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LARGE SCALE COMPOSTING OF KALLAR GRASS *LEPTOCHLOA FUSCA* (L.) KUNTH

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Abstract

Kallar grass, *Leptochloa fusca* (L.) Kunth was composted on a large scale by windrow (open-pile) method. Changes in temperature, substrate loss, cation-exchange capacity (CEC), carbon (C) and nitrogen (N) contents, and C/N ratio were followed for 150 days. Cation-exchange capacity was evaluated as an index of compost stability and its validity checked by physico-chemical changes during composting and by plant growth test. Composting of kallar grass for 150 days produced a substrate loss of 57%, lowered the C/N ratio from 67 to 17 and increased the CEC from 13 to 47 m eq/100g ash-free dry matter. Balance of N calculated at different stages of composting showed a net increase of 33-38% during 15 to 90 days. Kallar grass composted for 75 days or longer, did not cause reduction in dry-matter yield of wheat. Physico-chemical changes during composting and plant growth test indicated that kallar grass compost was stabilized after 75 days.

Introduction

Kallar grass, *Leptochloa fusca* (L.) Kunth a highly salt-tolerant grass, was proposed as the primary colonizer in a plant succession scheme for economic utilization of salt-affected lands (Sandhu & Malik, 1975). It grows widely on saline and saline-sodic soils in Pakistan and is known to ameliorate such soils (Hussain & Hussain, 1970) giving an yield of upto 22 tons dry matter/ha/yr (Malik *et al.*, 1986). Kallar grass can be used as forage, for pulping and fuel production (Malik *et al.*, 1986) besides its conversion into compost for application as an organic fertilizer and soil conditioner. Malik & Sandhu (1973) studied fungal flora of kallar grass compost. Previously we reported biochemical changes during composting of kallar grass in 1 m^3 in-ground pits and suggested the use of CEC as a rapid method for assessing the compost stability (Mahmood *et al.*, 1987). Experiments carried-out on the feasibility of composting kallar grass on a large scale is given in this report.

Materials and Methods

Kallar grass was harvested in September from saline soil of Bio-Saline Research Sub-station (BSRS) of Nuclear Institute for Agriculture and Biology (NIAB) at Lahore. It was chopped and air-dried before piling up for windrow composting (Poincelot, 1975). The material was moistened to 60% and piled up in a pile measuring 6.5 x 2.5 x 2 m high which accommodated about 1.6 tons of the moist material. For sampling, nylon net bags (60 mesh, 20x30cm) each filled with 1 kg of the moist material were burried in the middle of pile. Capillary-type dial thermometers with sensors placed centrally in the material, were used to record the temperature. The pile was turned at 6th, 15th and 62nd day and water was added to adjust the moisture.

Sample bags were removed in triplicate at different time intervals for determination of substrate loss and for chemical analyses. Substrate loss was determined by drying portions of the moist material at $105^{o}C$ to a constant weight. Chemical analyses were performed on air-dried material ground to pass a 1 mm sieve. Carbon content was estimated after ashing the material at $550^{o}C$ using the equation:

$$\%C = \frac{100 - \%\,Ash}{1.8} \quad \text{(Poincelot \& Day, 1973)}$$

For CEC, simplified method of Harada & Inoko (1980) was employed and total N was determined by a micro-kjeldahl method (Bremner & Mulvaney, 1982). Nitrogen balance of the pile at different stages of composting was calculated by the equation:

$$X = \left[\frac{B\,(100 - A)}{100\,C} - 1\right] \times 100$$

where X = % gain or loss(-) of N, A = % substrate loss ,B = % N content of the material after composting and C = % N content of the material before composting.

