TRANSFORMATION OF LEPTOCHOLA FUSCA L. KUNTH AND SESBANIA ACULEATA PERS. IN SOIL UNDER DIFFERENT CONDITIONS

by

F. Azam and Kauser A. Malik*

ABSTRACT

A laboratory experiment was undertaken to study the transformation of L. fusca and S. aculeata in soil under different salinity, temperature and moisture regimes. Mineralization of the two materials was retarded at high salinity and moisture but accelerated at high temperature. S. aculeata mineralized more rapidly than L. fusca under all the conditions but L. fusca contributed more to the stable organic matter component. S. aculeata proved to be a better source for the synthesis of microbial biomass than L. fusca.

Soil amended with L. fusca resulted in a net immobilization of mineral N. whereas S. aculeata amendment caused an accumulation of mineral N. Losses of mineral N were recorded in S. aculeata amended soils at high salinity, moisture and temperature.

INTRODUCTION

Plant residues added to the soil are transformed into CO_2, microbial material and relatively stable humus components (Shields et al., 1973). The rapidity with which these transformations occur, is governed mainly by the soil ecological conditions. Mineralization of C and N is retarded in the presence of high amounts of salts or excess moisture (Johnson and Guenzi, 1963; Agarwal et al., 1971; Laura, 1974; Malik and Haider, 1977; Malik and Azam, 1979; Malik et al., 1979). Ammonification and nitrification of organic N added as plant residues may be retarded or completely inhibited at high salinity (Johnson and Guenzi, 1963; Sandhu and Cornfield, 1967; Laura, 1974, 1977; Westerman and Tuckar, 1974; Heilman, 1975; Gandhi and Paliwal, 1976). Heavy losses of mineralized N have also been reported under conditions of high salinity (Laura, 1974, 1975; Gandhi and Paliwal, 1976).

Besides soil factors, chemical constitution of the plant residues is also an important factor in controlling the pattern of residue transformation into CO_2, microbial biomass and stable organic matter fractions. Haider et al., (1974) reported that easily degradable carbonaceous materials are rapidly oxidized while more resistant lignified materials are metabolized slowly but make heavy contribution to stable organic matter component. Similarly synthesis of microbial biomass have also been found to depend mainly on the chemistry of plant residues (Kassim et al., 1981).

The object of the present experiment was to study the transformation of plant residues in soil under different salinity, temperature and moisture regimes. Leptocholoa fusca L. Kunth. and Sesbania aculeata Pers. were used as test materials.

MATERIALS AND METHODS

Surface soils (0-15 cm) used in the study were

*Soil Biology Division, Nuclear Institute for Agriculture and Biology, Faisalabad

collected from Faisalabad district. The soils were air-dried, passed through a 2mm sieve and analysed for their chemical characteristics by methods described in USDA Handbook No. 60 (USDA, (1954). Textural analysis was made by Buyoucos method (Boyoucos, 1961). Organic C in soil and different soil fractions was determined by colorimetric method (Malik and Haider, 1977) and N by micro-Kjeldahl method (Bremner, 1965).

One hundred gram portions of the soils amended with 1% powdered plant material of L. fusca or S. aculeata were incubated in triplicate in plastic bottles for 8 weeks at 25, 30, and 35°C and moisture content equal to −1 and −1/3 bars. At the end of incubation period, soils were analysed for the distribution of C in different organic matter fractions (Malik et al., 1979), microbial biomass (Jenkinson and Powlson, 1976), total N (Bremner, 1965) and inorganic N (Bremner and Keeney, 1965).

The data were subjected to analysis of variance and a least significant difference (LSD) test (Steel and Torrie, 1960).

RESULTS

Table-1 presents the physico-chemical characteristics of soils. All the soils were clay loam in texture and had a C/N ratio of about 10. L. fusca had 42.0% C and 1.07% N whereas S. aculeata had 39.0% C and 4.01% N yielding C/N ratios of 39.25 and 9.73 respectively. Addition of S. aculeata had non-significant effect on ultimate C/N ratio of the soil.

Table-2 gives the results of CO_2−C lost from L. fusca and S. aculeata after 8 weeks of soil incubation under different conditions. Decomposition of S. aculeata was significantly more compared to L. fusca under all the conditions. High salinity and moisture significantly retarded the C mineralization whereas high incubation temperature acclerated the process. Retarding effect of salinity and moisture was more pronounced in L. fusca amendment compared to S. aculeata amendment.

