

# Biochemical changes during composting of kallar grass (*Leptochloa fusca* L. Kunth)

T. Mahmood, F. Azam & K. A. Malik\*

Nuclear Institute for Agriculture & Biology, Faisalabad, Pakistan

Received 3 January 1986; revised and accepted 30 March 1987

## Introduction

A large area in Pakistan is barren because of salinity. Methods generally recommended for reclamation of such soils are costly and therefore unattractive to farmers. A recent approach is to use these lands to cultivate salt-tolerant plants. Kallar grass (*Leptochloa fusca* L. Kunth), a highly salt-tolerant grass, is proposed as the primary colonizer in a plant succession scheme for the economic use of salt-affected lands (Sandhu & Malik 1975). The grass is widely cultivated on saline and saline-sodic soils in Pakistan and is well known to ameliorate such soils (Hussain & Hussain 1970). The grass can yield up to 40 tons biomass/ha/year.

An excellent way to use surplus agricultural residues is by converting them into compost which can then be employed as an organic fertilizer and soil conditioner (Hileman 1980). Kallar grass can serve as an ideal raw material for composting because of its relatively high lignin content which helps in better humus formation. The present study was carried out to follow the biochemical changes during composting of kallar grass and to devise criteria which can be adopted for determining compost stability.

## Materials and methods

Kallar grass was obtained from the Bio-Saline Research Substation of the Nuclear Institute for Agriculture and Biology (NIAB) at Lahore. It contained 4.6% water-soluble sugars, 10.0% hemicellulose, 37.0% cellulose, 23.06% lignin, 55.0% C, 0.9% N, 0.2% P, 0.5% K and 8.8% ash. Air-dried grass (35 kg) was chopped into 2 to 3 cm pieces, moistened to 60% and loosely filled in field pits (1.0 m<sup>3</sup>, interior lined with polyethylene sheets). For sampling purposes, 12 nylon net bags (60 mesh) each containing 200 g of the moist material were buried in each pit. Capillary-type dial thermometers, with sensors placed centrally in the material, were used to record the temperature. The openings of the pits were covered with 5-cm thick thermopore

\* To whom correspondence should be addressed at Soil Biology Division, NIAB, P O Box 128, Faisalabad, PAKISTAN.

sheets for insulation. The material was turned on the 2nd, 6th and 11th week and water was added to adjust the moisture content.

Sample bags were removed at weekly intervals for chemical analyses on air-dried material, ground to pass a 1-mm sieve. Water-soluble sugars, hemicellulose and cellulose contents were determined by an anthrone colorimetric method (Shirlaw 1969). The Tappi Standard method T<sub>13m</sub>-OS-54 (Anon. 1975) was employed to separate acid-hydrolysable carbon (AHC) and lignin-humus complex (LHC). The carbon content of the acid hydrolysate and compost was determined by an acid dichromate method (Torok & Csonkareti 1963) and the humic acid (HA) and fulvic acid (FA) contents were estimated as described by Malik *et al.* (1979). For cation-exchange capacity (CEC), a simplified method of Harada & Inoko (1980) was used and total N was determined by a micro-Kjeldahl method (Bremner & Mulvaney 1982).

A biological test based on carbon availability to soil microbes was performed to assess the stability of compost at different stages. A stable compost decomposes slowly in soil and evolves a lesser amount of CO<sub>2</sub> than an unstable compost (Poincelot 1972). This test was carried out by estimating cumulative CO<sub>2</sub>-C evolution from compost samples mixed with garden soil and incubated at 30 °C for one week. Portions of moist compost (5 g dry wt) in 250-ml Erlenmeyer flasks were mixed, each with an equal amount of fresh garden soil and connected to a manifold system for continuous aeration with CO<sub>2</sub>-free moist air. The effluent stream from each flask was conducted through a known quantity of 2.5M NaOH and the absorbed CO<sub>2</sub>-C was estimated titrimetrically at selected time intervals (Anderson 1982). Portions of the soil without compost treatment were incubated to serve as control. The CO<sub>2</sub>-C evolved from control was subtracted from that of compost treated soil to give the CO<sub>2</sub>-C evolved from compost.