A biological test for potential growth reducing effects of the compost was performed by growing wheat in soil amended with kallar grass material obtained at different stages of composting. For this purpose, 450 g portions of air-dried sandy-clay-loam was filled in 500 ml capacity plastic pots. Uncomposted kallar grass and the compost samples obtained after 45, 75, 105 and 150 days of composting were air-dried, ground and mixed in soil @ 0.25, 0.5 & 1.0% . Pots with unamended soil served as control. All treatments were in triplicate and laid out in a completely randomized design. The pots were irrigated to 60% WHC with a solution of $(NH_4)_2SO_4$, $(NH_4)_2PO_4$ & K_2SO_4 to supply N, P & K equivalent to 22, 11 and 11 ppm of soil, respectively. Ten wheat seeds were sown and after germination the stand was reduced to 5 plants/pot. Pots were irrigated regularly with deionized water to maintain the moisture at 60% WHC throughout the experimental period. Six weeks after germination, the plants were harvested, partitioned into root and shoot and dried at $70^{o}C$ to a constant weight.

The data of chemical changes during composting and of plant growth test were subjected to analysis of variance followed by LSD test for planned comparison of paired means (Gomes & Gomes, 1984).

Results and Discussion

Physico-chemical Changes: Figure 1 presents the temperature profile of the compost pile. Maximum temperature (77° C) was recorded after three days. First turning on 6th day caused a decline to 60° C followed by a 2nd peak of 72° C which maintained until 2nd turning made on 15th day. Thereafter the temperature declined gradually but remained at thermophilic stage for further 40 days.Third and last turning (62nd day) produced a thermophilic stage of very short duration (5 days) and thereafter the pile cooled gradually down to ambient temperature.

Results of changes in different chemical parameters during composting of kallar grass are presented in Table 1. Rate of decomposition was very rapid during initial 15 days and caused 22% substrate loss, probably due to rapid utilization of the sugars and other water soluble materials (Poincelot, 1975). Subsequently, substrate was utilized steadily producing a further loss of 8% during 15-75 days. This slow decomposition rate may be due to steady consumption of hemicellulose and cellulose fractions during the thermophilic stage (Chang, 1967; Regan & Jeris, 1970). Another flush of microbial activity was observed between 90-150 days causing 18% substrate loss which may in part be due to cellulolytic activity of mesophiles and decay of thermophilic microflora (Poincelot, 1975). Changes in the carbon content showed almost similar but opposite trend as observed for the substrate loss, the two parameters showing a correlation coefficient of - 0.9379 ($p < 0.01$). A loss of 9% C occurred during initial 45 days followed by other flushes each causing a loss of about 20 and 10% C during 45-75 and 90-150 days, respectively.

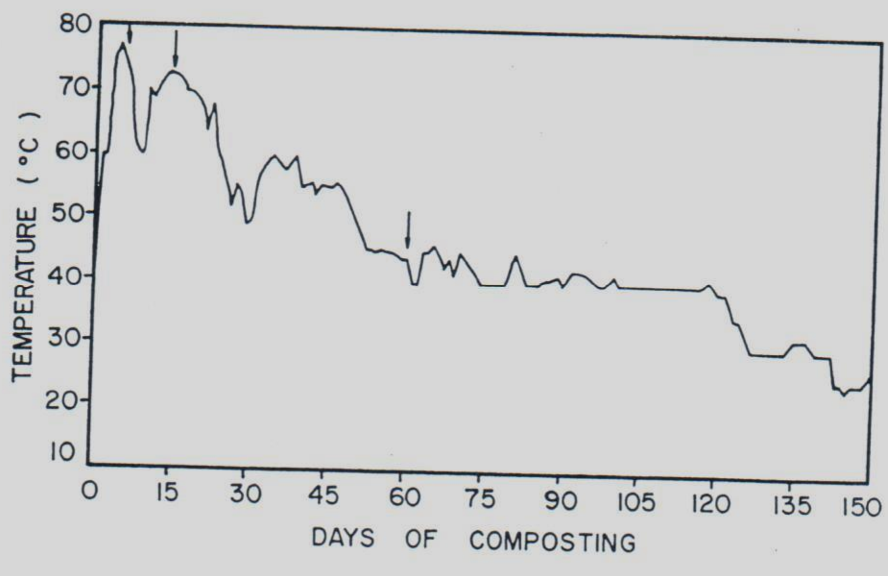

Fig.1. Temperature fluctuations during composting of Kallar Grass (Arrows indicate intervals when turning was carried out).