Results of alkali extractable C (humic acid +fulvic acid) are presented in Table 3. Addition of organic matter significantly increased the alkali extractable C and L. fusca amended soil contained significantly more extractable C compared to S. aculeata amended soils under all the conditions. The soils incubated at 25 and 30°C contained more extractable C at −1 bar compared to that at −1/3 bar. Maximum extractable C was found in normal soil and minimum in saline soil.

Table 4 presents the microbial biomass of different soils incubated for 8 weeks under different conditions. Organic amendment significantly increased the microbial biomass in all the treatments. However, more biomass was produced in soils amended with S aculeata. It decreased significantly with increase in salinity and temperature in amended as well as unamended soils.

A net mineralization of N was noted in unamended soils and soils amended with S. acuelata (Table 5). Maximum mineral N was found in normal soil and minimum in saline sodic soil. Soils amended with L. fusca showed an immobilization of N. In general, more mineral N accumulated at high temperature and −1/3 bar. In saline and saline sodic soils amended with S. aculeata, a reduction in mineral N content was observed at −1 bar and higher temperature (30 and 35°C). At −1 bar, mineral N accumulation was minimum in all the treatments.

Table 6 shows N balance at the end of incubation period. Depending upon the incubation conditions, different amounts of N were lost from the soil system. Significantly higher losses were observed in soil amended with S. aculeata particularly at temperature and moisture. Losses were maximum in saline sodic soil.

DISCUSSION

Ecological conditions in soil and the chemical

TABLE – 1

PHYSICO-CHEMICAL* ANALYSIS OF SOILS

Pakistan J. Soil Sc. 1(3) 1-80 (1985)

Soil	Texture	Saturation percentage (SP)	Electrical conductivity $mScm^{-1}$	pH	CO_3 +HCO_3	Cl	Na	Ca+Mg	K	SAR	ESP
					me/l						
Normal	Clay loam	34	1.8	7.9	6.6	6.0	12.0	26.0	1.2	3.33	3.52
Saline	Clay loam	30	6.8	8.4	4.3	13.2	28.7	24.3	1.0	8.22	6.80
Saline-sodic	Clay loam	30	12.3	8.6	4.6	25.9	52.3	20.6	3.4	16.29	18.55

SAR = Sodium adsorption ratio

ESP = Exchangable sodium percentage

* Chemical analysis based on saturation extract

TABLE – 2

EFFECT OF SALINITY, MOISTURE AND TEMPERATURE ON THE LOSS OF C FROM S. ACULEATA AND L. FUSCA DURING 8 WEEKS OF INCUBATION IN SOIL.

Soil	Temp. °C	% C lost*			
		S. aculeata		L. fusca	
		A	B	A	B
Normal	25	63.33	55.13	57.62	45.71
	30	67.69	59.49	60.71	47.62
	35	68.72	60.26	63.10	48.10
Saline	25	55.64	46.92	54.76	41.19
	30	62.31	57.69	58.33	48.33
	35	62.82	60.26	61.90	48.81
Saline-sodic	25	51.28	43.08	46.43	32.86
	30	54.87	49.74	51.67	41.19
	35	58.97	52.31	54.76	43.57

LSD (P = 0.05) 2.56

A = – 1/3 bar

B = –1 bar

* C added as L. fusca or S. aculeata – (residual C in amended soil – residual C in unamended soil / C added as L. fusca or S. aculeata) x 100

TABLE – 3

ALKALI EXTRACTABLE C IN SOILS AFTER 8 WEEKS OF INCUBATION AT DIFFERENT TEMPERATURE AND MOISTURE REGIMES AND WITH OR WITHOUT AMENDMENT.

