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Changes in biochemical properties during decomposition of various crop residues

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Abstract
The present investigation was conducted during 2017-18 to study the biochemical and biological changes during decomposition of crop residues at Research Farm, Department of Soil Science and Agricultural Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The various crop residues viz; wheat straw, shredded cotton stalks, sorghum stubbles and glyricidia leaves along with rock phosphate, urea, elemental sulphur, cow dung slurry and PDKV decomposing culture were decomposed upto 120 days by pit method. The experiment was laid in completely randomized design with four replications. The moisture content of compost was maintained at 60 to 70%. The changes in various biochemical parameters were monitored at regular intervals. The biochemical properties of compost revealed that, cellulose, hemicellulose and lignin content significantly decreased as the decomposition progressed. However the higher cellulose (15.37%) and lignin (7.45%) was observed in compost prepared from 30% wheat straw + 30% shredded cotton stalks + 20% glyricidia leaves + 20% sorghum stubbles at 120 days of decomposition whereas, the hemicellulose content was observed in 100% shredded cotton stalks. The pH, organic carbon and C: N ratio decreased with increased in decomposition. The CO_2 evolution increased initially during first sixty days and thereafter decreased as decomposition progressed. The CO_2 evolution was increased upto 90 days, thereafter decreased slightly up to 120 days of decomposition of various crop residues. However, the combination of crop residues in equal proportion i.e. 25% wheat straw+25% shredded cotton stalks + 25% glyricidia leaves +25% sorghum stubbles were found beneficial for increasing CO_2 evolution.

Keywords: Wheat straw, cellulose, hemicelluloses, CO_2 evolution, lignin

Introduction

India being an agriculture dominant country produces more than 500 million tonnes of crop residues annually. These residues are used as animal feed, for thatching houses as well as a source of domestic and industrial fuel. A large portion of unused crop residues are burnt in the field primarily to clean the left over straw and stubbles after the harvest. Non availability of labour, high cost of residue removal from the field and increasing use of combines in harvesting the crops are the main reasons behind burning of crop residues in the field. Burning of crop residues causes' environmental pollution is hazardous to human health. It produces greenhouse gases causing global warming and results in loss of plant nutrients like N, P, K and S. Therefore, appropriate management of crop residues assumes a great significance. A mass of rotted organic matter made from waste is called as compost. The compost made from waste like sugarcane trash, paddy straw, weeds and other plants waste materials called as compost.

Composting is natural process of decomposition of organic matter by micro-organisms under control conditions. It considered as a valuable soil amendment. Farm compost is poor in P content (0.4-0.8%). Addition of P makes the compost more balanced and supplies nutrient to micro–organisms for their multiplication and faster decomposition. The addition of P also reduces N loss. Enriched compost enhances the chemical properties of soil as well as improved physical and biological properties of soil. Over exploitation and abusive use of chemical fertilizers leads to soils poorer in humus content. Composting can not only transform waste by reducing its harmful effect but also corrects when added to soil, the deficit inorganic matter.

Therefore, if agriculture is to meet the demand for food, the development of soil atmosphere that exhibits higher crop yield, is imperative. The inadequate supply of essential plant nutrients in soil is a growth-limiting factor towards production. Among all the elements required by a plant, phosphorus is one of the most important nutrients for crop production, and emphasis is being given on the efficient use of P fertilizer for sustainable crop production. Composting is the biological stabilization and decomposition of organic substrates by a mixed microbial population under the condition which allow for the development thermophillic temperature as a consequence of biologically produced heat. The final product of composting is stable for the storage and application to the land without adverse environmental effects. In this context, under certain soil and climate condition, the direct application of rock phosphate is an agronomic and economically sound alternative to the more expensive superphosphate in the tropics.

Rock phosphate contains impurities, which include silica, clay minerals, calcite, dolomite, and hydrated oxides of iron and aluminum in various combinations and concentrations. Some of which may have a marked influence on the performance of a rock phosphate used for direct application. India has reserve of 14.7 million tons of high grade rock phosphate (+30% P_2O_5) and about 190 million tons of low grade rock phosphate with an average of 12% P_2O_5 (Jaggi, 2000) [8].

Materials and Methods

Experiment was conducted at Research Farm, Department of Soil Science and Agricultural Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during 2017-18. The compost was prepared by decomposing various crop residues (wheat straw, shredded cotton stalks, glyricidia leaves, sorghum stubbles), cow dung slurry with rock phosphate, urea, elemental sulphur and PDKV, decomposer. The enriched compost were prepared by mixing various crop residues and rock phosphate. The treatment combinations are given below. T_1 - 100% Wheat Straw, T_2 - 100% Shredded Cotton Stalk T_3 - 50% Wheat Straw + 50% Shredded Cotton Stalks, T_4 - 40% Wheat Straw + 40% Shredded Cotton Stalks+ 20% Glyricidia Leaves, T_5- 30% Wheat Straw + 30% Shredded Cotton Stalks + 20% Glyricidia Leaves + 20% Sorghum Stubbles and T_6 - 25% Wheat Straw + 25% Shredded Cotton Stalks + 25% Glyricidia Leaves + 25% Sorghum Stubbles.

