Significance of Nitrogen and Phosphorus Amendments in Composting of Kallar Grass [*Leptochloa fusca* (L.) Kunth]

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Abstract: Study was conducted on the role of nitrogen (N), applied either alone or in combination with phosphorus (P), in composting of kallar grass [*Leptochloa fusca* (L.) Kunth] with particular emphasis on carbon (C) and N conservation during composting. Nitrogen was added as ammonium sulphate and P as single superphosphate. Addition of N alone, though accelerated the composing rate, it did not conserve C and N during composting. However, application of P along with optimum level of N accelerated the composting rate, stimulated the substrate transformation into humic acid, and decreased the N loss. The results erriphasized the need of phosphorus amendment along with nitrogen to conserve C and N during composting of kallar grass.

Key words: Nitrogen, phosphorus, kallar grass

Introduction

Carbon/Nitrogen (C/N) ratio and decomposition or organic matter are closely related factors and play a significant role in determining the rate of composting (Poincelot, 1974; Nakasaki *et al*., 1992; Rao *et al*., 1995). The optimum C/N ratio for composting is a function of the carbon availability to the microbes involved in the process and is reported to vary from 15 to 50 for different substrates (Galler and Davey, 1971; Golueke, 1974; Rao *et al*., 1995). Besides N, the significance of P for efficient composting has also been pointed out by several workers (Braun, 1962; Bollen, 1969; Galler and Davey, 1971; Smith *et al*., 1998). Braun (1962) recommended a P content of at least 0.2 percent whereas Bollen (1969) and Galler and Davey (1971) suggested N/P ratio of 2 and 5, respectively.

Although addition of N and P is known to enhance the decomposition rate of cellulose and hemicellulose thereby reducing the composting time, the role of such amendments in conserving C through its transformation into stable component i.e. humans, is less well understood. This paper reports the effect of N and P amendments on composting of kallar grass [*Leptochloa fusca* (L.) Kunth] with particular emphasis on conservation of C and N during composting. The grass is widely cultivated on salt-affected lands in Pakistan due to its ameliorative effects (Malik *et al*., 1986) and its value as a substrate for compost production has been established (Malik and Sandhu, 1973; Mahmood *et al*., 1985, 1987, 1991).

Materials and Methods

Kallar grass was obtained from the Bio-Saline Research Substation of the Nuclear Institute for Agriculture & Biology at Lahore. The grass used to study the effect of nitrogen amendments contained 47 C, 0.83 N, 0.19 P and 8.80 percent ash. The grass was air-dried, chopped into 2-3 cm pieces and moistened to 60 percent either with water (NO treatment), or with solutions of ammonium sulphate to lower the initial C/N ratio (57) to 40 (N1 treatment) or 30 (N2 treatment). The moistened grass was loosely filled in field pits (1.0 m^3, interior lined with polyethylene sheets). For sampling purpose, nylon-net bags (60 mesh) containing 500 g of the similarly treated material, were buried in the middle of pits. The pits were closed at the top with 5 cm thick thermopore sheets. The material was turned on the 2nd, 6th and 11th week and water was added to adjust the moisture content.

The grass material used to study the effect of P amendment was relatively aged and contained 47 C, 0.51 N, 0.10 P and 10.54 percent ash. The chopped grass was moistened to 60 percent either with a solution of ammonium sulphate to reduce the initial C/N ratio (92) to 30 (N + P0 treatment), or with solutions of ammonium sulphate plus single superphosphate to reduce the C/N ratio to 30 and the initial N/P ratio (16) to 8 (N + P1 treatment) or 4 (N + P2 treatment). Rest of the procedures were same as described earlier.

