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Exhangeable cations and anions capacity of soil experiencing mortility of shisham (*Dalbergia sissoo*) in semi-arid regions of Haryana, India

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ABSTRACT
In order to study the chemical properties of soils under healthy as well as dead trees of *Dalbergia sissoo* six different locations selected in Chaudhary Charan Singh Haryana Agricultural University, Hisar and nearby places with an objective to ascertain whether the mortality is caused by any chemical properties of soils . Soil samples from six different depth upto 150 cm were collected and analysis for pH, E.C, Exchangeable cations and anions of soil. The concentration of exchangeable cations were found higher in the soils under healthy trees as compared to dead trees while the pH, E.C and exchangeable anions were higher under dead trees and its concentration increased with the increase in the soil depth at all the six locations.

Key words : *Dalbergia sissoo,* Mortality Exchangeable cations and anions, Semi-arid

INTRODUCTION

Dalbergia sissoo (shisham) is one of the few important broad-leaved leguminous trees. It is grows in the entire sub-Himalayan tract and also in the Himalayan valleys upto an elevation of about 1500m. It is grown throughout Indo-gangetic plain and Rajasthan. It is a large deciduous tree and it has been widely used for afforestation, soil conservation, ravine reclamation etc. in many parts of the country. It has a good atmospheric N_2-fixing ability, therefore, it is extensively planted in social and agro-forestry programmes.

After been grown successfully for hundreds of years, trees of *Dalbergia sissoo* in their natural and man-influenced ecosystem are adversely affected by various biotic and abiotic factors. Since a number of stress factors such as changing climatic conditions, stagnation of soil water, longer dry spell, soil compaction, salt accumulation, imbalance of soil nutrients and improper site for plantation, adversely affects tree health which invite the secondary pathogen and insects that attack the weakened tree and finally leads to death of tree. So keeping in view above points, present study was undertaken to know whether the chemical properties of soil responsible for decline of *Dalbergia sissoo.*

MATERIALS AND METHODS

Healthy and dead trees of *Dalbergia sissoo* were selected from the campus CCS HAU, Hisar (Lat. 29°10¢ N, Long. 75°46¢ E and Alt. 215.2 m above mean sea level) and nearby places. The distances between healthy and dead trees were about 4-5 m. The trees were about 10-15 years of age, their girth varied from 68 to 69 cm and height 8-14 m. From each location, two trees one healthy and one dead were selected. Four points at a distance of 1.5 meter from the base of trees in East, West, North and South directions were marked. From these points with the help of an auger, soil sample were drawn at a depth of 0-15, 15-30, 30-60, 60-90, 90-120 and 120-150 cm from these directions. Samples from each direction and depth were mixed together and one composite sample was drawn. In this way samples were collected from six different locations under dead and healthy trees. Soil sample were air dried, ground with pestle and mortar and passed through 2mm sieve and analyzed, pH (Kalra and Maynard,1991), Exchangeable cations like $Ca^{2+,}$ Mg^{2+} (Kanwar and Chopra,1976) Na^+ and K^+ on Elico flame photometer, E.C, Water soluble anions like Bicarbonate and chloride , (Richards, 1954) and Sulphate (Chesnin and Yien, 1951).

RESULTS AND DISCUSSION

Soil pH :

The soil pH values (1:2 soil water ratio) at different depth and at various locations are presented in Table-1. In general the soil pH values were higher in soils under dead trees as compared to healthy trees at all the locations and depth. Among healthy trees the lowest pH values i.e. 7.5 was recorded at the surface layer of location L3 and highest 9.1 at lowest depth at location L_6. In case of dead trees pH values varied from 7.9 (in surface level at location L_3) to 9.3 in the soil sample at lower most depth at location L_6. In both the cases the pH values increased with the increasing in soil depth.

The low pH values of upper surface layer may be

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Table 1: pH (1:2 soil water ratio) of the soil under healthy and dead trees of D. sissoo.

