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Comparative efficacy of Lantana, Sesbania and crop residues as nutrient source under submerged field conditions

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ABSTRACT

Lantana is an obnoxious weed in the pastures and forest land. The prospect of utilizing its huge biomass as an organic source of nutrient compared to Sesbania, wheat straw, mustard straw and chickpea straw was studied under submerged field conditions. These were chopped, taken in nylon mesh bags and then placed (0-10 cm) in a puddled field. One set of bags was dipped in butachlor solution (3000 ug/ml) prior to its placement in field. Three replicates of each treatment were taken out periodically and analysed for NPK and S content. The butachlor showed no effect on dry matter decomposition rate. The decomposition half-life of Lantana (26 d) was lower than that of wheat (45 d), mustard (41 d) and chickpea (34 d) straws and similar to Sesbania (26 d). Lantana was also superior to wheat, mustard and chickpea straws, and comparable to Sesbania in terms of NPS mineralization.

Key words: Lantana, Weed utilization, Decomposition, Mineralization

Soil organic matter is vital for a healthy, living and productive soil that will sustain plant, crops and animal production. The amount of organic matter present in the soil depends on additions and decomposition. The Indian soils are traditionally poor in soil organic carbon content. The general practice of intensive cropping with imbalanced fertilizer use by the Indian farmers may further decrease it, as evidenced by the data from the long-term fertility experiments (Swarup 1998). The long-term fertility data also showed the better productivity and higher soil organic carbon content when the soil received both organic and inorganic than the inorganic sources of nutrient alone. Lantana is one of the most obnoxious weeds, grows vigorously and threatening the biodiversity and ecological balance of forest and grazing lands, and also causing environmental problem along the roadsides and railway tracks in India. The gigantic growth of this weed could well be turned into an opportunity if it could be used as a green manure source in Indian agriculture. This would also indirectly help in controlling this weed.

Butachlor is most widely used rice herbicide and its consumption is highest among all the herbicides that are sold in India (Pesticide Association of India 2003). Concerns are generally raised about the impact of herbicides on wider agro-ecosystem (Zwieten 2004). Reports are available to indicate the toxic impacts of herbicides on cellulolytic microorganisms and cellulose degradation in soil (Smith and Mayfield 1977, Grossbard and Wingfield 1978). The effect of butachlor on total soil microbial population was studied by various workers (Mukhopadhyay 1980, Mandal *et al*. 1987, Raut *et al*. 1997, Shukla 1997, Shukla and Mishra 1997), but hardly any information is available about its effect on decomposition of crop residues and green manures in soil. An experiment was conducted to study (i) the decomposition rate of Lantana, Sesbania, wheat straw, mustard straw and chickpea straw in soil in presence and absence of butachlor, and (ii) the mineralization pattern of C, N, P, S and K from Lantana, Sesbania, wheat straw, mustard straw and chickpea straw.

MATERIALS AND METHODS

The experiment was conducted during *kharif, 2004* at National Research Centre for Weed Science (India) farm by following the nylon mesh bag technique (Schinner 1995). The soil was a black sandy clay loam (Vertisol) with pH 7.25, EC 0.38 dS/m, organic carbon 7.5 g/kg, available P 14 mg/kg and available K 180 mg/kg. Wheat straw, Chickpea straw, Mustard straw, green biomass of *Lantana camara* and 60 day old *Sesbania aculeata* were chopped into smaller pieces of 2-3 cm sizes and taken into the nylon mesh (1 x 1 mm) bags (20 cm X 30 cm) @ 30 g dry matter/bag. One set of these filled bags was placed as such in a puddled field at 0-10 cm depth in slanting position; and another set was dipped in the butachlor solution of 3000 ug a.i./ml concentration for 1h and then placed in the field similarly. The bag dimension permitted the plant materials to be spread in a thin layer within the bag, thereby ensuring close contact between the organic residues and soil. The field was kept submerged (5-7 cm) through out the period of study (60 days). The content of C, N, P, S and K of the plant materials used in the study are given in table 1. Four bags of each treatment combination were pulled out of the soil at a time laps of 15, 30, 45 and 60 days. The bags were washed properly under running water to remove adhered soil particles, with utmost care to prevent physical loss of residues from the bags, and dried in oven at 65^{0}C. The dry matter was then removed from the bag, weighed, ground and analysed for C, N, P, S and K content.

