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Analysis and Characterization of Biochemical Changes in Paddy Crop Residues during their Decomposition in Nature: A Haryana Study

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Abstract
Studies were carried out to assess biochemical changes in Paddy crop residues (straw) during their decomposition in nature. Cellulose, hemicelluloses and lignin together constituted major proportions of these resources. The straw samples prepared for investigation, 30 nylon net bags (15 x 10 cm) with mesh sizes of 1 mm were used. Each bag filled with 10g straw and were placed randomly in the holes-one bag per hole in long pits having dimensions 200 x 50 x 50 cm. The pits were filled with soil and the location of different holes was recorded. Cold water-soluble fraction was maximum on 45th day. A good proportion (36.59%-87.99%) of water-soluble fractions was lost during early stages of decomposition. In general, the proportion of loss of hemicelluloses was always more than that of cellulose-though the rate of cellulose decomposition picked up later. The differences in the relative loss of hemicellulose and cellulose in different components could be related to anatomical difference in the paddy resources. A substantial proportion of pectin was decomposed in the beginning in the paddy straw, while lignin proved to be most resistant fraction. The cellulose: hemicellulose ratio did not become constant in the late stages of decomposition.

Keywords: Paddy straw, Microbial decomposition, Cellulose, Hemicellulose, Lignin, Pectin

Introduction

India is fighting with many problems in agricultural sector in terms of environmental pollution, soil infertility and food scarcity. The agricultural land is decreasing and the demand of food grains is increasing day by day. The maintenance of soil fertility an important factor of preserving the environment [1]. Natural decomposition of paddy residues is necessary to control the pollution and soil texture. With increasing mechanization now years are harvested leaving stem and leaf in the field [2,3,6] Haryana is known to produce paddy and paddy straw burning is the usual practice for the farmers to degrade the straw easily and to grow new crop soon as well. This study is focusing the degradation of the paddy straw in natural conditions. It would therefore, be interesting to determine the biochemical changes during their decomposition.The decomposition of paddy straw residues usually follows a sequential pattern with respect to the loss of different classes of organic components during the decay process. In order to have a better understanding of the decomposition of any resource, it is desirable to know the trend of disappearance of its constituents, since the rate at which these constituents disappear shall determine the pattern of loss in the weight of straw during a given time interval [4]. The enzymatic potential of soil fungi plays a significant role in improving soil quality and fertility [20]. Several studies carried out on the pattern of microbial colonization or decomposing agricultural residues *viz.* wheat straw [20]. The soil moisture, temperature and the C/N ratio of crop residue also affect the decomposition of crop residue [2]. (Dash et al., 2021) [9] found that microbial consortium decomposed the rice straw faster on reduction of C:N ratio and reduction of lignin, hemicellulose, and cellulose contents. Though several reports are available concerning biochemical changes during the decomposition of intact paddy straw, this study seems to have been undertaken to compare the biochemical changes in paddy straw during decomposition [5]. The present communication deals with the results of the studies carried out to assess the changes in petroleum ether-soluble, cold water-soluble, hot water-soluble fractions as well as that in hemicelluloses. Lignin, pectin and ash content during the decomposition of paddy straw collected at different stages of decomposition in nature [19].

Material and Methods

1. Collection and Preparation of Samples for decomposition:

In the month of April 2021 some bundles of harvested rice crop were collected from the fields of village Mullana, District Ambala, Haryana. The seeds were removed from the spikes to collect Straw. Unseparated straw (without grains) served as combined straw. Hence, one type of sample was prepared for investigation viz., straw. 30 nylon net bags (15 x 10 cm) with mesh sizes of 1 mm were prepared. Bags filled with the samples of 10g straw, each were taken to experimental site for further investigations. Long pits having dimensions 200 x 50 x 50 cm were dug. Small holes were made in the side walls of pits-the distance between the adjacent holes being 15 cm. All bags of straw residues were placed randomly in the holes-one bag per hole. The pits were filled with soil and the location of different holes recorded Fig.1 and 2 [23].

Fig. 1 and 2 Placement of Samples at experimental site

2. Recovery of Samples for Analysis:

The analysis of the samples for Mycobiota and biochemical constituents was done immediately on the first day. Samples for further analysis were collected on 45th, 100th, 175th, 220th, 310th and 390th day. On the specified day, four bags each containing straw (mixed) were collected from different holes. Each of the bags was placed separately in a fresh polythene bag. All of these were brought to the laboratory and stored in a refrigerator at 5± 1°C till further studies were made.