Depth (cm)	L_1		L_2		L_3		L_4		$L_{5`}$		L_6	
	H	D	H	D	H	D	H	D	H	D	H	D
0-15	8.0	8.1	7.9	7.9	7.5	7.9	7.8	8.0	7.9	8.0	8.1	8.4
15-30	8.1	8.3	8.2	8.0	7.9	8.0	8.1	8.2	8.0	8.1	8.2	8.2
30-60	8.2	8.4	8.3	8.1	8.0	8.1	8.3	8.3	8.3	8.2	8.5	8.6
60-90	8.4	8.7	8.3	8.2	8.1	8.2	8.7	8.5	8.4	8.7	8.5	8.7
90-120	8.5	9.0	8.4	8.6	8.2	8.9	8.8	8.7	8.8	8.7	8.6	9.1
120-150	8.6	9.1	8.5	8.9	8.2	9.0	8.8	8.8	9.1	9.0	9.1	9.3
Mean	8.3	8.6	8.2	8.2	7.9	8.3	8.4	8.4	8.4	8.4	8.5	8.7
Mean difference	-0.30		-0.02		-0.36		0.00		-0.03		-0.21	
SE	0.21	0.36	0.17	0.35	0.24	0.43	0.37	0.27	0.42	0.36	0.32	0.38
T	4.40*		-1.02		2.86*		0.00		0.44		3.36*	
T, 5%	2.015											

* Significant, H = Healthy, D= Dead, SE= Standard Error

attributed to the higher accumulation of organic matter on surface due to higher litter fall and its subsequent decomposition and formation of organic acid. Subhanu (2002), Nandi *et al*., (1991) and Kumar *et al*., (1998) also reported the lowering of soil pH under *Acacia nilotica,Dalbergia Sissoo* plantations.

The paired t-test value showed that at location L_1, L_3 and L_6 these values under dead trees were significantly higher than the healthy trees, values being 4.401, 2.868 and 3.683 respectively. Sharma *et al*. (1998) reported that the soil pH of dead *Dalbergia sissoo* plantation varied from 7.5 to 9.7 as compared to near neutral pH in healthy localities.

Electrical conductivity (dSm^{-1}) :

The electrical conductivity of soils increased with depth in case of soils under healthy as well as dead trees of *Dalbergia sissoo* (Table-2). In general, the EC was higher in the soil under dead trees as compared to healthy trees at all the six locations. Under the healthy trees the EC value varied from 0.30 dSm^{-1} (surface) at location L_3 and L_6 to 0.45 dSm^{-1} (lower most depth) at location L_1.

Table 2: Electrical conductivity (dSm^{-1}) of the soil under healthy and dead trees of *D. sissoo*

Depth (cm)	L_1		L_2		L_3		L_4		$L_{5`}$		L_6	
	H	D	H	D	H	D	H	D	H	D	H	D
0-15	0.34	0.36	0.32	0.34	0.30	0.33	0.29	0.32	0.28	0.33	0.30	0.33
15-30	036	0.38	0.32	0.35	0.35	0.38	0.30	0.34	0.29	0.31	0.32	0.35
30-60	0.41	0.42	0.35	0.36	0.36	0.34	0.35	0.37	0.32	0.30	0.37	0.39
60-90	0.40	0.46	0.36	0.38	0.37	0.38	0.39	0.37	0.32	0.33	0.37	0.40
90-120	0.45	0.43	0.37	0.38	0.38	0.36	0.40	0.43	0.34	0.36	0.39	0.41
120-150	0.45	0.47	0.42	0.40	0.41	0.43	0.44	0.42	0.40	0.39	0.43	0.40
Mean	0.40	0.42	0.35	0.36	0.36	0.37	0.36	0.37	0.32	0.33	0.36	0.38
Mean difference	0.02		0.01		0.01		0.01		0.01		0.02	
SE	0.02	0.02	0.02	0.01	0.02	0.01	0.02	0.02	0.02	0.01	0.019	0.131
t	0.79		1.66		0.88		0.90		1.15		1.75	
t, 5%	2.015											

* Significant, H = Healthy, D= Dead, SE= Standard Error

Among the dead trees minimum EC was found on the surface (0.32) at location L_4 and maximum in lower most depth (0.47) at location L_1. It is evident from the data that the trees helped in lowering down the salt concentration in soil. The reduction was maximum under the healthy trees of *Dalbergia sissoo.* The effectiveness of *Dalbergia sissoo* in improving soil by lowering its EC values might be attributed to its relative tolerance under adverse soil conditions, amount of litter fall and its chemical composition. The results are in conformity with the finding of Kumar *et al*., (1998) and Nandi *et al*., (1991) and Subhanu (2002). They also reported the lowering down of EC under *Dalbergia, Eucalyptus* and *Acacia* plantation in arid conditions.