Sample bags were removed in triplicate after every 2 weeks for determining substrate loss. The material was air-dried and ground to pass a 1 mm sieve before performing chemical analysis. The Tappi Standard method T13m-OS-54 (Anonymous, 1975) was employed to separate the acid-hydrolysable carbon (AHC, which refers to the C contained in carbohydrate fractions) from lignin-humus complex (LHC, the component, which is comparatively resistant to microbial attack). The C content of acid hydrolysate was determined by an acid dichromate method (Torok and Csonkareti, 1963) and humic acid (HA) content was estimated as described by Malik *et al.* (1979). Humification productivity (the ratio of humus produced to C lost as CO_2) was calculated as described by Franklova and Novak (1967). Total N was determined by a micro-Kjeldahl method (Bremner and Mulvaney, 1982) and N-balance calculated as

described by Mahmood *et al.* (1991). All assays were performed in triplicate.

Results and Discussion

Effect of added N on composting: Fig. 1 presents biochemical changes during composting of kallar grass amended with different levels of N. The rate of substrate decomposition was rapid during the first 4 weeks of composting resulting in a loss of 26-42 percent different treatment. Subsequently, the decomposition was relatively slow and caused a further loss of 8-10 percent. Addition of N resulted in 21 and 29 percent increase in the substrate decomposition in N1 and N2 treatments, respectively. Acid-hydrolysable C was utilized steadily and after 12 weeks a loss of 17-36 percent was recorded. Addition of N stimulated the consumption of AHC, the effect being more pronounced at higher rate of N. Our results are consistent with the findings of others that N amendments e.g. urea (Solbraa, 1979; Castro-Gomez and Park, 1983; Rao *et al.*, 1995) or ammonium sulphate (Poincelot and Day, 1973) increase the decomposition rate during composting of lignocellulosic wastes deficient in N. Lowering the C/N ratio with goat dung, cow dung or chicken manure, is also known to accelerate the composting (Thambirajah *et al.*, 1995).

The content of LHC increased as the composting progressed and after 12 weeks an increase of 62, 41 and 64 percent over the initial LHC content of kallar grass was recorded in N0, N1 and N2 treatments, respectively. This indicates that addition of lower amount of N (N1 treatment) accelerated the decomposition of the stable component (LHC), whereas at higher N addition (N2 treatment) LHC content was comparable with that of the unamended control. Humic acid, another stable fraction, showed occasional increase and breakdown during composting. Addition of N caused marked increase in humic acid synthesis, the increase being more pronounced during first 6 weeks, particularly at higher amount of the added N. After 12 weeks, HA content increased by 103, 123 and 134 percent over the initial HA content in N0, N1 and N2 treatments, respectively. This corresponds to 19-36 percent stimulation in the synthesis of HA due to N amendments. Humification productivity after 12 weeks of composting was found to be 0.102, 0.100 and 0.102 for N0, N1 and N2 treatments, respectively. This indicates that, although addition of N increased the humification process, the effect on substrate mineralization was more pronounced than on its transformation into humus component. It also appears that addition of higher amount of N caused decomposition of HA fraction during later stages of composting as evidenced by the lower HA content of N2 treatment after 8 weeks of composting. No reports are available on the observed effect of N amendments on the HA fraction during composting of lignocellulosics.

Besides accelerating the overall composting process,

addition of N also caused substantial loss of N during composting. As indicated by the N-balance after 12 weeks of composting, 13 and 61 percent of the initial N was lost in N1 and N2 treatments, respectively. It appears that the compost achieved stability earlier than 12 weeks due to N addition and the excess N accumulated as ammonia which was lost through volatilization. On the other hand, a slight (2%) gain in the N-balance for NO treatment indicates that in the unamended kallar grass, the decomposition was slow and due to rapid recycling of N, little was left to accumulate as ammonia. The positive N-balance in the NO treatment may partly be attributed to N2-fixation which was probably inhibited in N and N2 treatments due to the presence of inorganic N (Drozd *et al.*, 1972; Cejudo and Paneque, 1986).