All analyses were made in triplicate. Correlation and regression among various parameters used to assess the compost stability were performed as described by Steel & Torrie (1960).

## Results and discussion

### *Biochemical changes*

Figure 1 presents the changes in temperature during the composting period. Maximum temperature (69 °C) was achieved after three days followed by a decline to 40 °C after 10 days. After the first turning, a rise in temperature to 60 °C was recorded. The temperature remained at the thermophilic stage for four weeks and declined to ambient after six weeks. Further turning and moistening had no effect on the temperature profile, indicating that the compost had achieved stability (Poincelot 1972).

The rate of decomposition was very rapid during the first six weeks causing up to 32% weight loss (Fig. 2). Subsequent decomposition was slow resulting in a further loss of 4%. Malik & Sandhu (1973) reported a similar trend during the composting of kallar grass. The total nitrogen content of the composted material increased from 0.9% to 1.5% after twelve weeks and as a result, the C/N ratio decreased from 62 to 29. The total ash content almost doubled in the first six weeks followed by only a slow increase during the subsequent period (Fig. 2).

Figure 3 gives the changes in contents of carbohydrates and lignin humus complex.

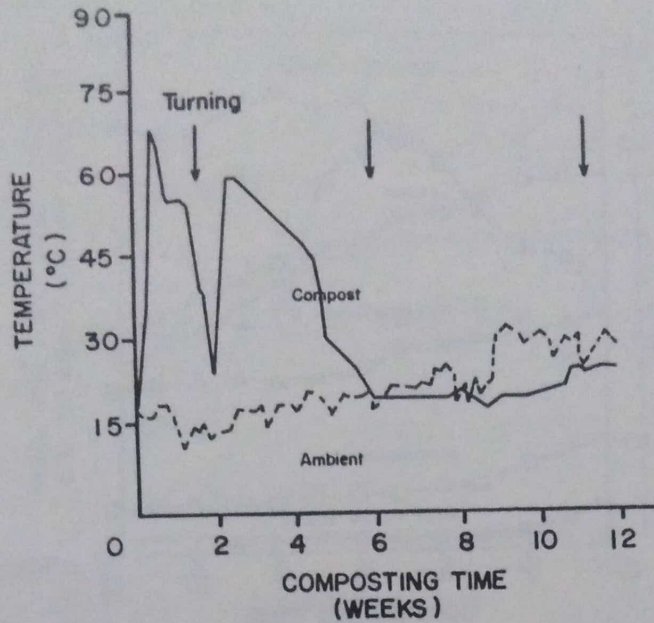


Fig. 1 Temperature fluctuations during composting of kallar grass.

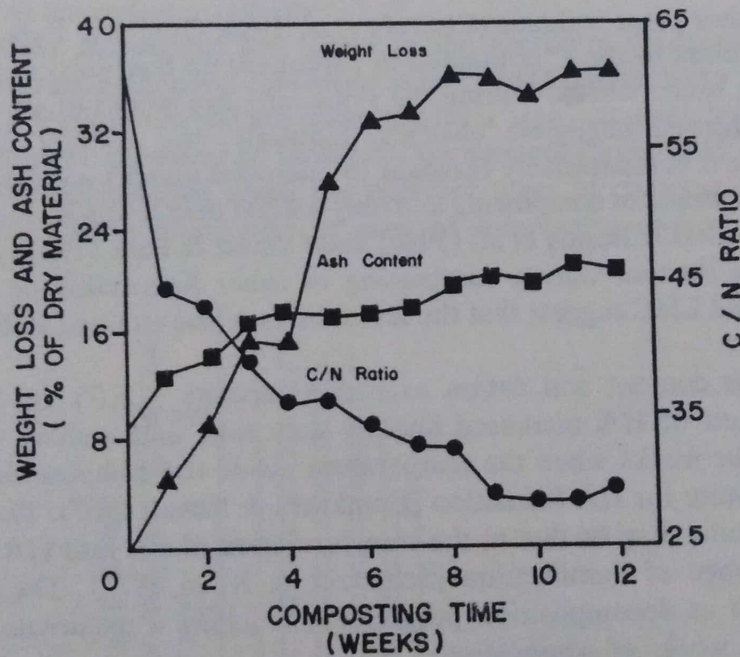


Fig. 2 Weight loss, ash content and C/N ratio of kallar grass during composting.