Paired t test value showed was no significant difference in EC values in soils under dead and healthy trees.

Exchangeable calcium (C mol kg^{-1}) :

The minimum exchangeable calcium (4.0 C mol kg^{-1}) was observed at the surface layer of location L_1 and L_2 and maximum (6.8 C mol kg^{-1}) at the lower most soil depth of location L_2. In case of dead tree minimum exchangeable Ca was found 2.9 C mol kg^{-1} at the surface layer of location L_4 and maximum 6.4 C mol kg^{-1} in the low most soil depth of location L_2 (Table-3). The exchangeable calcium increased with increasing soil depth both in the soil under healthy as well as dead trees of *Dalbergia sissoo*. Maximum exchangeable calcium were observed in the soil of health[y trees as compared to the soils under dead trees of *Dalbergia sissoo*.

The paired t-test value showed that at location L_2, L_3, L_4 and L_6 these values under healthy trees were significantly higher than dead trees, values being 2.366, 3.024, 4.385 and 2.236.

Exchangeable Magnesium (C mol kg^{-1}) :

The data presented in Table-4 revealed that the minimum exchangeable magnesium, 2.0 C mol kg^{-1} was observed at the surface of location L_4 and maximum, 3.9 C mol kg^{-1} at 120-150cm soil depth at locations L_4 and L_6 in case of healthy trees. Among dead trees the minimum exchangeable magnesium 2.0 C mol kg^{-1} was observed at the surface of location L_1 and maximum 3.9 C mol kg^{-1} at the lower most soil depth at locations L_5. The exchangeable calcium, magnesium also increased with increasing soil depth (Similar results were also reported by Singh, 2002) both in healthy as well as dead trees. Exchangeable magnesium content more in the soil of healthy trees as compared to dead trees.

Significantly higher pair t-test values were observed under the healthy trees soils as compared to dead trees at locations L_2 and L_6, values being 4.111 and –4.472 respectively.

Exchangeable sodium (C mol kg^{-1}) :

In case of healthy trees the minimum exchangeable sodium 0.41 C mol kg^{-1} was observed at the surface of location L_2 and maximum 0.84C mol kg^{-1} in the lower most soil depth at location L_3 (Table-5). Under dead trees the minimum exchangeable sodium 0.39 C mol kg^{-1} was observed at the surface of location L_2 and maximum 0.82

Table 3: Exchangeable Calcium (Cmol Kg^{-1}) of the soil under healthy and dead trees of *D. sissoo*

Depth (cm)	L_1		L_2		L_3		L_4		$L_{5`}$		L_6	
	H	D	H	D	H	D	H	D	H	D	H	D
0-15	4.0	4.0	4.0	4.0	4.3	4.2	4.2	3.9	4.3	4.2	4.4	4.2
15-30	4.1	4.2	4.2	4.3	4.7	4.3	4.5	4.3	4.7	4.6	4.8	4.7
30-60	4.3	4.4	5.1	4.9	5.5	4.9	5.0	4.5	4.9	4.8	5.1	5.2
60-90	5.1	5.0	6.2	5.7	6.1	5.9	5.6	5.0	5.1	5.0	5.6	5.5
90-120	5.6	5.2	6.5	6.0	6.4	6.1	5.9	5.8	5.7	5.7	5.9	5.7
120-150	6.3	5.7	6.8	6.4	6.6	6.6	6.3	6.0	6.6	6.0	6.4	6.3
Mean	4.90	4.75	5.46	5.21	5.60	5.33	5.25	4.91	5.21	5.05	5.36	5.26
Mean difference	0.15		0.25		0.26		0.33		0.16		0.10	
SE	0.37	0.26	0.49	0.39	0.38	0.41	0.33	0.34	0.33	0.27	0.30	0.30
t	1.27		-2.36*		3.02*		4.38*		1.89		2.236*	
t, 5%	2.015											

* Significant, H = Healthy, D= Dead, SE= Standard Error

Table 4: Exchangeable Magnesium (Cmol Kg^{-1}) of the soil under healthy and dead trees of *D. sissoo*