Table 1. C, N, P, S and K content of residues before and after decomposition period (60 d).

Element	Wheat straw		Mustard straw		Chickpea straw		Lantana		Sesbania	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Carbon (%)	47.0	28.8	46.0	31.9	43.7	31.0	46.6	35.0	45.4	38.6
Nitrogen (%)	0.54	0.70	0.64	0.94	0.74	0.99	2.33	3.11	2.58	2.76
Phosphorus (%)	0.11	0.16	0.09	0.13	0.11	0.14	0.25	0.53	0.15	0.20
Sulphur (%)	0.13	0.18	0.16	0.27	0.12	0.16	0.21	0.45	0.30	0.40
Potassium (%)	1.42	0.26	0.39	0.23	1.58	0.24	0.68	0.25	0.58	0.18
C:N	87.0	40.1	71.8	34.1	59.0	31.2	20.0	11.2	17.6	14.0
C:P	427	186	511	242	397	230	186	66	297	197
C:S	362	130	288	118	352	200	222	78	150	92

The amount of dry matter, carbon, nitrogen, phosphorus, sulphur and potassium decreased from initial amount taken in the nylon mesh bags were considered as the measure of decomposition, and mineralization of C, N, P, S and K, respectively. The decomposition data was fitted to the first order kinetics (eq. 1) to calculate the half life (eq. 2) of decomposing materials.

$$\ln (M_o/M_t) = ä\, t \quad .... (1)$$

where, M_o is the initial mass (g) of the decomposing material, M_t is the mass remained at time t (day) and ä is a rate constant (per day).

$$\text{Half life } (t_{1/2}) = \ln 2 / ä \quad .... (2)$$

The amount of nutrient element mineralized from the decomposing material at time t was calculated as:

$$\text{Mineralization (mg/kg dry matter)} = (M_o c_o - M_t c_t)/M_o \quad ....(3)$$

$$\%\text{mineralization} = 100(M_o c_o - M_t c_t)/M_o c \quad ...... (4)$$

where, c_o and c_t are the content of the given element (mg/kg dry matter) in the decomposing material at time 0 (initial) and t, respectively.

RESULTS AND DISCUSSION

Decomposition of organic matter

The amount of residues remained in the bags decreased with increase in the burial period, indicating the decomposition of residues in soil. The amount of dry matter remained in the butachlor treated and untreated nylon mesh bags after different period of decomposition of Lantana is depicted in (Fig. 1). Similar trend was also observed for Sesbania, mustard straw and chickpea straw (data not shown). In general, the plant materials decomposed at relatively faster rate during first 15 days and the rate slowed down later. Similar trend of decomposition of crop residues was reported earlier (Gilmour *et al.* 1998, Mishra *et al.* 2001a). The amount of plant materials decomposed at the end of the study are given in table 2. The result showed that the amount of dry matter decomposed during the course of study significantly varied among the materials tested, but there was no significant effect of butachlor on the extent of decomposition. Similar results were also recorded for the other plant materials tested. The quantity of Lantana dry matter decomposed was similar to Sesbania but significantly higher than the crop residues tested. Schroder (1979) observed that the decomposition of pure cellulose, but not of wheat straw, was retarded in soils to which herbicides MCPA and dichlorprop were applied for a number of years. This was attributed to the unfavourable nutrient conditions in case of cellulose decomposition.

At the end of the study (60 d), respectively 74.7, 74.3, 67.0, 60.7 and 56.3% of Sesbania, Lantana, chickpea straw, mustard straw and wheat straw placed in the nylon mesh bag was decomposed. The extent of wheat straw decomposition as recorded in the given study is comparable to the data from a field study reported earlier by Mishra *et al.* (2001a).

Table 2. Decomposition and C mineralization of butachlor treated and untreated plant materials.