All the water-soluble materials were utilized within nine weeks whereas 45% of the hemicellulose was consumed in the first three weeks. Hemicellulose decomposition during the later stage was slow. Cellulose was not attacked during the first two weeks, but later, it was steadily utilized resulting in a net loss of about 45%. Similar changes in water solubles, hemicellulose and cellulose components have been reported during

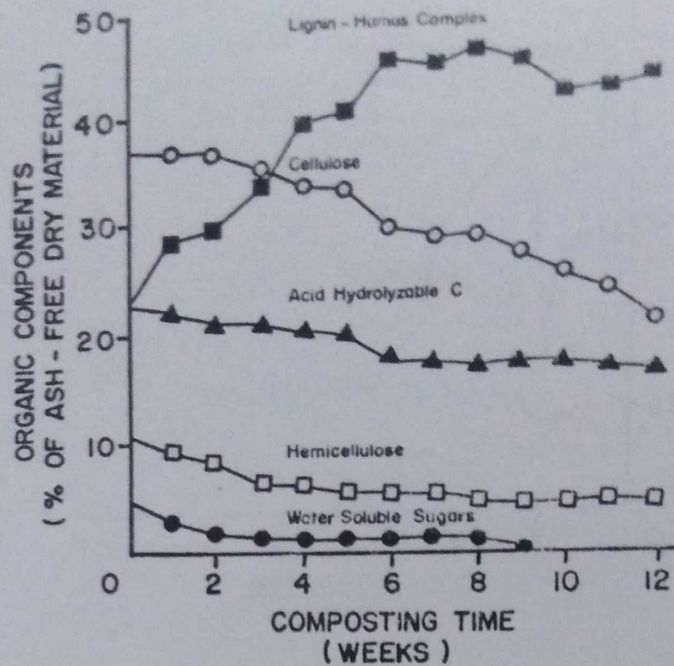


Fig. 3 Changes in major organic components during composting of kallar grass.

composting of other plant residues (Elserafy *et al.* 1980; Gomez & Park 1983). AHC content (which refers to the C contained in carbohydrate fractions) decreased from 22.9 to 17.5% in seven weeks. During the remaining five weeks of composting, the AHC content showed negligible changes. Similarly, the amount of LHC (the component which is comparatively resistant to microbial attack) increased from 23.6 to 45.2% after six weeks of composting and only a slight decrease was observed during the subsequent period. Elserafy *et al.* (1980) and Gomez & Park (1983) found similar increase in lignin content during composting of other lignocellulosic wastes. The results of AHC and LHC suggest that the test substrate had attained stability after six weeks.

Data on humus content and cation exchange capacity (CEC) are presented in Fig. 4. The amount of HA increased linearly with time and a sharp increase was observed after four weeks when the temperature inside the compost was 35 °C; the optimum temperature for HA formation (Franklova & Novak 1967). The decrease in FA content with time may be due to the transformation of FA into HA, since this is the normal sequence of humification (Schnitzer & Khan 1972). The CEC of the material increased as decomposition progressed, reaching a maximum of 24 mEq/100 g after twelve weeks of composting.

Results of cumulative  $\text{CO}_2\text{-C}$  evolved from compost samples obtained at different stages of composting are given in Fig. 5. Evolution of  $\text{CO}_2\text{-C}$  decreased with increasing sample age, but compost samples taken after the sixth week showed much less  $\text{CO}_2\text{-C}$  evolution when compared to the samples withdrawn at earlier stages of decomposition. Moreover, 0 to 6-week-old compost continued to evolve  $\text{CO}_2\text{-C}$  whereas in samples taken thereafter, no  $\text{CO}_2\text{-C}$  was recorded after the seventh day of incubation (individual trends not shown). The results of cumulative  $\text{CO}_2\text{-C}$  evolution are in agreement with those observed for AHC, again suggesting that six weeks of composting were enough to obtain a stable compost from kallar grass.

