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Biochemical Changes During Solid State Fermentation of Wheat Crop Residues by *Aspergillus flavus* Link and *Aspergillus niger* van Tieghem

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Abstract: In the present investigation authors assessed the biochemical modifications during solid-state fermentation of various ingredients of post harvested wheat crop leftovers by the application of *Aspergillus flavus* Link and *Aspergillus niger* van Tieghem. The post harvested wheat crop residues samples, including internodes, leaves, chaff, and straw, were assembled from a natural field and subjected to different decomposition stages for 40 and 60 days. The collected samples were allowed for biochemical modifications and results compared with undecomposed initial samples. The fungi *A. flavus* caused maximum decomposition of leaves, followed by straw chaff and internodes. The contribution of different fractions to the loss is fat and waxes, followed by simple sugars, amino acids, peptides, minerals, etc., during the first 40 days. In the next 20 days, the decomposition rate increased in wheat leaves, chaff, and straw with peak decomposition or loss of hemicellulose, cellulose, lignin, and pectin. The fungi *A. niger* caused a primary loss in weight of leaves during the first 40 days and followed mixed straw, chaff, and internodes during *in vitro* investigation. The loss in dry weight of internodes at successful experimentation and treatment of 40 days for the decomposition was recorded significantly because of the hemicellulose and cellulose components decomposition. However, pectin decomposition contributed to a reasonable extent to the loss of dry weight than other trace fractions. The components like leaves, chaff, and straw showed the same trends in biochemical changes as well. The partial decomposition of lignin was recorded during this period of investigation. The significance of useful facts was uncovered by performing suitable descriptive and inferential statistics. This study has a socio-economic relevance to managing the agricultural residues as a valuable natural resource for green and sustainable Agri-Farming.

Keywords: wheat crop residues; *Aspergillus flavus; Aspergillus niger;* solid-state fermentation; green natural resources; sustainable Agri-Farming.

1. Introduction

The burning of crop residues is a big problem in modern agriculture, causing air pollution and contributing to global warming. According to the FAO, the post harvested leftovers of the crops might be a monetary asset for agrifarming in the economically rising countries [1]. After harvesting, the components leftover here in the crop field and agriculture

soil system are the principal contributing factors in maintaining health, fertility, nutrients, and augmented organic matters [2, 3]. Thereby the post harvested residues of the crops have found efficiency in augmenting the soil fertility by their availability, biochemical properties, and decomposition. Coulibaly *et al*. evaluated the chemical composition and mechanism of release of nutrients from crop residues and documented the stalk of corns and sorghums, straw of millets, and rice, with higher nitrogen (N) and phosphorous (P) amounts [4]. The decomposition rate of crop residues and nitrogen release were highly affected by environmental moisture and temperature [5]. The application of crop residues increased the soil organic matter and microbial communities to intensify the agricultural system [6] sustainably. The soil aggregation is mainly influenced by the released biochemical during decomposition [7]. According to Halder *et al*., high soluble sugars of residues resulted in transient aggregate stability, but the cellulose's persistent aggregate stability was mainly contributed by the cellulose [8].

The straw of wheat comprises the lignocellulosic materials, including lignin, cellulose, hemicelluloses, pectin, starch, a simple sugar, minerals, fat, and waxes [9]. Therefore, it is essential to find the rate of biochemical changes and type of the natural compound that had degraded during decomposition through *in vitro* investigation. Chang studied and published the modifications in biochemical configurations that occurred in wheat's strw at the time of composting [10]. Charaya has substantiated and documented based on in vitro findings and stated that the alterations and modifications occur in the straw of wheat decomposing out of the soil, at the surface of the soil, and under the soil [11]. Robinson *et al*. have carried out quite a similar study with wheat straw and leaf in UK. Still, no study has been carried out to compare the biochemical changes in all four components (internodes, leaves, chaff, and straw) of wheat crop residues [12]. Emtiazi *et al*. reported that 250 CMC (carboxymethyl cellulose) or endoglucanase was produced during the decomposition of straw [13].