Materials	Dry matter decomposed (g/bag)			Carbon mineralization (%)		
	Control	Butachlor	Mean	Control	Butachlor	Mean
Wheat	16.9	17.0	16.9	73.5	73.0	73.3
Mustard	18.2	18.2	18.2	72.8	72.7	72.7
Gram	20.2	20.1	20.1	76.6	76.6	76.6
Lantana	22.3	22.4	22.3	80.6	80.9	80.7
Sesbania	22.2	22.6	22.4	78.1	78.9	78.5
Mean	19.9	20		76.3	76.4	
LSD (0.05)	Straw 1.2; Herbicide NS			Straw 3.6; Herbicide NS		

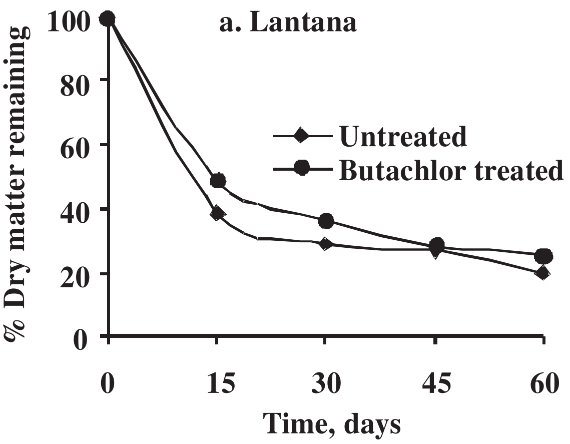

Fig. 1. Effect of butachlor on degradation of *Lantana* in soil.

The decomposition data showed satisfactory fit to the first order kinetics with the R^2 values of 0.9425, 0.9454, 0.9566, 0.8564 and 0.8533 for wheat straw, mustard straw, chickpea straw, Lantana and Sesbania, respectively. The decay rate constant (K) as calculated from the first order equation was 0.0154, 0.017, 0.0203, 0.0265 and 0.0265 per day, and the half life ($t_{1/2}$) was 45, 41, 34, 26 and 26 days for the respective plant materials. This indicated that the rate of decomposition of Lantana was similar to Sesbania and much faster than the given crop residues. The relatively narrow C:N, C:P and C:S ratios of Sesbania and Lantana (Table 1) could have favoured their faster decomposition than the given crop residues. The data thus indicated that incorporation of Lantana biomass holds promise for improving the soil fertility.

C, N, P, S and K content

The mean C content of the wheat straw decreased from an initial value of 47% to 28.8% at 60 d (Table 1). Similarly, C content decreased by 14.1, 12.7, 11.6 and 6.8% from the corresponding initial levels in mustard straw, chickpea straw, Lantana and Sesbania, respectively. Unlike C content, there was an increasing trend in the N, P and S content of the tested materials during decomposition period. After 60 days of decomposition, N content increased to 1.30, 1.47, 1.34, 1.33 and 1.07; P content increased to 1.45, 1.44, 1.27, 2.12 and 1.33; and S content increased to 1.38, 1.69, 1.33, 2.14 and 1.33 times of their corresponding initial levels in wheat straw, mustard straw, chickpea straw, Lantana and Sesbania, respectively. An increase in N content of wheat straw during its decomposition was observed by various workers (Christensen 1985, Mishra *et al.* 2001a). Similarly, an increase in P content of rice straw after its application in soil was reported by various workers (Fores *et al*. 1988, Tian *et al*. 1992, Mishra *et al*. 2001b). The K content, however, decreased as the decomposition of the residues progressed. As this element is not bound in any organic compound (Mengal and Kirby 1987), unlike N, P and S, its release does not require involvement of microorganisms.

Mineralization of C, N, P, S and K

The total C mineralization from the butachlor treated and untreated materials are given in table 2. Similar to the decomposition of total dry mater, C mineralization significantly varied among the materials but was not affected by butachlor treatyment. Similarly the mineralization of N, P, S and K from the plant residues at different period of decomposition was not affected by butachlor treatment (data not shown). The result thus indicated that the decomposition and subsequent release of plant nutrients was not affected by butachlor. Overall, 42.3-72.9% of N, 37.4-65.8% P, 33.0-66.6% of S and 77.1-94.9 % of K of the tested materials was released during the decomposition process. Similar result in respect of N and P mineralization from wheat residue was reported by Mishra *et al.* (2001a).