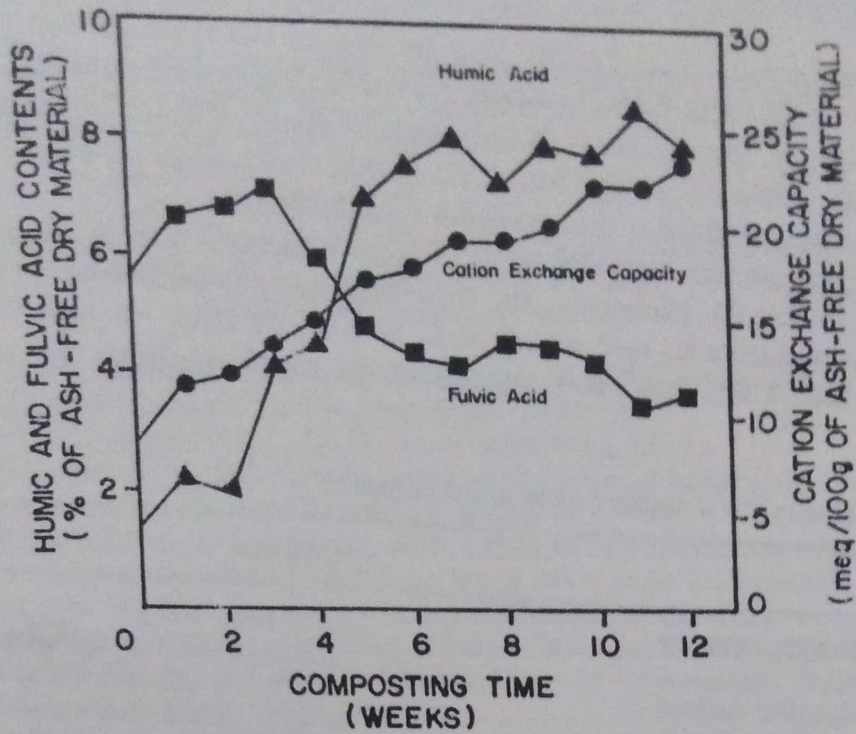


Fig. 4 Changes in humus content and cation-exchange capacity of kallar grass during composting.

#### Assessment of the compost stability

Although many discussions are found in the literature concerning assessment of compost maturity, no general conclusion is reached (Marciszewska 1965; Spohn 1969; Lossin 1971). Various criteria are suggested for a 'ripe' compost, but these are usually based on physical, chemical or biological parameters (Solbraa 1979) and cannot be generalized in quantitative terms for different types of compost. The reasons may partly be due to the differences in aims of composting and/or variable substrate

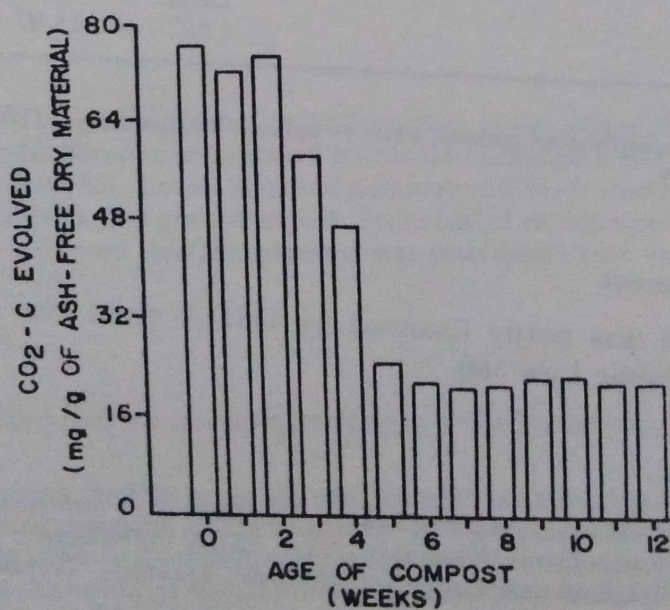


Fig. 5 Cumulative CO<sub>2</sub>-C evolved (in one week) from kallar grass at different stages of composting.

composition. In the present study, one biological ( $\text{CO}_2$ -evolution) and four chemical (CEC, HA, AHC and LHC) parameters were evaluated as indices for determining compost stability. On the basis of sequence of changes in these parameters (Figs 3-5), some criteria could be established for a stable compost prepared from kallar grass or other substrates of similar composition (Table 1).