Effect of added P on composting: Fig. 2 present biochemical changes during composting of kallar grass amended with N and different levels of P. When the grass was composed at a fixed C/N ratio of 30, addition of P increased the substrate loss. During first 4 weeks, 58 and 66 percent substrate was consumed in N + P1 and N + P2 treatments, respectively over the unamended P treatment (N+ -4- P0). As the composting progressed, the stimulatory effect of the added P decreased and substrate consumption was even retarded beyond 6 weeks when P was added in higher amount (N + P2). However, with lower P amendment (N+P1) 15 percent substrate loss was recorded as compared to the unamended P treatment. Both levels of the added P accelerated the utilization of AHC component at least during the first 4 weeks, the effect being more pronounced with N + P2 treatment. However, by the end of 12 weeks of composting, AHC consumption with lower P amendment (N + P1) was comparable (17.7%) with that of the unamended P treatment (17.4%). On the other hand, in N + P2 treatment, up to 27 percent more AHC was consumed as compared to other treatments.

Transformation of the substrate into LHC increased at higher dose of P (N + P2 treatment), the difference being more pronounced during the first 4 weeks. On the contrary, when P was added in lesser quantity (N + P1 treatment), the LHC content was not much different than the control. Taking into account the results of substrate loss, AHC and LHC, it appears that along with optimum levels of N (C/N 30), P added in lower amount (N + P1 treatment) caused higher substrate loss, mainly due to consumption of the stable component i.e. LHC and not from the labile carbohydrate component i.e. ARC. The reverse n true when P was applied at higher rates (N + P2 treatment), Humification productivity after 12 weeks of composting was 0.199, 0.189 and 0.231 for N + PO, N + P1 and N + P2 treatments, respectively. This indicates that higher amount of the added P contributes significantly towards transformation of the substrate into stable component i.e HA rather than its mineralization to CO_2 as observed for N + PO and N + P1 treatments. This is also evidenced by the data on HA content. After 12 weeks of composting, HA
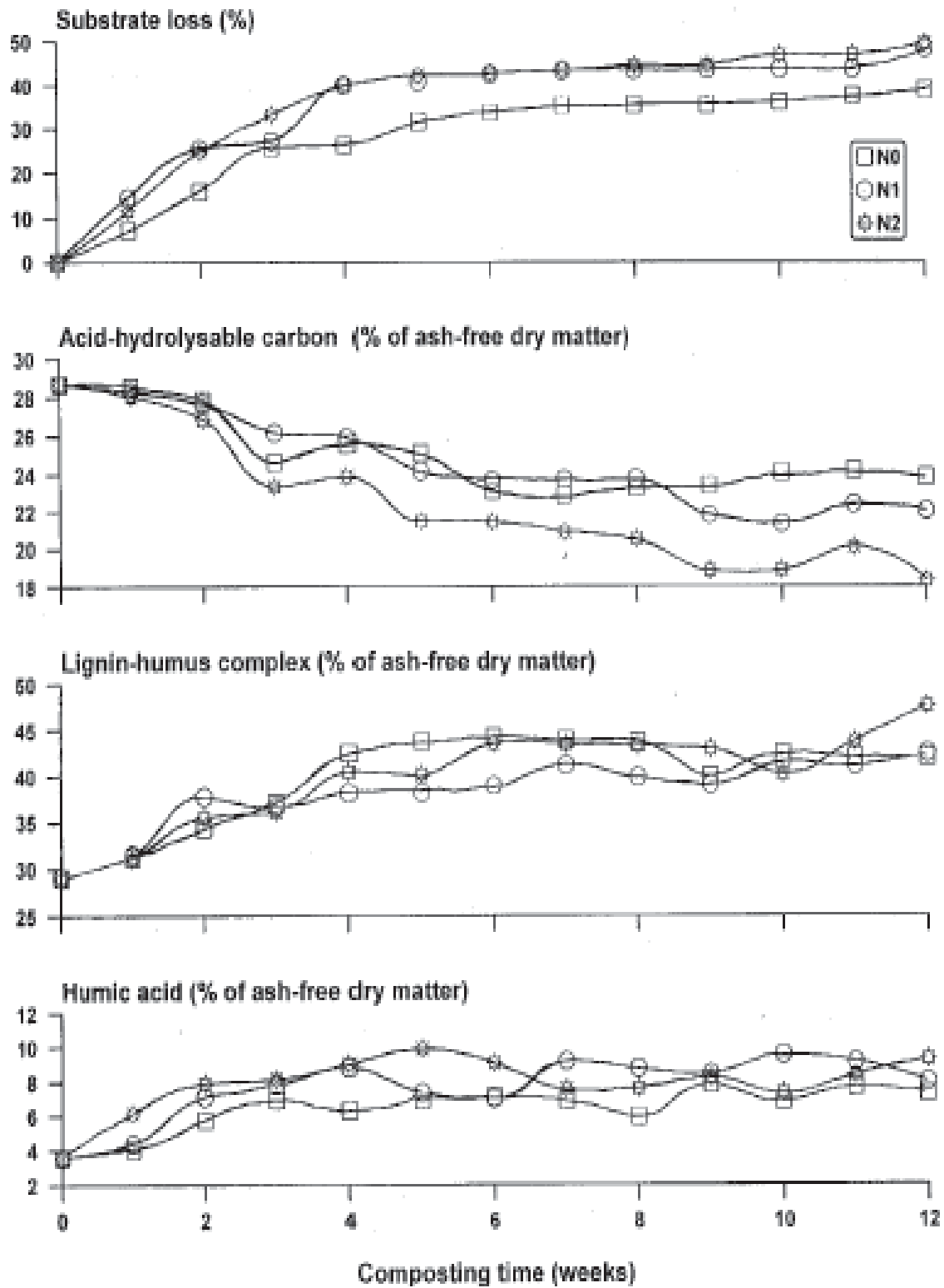
Fig. 1: Biochemical changes during composting of kallar grass amended with different levels of nitrogen (N0: C/N = 57; N1 :C/N — 40;N2: C/N = 30)
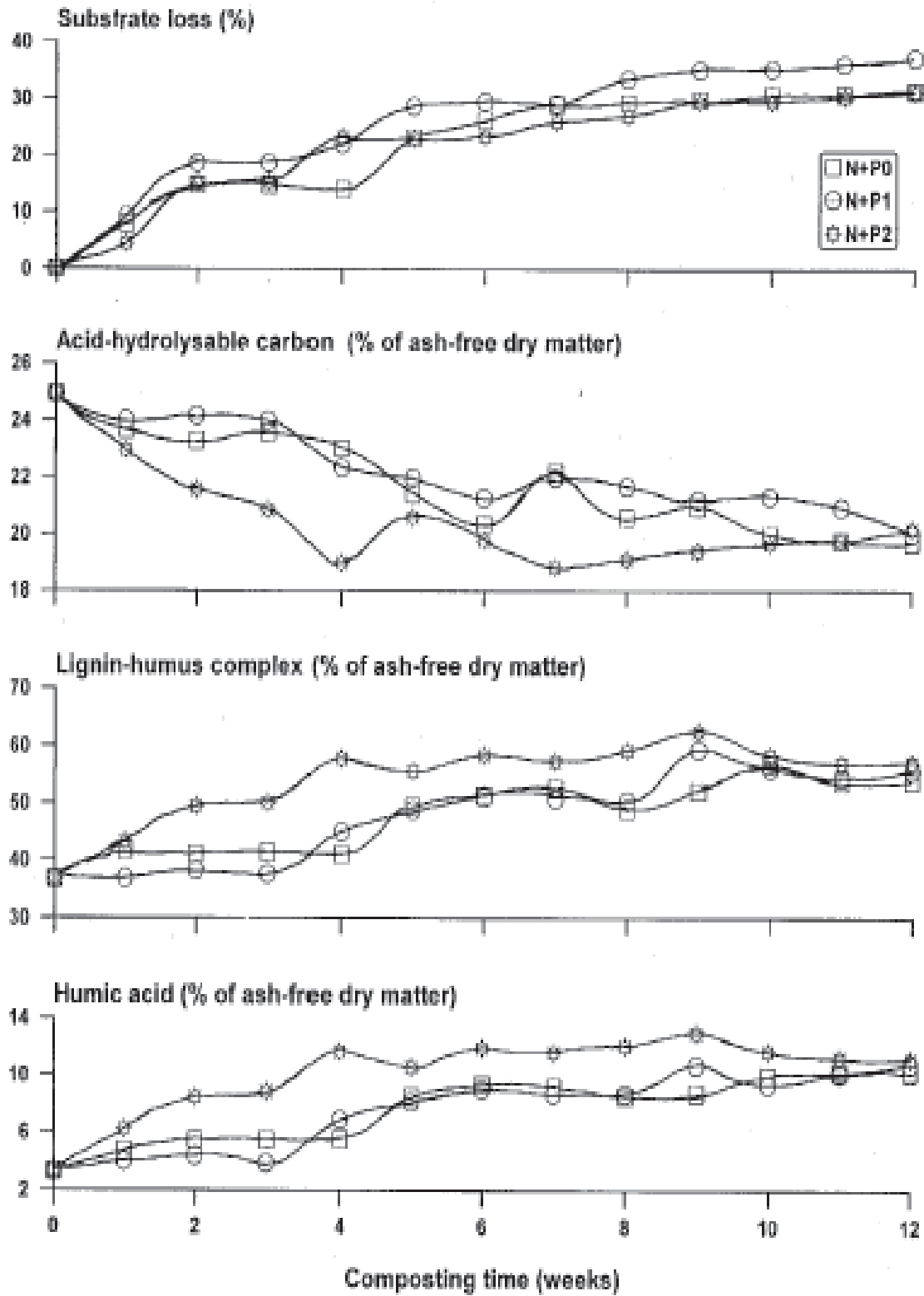
Fig. 2: Biochemical changes during composting of kallar grass amended with nitrogen and different levels of phosphorus (N +P0: C/N = 30; NIP= 16; N +P1: C/N = 30, N/P = 8; N + P2: C/N = 30, N/P = 4)