C mineralization accounted for 61.1% of the weight loss of wheat straw and it was highest among the plant materials tested. The contribution of C mineralization towards total weight loss of mustard straw, Lantana, chickpea straw and Sesbania was respectively 55.2, 50.6, 50.0, and 47.7%. This showed that C mineralization accounted for about half of weight loss of the plant materials in the given experimental conditions. Similar observation was reported by Mishra *et al*. (2001a) in respect to the wheat straw decomposition. The loss of other elements associated with C, *viz*. oxygen and hydrogen, and loss of soluble components such as potassium, chlorides and certain organic substances produced as intermediate products during decomposition, could have accounted for the remaining loss in total weight.

Throughout the decomposition period, the percent mineralization of total initial N was significantly higher in case of Lantana than the crop residues tested (Fig. 2). Respectively 43.6, 42.3, 55.9, 65.8 and 72.9% of the total initial N of wheat straw, mustard straw, chickpea straw, Lantana and Sesbania was mineralized by the end of study. This indicated that the N present in Lantana is more easily mineralizable than the N present in the tested crop residues. The quantity of N mineralized was highest from Sesbania followed by Lantana, chickpea straw, mustard straw and wheat straw. The data showed that although Lantana was inferior to *Sesbania* but it was a much better organic N source than the crop residues tested (Table 3).