All the parameters mentioned in Table 1 show a highly significant correlation ( $P < 0.001$ , Table 2). However, the time required for estimation of CEC, HA, AHC, LHC and cumulative  $\text{CO}_2$ -C was 2, 4, 8, 10 h and 1 week, respectively. It is therefore suggested that CEC and HA can serve as rapid methods for assessing compost stability.

**Table 1** Criteria for a stable kallar grass compost

Parameter	Criterion
Cation-exchange capacity	$\geq 20$ meq $100 \text{ g}^{-1}$ ash-free compost
Humic acid	$\geq 8\%$ of ash-free compost
Acid-hydrolysable carbon	$\leq 17\%$ of ash-free compost
Lignin-humus complex	$\geq 45\%$ of ash-free compost
$\text{CO}_2$ -C evolved*	$\leq 22 \text{ mg g}^{-1}$ ash-free compost

\* Cumulative  $\text{CO}_2$ -C evolved in 1 week.

**Table 2** Correlation and regression among various parameters used for assessing the compost stability

Correlation coefficient*	Regression equation†
-0.9162	$\text{CO}_2\text{-C} = 119.01 - 4.68 \text{ CEC}$
-0.9873	$\text{CO}_2\text{-C} = 90.17 - 8.46 \text{ HA}$
-0.9588	$\text{AHC} = 27.34 - 0.51 \text{ CEC}$
-0.8914	$\text{AHC} = 23.44 - 0.80 \text{ HA}$
0.8703	$\text{LHC} = 15.01 + 1.38 \text{ CEC}$
0.9078	$\text{LHC} = 23.97 + 2.41 \text{ HA}$

\*  $P < 0.001$ .

† AHC = Acid-hydrolysable carbon; LHC = lignin-humus complex; HA = humic acid; CEC = cation-exchange capacity.

### Acknowledgement

This research was partly financed by USDA grant No. PK-ARS-195, FG-Pa-369 under U.S. Public Law 480.

### References

- ANDERSON, J. P. E. 1982 Soil respiration. In *Methods of Soil Analysis. Part 2*, ed. Page, A. L. pp. 831-871. Madison, Wisconsin: ASA, SSSA Publishers.
- ANON. 1975 *Standard and Suggested Methods*. Georgia: Technical Association of Pulp and Paper Industries.
- BREMNER, J. M. & MULVANEY, C. S. 1982 Nitrogen-total. In *Methods of Soil Analysis Part 2*, ed. Page, A. L. pp. 595-662. Madison, Wisconsin: ASA, SSSA Publishers.
- ELSERAFFY, Z. M., SOMBOL, H. A. & ELTANTAWY, I. M. 1980 The problem of water hyacinth in