The plant stem (internodes) and the foliar parts (leaves) make the main or gross parts or ingredients of the straw, and it was found to varied immensely in its biochemical structures and physical features as well[14-16]. The wheat spikelet is composed of several flowers that enclose two pieces of chaff or the outer gloms [17]. With increasing mechanization, now wheat ears are harvested, leaving stems and leaves in the field. It would, therefore, be interesting to determine the biochemical changes during their decomposition. Several researches was done to work out the mechanism of microbial pioneering, establishment, growth, reproduction, and richness of fungal communities on a single conjugated post harvested resource, i.e., 'straw' only, as a part of stem including nodes, internodes, and leaves [18-30]. It would, consequently, be fascinating and impressive to ascertain the extent to which the distribution of saprobic fungi varies between different components of the wheat straw (internode, leaves, stem, and chaff) separately with respect to intact straw. Therefore, the present study was planned to investigate biochemical changes during solid-state fermentation of various ingredients of and constituents of post harvested residues of the what crop (for example, straw, leaves chaff, and internodes) individually using *Aspergillus flavus* and *A. niger* as a potential decomposer for the eco-friendly management of the agricultural residues, as a valuable natural resource to promote green and sustainable Agri-Farming.

2. Materials and Methods

The crude and natural post harvested residues of the wheat crop in the form of budles were collected from the rural area of village Kanauja, Ghaziabad (Uttar Pradesh), India. The

components of the residues were segregated into three groups: internodes, leaves, and chaff. The mixed residues were placed in different groups of bundles and used as a combined material during *in vitro* investigation. Therefore, four types (internodes, leaves, chaff, and straw) of substrates were used during *in vitro* investigation.

2.1. Preparation of samples.

The potential of screened and targeted fungi to biochemically break down crop residues has been determined *in vitro* by modifying the methods proposed by Hering [31] and Ivarson [32]. The wheat internodes, leaves, chaff, and combined straw were chopped into smaller pieces and air-dried completely. The 2 g- of each residue were placed in the 24 Erlenmeyer conical flasks (250 ml). Amongst these, 6 flasks contained wheat internodes, 6 flasks with wheat leaves, 6 flasks comprising wheat chaff, and 6 flasks with the combined straw. Out of these 6 flasks of each residue set, 4 were treated as experimental flasks and 2 as control flasks during the investigation.

2.2. Inoculation and incubation.

The test fungi *Aspergillus flavus* and *A. niger* were isolated from decomposing wheat crop residues in natural conditions and cultured separately on Czapek's Dox Agar (CDA) media after correct identification. After the successful mass culture, the surface growth of individual species was removed with a sterile spatula and mixed thoroughly in two separate flasks (250 ml of capacity) containing sterile distilled water (150 ml). The 10 ml of *A. flavus* inoculum was added centrally into two flasks, and likewise, 10 ml inoculum of *A. niger* was also added into the two flasks of four residue sets. All the flasks [16 experimental (8 flasks with 2 of each residue for *A. flavus* and 8 flasks with 2 of each residue for *A. niger*) and 8 flasks (2 of each residue) control] were incubated at 25±1^{o}C in a BOD incubator for 40 days and 60 days. When the experiment was successfully completed, the flasks were Hot Air Oven (HAO) dried at 70 ^{o}C, for 48 hours, and finally, the dry weight of the residues was recorded using monpanic balance. The index of the efficiency of the experimental fungus was enumerated by subtracting the loss in the weight of inoculated flasks from the loss in the control flask was taken as an index of the capacity of the test fungus to decompose the particular residue. Biochemical modifications during the degradation of crop residues were estimated using the quantitative biochemical analysis method proposed by Waksman [33], modified by Waksman and Stevens [34], and Gentry and Zuberer [35].

3. Results

It was apparent from Table 1, that *Aspergillus flavus* brought about the highest degradation of leaves (19.62%, 32.86%) followed by straw (18.40%, 24.02%), chaff (15.58%, 18.94%), and internodes (08.19%, 10.75%) during 40 and 60 days of estimation. Wheat internodes lost as much as 8.19% of their dry weight in 40 days. The contribution of different fractions to the loss were recorded as petroleum ether-soluble fraction (0.83%), water-soluble fractions (0.37%), hemicellulose (4.04%), cellulose (2.32%), lignin (0.33%) and pectin (0.29%). Thus, loss in hemicellulose and cellulose mainly accounted for the loss in the dry weight of internodes due to *A. flavus* initially. In the next 20 days, the rate of decomposition was slowed down markedly; only 2.66% of internodes were decomposed during this period; however, the other fractions underwent slight decomposition.