Soil	Temp. °C	Amendment					
		Nil		S. aculeata		L. fusca	
		A	B	A	B	A	B
		mg g^{-1} soil					
Normal	25	1.00	1.38	1.61	1.43	1.84	1.78
	30	0.93	1.19	1.54	1.34	1.75	1.64
	35	0.91	1.13	1.49	1.34	1.65	1.63
Saline	25	0.69	0.60	1.23	1.16	1.43	1.16
	30	0.67	0.79	1.23	1.03	1.45	1.03
	35	0.66	0.81	1.17	1.03	1.36	1.03
Saline-sodic	25	0.79	0.95	1.38	1.20	1.68	1.58
	30	0.73	0.86	1.32	1.01	1.58	1.36
	35	0.68	0.83	1.20	1.03	1.52	1.30

LSD (P = 0.05) 0.08

A = −1/3 bar

B = −1 bar

MICROBIA BIOMASS OF SOILS INCUBATED AT 25, 30 OR 35 °C FOR 8 WEEKS WITH OR WITHOUT ORGANIC AMENDMENT

Temp. °C	Soil	Amendment		
		Nil	S. aculeata	L. fusca
		mg 100 g^{-1} soil		
25	Normal	27.75	42.57	37.93
	Saline	17.57	40.15	32.37
	Saline-sodic	16.84	27.93	28.68
30	Normal	25.97	30.53	24.97
	Saline	16.84	28.28	21.28
	Saline-sodic	15.73	24.97	21.26
35	Normal	18.85	28.68	25.00
	Saline	14.26	29.62	15.73
	Saline-sodic	14.26	25.00	16.64

LSD (P = 0.05) 2.18

TABLE –5

MINERAL N (NH_4 + NO_3) CONTENT OF SOILS AFTER 8 WEEKS OF INCUBATION AT DIFFERENT TEMPERATURE AND MOISTURE REGIMES AND WITH OR WITHOUT ORGANIC AMENDMENT

Soil	Temp. °C	Amendment: Nil A	Nil B	S. aculeata A	S. aculeata B	L. fusca A	L. fusca B
		ug N g^{-1} soil					
Normal	25	45.5	18.4	280.6	163.5	11.7	Tr
	30	67.2	29.4	318.6	187.9	19.6	Tr
	35	75.1	23.9	343.7	199.0	16.2	Tr
Saline	25	45.5	8.2	274.1	130.0	10.4	Tr
	30	67.2	14.8	284.3	110.2	23.3	Tr
	35	75.1	16.6	305.3	113.3	16.0	Tr
Saline-sodic	25	52.2	12.4	251.4	108.6	9.3	13.3
	30	61.5	12.5	255.5	96.0	34.2	11.8
	35	60.1	10.9	264.2	92.5	33.2	7.6
LSD (P = 0.05)		7.6					

Tr = Traces

A = –1/3 bar

B = –1 bar

TABLE – 6

NITROGEN BALANCE* OF DIFFERENT SOILS INCUBATED FOR 8 WEEKS AT VARIOUS MOISTURE AND TEMPERATURE REGIMES AND WITH OR WITHOUT AMENDMENT

Soil	Temp. °C	Amendment					
		Nil		S. aculeata		L. fusca	
		A	B	A	B	A	B
		μg N g^{-1} soil					
Normal	25	–6.0	–16.3	–15.0	–45.0	–16.0	–19.8
	30	+8.8	–15.7	–2.0	–60.9	–19.1	–25.3
	35	+5.1	–20.7	–28.7	–56.6	–14.9	–26.3
Saline	25	–3.2	–18.4	–13.7	–85.6	–12.0	–12.4
	30	–0.4	–25.3	–18.1	–98.0	–11.2	–27.0
	35	–17.2	–31.1	–19.6	–99.7	–10.0	–36.4
Saline-sodic	25	–11.7	–29.7	–33.9	–102.4	Nil	–14.0
	30	–13.7	–32.5	–27.7	–126.1	–4.2	–36.3
	35	–13.2	–26.7	–38.3	–125.9	–10.7	–40.0
LSD (P = 0.05) 4.9							

* Total N after incubation minus that before incubation

A = –1/3 bar

B = –1 bar

make up of the plant residues are important factors which control the speed and pattern of C and N transformation of plant residues. Present investigations have revealed that salinity of soil and high moisture content retard the process of C and N mineralization and synthesis of microbial biomass. Retarding or inhibitory effects of salinity and high moisture are very well documented in the literature (Johnson and Guenzi, 1963; Agarwal et al., 1971; Laura, 1974; Malik and Haider, 1977; Malik and Azam, 1979; Malik et al., 1979). Present study revealed that intensity of these effects vary with the nature of plant residues. Retarding effect of salinity and moisture on C mineralization were more pronounced in L. fusca amended soils than S. aculeata amended soils. This could be explained on the basis of differential response of the microflora involved in the decomposition of the two materials towards high salinity and moisture. In a previous study (Malik and Azam, 1979), it was noticed that S. aculeata amended soils had Aspergillus species as dominant fungi whereas in L. fusca amended soils many speices of dematiaceous fungi were found. Some unpublished results indicated that these two fungal groups differ widely in their salt tolerance.