Table 1. Changes in different chemical parameters during composting of kallar grass*.

Composting time (days)	Substrate loss	Ash content	Carbon content	Nitrogen content (mg/g oven-dry material)	C/N ratio	Nitrogen-balance (% gain or loss (-) of N)	Cation-exchange capacity (m eq/100g ash-free dry material)
	(----% of oven-dry material----)						
15	21.96	23.38	42.56	8.18	52.03	- 5.00	12.61
45	19.28	25.91	41.16	11.05	37.25	32.74	16.74
75	30.17	41.97	32.24	13.25	24.33	37.69	28.66
90	38.85	44.68	30.73	14.85	20.69	35.13	34.97
105	54.61	52.01	26.66	14.20	18.78	- 4.09	46.56
150	56.87	52.61	26.33	15.33	17.18	- 1.61	46.69
LSD (0.05)	11.54	4.90	2.72	2.08	1.97	22.3	06.73
(0.01)	16.18	6.86	3.81	3.15	2.77	31.34	9.44

* The uncomposted kallar grass contained 45.2% C, 6.72 mg/g N, 0.13% P, 18.6% ash and had a CEC of 12.7 m eq/100g ash-free dry matter.

Nitrogen content of the material increased steadily and almost doubled after 75 days of composting. The increase in the N content and loss of C caused narrowing of C/N ratio of the material at different stages of composting. During earlier 75 days the initial C/N ratio of 67 was lowered to 24 while during 75-150 days of composting the ratio further decreased to 17, indicating that major changes in the C/N ratio took place during initial 75 days. Nitrogen balance of the compost pile showed a N loss of 5% after 15 days. Nitrogen loss during initial stages of composting is attributed to the accumulation and volatilization of ammonia produced by the oxidative deamination of amino acids (Poincelot, 1975). The N loss is particularly favoured by warmth and alkalinity of thermophilic stage (Poincelot, 1974). On the other hand, during 45-90 days a considerable gain (33 to 38%) in N balance was observed which may be due to N_2 fixation by the compost microflora. Athough non-symbiotic N_2 fixation has been reported during decomposition of forest litter layers (O'Connell *et al.*, 1979), no reports are available on biological nitrogen fixation during composting and the phenomenon needs further experimental corroboration. During later stages of composting a deficit in N balance was observed. Although the net N loss after 105 days was only 4%, the actual N loss during 90-105 days was as high as 39%. Nitrogen loss during later stages of composting may be attributed to accumulation of mineral N and its subsequent loss through ammonia volatilization and/or denitrification (Poincelot, 1974). It appears that the compost had achieved stability within 90 days as evidenced by the low pile temperature and substrate loss after 90 days. This resulted in an accumulation of mineral N in excess of microbial needs and its subsequent loss.

Cation-exchange capacity increased slowly during earlier stages of composting and reached 29 m eq/100 g ash-free dry matter after 75 days which corresponds to about 126% increase over the initial CEC of the kallar grass used. CEC is known to increase with decomposition due to microbial transformation of lignocellulosics into humus (Muller, 1933). However, polymerization reactions leading to synthesis of humic compounds occur after compost has cooled to ambient temperature (Poincelot, 1975) and optimum temperature for humic acid synthesis is reported to be 35^{o} C (Franklova & Novak, 1967). Therefore, as temperature of the pile shifted to mesophilic range, a rapid increase in CEC was recorded and after 150 days the compost attained a CEC of 47 m eq/100g ash-free dry matter which corresponds to 267% increase over the initial.