As much as 19.62% decomposition was observed in wheat leaves inoculated with *A. flavus*. The contribution of different fractions to this loss in dry weight being: petroleum ether fraction (0.87%), water-soluble fractions (7.7%), hemicellulose (2.62%), cellulose (5.38%), lignin (0.15%) and pectin (2.91%). Thus, a major proportion of decomposed components comprised water-soluble fractions and cellulose. The decomposition of lignin was almost negligible throughout the investigation. In the next 20 days, the decomposition rate increased so that as much as 13.24% loss in the dry weight of leaves occurred. During this time, the losses in hemicelluloses (6.12%) and cellulose (4.16%) comprised a major share of the decomposed component (10.28%), the rest of the components undergoing only slight or meager decomposition.

Inoculation of chaff with *A. flavus* resulted in a loss of 15.58% in its dry weight during the first 40 days. Most of it was due to the loss of hemicellulose (7.81%), cellulose (3.76%), and pectin (2.28%). These three components accounted for 13.22% of decomposition during the first 40 days. In the next 20 days, the decomposition rate slowed down very much, and only 3.36% of the dry weight of chaff was lost. Slight decomposition occurred in all the fractions with a bit greater in the case of hemicellulose (1.19%) and pectin (1.0%).

Inoculation of mixed straw with *A. flavus* resulted in a loss of 18.4% of dry weight during the first 40 days. A major proportion of this was due to the decomposition of hemicellulose (9.68%), cellulose (3.92%), water-soluble fractions (2.94%), and pectin (1.08%). During the next 20 days, the decomposition rate slowed down substantially, and only a 5.62% loss in dry weight of straw occurred. The loss of cellulose (2.0%), hemicellulose (1.71%), and pectin (1.19%) accounted for most of the decomposition of straw during this period.

Table 1. Biochemical fractions (% dry weight) in wheat crop residues inoculated with *Aspergillus flavus.*

S. No.	Fractions	Days	Wheat crop residues			
			Internodes	Leaves	Chaff	Straw
1.	Petroleum ether-soluble fraction (fat and waxes)	00	1.05	1.10	1.10	1.05
		40	0.22	0.23	0.21	0.22
		60	0.18	0.14	0.15	0.15
2.	Cold water-soluble fraction (simple sugars, amino acid, peptides, minerals)	00	6.70	9.80	2.56	7.02
		40	6.50	3.00	1.52	4.80
		60	6.30	1.89	1.49	4.30
3.	Hot water-soluble fraction (starch, pectin, hexosans)	00	0.69	4.31	0.81	1.70
		40	0.52	3.41	0.48	1.58
		60	0.45	2.17	0.45	1.54
4.	Hemicellulose	00	19.86	23.45	31.75	28.54
		40	15.82	20.83	24.57	18.68
		60	14.97	14.71	23.28	16.97
5.	Cellulose	00	54.89	48.70	55.05	49.86
		40	52.57	43.32	51.29	45.94
		60	51.84	39.16	50.62	43.94
6.	Lignin	00	13.17	4.85	3.68	7.55
		40	12.84	4.72	3.59	7.19
		60	12.69	4.59	3.31	7.08
7.	Pectin	00	3.13	6.65	4.17	3.55
		40	2.84	3.74	1.89	2.47
		60	2.31	2.35	0.89	1.28
8.	Ash content	00	0.51	1.14	0.88	0.73
		40	0.50	1.13	0.87	0.72
		60	0.51	1.13	0.87	0.72
Total		00	100.00	100.00	100.00	100.00

S. No.	Fractions	Days	Wheat crop residues			
			Internodes	Leaves	Chaff	Straw
		40	91.81-8.19	80.38-19.62	84.42-15.58	81.60-18.40
		60	89.25-10.75	67.14-32.86	81.06-18.94	75.98-24.02

As was revealed in Table 2, inoculation with *Aspergillus niger* caused a maximum loss in the weight of leaves (20.12%, 34.95%), followed by the mixed straw (16.80%, 25.33%), chaff (13.30%, 23.33%), and internodes (9.85%, 15.39%) after 40 days and 60 days of incubation. The loss in the dry weight of internodes in the 40 days of experimentation for the biochemical decomposition was recorded and documented principally because of the breakdown of hemicellulose and cellulose. However, a reasonable extent is due to the loss of pectin. The losses in other fractions contributed little quantities to the decomposition of internodes. In the subsequent 20 days, the decomposition rate was slightly slower, and only 4.46% of losses occurred in the dry weight of internodes. Interestingly, all the fractions of the internodes underwent losses to a reasonable extent, except cellulose and lignin, which underwent only negligible decomposition during these last 20 days.