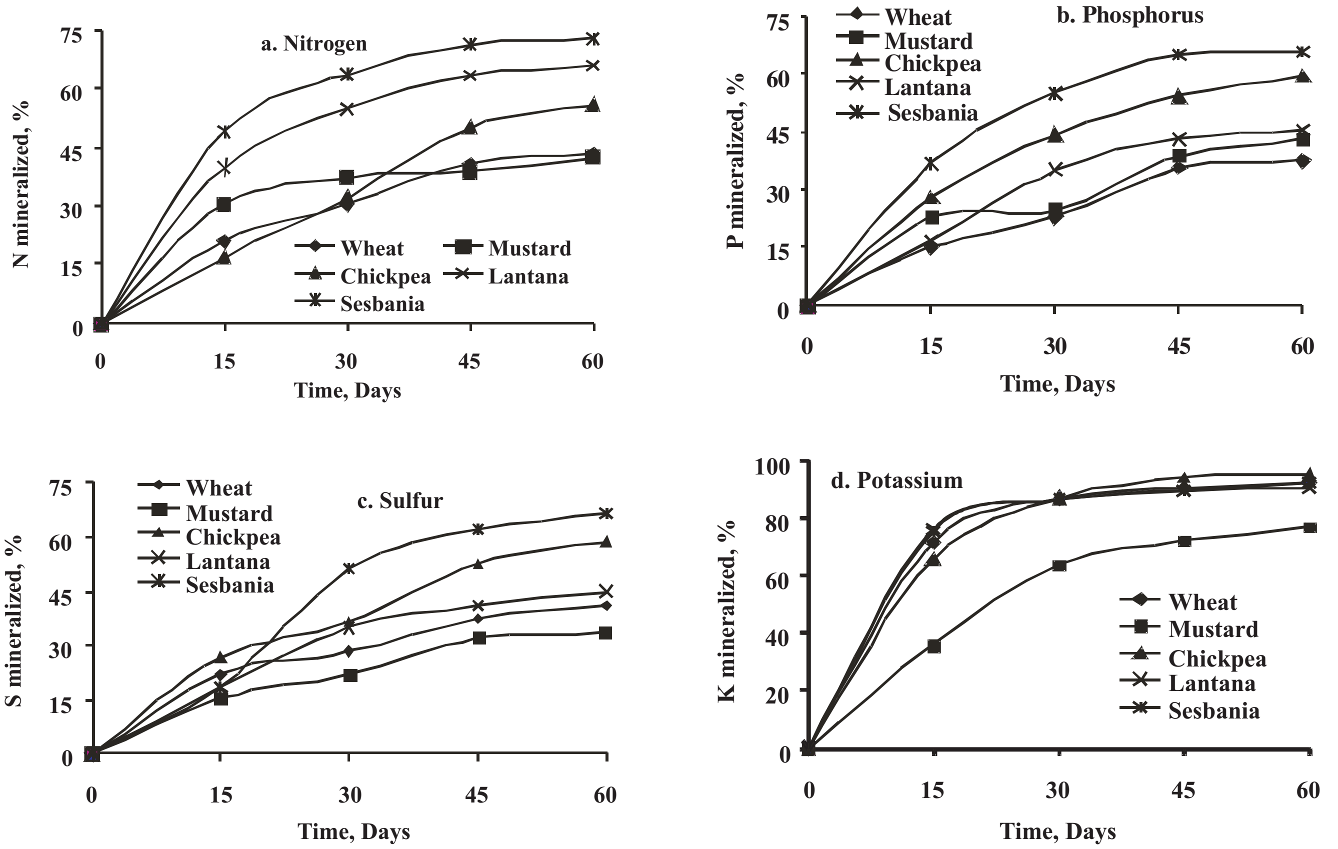

Fig. 2. Mineralization of initial a. nitrogen, b. phosphorus, c. sulfur and d. potassium of the plant materials after different period of decomposition.

Among the materials tested, the percent mineralization of initial P was highest in case of Sesbania (Fig. 2). By the end of study the mineralization of total initial P of wheat straw, mustard straw, chickpea straw, *Lantana* and Sesbania was respectively 37.4, 43.1, 59.6, 45.3 and 65.8%. Although percentage of initial P released from *Lantana* during the course of its decomposition was lower than that of *Sesbania* and chickpea straw the actual quantity of P released from Lantana was highest among all the plant materials tested (Table 3), due to its higher initial P content compared to other organic sources.

Table 3. The amount of N, P, S and K released from the tested materials (g/kg) during 60 days of decomposition.

Materials	N	P	S	K
Wheat	2.4	0.41	0.51	13.1
Mustard	2.7	0.39	0.53	3.0
Gram	4.1	0.66	0.66	15.0
Lantana	15.3	1.13	0.94	6.2
Sesbania	18.8	0.99	2.00	5.4
LSD (0.05)	0.5	0.09	0.09	0.1

Similarly, the percent mineralization of initial S from Lantana was lower compared to Sesbania and chickpea straw, but was higher compared to wheat straw and mustard straw (Fig. 2). The highest amount of S was mineralized during the decomposition period from Sesbania followed by Lantana, chickpea straw, mustard straw and wheat straw (Table 3). Similar to N, Lantana was inferior to Sesbania but superior to the crop residues tested in terms of S mineralization.

During the decomposition period more than 90% K was released from wheat straw, chickpea straw, Lantana and Sesbania (Fig. 2). The percent release of K was lowest in case of mustard straw. The quantity of K released was highest from chickpea straw followed by wheat straw, Lantana, Sesbania and mustard straw (T able 3). Christensen (1985) reported that as much as 90 per cent of K from the barley straw was lost through leaching. Tian *et al.* (1992) reported that most of K in the rice residue was released in less than 41 days. Mishra et al. (2001b) also reported that as much as 79 percent of K was released from the rice straw applied to a wheat field with in five weeks.

The C:N, C:P and C:S ratios of all the plant materials considerably narrowed down during the decomposition process (Table 1). However, the C:N ratio of wheat straw, mustard straw and chickpea straw in the nylon mesh bag remained greater than the desired value of 30 even at 60 days decomposition. On the basis of the initial C:N, C:P and C:S ratios and the N, P and S mineralization data it could be said that the Lantana is a better organic source of these plant nutrients than the crop residues.

The results of the present investigation suggest that the application of butachlor did not hinder the decomposition of organic amendment in field condition. Sesbania and Lantana were more easily degradable than the wheat straw, mustard straw and chickpea straw. The results also indicated that Lantana is superior to wheat straw, mustard straw and chickpea straw as an organic source of N, P and S. It is also comparable to Sesbania as an N, P and K source. In the recent years, recycling of crop residues is widely advocated in view of the declining organic C and nutrient reserves in soil. However, in India most of the crop residues are used as cattle feed and as a consequence in many a time it becomes impractical to the farmers to recycle the crop residues. In many parts of India, due to tremendous shortage to water during the summer months, it is virtually impossible for farmers to grow Sesbania as a green manure crop. Lantana grows vigorously in wastelands and is not eaten by cattle. Thus, the use Lantana biomass as a nutrient source could be a more practical and economical substitute to crop residues as well as to Sesbania in such situations.

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