- rivers and canals. I. Production of compost from plant. *Soil Science and Plant Nutrition* **26**, 135-138.
- FRANKLOVA, S. & NOVAK, B. 1967 The effect of different temperatures on the humification of organic matter. In *Studies about Humus*, ed. Novak, B. & Rypacek, V. pp. 175-178. Prague: Czechoslovak Academy of Agriculture.
- GOMEZ, R. J. H. & PARK, Y. K. 1983 Conversion of cane bagasse to compost and its chemical characteristics. *Journal of Fermentation Technology* **61**, 329-332.
- HARADA, Y. & INOKO, A. 1980 The measurement of the cation-exchange capacity of composts for the estimation of the degree of maturity. *Soil Science and Plant Nutrition* **26**, 127-134.
- HILEMAN, L. H. 1980 Composting agricultural residues. *Compost Science/Land Utilization* **21**, 49.
- HUSSAIN, M. & HUSSAIN, A. 1970 Chemical analysis of kallar grass. *Directorate of Land Reclamation Pakistan Research Publications (Lahore)* **11**, (49).
- LOSSIN, R. D. 1971 Compost studies. II. *Compost Science* **12**, 12-13.
- MALIK, K. A. & SANDHU, G. R. 1973 Some studies on the fungi of kallar grass (*Diplachne fusca* (L.) p. Beauv.) compost. *Pakistan Journal of Botany* **5**, 57-63.
- MALIK, K. A., BHATTI, N. A. & KAUSER, F. 1979 Effect of soil salinity on decomposition and humification of organic matter by cellulolytic fungi. *Mycologia* **71**, 811-820.
- MARCIXZEWSKA, S. M. 1965 New method for determination of the maturity of compost based on the determination of carbon dioxide. *Gaz, Woda i Technika Sanitarna* **39**, 57-63.
- POINCELOT, R. P. 1972 *The Biochemistry and Methodology of Composting*. Bulletin 727. 38 pp. Connecticut Agricultural Experiment Station.
- SANDHU, G. R. & MALIK, K. A. 1975 Plant succession — A key to the utilization of soils. *Nucleus* **12**, 35-38.
- SCHNITZER, M. & KHAN, S. U. 1972 *Humic Substances in the Environment*. New York: Marcel Dekker, Inc.
- SHIRLAW, D. W. G. 1969 The characterization of carbohydrates. In *A Practical Course in Agricultural Chemistry*, ed. Shirlaw, D. W. G. pp. 122-130. Oxford: Pergamon Press.
- SOLBRAA, K. 1979 Composting of bark. III. Experiments on a semi-practical scale. *Meddelelser fra Norsk Institutt for Skogforskning* **34**, 387-439.
- SPOHN, E. 1969 How ripe is compost? *Compost Science* **10**, 24-26.
- STEEL, R. G. D. & TORRIE, J. H. 1960 *Principles and Procedures of Statistics*. New York: McGraw-Hill Book Co. Inc.
- TOROK, L. & CSOKKARETI, K. 1963 Determination of carbon in composts by measuring oxygen consumption with a dichromate method. *Agrokemia es Talajtan* **12**, 631-642.

## Summary

Biochemical changes during composting of kallar grass (*Leptochloa fusca* L. Kunth) were studied for twelve weeks. Some criteria based on cation-exchange capacity, acid-hydrolysable carbon, lignin-humus complex, humic acid and cumulative CO<sub>2</sub>-C evolution were established for assessing the stability of kallar grass compost. Sequence of changes in different chemical and biological parameters indicated that the compost was stabilized in six weeks.

## Résumé

*Modifications biochimiques au cours du compostage du kallar-grass (Leptochloa fusca, L. Kunth)*

Les modifications biochimiques au cours du compostage du kallar-grass (*Leptochloa fusca*, L. Kunth) ont été étudiées pendant douze semaines. Plusieurs caractéristiques, comprenant la capacité d'échange de cations, l'hydrolyse acide du carbone, le complexe lignine-humus, les acides humiques et le dégagement de CO<sub>2</sub> ont été établies pour évaluer la stabilité du compost de kallar-grass. La séquence de ces différents paramètres chimiques et biologiques montre que le compost est stable au bout de six semaines.

### Resumen

*Cambios bioquímicos durante el compostaje del kallar (Leptochloa fusca L. Kunth)*  
Se han estudiado los cambios bioquímicos que tienen lugar durante y el compostaje del kallar (*Leptochloa fusca* L. Kunth) durante un periodo de 12 semanas. Se establecen criterios para valorar la estabilidad del compuesto, basados en: la capacidad de intercambio catiónico, el carbono ácido hidrolizable, el complejo ligno-húmico, los ácidos húmicos, y la evolución acumulativa C-CO<sub>2</sub>. La secuencia de cambios en los distintos parámetros químicos y biológicos indican que el compuesto se estabilizó en 6 semanas.