Depth (cm)	L_1		L_2		L_3		L_4		$L_{5`}$		L_6	
	H	D	H	D	H	D	H	D	H	D	H	D
0-15	2.1	2.0	2.2	2.1	2.4	2.3	2.0	2.2	2.4	2.2	2.4	2.3
15-30	2.3	2.2	2.5	2.5	2.5	2.4	2.4	2.4	2.5	2.4	2.7	2.5
30-60	2.7	2.6	2.6	2.6	2.7	2.5	2.6	2.5	2.7	2.7	3.0	2.8
60-90	2.8	2.9	2.9	2.8	2.8	2.7	3.0	2.7	2.9	2.9	3.3	2.9
90-120	3.6	3.7	3.1	3.0	3.1	3.2	3.7	3.1	3.5	3.3	3.6	3.5
120-150	3.8	3.9	3.7	3.5	3.6	3.6	3.9	3.7	3.8	3.9	3.9	3.7
Mean	2.90	2.88	2.83	2.75	2.85	2.78	2.93	2.76	2.96	2.90	3.15	2.95
Mean difference	-0.02		-0.08		0.06		-0.16		-0.06		-0.20	
SE	0.27	0.31	0.62	0.19	0.18	0.20	0.30	0.22	0.23	0.25	0.22	0.22
t	0.41		4.11*		1.58		1.49		1.34		4.47*	
t, 5%	2.015											

* Significant, H = Healthy, D= Dead, SE= Standard Error

Table 5: Exchangeable Sodium (Cmol Kg^{-1}) of the soil under healthy and dead trees of *D. sissoo*

Depth (cm)	L_1		L_2		L_3		L_4		$L_{5`}$		L_6	
	H	D	H	D	H	D	H	D	H	D	H	D
0-15	0.42	0.41	0.41	0.39	0.42	0.40	0.43	0.41	0.42	0.41	0.43	0.40
15-30	0.51	0.50	0.43	0.45	0.51	0.47	0.48	0.46	0.51	0.50	0.47	0.43
30-60	0.63	0.59	0.60	0.52	0.63	0.55	0.51	0.43	0.63	0.59	0.59	0.52
60-90	0.62	0.60	0.69	0.69	0.79	0.65	0.63	0.62	0.62	0.60	0061	0.63
90-120	0.70	0.71	0.72	0.73	0.80	0.77	0.69	0.71	0.70	0.71	0.66	0.71
120-150	0.76	0.75	0.75	0.76	0.84	0.82	0.72	0.74	0.76	0.75	0.71	0.76
Mean	0.60	0.59	0.60	0.59	0.66	0.61	0.57	0.56	0.60	0.59	0.57	0.57
Mean difference	0.01		0.01		0.05		0.02		0.01		0.03	
SE	0.50	0.51	0.60	0.64	0.70	0.67	0.48	0.59	0.50	0.52	0.44	0.60
t	2.00		0.66		2.85*		1.00		2.00		0.16	
t, 5%	2.015											

* Significant, H = Healthy, D= Dead, SE= Standard Error

C mol kg^{-1} at the lower most soil depth of location L_3. The exchangeable sodium was more in the soil of healthy trees as compared to dead trees of *Dalbergia sissoo*. Exchangeable sodium increased with depth in case of healthy as well as trees of *Dalbergia sissoo*. Similar observations were observed by Singh, (2002).

In case of healthy trees the paired t-test value show the significant difference at location L_3 in comparison to dead trees, value being 2.353.

Exchangeable potassium (C mol kg^{-1}) :

The perusal of the data (Table-6) revealed that the minimum exchangeable potassium i.e. 0.26 C mol kg^{-1} was observed at the surface of locations L_1 and L_6 and maximum i.e. 0.76 C mol kg^{-1} in the lower most soil depth at location L_2. In case of dead trees the minimum value (0.25 C mol kg^{-1}) was observed at the surface of locations L_1 and L_6 and maximum 0.73 C mol kg^{-1} at the 120-150 cm depth of locations L_3 and L_4. The exchangeable potassium increased with depth. Similar observation were observed by Singh (2002) in soils under both the healthy as well as dead trees. Exchangeable potassium was observed more in the soil of healthy trees as compared to dead trees of *Dalbergia sissoo*.