3. Biochemical Changes during Decomposition

A system of approximate quantitative analysis as proposed by and modified by [23] to determine the mechanism of decomposition of plant residues, was followed in the present study the same method with modifications. Two grams of oven-dry material were cut into very minute pieces with the help of scissors and extracted for 24 hrs. With cold petroleum ether in a closed flask. The solvent was removed, and the material was again extracted twice with petroleum ether in the same way. The material was oven-dried and the loss in weight was recorded which was taken as the weight of fats and waxes. The remaining material was extracted with 150 ml of distilled water and allowed to stand in the cold for 24 hours. After filtration, the material was oven-dried and weighed again. The loss in weight represented simple sugars, amino acids, peptides, and soluble minerals. The residue was extracted with boiling water for 30 minutes; this time, the loss in weight represented starch, pectin's, and other hexoses of microbial origin. Hemicelluloses were determined by extracting the water-extracted residue with 24% KOH for 4 hours at 25°C. The residue from this was hydrolyzed with 80% sulphuric acid (w/w). For this, the alkali-extracted residue was taken in 250 ml. Erlenmeyer flasks. 10 ml of 80% sulphuric acid were added to the flask and allowed to act upon the material for two and a half hours. After this, 150 ml of distilled water was added to the flask which was autoclaved at 120°C for 1 hour. The contents were diluted, filtered and oven dried. The loss in weight represented the weight of cellulose. The residual fraction minus the ash content was taken to be lignin [4]. The ash content was determined by igniting the fraction in muffle furnace and weighing the ash left. The separate sample (2 g dry wt.) was extracted with 40% Ammonium oxalate solution. The loss in weight was taken as weight of pectin's.

Results

1. Rate of decomposition of Paddy straw

Assessed the rate of decomposition of paddy straw in the natural environment and it was observed that in the first lot there were four bags named A, B, C and D. The 10 grams of weight was taken initially and in 45 days the highest decomposition was observed in Sample 'A' i.e., 4.34% followed by the series of 100th day, 175th day and 220th day. The higher decomposition is observed in sample A i.e., 3.52% in 100th day, 2.15% in 175th day, 1.51% in 220th day and at 390th day it is 1.11%. More or less same pattern were observed in the sample 'B', 'C' and 'D' (Table.1and Fig. 3).

Table 1: Decomposition of paddy straw sample in soil at different time period

Time period (days)	weight remaining observed in sample /10 g			
	A	B	C	D
0	10	10	10	10
45	4.34±1.53	6.29±0.42	4.93±0.94	7.95±2.08
100	3.52±1.17	5.21±0.52	3.6±1.09	6.43±1.74
175	2.15±1.06	3.29±0.08	3.19±0.02	4.21±1.00
220	1.51±0.63	2.46±0.23	2.14±0.0	2.48±0.34
310	1±0.66	1.7±0.04	1.95±0.29	2±0.34
390	1.11±0.13	1.2±0.04	1.45±0.21	1.32±0.01

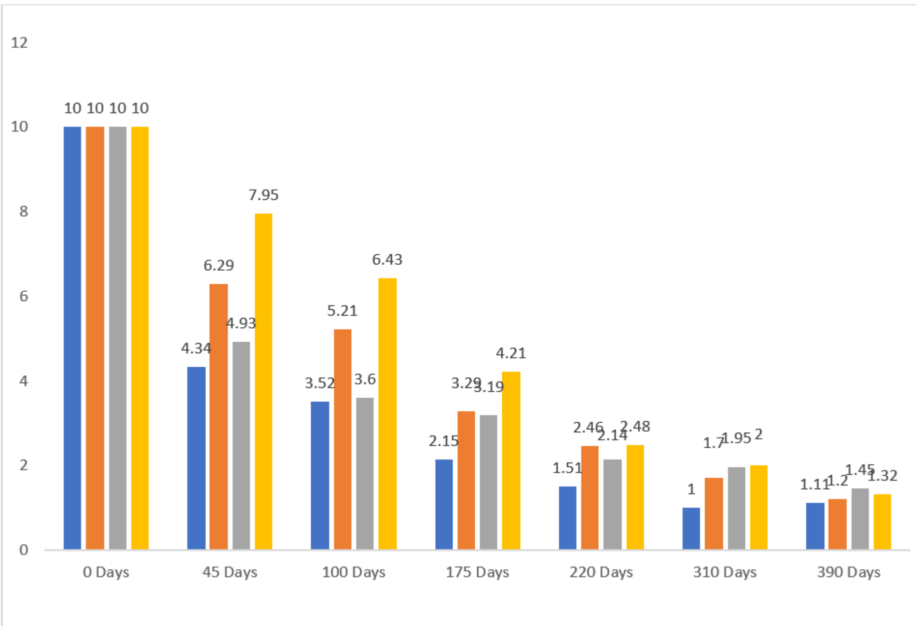

Fig 3: Weight loss during Decomposition of Paddy straw in the natural environment