The compost were prepared by pit method. Turnings were given at 15 days interval up to 90 days of decomposing. After 90 days of decomposing, heaps of compost were collected at one place and allowed to cure for another 30 days. Temperature were recorded at 7 days of interval. Compost were watered regularly at 5–7 days of interval, so as to maintain moisture content up to 60-70%.

Total carbon was determined by loss on ignition method (Jackson 1973) [7]. Total nitrogen was estimated by using Micro Kjeldahl's method as described by Piper (1966). The total P was determined by using Vanado molybdate yellow colour method from di-acid extract as described by Jackson (1973) [7]. The total K was determined in di-acid extract by using flame photometer as described by Piper (1966).

Cellulose and hemicellulose was estimated following the method of AOAC, (1975), was estimated following the method of AOAC (1990). Lignin was estimated following the method of Goering and Vansoest (1975) [5].

The CO_2 evolution at 15,30,60,90 and 120 days of decomposition determined by alkali trap method as described by Anderson and Flanagan (1989) [1]. Experimental data were analysed by adopting standard statistical method of analysis of variance as given Gomez and Gomez (1984).

Result and Discussion

Cellulose

The cellulose content was decreased with the decomposition of crop residues. At 15 days, the cellulose content ranged between 22.40 to 27.90% which was gradually decreased upto 120 days and was ranged between 10.64 to 15.37%. Among various treatments minimum cellulose content (22.40%) were recorded in treatment 100% WS (T_1) followed by 25.42% in treatment 100% SCS (T_2) and 26.05% in treatment 50% WS + 50% SCS (T_3). The maximum cellulose content were recorded 27.90% in treatment 30% WS + 30% SCS + 20% glyricidia leaves + 20% sorghum stubbles (T_5). Cellulose is easily degradable organic matter and its degradation starts the movement of organisms in raw materials which are piled up. Mesophilic bacteria, actinomycetes, fungi and protozoa are the microorganism which grow at temperature between 10 and 45 °C. Similar findings were observed by Sarika *et al.* (2014) [12], Parveen and Padmja (2010) [10]. The highest degradation for cellulose was observed due to proper combination of waste materials which resulted in better biological activity. The cellulose degradation of 31.55% in uninoculated and 20.56% in fungal consortium inoculated during composting of water hyacinth and municipal solid waste.

Hemicellulose

Like cellulose, the hemicelluloses content was decreased significantly with the decomposition of crop residues. At 15 days stage of composting the hemicellulose content ranged between 18.11 to 23.33% which is gradually decreased at 120 days and it was ranged between 3.61 to 7.33%. Similar findings were observed by Sarika *et al.* (2014) [12] and Zeng *et al*. (2010) [13]. They reported that the maximum amount of 27% of hemicellulose was present in water hyacinth. The highest reduction of 45.16% in hemicellulose in trial 4. Reported 76% reduction in hemicellulose in 12 month during olive mill composting. Reported maximum degradation of hemicellulose as compared to lignin and cellulose during composting. In all the five trials, it was found that the amount of hemicellulose present in compost at the end of 20 days was less than 10% indicating very rapid degradation of hemicellulose under microbial activity.

Lignin

The lignin content ranged between 10.52 to 20.61%. Significant decrease in lignin content was observed at 15 days i.e. (10.52%) in 100% SCS (T_2) followed by 14.84% in compost prepared by 40% WS + 40% SCS + 20% glyricidia leaves (T_4) and 15.28% in compost prepared by 25% WS + 25% SCS + 25% glyricidia leaves + 25% sorghum stubbles (T_6). The similar findings were observed by Sarika *et al.* (2014) [12], Garcia *et al.* (2003) [4] and Feng *et al*. (2011) [3]. They reported that the maximum biodegradation of lignin was observed in trial 4 (39.72%) as compared to other trials. It can be attributed as; proper proportion of initial waste mixture enhanced the growth and activity of microorganisms. Observed 60% decrease in lignin amount during composting of olive mill waste.

CO_2 evolution

The data pertaining to periodical changes in CO_2 evolution. Respirometric studies, which determined the O_2 consumption or CO_2 evolution under aerobic conditions because mineralization of the organic matter by microbes during decomposition of CO_2 evolution is an important feature that determines compost quality and relates to the degree to which the rate of microbial active and organic matter has been stabilized. The respiration rate increased up to 60 days of composting, thereafter, the respiration rate was decreased at 90 and 120 days of composting in respect of various treatments. The higher CO_2 evolution was observed in compost prepared from 25% WS + 25% SCS + 25% glyricidia leaves + 25% sorghum stubbles, suggesting that higher rate of CO_2 evolution associated with higher decomposition rate and relatively less C:N ratio. Bharadwaj and Gaur, 1970 reported that increase in the reduction of carbon content was due to the increase in the microbial activities with the fineness of the materials and availability of oxygen during decomposition.