content increased by 164, 179 and 188 percent in N+P0, N + P1 and N + P2 treatments, respectively. This corresponds to 9-15 percent increase in HA synthesis due to P treatments. Effect of added P on HA synthesis was more pronounced during initial stages of composting as after 4 weeks 43, 79 and 203 percent increase in HA was recorded for N + P0, N + P1 and N + P2 treatments, respectively. This corresponds to an increase of 84 and 371 percent in N +P1 and N +P2 treatments, respectively over N + P0 treatment. Although at lower P addition also, an increase in humification was recorded, the net effect i.e. humification productivity was low because of the higher substrate loss. Addition of P is known to accelerate the decomposition of lignocellulosics and the increased substrate decomposition is also reported to occur mainly in hemicellulose and cellulose fractions (Korovkin, 1952; Solbraa, 1979). However, the effect of added P on transformation of substrate into stable fractions i.e. HA or LHC has not been reported earlier.

Besides conserving C, addition of P in appropriate ratio with N, also helped conserving N during composting as N-balance after 12 weeks of composting showed 40, 2 and 9 percent loss of N initially present in N + P01, N + P1 and N + P2 treatments, respectively. It appears that without P amendments, the surplus N accumulated as ammonia after the compost was stabilized, and was lost. Conservation of N due to P amendment may partly be due to decreased number of denitrifying bacteria (Korovkin, 1952) and/or due to increased N_2 fixation (Berezova *et al.*, 1955). Low N loss due to superphosphate amendment may also be attributed to lower NH_3 volatilization as a result of lower pH. A decrease in the compost pH due to superphosphate amendments has been reported by Solbraa (1979).

Results of the present study imply that, addition of N alone though accelerates the composting of lignocellulosics, it does not conserve C and N during composting. However, application of P along with optimum level of N, accelerated the composting rate, stimulated the substrate transformation into humic acid, and decreased the loss of N.

Acknowledgments

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