflets	77	105	59	53	96	148
	Leaf area	8006	10575	5606	5453	7752	14123
T_2	Height	80.4	93.6	100.0	105.1	112.5	116.6
	Collar diameter	1.01	2.37	3.00	4.88	5.12	5.50
	Number of leaflets	84	128	66	70	124	186
	Leaf area	8652	12850	6270	7287	9984	17741
T_3	Height	86.8	96.2	107.0	113.2	119.5	124.1
	Collar diameter	0.88	2.12	3.56	5.20	5.66	6.70
	Number of leaflets	91	136	79	74	132	197
	Leaf area	9398	13600	7505	7699	10606	18786
T_4	Height	65.1	79.1	86.0	91.4	95.3	99.4
	Collar diameter	1.06	1.72	2.75	3.21	4.02	4.55
	Number of leaflets	65	104	82	37	72	106
	Leaf area	6772	10425	7790	3862	5774	10093

Table-4 : Height (cm), Collar diameter (cm), number of leaflets and lef area (cm^2) of Subabul (Leucaena Leucocephala) as affected by levels of fly ash addition to soil

Treatments	Parameter	Plant age (days)					
		60	120	180	240	300	360
T_0	Height	87.7	142.6	168.5	178.9	185.6	193.1
	Collar diameter	0.73	1.57	2.01	2.49	2.72	3.12
	Number of leaflets	1583	4574	7580	8066	8310	8541
	Leaf area	1362	3887	4685	6937	7894	8541
T_1	Height	90.8	163.4	183.0	195.9	201.9	207.5
	Collar diameter	0.89	1.57	2.31	2.68	3.15	3.54
	Number of leaflets	1827	4175	7620	8285	8541	9087
	Leaf area	1571	4731	5715	7124	8113	9087
T_2	Height	99.1	166.8	190.5	197.9	205.6	212.0
	Collar diameter	1.03	1.74	2.56	2.91	3.76	4.26
	Number of leaflets	2015	4295	7860	8553	8900	9472
	Leaf area	1732	3650	5335	7355	8455	9442
T_3	Height	102.3	168.4	195.0	216.3	221.1	227.0
	Collar diameter	1.23	2.01	2.78	3.26	3.90	4.65
	Number of leaflets	1997	6295	8020	9346	9729	10810
	Leaf area	1717	5350	6015	8271	9242	10810
T_4	Height	85.0	183.1	193.0	197.0	209.2	213.4
	Collar diameter	1.18	1.95	2.68	2.83	3.18	3.47
	Number of leaflets	1340	6890	7700	8150	83.76	8644
	Leaf area	1152	4856	5775	7008	7957	8644

fly ash up to 20% level (Table). Except Shisham, all the four species viz. Sababul, Chakundi, Black Siris and Gamhar showed increase in height at 50% level (T_4) as compared to control (T_0) and 5% fly ash level (T_1) although (T_4) was inferior to T_2 and T_3 in all the five species.

Number of leaflets/leaves and leaf area

Application of fly ash to soils produced the following pattern in the increase of number of leaflets/leaves and leaf area in Black Siris, Chakundi and Gamhar (Table 1-3).

20% level (T_3) > 10 % level (T_2) > 5% level (T_1) > Control (T_0) > 50% level (T_4)

However, Subabul and Shisham presented the following pattern (Table-4 and 5).

$$T_3 > T_2 > T_1 > T_4 > T_0$$

Addition of flyash to soil has been shown to change the physical, chemical and biological characteristics of the recipient soils, thereby affecting their agronomic value (Chang et.al) 1977. Arthur et.al. 1984, Eary et.al 1990. Mattigod et.al. 1990, Singh et.al. 1994). At low application rate, fly ash amended soil shows improvement in agronomic properties such as water holding capacity (WHC), bulk density and hydraulic conductivity (Chang et.al 1977). AT an application rate of 25% (w/w)., there was a increase in WHC, and decrease in bulk density and hydraulic conductivity. However, even with increase in WHC, the amount of water available to plants did not change. The inpedence of water flow at high fly ash application rates was suggested to be caused due to pozzolanic nature of coal ash which tends to cement soil particles under wet condition.