Table 1: Changes in cellulose as influenced by various crop residues during periodic decomposition

Treatments		Cellulose (%) Days after decomposition				
		15	30	60	90	120
T_1	100% WS	22.40	19.31	17.16	15.23	12.17
T_2	100% SCS	25.42	23.29	20.88	17.61	13.21
T_3	50% WS + 50% SCS	26.05	22.68	20.0	16.08	10.64
T_4	40% WS + 40% SCS + 20% Glyricidia Leaves	27.26	24.29	21.25	18.09	13.62
T_5	30% WS + 30% SCS + 20% Glyricidia Leaves + 20% Sorghum Stubbles	27.90	25.12	22.52	19.34	15.37
T_6	25% WS + 25% SCS + 25% Glyricidia Leaves + 25% Sorghum Stubbles	26.41	23.66	20.17	18.11	13.48
SE(m)±		0.483	0.551	0.390	0.372	0.424
CD at 5%		1.447	1.650	1.166	1.114	1.271

Table 2: Changes in hemicellulose content as influenced by various cropresidues during periodic decomposition

Treatments		Hemicellulose (%) Days after decomposition				
		15	30	60	90	120
T_1	100% WS	18.11	15.32	11.32	5.24	3.61
T_2	100% SCS	23.33	18.26	15.70	11.36	7.33
T_3	50% WS + 50% SCS	21.35	17.10	13.60	9.44	5.49
T_4	40% WS + 40% SCS + 20% Glyricidia Leaves	22.44	18.12	14.16	8.53	4.41
T_5	30% WS + 30% SCS + 20% Glyricidia Leaves + 20% Sorghum Stubbles	22.82	19.04	15.14	9.74	5.98
T_6	25% WS + 25% SCS + 25% Glyricidia Leaves + 25% Sorghum Stubbles	21.64	18.09	14.48	8.51	4.54
SE(m)±		0.498	0.474	0.561	0.425	0.297
CD at 5%		1.492	1.419	1.680	1.272	0.890

Table 3: Changes in lignin content as influenced by various crop residues during periodic decomposition

Treatments		Lignin (%) Days after decomposition				
		15	30	60	90	120
T_1	100% WS	20.61	18.45	13.75	9.48	6.33
T_2	100% SCS	10.52	9.42	8.51	7.47	4.70
T_3	50% WS + 50% SCS	18.38	15.20	11.31	8.76	5.71
T_4	40% WS + 40% SCS + 20% Glyricidia Leaves	14.84	12.20	10.43	7.32	6.19
T_5	30% WS + 30% SCS+20% Glyricidia Leaves + 20%Sorghum Stubbles	15.71	14.37	13.15	10.33	7.45
T_6	25% WS + 25% SCS + 25% Glyricidia Leaves + 25% Sorghum Stubbles	15.28	14.22	12.35	9.38	5.41
SE(m)±		0.307	0.375	0.390	0.422	0.470
CD at 5%		0.920	1.122	1.166	1.262	1.408

Table 4: Changes in CO_2 evolution as influenced by various crop residues during periodic decomposition

Treatments		CO_2 evolution (mg CO_2 100 g 24 h^{-1}) Days after decomposition				
		15	30	60	90	120
T_1	100% WS	24.38	38.02	53.71	37.49	29.68
T_2	100% SCS	26.47	43.67	56.51	41.50	33.74
T_3	50% WS + 50% SCS	25.21	41.20	54.84	43.43	31.45
T_4	40% WS + 40% SCS+ 20% Glyricidia Leaves	27.15	44.44	58.73	46.68	34.77
T_5	30% WS + 30% SCS + 20% Glyricidia Leaves + 20% Sorghum Stubbles	28.76	46.76	61.62	47.75	36.48
T_6	25% WS + 25% SCS + 25% Glyricidia Leaves + 25% Sorghum Stubbles	31.75	48.77	64.88	52.44	41.55
SE(m)±		0.064	0.113	0.078	0.112	0.124
CD at 5%		0.192	0.337	0.232	0.335	0.372

Conclusion

From the above study it can be concluded that, compost prepared from 50% wheat straw + 50% shredded cotton stalks recorded relatively lower cellulose at 120 days of composting. Compost prepared from 100% wheat straw recorded relatively lower hemicellulose at 120 days of composting. Compost prepared from 100% shredded cotton stalks recorded relatively lower lignin at 120 days of composting.

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