A 20.12% reduction in the dry weight of wheat leaves was observed due to inoculation with *A. niger* in the first 40 days, most of which was due to the degradation of hemicellulose, water-soluble fraction, cellulose, and pectin. The lignin fraction did not appear to have undergone decomposition during this period. The decomposition continued faster during the next 20 days, along with all the fractions, though cellulose and hemicellulose decomposition rates decreased considerably. Lignin also decomposed only slightly during this period.

Table 2. Biochemical fractions (% dry weight) in wheat crop residues inoculated with *Aspergillus niger.*

S. No.	Fractions	Days	Wheat crop residues			
			Internodes	Leaves	Chaff	Straw
1.	Petroleum ether-soluble fraction (fat and waxes)	00	1.05	1.10	1.10	1.05
		40	0.82	0.57	0.50	0.53
		60	0.30	0.21	0.29	0.18
2.	Cold water-soluble fraction (simple sugars, amino acid, peptides, minerals)	00	6.70	9.80	2.56	7.02
		40	5.89	5.48	1.56	5.90
		60	5.20	2.43	1.55	4.73
3.	Hot water-soluble fraction (starch, pectin, hexosans)	00	0.69	4.31	0.81	1.70
		40	0.46	3.31	0.50	1.33
		60	0.37	2.98	0.45	1.30
4.	Hemicellulose	00	19.86	23.45	31.75	28.54
		40	16.88	16.67	25.98	21.43
		60	14.33	11.24	20.53	18.17
5.	Cellulose	00	54.89	48.70	55.05	49.86
		40	50.70	44.07	49.70	43.85
		60	50.53	41.16	47.30	41.29
6.	Lignin	00	13.17	4.85	3.68	7.55
		40	12.96	4.92	3.61	7.26
		60	12.46	4.57	3.59	7.15
7.	Pectin	00	3.13	6.65	4.17	3.55
		40	1.94	3.74	3.96	2.18
		60	0.92	1.34	2.11	1.13
8.	Ash content	00	0.51	1.14	0.88	0.73
		40	0.50	1.12	0.87	0.72
		60	0.50	1.12	0.87	0.72
Total		00	100.00	100.00	100.00	100.00
		40	90.15-9.85	79.88-20.12	86.70-13.30	83.20-16.80

S. No.	Fractions	Days	Wheat crop residues			
			Internodes	Leaves	Chaff	Straw
		60	84.61-15.39	65.05-34.95	76.67-23.33	74.67-23.33

About 13.30% of the chaff got decomposed during the first 40 days due to *in vitro* inoculation of *A. niger*. Substantial losses in the dry weights of all the fractions contributed to it, except lignin and pectin, which decomposed slightly only. The decomposition rate augmented in the next 20 days due to the utilization of principally hemicelluloses, cellulose, and pectin to a considerable extent. The lignin, water-soluble, and petroleum ether-soluble fractions did not contribute much to the loss.

Straw inoculated with *A. niger* lost about 16.80% of its dry weight. The hemicellulose (7.11%), cellulose (6.01%), the water-soluble fraction (1.49%), and pectin (1.37%) mainly contributed to this loss. Lignin and petroleum ether-soluble fractions were utilized to a very small extent only. In the next 20 days, the decomposition rate was maintained, and all the fractions underwent moderate decomposition, except lignin, whose weight was reduced slightly only.

3.1. Descriptive analysis.

The Main-Effect plot was chalked out to visualize the clear impact of each factor by varying it independently while making the other factors fixed at a certain value (Figure 1). The *A. niger* seemed to be dominating the *A. flavus* by holding other factors at some favorable values. Maximum decomposition occurs in the first 40 days, and the decomposition rate decreases linearly between 40 days and 60 days. As far as crop parts were concerned, the third panel of the Main-Effect plot depicted the descending order of decomposition as; leaves>straws>chaffs>internodes, respectively. More than a 10% reduction in decomposition rate was found by just varying the type of crop residues from leaves to internodes by taking the other factors' constants.