As commonly observed (Laura, 1974; Gandhi and Paliwal, 1976), mineral N accumulated in unamended soils during 8 weeks of incubation, although its quantity differed with incubation conditions. L. fusca, with a wide C/N ratio resulted in a net immobilization of N upon incubation in soil. Accumulation of small quantities of mineral N after 8 weeks −1/3 bar, however, indicated the start of remineralization. At −1/3 bar, a persistant immobilization was observed in normal and saline soil amended with L. fusca. In saline-sodic soil, however, immobilization of N was apparantly incomplete.

S. aculeata, having high N content and thus a narrow C/N ratio, served as suitable material to study the effect of different ecological parameters on mineralization of organic N. The study showed that at −1/3 bar, N mineralization was retarded with increase in salinity but accelerated at high temperature. Similar results have been obtained by other workers also (Johnson and Guenzi, 1963; Sandhu and Cornfield, 1967; Singh et al., 1969; Agarwal et al., 1971; Laura, 1974, 1977; Westerman and Tucker; 1974; Heilman, 1975; Gandhi and Paliwal, 1976). In this study, however, complete inhibition was not observed. At −1 bar, N mineralization was highly retarded. In saline and saline sodic soil, however, it was observed that mineral N decreased at high temperatures. Results in Table-6 indicated that this was in fact not a reduced mineralization. Instead, considerably more mineral N was lost at these temperatures.

Microbial biomass (Table-4) was found to be more in S. aculeata amended soils under all the conditions. This may be attributed to the composition of microbial biomass. Aspergillus species (hyaline fungi), involved in the decomposition of S. aculeata, are themselves rapidly decomposed during incubation subsequent to fumigation treatment. Dematiaceous fungi on the other hand are least decomposable. This difference in decomposition has been reported by Martin et al., (1959), Mayaudon and Simonart (1963), Hurst and Wagner (1968). Microbial biomass was invariably less in soils incubated at high temperature with or without amendment. It seems that already after 8 weeks, degradation of microbial biomass had started at higher temperature because of exhaustion of easily available energy and C source.

L. fusca contributed more to alkali extractable organic matter fractions than S. aculeata (Table-1) because of its relatively high lignin content. Lignins have been shown to be the main raw material for the synthesis of humic compounds (Haider et al., 1977). In a tracer study it was found that lignins were directly added to humic acid. Haider et al., (1974) also found a differential stabilization of different plant components. In addition to the differences in lignin content, the fungi involved in the decomposition of the two materials may also be responsible for this difference. In a study (unpublished) it was

found that mycelium of dematiaceous fungi isolated from L. fusca amended soils contributed heavily to humic acid component while Aspergillus species (isolated from S. aculeata amended soils) made a negligible contribution to this fraction. Similar observations have been recorded by Hurst and Wagner (1969).

In general, extractable C was more at low temperature. This may be due to the extractability of undecomposed plant material which may be more at lower temperature as a result of lesser decomposition. Another possibility is that humic compounds may be in a more active state at high temperature resulting in a regular synthesis and degradation, the latter process apparently being more rapid. Malik (1978) pointed out such phenomenon in arid region soils. More extractable C in unamended soils at −1 bar, compared to that at −1/3 bar, may be due to same reason. In amended soils, however, less C was extractable at −1 bar. This may be due to more humification of plant material at −1/3 bar, and a rapid turnover and humification of microbial material. At −1 bar, however, more of the plant residue C may be in microbial biomass from where it is not easily extractable.

Results of the present study, in addition to confirming earlier reports by other workers, also point out the role of soil fungi in a differential transformation of different plant residues in soils incubated under different conditions. Studies on the composition of soil microflora, therefore, seem to be essential for a better understanding of organic matter dynamics in soils.

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