2.Biochemical changes occur during decomposition of paddy straw

It can be observed that, a good proportion of water-soluble fraction (12-17%) was lost during first 45 days. As the decomposition progressed, the water-soluble substances were lost rapidly; the starch and other hexosans disappeared completely by 175th. The hemicellulose, cellulose and lignin also disappeared about 50% upto 175th days. (Fig.4, Table. 2).

Table 2: Major Biochemical fraction (% initial dry weight) of paddy straw at different stages of decomposition

Sr. No.	Fraction	Days of Decomposition/2g						
		0	45	100	175	220	310	390
1.	Petroleum ether-soluble fat and waxes	0.25	0.2	0.15	-	-	-	-
2.	Cold water soluble (simple sugar, amino acids, peptides and soluble minerals	0.33	0.21	0.2	0.15	0.13	0.1	0.08
3.	Hot water-soluble (starch and other hexosans)	0.21	0.18	0.15	-	-	-	-
4.	Hemicellulose	0.25	0.19	0.18	0.15	0.12	0.1	0.04
5.	Cellulose	0.27	0.17	0.16	0.12	0.1	0.09	0.05
6.	Lignin	0.28	0.16	0.19	0.16	0.11	0.09	0.08
7.	Pectin	0.2	0.15	0.2	0.18	0.15	0.12	-
8.	Ash content	1.02	0.75	0.8	0.42	0.38	0.2	0.18
Total		2	2	2	1.18	0.99	0.7	0.25

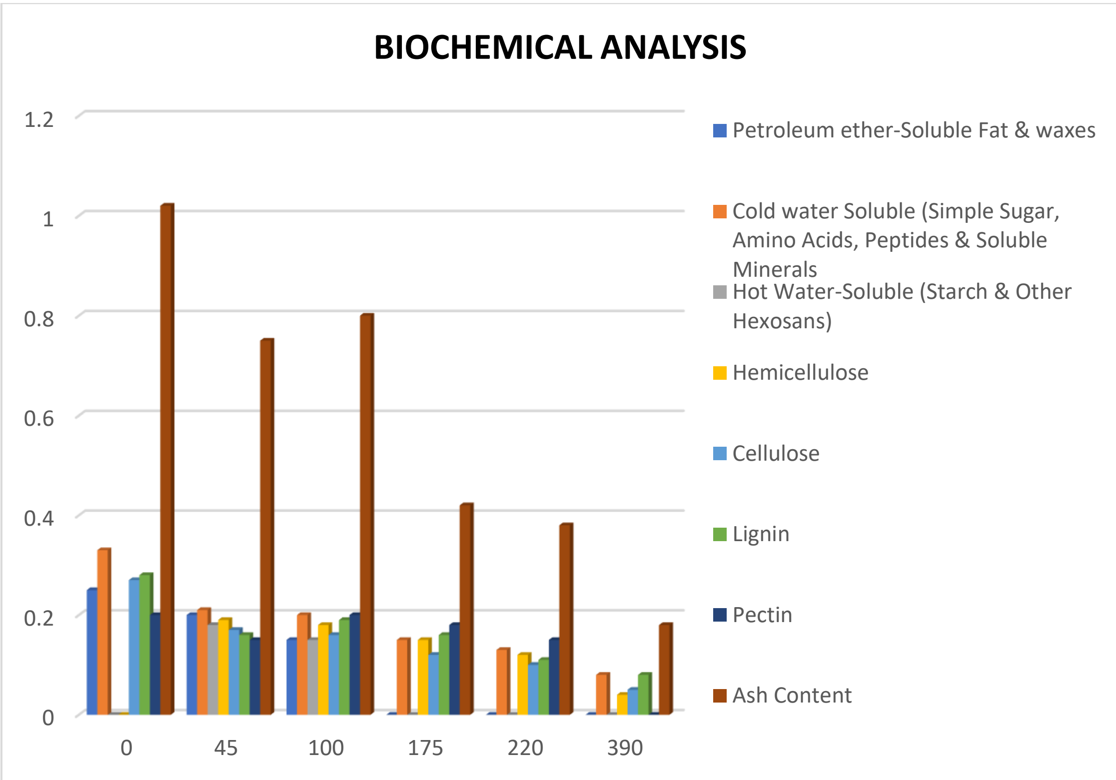

Fig 4: Biochemical changes during decomposition of Paddy straw in the natural environment