Plant Growth Test: There was no effect of applying composted or uncomposted kallar grass on root dry matter yield of wheat (Table 2). However, uncomposted kallar grass caused reduction in dry matter yield of wheat shoot when applied @ 0.5 and 1.0%. Similarly, 45 days old compost significantly reduced the shoot dry matter yield at 1.0% but not at lower amendment levels. On the other hand, kallar grass composted for 75 days or longer, did not cause reduction in dry matter yield of shoot. Injurious effects of applying either uncomposted lignocellulosics or their unfinished composts, have been frequently reported and include symptoms such as nitrogen deficiency (Poincelot, 1975), chlorosis, root injury, wilting etc., (Patrick, 1971; Borner, 1971), resulting in retarded growth and dry matter yields. Reduced shoot dry matter yield of wheat due to application of higher doses of kallar grass as such or at earlier stages of composting may be due to the presence of potential growth reducing substances as well as microbial immobilization of soil/fertilizer N. Negative effects were not observed at low amendment rates, probably because the amount of oxidizable carbon was not that high to cause a net immobilization of N. However, our unpublished data indicate that a mature kallar grass may have a C/N ratio of 90 and can cause N-starvation and other adverse effects on plants when applied to soil even at lower rates. In the present study it seems that growth retarding effects were eliminated after composting kallar grass for 75 days or more, indicating that the compost had achieved some degree of stability. Moreover, the compost removed after 75 days or later, did not show an increase in the dry matter yield as compared to the unamended control but had no negative effects either. It appears that nitrogen availability to plants was also reduced to some extent by mature compost. This may be due to stimulated denitrification because of easily degradable microbial carbon contained in the compost. Role of easily degradable carbon in increasing denitrification is well documented (Fillery, 1983). Although in the short term growth test, beneficial effects of kallar grass compost were not expressed, results of field experiments carried out at NIAB indicate that application of kallar grass compost , alone or in combination with

Table 2. Dry matter yield of wheat grown in the presence of NPK with or without Kallar grass at different stages of composting.

Compost Age (Days)	Application rate (%)	Dry matter yield (mg/pot) Root	Shoot	Total
Unamended	---	588	920	1508
Uncomposted	0.25	601	823	1424
Uncomposted	0.50	647	716	1363
Uncomposted	1.00	586	541	1127
45	0.25	585	879	1464
45	0.50	620	829	1449
45	1.00	634	748	1382
75	0.25	611	896	1507
75	0.50	643	954	1597
75	1.00	609	930	1539
105	0.25	550	999	1549
105	0.50	636	987	1623
105	1.00	600	938	1538
150	0.25	635	986	1621
150	0.50	663	917	1580
150	1.00	683	920	1603
LSD (0.05)		NS	119	202
(0.01)		-	160	272

inorganic N fertilizers significantly increased rice and wheat yields and that the beneficial effects of compost application persisted atleast for three successive crops (Azam, 1990).

Assessment of the Compost Stability: The question as to when compost is finished has been discussed by several authors without any general conclusions (Marcixzewska, 1965; Spohn, 1969; Lossin, 1971). The reasons may partly be the differences in aims of composting and/or variable substrate composition. Various criteria suggested for a 'ripe' compost are usually based on physical, chemical, microbial and plant growth tests (Solbraa, 1979). Poincelot (1975) recommended several tests such as one chemical and one biological, before assuming the compost is finished. In a previous study (Mahmood *et al.*, 1987) based on several physico-chemical and biological parameters, we found that a kallar grass compost can be regarded as stable when it attains a CEC of atleast 20 m eq/100g ash-free dry matter. In the present study, kallar grass attained a CEC of 29 m eq/100g ash-free dry matter after 75 days of windrow composting and at this stage it did not exert injurious effects on plant growth, thereby suggesting that the compost was stabilized. These results further confirm the validity of CEC as a rapid method for determining the compost stability. The results also suggest that when the compost becomes stable, it should be removed from the pile as composting beyond this stage may cause heavy loss of N as evidenced by the N-balance.

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