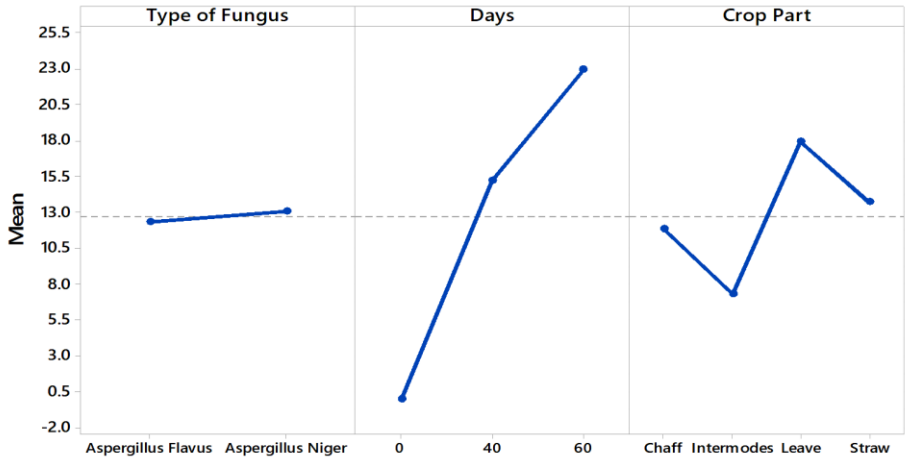

Figure 1. Main-effect plot of decomposition (%) for an overall biochemical fraction of wheat crop residues.

The Multi-vary chart of percentage residues decomposition for overall biochemical fraction by varying the considered factors indicated the high impact of *A. niger* compared to *A. flavus*, irrespective of various crop parts (Figure 2). Moreover, it also uncovered that *A. niger* decomposition continued more actively even after 40 days (i.e., up to 60 days) as compared to *A. flavus*, except in the case of leaves. Therefore, maximum decomposition took place in leaves, whereas internodes had the least decay in 60 days. The straws and chaffs had almost similar

decomposition rates with the inoculum of both fungi. The dashed red line highlighted the impact of fungi on various crop residues. However, and continuous green line described the overall influence of time and fungi corresponding to different crop residues.

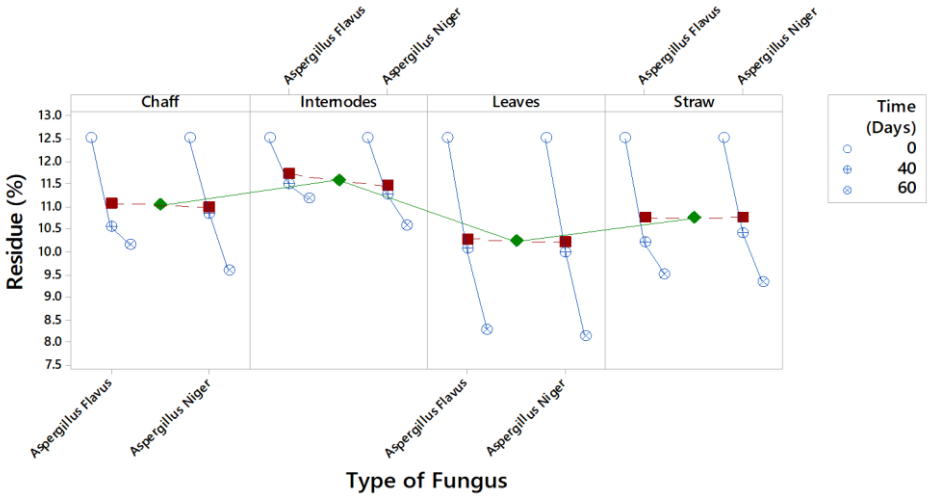

Figure 2. Multi-vary analysis for wheat crop residues (%) corresponding to time and inoculated fungi.

3.2. Regression analysis.

The descriptive analysis only analyses the sample data taken, but the results could not be deduced with a certain degree of confidence for the general population without the help of some appropriate hypothesis testing. So to predict inferences from the above study with 95% confidence, Regression analysis was carried out using statistical software called 'Minitab' (Table 3). The p-value of the Fitted Regression-Model came out to be 0.000 (less than 0.05) and around 99.8% with S=0.707193, R-sq=99.87%, R-sq(adj)=99.8%, R-sq(pred)=99.74%, which made it statically significant with 95% surety and evaluated its predictive correctness up to sufficient limit.

Table 3. Regression analysis at different degrees of freedom using Fitted Regression-Model.