Discussion

The decomposition of crop residues depends on their biochemical constituents, microbial decomposer, nutrient availability, which results in the production of stabilized C and N [6,15,21and 26). The soil moisture, temperature and the C/N ratio of crop residue also affect the decomposition of crop residue [2]. The paddy straw residues decomposed at different rates, the results being in conformity with the many workers [1,24] who showed that cellulose and different fractions of the aboveground Phyto mass decay differently. Fast decomposition of sugar and water-soluble substances is ascribed either to leaching or to fast metabolism by coloniser sugar fungi [7,8].The simple sugars, amino acids, peptides etc. also went on decreasing gradually but Inspite of their small concentrations the resources were never free of these; rather, at some places, a rise in sugar concentration occurred as has been observed earlier also [4,9]. This can be explained to be due to the products of hydrolysis of cellulose and other fractions being produced at a rate higher than that of their utilization [11]. Similar explanations had been given by Lawther et al., (1996) [14] to account for the appearance of non-cellulolytic fungi in the decaying pine stumps. Singh et al.,[18,19] found that even such a rapidly decomposing compound as glucose has been found in concentrations of up to 1% in scoots pine needle litter that has been decomposing in the field for up to five years. The scheme of fungal succession proposed by Singh et al., [26] included a place for "associated secondary saprophytic sugar fungi, sharing products of cellulose decomposition." This is an indication that during decomposition, it may happen that the rate at which hexosans and pentoses are formed may exceed the rate of their utilization by the decay fungi. The proportion of hemicellulose lost in the beginning was always more than that of cellulose in general. This is in conformity with the earlier observation made by a number of workers including Kausar et al., (2010) as well as Lawther et al., (1996) and Zhao et al., (2018)[10,12,24]. During decomposition 31.15% and 26.73% of hemicellulose and cellulose were lost respectively in the initial periods. These differences in the rates of decomposition of hemicellulose and cellulose in different resources may be attributed to the anatomical differences between them (Singh et al., 2016; 2017). A substantial proportion of pectin was decomposed in the beginning. (Kausar et al., 2010 and Zhou et al., 2018) [12,14,25] believed good pectolytic activity to be responsible for initial colonisation by the fungi. Earlier, (Wanmolee et al., 2016 and Zhou et al., 2018) [22,25] had pointed out that primary colonizers are the decomposers of the pectin cementing the cell wall. Pectin continued to be degraded gradually and disappeared completely by the sub terminal stage of decay. The lignin constituted the most resistant fraction and decomposed very slowly (Singh et al., 2018) [18]. The present study reveals that a much higher percentage of initial lignin content in 49% in straw remained at the end of the experiment. Similar results were obtained by (Wanmolee, et al, 2016 and Zhou et al., 2018) [22,25]. Thus, the view of several earlier workers including (Bhattacharya et al., 2020 and Guan et al., 2018) [5,10] that lignins are highly resistant and consequently become more abundant in the residual decaying matter, stands vindicated by the present study also Rezgui et l., [26] suggested that the ratio between hemicelluloses and celluloses becomes constant in the later stages of decomposition [13,16,17,20].Therefore, an attempt was made to test whether the results of the present study show any correspondence with the suggestion. The *in-vivo* decomposition of several types of cover crops is a very promising and holistic agricultural method because it is expected to supply a variety of biochemical compounds to the soil, necessary for soil fertility and high yield of crops [3,7,11]. Additionally Soil organic matter or humus contents increases soil aeration, retention of moisture, pH, buffering capacity and cation exchange capacity of soil [8]. This study revealed that biochemical present in the field crop residues are essential constituents to maintain the soil health.

Conclusion

In Haryana and Punjab, the burning of crop residues is the main cause of the environmental pollution. Burning of paddy straw in the open fields leads to the degradation of the soil quality and effect the natural micro-flora. The potential of the degradation of paddy straw is discussed in terms of its biochemical changes that occur during the decomposition of the paddy straw in the natural environment. The decomposition of the paddy crop naturally is important as this is the major point of clash now in between the farmers and government. The decomposition of paddy straw in natural conditions enhance humus contents and helps in improving physical, chemical, and biological properties of soil.

Conflict of interest

There are no conflicts of interest declared by the author.

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