In case of healthy trees the paired t-test values show the significant difference at location L_1, L_2, L_3, L_4 and L_6

Table 6: Exchangeable potassium (Cmol Kg^{-1}) of the soil under healthy and dead trees of *D. sissoo*

Depth (cm)	L_1		L_2		L_3		L_4		$L_{5`}$		L_6	
	H	D	H	D	H	D	H	D	H	D	H	D
0-15	0.26	0.25	0.30	0.27	0.32	0.31	031	0.30	0.28	0.26	0.26	0.25
15-30	0.27	0.26	0.40	0.40	0.41	0.42	0.42	0.38	031	0.30	0.28	0.29
30-60	0.31	0.28	0.52	0.48	0.52	0.49	0.47	0.42	0.37	0.36	0.36	0.42
60-90	0.39	0.32	0.59	0.52	0.61	0.60	0.56	0.52	0.42	0.40	0.40	0.47
90-120	0.48	0.39	0.67	0.61	0.69	0.68	0.69	0.61	0.46	0.42	0.45	0.52
120-150	0.52	0.48	0.76	0.70	0.75	0.73	0.75	0.73	0.59	0.53	0.57	0.58
Mean	0.37	0.33	0.54	0.49	0.55	0.53	0.53	0.49	0.40	0.37	0.38	0.42
Mean difference	0.04		0.04		0.01		0.04		0.03		-0.03	
SE	0.45	0.36	0.69	0.62	0.67	0.65	0.68	0.64	0.46	0.39	0.46	0.52
t	3.14*		4.11*		2.15*		4.00*		3.32		-2.40*	
t, 5%	2.015											

* Significant, H = Healthy, D= Dead, SE= Standard Error

values being 3.140, 4.111, 2.150, 4.000 and 2.406 respectively.

Exchangeable Bicarbonate (meq/l) :

In the soils under healthy trees the highest concentration (5.00 meq/l) was observed at locations L_2 and L_5 and in soils under dead trees 6.0 meq/l at location L_2 (Table-7). There was no definite pattern in distribution of bicarbonate in soil profile under healthy as well as dead trees. The mean values showed that the concentration of bicarbonate were more in sols under dead trees as compared to healthy trees. But at location L4 the values of t was significantly more in soils under dead trees as compared to healthy trees, t = 3.873.

Exchangeable Sulphate (meq/l) :

The sulphate concentration is presented in Table-8. The data revealed that sulphate concentration varied from 0.76 meq/l to 0.52 meq/l in case of healthy trees and 0.76 meq/l to 0.53 meq/l in case of soils under dead trees. The

Table 7: Bicarbonate concentration (meq/l) of the soil under healthy and dead trees of *D. sissoo*

Depth (cm)	L_1		L_2		L_3		L_4		$L_{5`}$		L_6	
	H	D	H	D	H	D	H	D	H	D	H	D
0-15	4.71	4.92	5.00	5.03	4.81	4.92	4.61	4.73	5.00	5.10	4.60	4.70
15-30	2.63	2.71	2.24	2.30	2.76	2.83	2.36	2.42	2.20	2.30	2.32	2.34
30-60	4.52	4.63	4.52	4.47	4.53	4.62	4.31	4.50	4.40	4.50	4.23	4.36
60-90	2.94	2.97	2.43	2.48	2.81	2.86	2.71	2.74	2.42	2.47	2.51	2.70
90-120	3.01	3.10	3.30	3.29	2.91	3.02	2.82	2.86	3.20	3.30	2.56	2.70
120-150	4.50	5.00	5.00	6.00	4.81	4.93	4.10	4.10	4.20	5.30	4.58	4.80
Mean	3.72	3.88	3.74	3.92	3.77	3.86	3.48	3.61	3.57	3.83	3.46	3.60
Mean difference	-0.17		-0.18		-0.09		-0.12		0.25		-0.13	
SE	0.86	0.97	1.15	1.35	0.95	0.96	0.87	0.94	1.04	1.20	1.01	1.03
t	1.74		1.00		0.79		3.87*		1.54		1.86	
t, 5%	2.015											

* Significant, H = Healthy, D= Dead, SE= Standard Error

Table 8: Sulphate concentration (meq/l) of the soil under healthy and dead trees of *D. sissoo*