All the growth parameters viz. collar diameter, height, number of leaflets/ leaves and leaf area of all the five tree species increased continuously with addition of fly ash to soil up to 20% level. Even the addition of fly ash up to 50% level was found to be better than control in enhancing growth of leguminous tree species (Shisham, Chakundi, Subabul and Black Siris). However, Gamhar, a non-leguminous tree species, responded unfavourably to the addition of fly ash up to 50% level although it also showed positive response in growth parameters up to 20% level. Since leguminous tree species are reported to biologically fix atmospheric nitrogen and fly ash is reported to be deficient in nitrogen, therefore, the performance of leguminous tree species have been found better in this experiment as compared to non-leguminous one. Based on acetylene reduction rates, Hogberg and Kvarnstrom (1982) reported annual nitrogen fixation rates of 110 ± 30 kg ha -1 in Subabul. Further studies are required to determine the relative nitrogen fixing ability of these leguminous tree species in fly ash amended soils.

Table-5 : Height (cm), Collar diameter (cm), number of leaflets and lef area (cm^2) of Shisham (Dalbergia sissoo) as affected by levels of fly ash addition to soil

Treatments	Parameter	Plant age (days)					
		60	120	180	240	300	360
T_0	Height	71.4	100.2	109.7	116.1	121.3	126.2
	Collar diameter	0.63	1.13	1.48	1.96	2.24	2.64
	Number of leaflets	100	130	40	236	419	757
	Leaf area	1005	1172	400	2360	3861	6969
T_1	Height	81.0	116.2	127.0	135.6	141.4	148.8
	Collar diameter	0.76	1.34	2.70	3.32	3.83	4.50
	Number of leaflets	109	143	56	340	622	1059
	Leaf area	1097	1291	560	3400	5722	9742
T_2	Height	91.5	116.0	128.7	136.2	143.0	150.6
	Collar diameter	0.82	1.51	2.85	2.54	4.11	4.99
	Number of leaflets	113	155	63	430	754	1161
	Leaf area	1130	1401	630	4302	6943	10688
T_3	Height	98.7	119.5	129.0	138.0	146.1	152.8
	Collar diameter	0.87	1.75	3.50	3.99	4.56	5.41
	Number of leaflets	117	172	58	474	838	1314
	Leaf area	1172	1552	580	4742	7709	12095
T_4	Height	82.3	112.6	122.0	126.8	130.8	135.5
	Collar diameter	0.74	1.41	1.97	2.50	3.07	3.22
	Number of leaflets	107	150	32	289	492	787
	Leaf area	1072	1356	320	2895	4526	7242

Use of fly ash in reclaiming the wastelands has been suggested. This is particularly favourable for acidic soils of Chotanagpur region as the flyash has alkaline character. On the basis of our study, it has been found that the flyash addition to soil and a beneficial impact on the growth of the aforesaid tree species. Thus, these tree species are recommended for afforestation and reforestation of wastelands and 20% fly ash (w/w) levels.

CONCLUSION

Growth of five tree species namely Subabul (Leucaena Leucocephala). Chakundi (Cassia siamea), Black siris (Albizia lebbek), Shisham (Dalbergia sissoo) and Gamhar (Gmelnia arborea) was studied in fly ash amended soil. Fly ash levels ranged from 0 to 50%. Collar diameter, height, number of leaves and leaf area of all the five tree species increased progressively up to 20% fly ash addition. In leguminous tree species (Gamhar, Chakundi, Subabul and Black Siris) fly ash addition up to 50% (w/w) was better than no application. Non-leguminous tree species such as Gamhar showed response up to 20% level of fly ash application.

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