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	64	47966.9	749.484	1498.60	0.000
Time (Days)	1	0.0	0.000	0.00	0.988
Type of fungi	1	0.5	0.491	0.98	0.324
Fractions	7	6075.6	867.944	1735.46	0.000
Crop residues	3	0.5	0.151	0.30	0.824
Time (Days)*Fractions	7	90.8	12.967	25.93	0.000
Time (Days)*Crop residues	3	0.0	0.000	0.00	1.000
Fractions*Crop residues	21	447.8	21.323	42.63	0.000
Time (Days)*Fractions*Crop residues	21	44.2	2.104	4.21	0.000
Error	127	63.5	0.500		
Total	191	48030.5			

The regression model had formulated statistical equations to calculate residue (%) for each fraction of wheat crop as a function of time. The magnitude of time coefficient would signify about the importance of time for decomposition with respect to % residue of each fraction through regression equations [ash content ($0.814-0.0002X_1$), cellulose ($52.086-0.1072X_1$), cold-water-soluble fraction ($6.484-0.0512X_1$), hemicellulose ($25.962-0.1510X_1$), hot water-soluble fraction ($1.880-0.0110X_1$), lignin ($7.329-0.0061X_1$), pectin ($4.452-0.0459X_1$), petroleum ether-soluble fraction ($1.058-0.0149X_1$)]. These equations defined around 99.8% of the variability in the residue (%) with 95% confidence. The residue (%) can

be assessed with these model equations at any time value for any wheat crop's biochemical fraction.

3.3. Interactions analysis.

During Descriptive analysis, time, type of fungi, and type of crop residue seemed to be important factors. However, decomposition was questionable. These factors were not so dominating or statistically significant because of their respective p-values of more than 0.05. But the Two-way and Three-way interactions (when these factors varied in combinations) were extracted as a statistically important tool, as corresponding p-values were less than the deciding limit. It implied these factors became important when varied together or in combinations, so their indirect impact should not be ignored. In order to understand further, critical factor combinations were worked out through an interaction plot (Figure 3). The first plot described the interaction of time and fraction, which seemed to be critically important as lines plot were crossing each other. Similarly, the interaction of time and type of crop residue (crop part) also showed a lot of crossings and justified its lower p-value. The interaction profile for fraction and type of crop residue (crop part) was highly crisscrossing and defined its statistical importance.

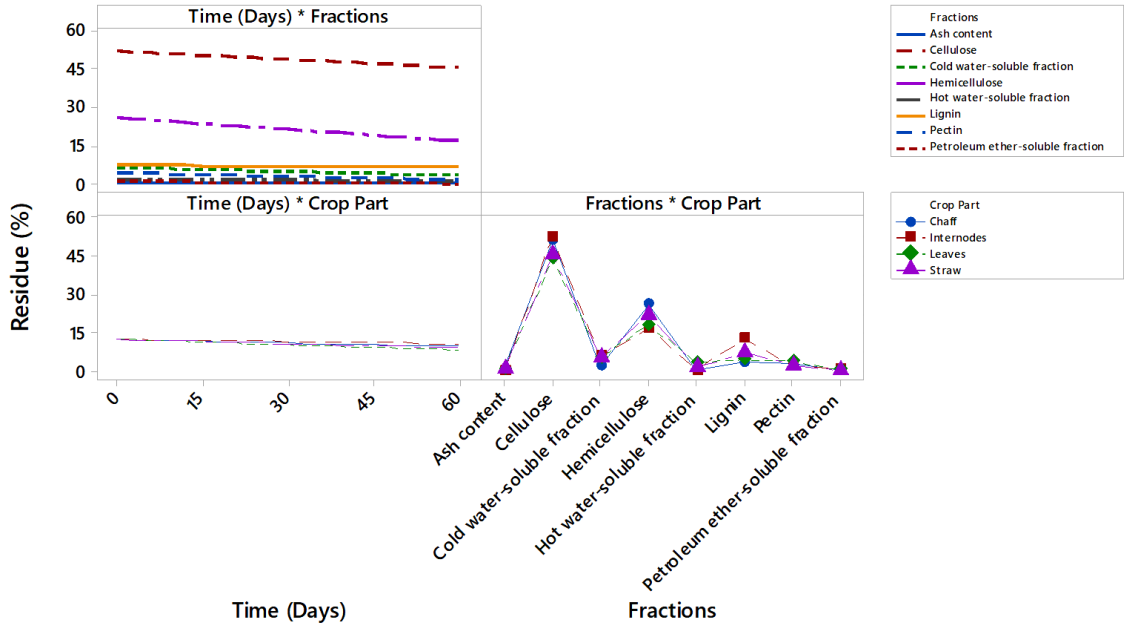

Figure 3. The critical factor-combinations (time, fraction, and crop part) analysis through interaction plots.