Depth (cm)	L_1		L_2		L_3		L_4		L_5`		L_6	
	H	D	H	D	H	D	H	D	H	D	H	D
0-15	0.70	0.73	0.72	0.72	0.71	0.72	0.67	0.68	0.71	0.72	0.70	0.71
15-30	0.55	0.56	0.53	0.54	0.52	0.53	0.56	0.56	0.56	0.57	0.56	0.57
30-60	0.58	0.57	0.56	0.57	0.56	0.57	0.57	0.58	0.57	0.59	0.57	0.58
60-90	0.67	0.66	0.63	0.64	0.63	0.66	0.60	0.61	0.66	0.67	0.66	0.67
90-120	0.67	0.67	0.69	0.70	0.66	0.67	0.66	0.67	0.66	0.67	0.68	0.68
120-150	0.76	0.75	0.74	0.74	0.75	0.76	0.73	0.75	0.74	0.76	0.74	0.75
Mean	0.65	0.65	0.64	0.65	0.63	0.65	0.63	0.64	0.50	0.66	0.65	0.66
Mean difference	-0.01		-0.06		-0.01		-0.01		-0.01		-0.01	
SE	0.41	0.06	0.07	0.07	0.07	0.07	0.05	0.06	0.06	0.06	0.06	0.06
t	0.23		1.63		1.25		3.87*		6.18*		4.98*	
t, 5%	2.015											

* Significant, H = Healthy, D= Dead, SE= Standard Error

sulphate concentration was significantly more in soil under dead *Dalbergia sissoo* trees to the soils under healthy trees at locations L_4, L_5 and L_6, t-test values being 3.873, 6.187 and 4.989 respectively.

Exchangeable Chloride (meq/l) :

The chloride concentrations in soils under healthy and dead trees of Dalbergia sissoo are presented in Table-9. In the soils under healthy trees the chloride concentration varied from 3.47 to 2.36 meq/l whereas in case of dead trees it varied form 3.46 to 2.43 meq/l. the t-test values showed that their was no significant difference among the chloride concentration among the soils under healthy and dead trees.

CONCLUSION

The cations exchangeable capacity were higher in the soils under healthy trees as compared to dead trees while the pH, EC, anions exchangeable capacity were higher under dead trees as compared to healthy trees

Table 9: Chloride concentration (meq/l) of the soil under healthy and dead trees of *D. sissoo*

Depth (cm)	L_1		L_2		L_3		L_4		L_5`		L_6	
	H	D	H	D	H	D	H	D	H	D	H	D
0-15	2.45	2.44	2.85	2.84	2.78	2.77	2.37	2.36	2.84	2.80	2.80	2.78
15-30	2.63	2.60	2.98	2.98	2.86	2.85	2.54	2.54	2.90	2.90	3.00	2.98
30-60	2.84	2.80	3.27	3.30	3.12	3.12	2.74	2.74	3.26	3.28	3.26	3.28
60-90	2.90	2.90	3.47	3.47	3.36	3.34	2.90	2.87	3.47	3.46	3.47	3.46
90-120	3.26	3.28	2.49	2.50	2.45	2.43	3.12	3.11	2.44	2.50	2.36	2.37
120-150	3.47	3.46	2.58	2.56	2.64	2.66	3.36	3.29	2.60	2.59	2.60	2.60
Mean	2.92	2.91	2.94	2.94	2.86	2.86	2.83	2.81	2.91	2.92	0.41	0.16
Mean difference	0.01		-0.01		0.01		0.02		-0.01		0.24	
SE	0.15	0.16	0.15	0.15	0.13	0.13	0.14	0.14	0.15	0.15	0.16	0.16
t	1.33		-0.23		1.08		1.82		-0.24		0.50	
t, 5%	2.015											

* Significant, H = Healthy, D= Dead, SE= Standard Error

and their concentration increased with increase in soil depth at all the six locations. Concentrations of exchangeable cations and anions of soils at all the sites under study were medium to high, which did not reflect any nutritional deficiency in the soil which could cause mortality in trees. From this study it may be concluded that at all sites under study the exchangeable capacity, pH, EC of soils could not cause mortality in *Dalbergia sissoo*

REFERENCES

Nandi, A., Basu, P.K. and Banerjee, S.K. (1991). Modification of some soil properties. *Eucalyptus* species. *Indian For.,* **117:** 53-57.

Kumar, R., Kumar, A. and Dhillion, R.S. (1998). Morphological and physico-chemical characteristics of soils under different plantations in arid ecosystem. *Indian J. For.,* **21 (3):** 248-252.

Singh, G., Singh, B., Kappusamy, V. and Bala, N. (2002). Variations in foliage and soil nutrient composition in *Acacia tortilis* plantation of different ages in North-Western Rajasthan. *Indian For.,* **128:** 514-522.

Subhanu (2002). Effect of different tree species on nutrient dynamic in soil Ph.D thesis, Haryana Agriculture University, Hisar.

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