3.4. Box-plot analysis.

The fraction or chemical content erupted as the most significant factor, which was assessed as highly impactful due to a 0.000 p-value. The wheat crop decomposition more or less depended upon the decomposition of its fractions. These fractions had their behavior while using different fungi as potential agents for solid-state fermentation of various crop parts with varying decomposing times. The box plot delineated the trend of residue (% residue) left for various existing wheat crop fractions (Figure 4). It showed ash content and petroleum-ether soluble fraction had maximum decomposition by leaving less than 1% of residue after 60 days. The cellulose (48%) and hemicellulose (20%) had high residue with many variations in their decomposing rates. The box height of lignin also predicted variable decomposition behavior, as mean and median slightly deviated from each other. The large standard deviation in the case

of the cold-water-soluble fraction was also uncovered and signified the uncertain decomposing rate.

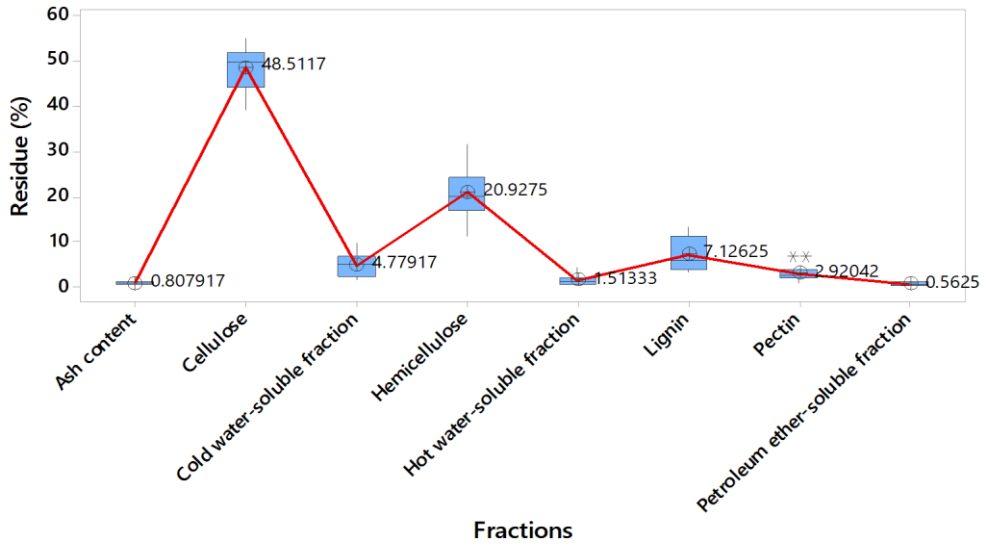

Figure 4. Box-plot analysis showing residue (%) box left for various existing wheat crop fractions.

4. Discussion

The decomposition rate varied not only from species to species but from resource to resource also. These results revealed that *Aspergillus flavus* possessed good cellulolytic, hemicellulolytic, and pectolytic ability though it lacked ligninolytic ability. It was found to be a slower decomposer of internodes and leaves among the fungal species studied [11,12, 36]. The utilization of cellulose and hemicellulose, water-soluble fraction, and pectin mainly accounted for the decomposition of crop residues inoculated with *A. flavus*. These observations also match with the biochemical potential of the fungus as A. flavus degraded negligible lignin. Both the straw and chaff have a greater amount of hemicellulose, and *A. flavus* has utilized a substantial amount of hemicellulose in chaff and straw. A substantial quantity of pectin was also degraded by *A. flavus.* It is quite possible that the greater pectolytic ability of the fungus aided in degrading a greater amount of hemicellulose by bringing about greater exposure of cell wall materials by degrading cementing material. *A. niger* lacked ligninolytic potential but possessed fairly moderate cellulolytic and pectolytic abilities and good hemicellulolytic potential. The crop residues inoculated with these fungi also decomposed all the fractions except lignin. The slower decomposition rate by *A. niger* may be attributed to the slow spread over litter in the initial phase followed by a considerable activity, as was observed by Frankland in the case of *Mycena galopus* [37]. The lignocellulolytic microbes played a significant role in the conversion of crop residues into different biochemical [38]. *Trichoderma lignorum* has been highly cellulolytic but could not cause much decomposition compared to the other fungi that possess lesser cellulolytic ability [39]. *A. terreus* decomposed the substrate at a faster rate and utilized lignin [40].

The findings reflected that *A. flavus* encompassed vigorous cellulolytic and pectolytic efficiency and exemplary fats, waxes, simple sugars, amino acids, peptides, and starch consuming characteristics. Thus, the observations above of degressions are more associated with its efficient cellulolytic potential. Cox *et al*. also observed that in the pine needles inoculated with *Trichoderma viride*, mass loss of carbohydrates was greater than lignin [41]. Several works of literature have observed similar results corroborated to the current investigation's findings [42-46]. Hatakka reported that the *Pleurotus* species decomposed the

lignin factor of wheat straw as well [47]. Veeken *et al*. reported that biomacromolecules showed different degradation rates during 4 weeks of composting, aliphatics, hemicelluloses and protein degraded faster than cellulose and lignin [48]. Feng *et al*. documented that applying ligninolytic enzyme on the lignocellulosic wastes has augmented the dedecomposition ratio of lignin and hemicelluloses by 5.24% and 11.74%, respectively [49]. According to Rajendran and Kathiresan, the concentration of nitrogen increased significantly with decomposition in the leaves of *Rhizophora apiculata* and *Avicennia marina*; changes were also observed in tannins and total amino acids, and sugars [50].

In most of the studies carried out earlier, the polysaccharolytic abilities of decomposer fungi and the overall rate of decomposition of the plant litters were taken into account so far. The ligninolytic, hemicellulolytic, and pectolytic activities of microorganisms during the decomposition of wheat straw and their components in natural conditions were observed [51-56]. The losses in components fractions were not given much attention. In the present study, not only was the capacity of selected fungal species to degrade wheat residues as a whole, but the degradation of different components and their enzyme potential *in vitro* was studied as well. With a few exceptions, it was possible to correlate the losses in different fractions of the residues with the biochemical potential of the colonizing fungal species. As for the exceptional cases where the two aspects do not corroborate, it must be mentioned that many workers have observed that some fungi known to be strong producers of a given enzyme *in vitro* may not be able to colonize a given substrate. The usual methods of testing for enzyme activity do not necessarily correlate with the abilities of the organisms in relation to the decomposition of tissue [57]. For example, *Trichoderma viride* is known to be an active producer of some of the most active cellulose systems [58]. But when inoculated on plant materials such as oak leaves, no cellulose breakdown was demonstrable [23]. The release of various biochemicals during the decomposition of wheat straw and their components in natural conditions depends on microorganisms' ligninolytic, hemicellulolytic, and pectolytic activities [51,52,54-56]. In the present study, *A. flavus* and *A. niger* have been found to be highly cellulolytic but could not cause much decomposition compared to the other fungi that possess the lesser cellulolytic ability.

The exploration literature and their comparative account with the current investigation showed that the decomposition of crop residues depends on their biochemical constituents, microbial decomposer, and nutrient availability, which results in the production of stabilized carbon (C) and nitrogen (N) [59-62]. The soil moisture, temperature, and the C/N ratio of crop residue may also affect the decomposition of crop residue [63]. Dash *et al*. found that microbial consortium has decomposed the rice straw faster at a reduced C:N ratio, lignin, hemicellulose, and cellulose constituents [64]. The enhanced addition of rice residues resulted in reduced weed density and helped improve the soil's physical, chemical, and biological characteristics [65]. The *in situ* decomposition of various cover crops can be a very promising and holistic agricultural method because of a more than expected supply of immense biochemical constituents to the soil, necessary for soil fertility and high yield of crops [66-68]. Additionally, soil organic matter or humus contents were also helpful in increasing the soil aeration, retention of moisture, pH, buffering capacity, and role of soils in cation exchange [69]. Therefore, the present study revealed that biochemical constituents present in crop residues and their effect on the decomposition using microflora would give a new dimension for eco-friendly management of the field crop residues that supply the essential constituents to

maintain the soil health, fertility, decomposers diversity necessary to broken the lignocellulosic bond.

5. Conclusions

There was sufficient variation in the capability of different fungal species to decompose different resources under consideration. The decomposition rate varied not only from species to species but from resource to resource also. Interestingly, the same resource was often decomposed by a given fungus faster in the first 40 days and by a different fungus in the subsequent 20 days. In the present study, not only was the capacity of selected fungal species to degrade wheat residues as a whole but also the degradation of different components and their enzyme potential in vitro worked out. Multiple regressions have given deep insights and modeled required equations for residue (%), which can have huge scope for associated practitioners and researchers. This study would help determine the bioinoculant according to their potential for degradation of specific biochemical constituents of agricultural residues in the interest of the environment because residue burning is a big problem in India and other countries. The authors wish to propose the socio-economic relevance of the current study in the management the post harvested agricultural residues as a valuable natural resource to soil fertility for green and sustainable Agri-Farming.

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Conflicts of Interest

The authors declare no conflict of interest.

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