Decomposition of Litter and Role of Thermophilic Fungi

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ABSTRACT

Thermophilic and mesophilic fungi play key role in leaf litter decomposition as they are capable of actively decomposing lignin and other components in ecosystems it reflects the quality of maturing compost. The succession of thermophilic and thermotolarent fungi in decomposing leaf litter of H. suaveolensis, orange fruit-peel, wood chips, paddy straw and mixed leaf litter was studied. Percentage of incidence and frequency of both mesophilic and thermophilic fungi and physico-chemical changes were recorded during different stages of litter decomposition.

Keywords: mesophilic fungi, thermophilic fungi, decomposition, percentage of incidence physico-chemical changes

INTRODUCTION

Decomposition of organic matter is an aerobic exothermic degradation of plant litter resulting in partial mineralization and profound organic transformations due to the metabolism of complex microbial population dynamic changes in temperature, moisture content, oxygen concentration and nutrient availability. These factors, inturn, strongly affect the structure and diversity of the microbial community and their activities and the physical and chemical characteristics of the substratum [1]. The result of such a process is a biologically stable and humified end product, the compost, which can be applied in agriculture (fig.1).

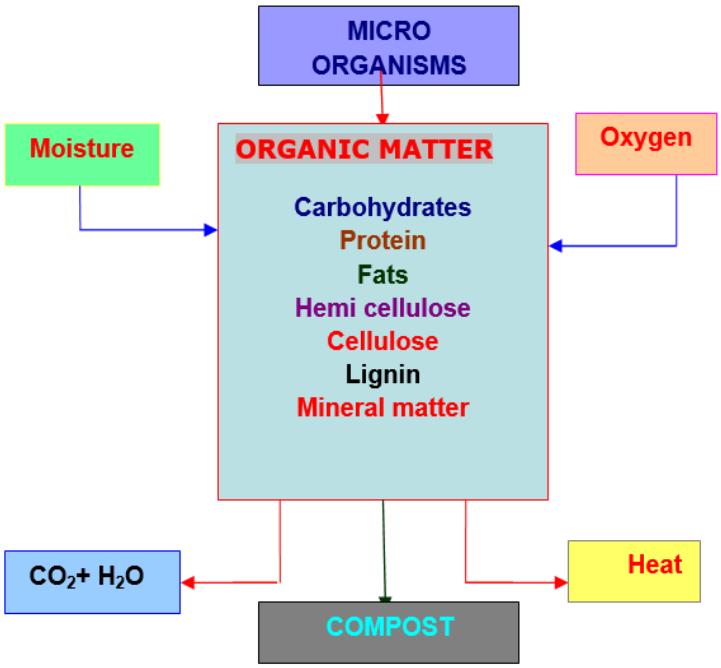


Fig.1. Basic concept of decomposition

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In the process succession of microorganisms such as thermophilic and mesophilic microorganisms take part leading to the humus formation. Micro-and macro arthropods and other animals contribute their part in the process.

Therefore, monitoring of the microbial succession for the effective management of the decomposition process is of prime importance. This process of decomposition of dead plant material and liberation of nutrients has great relevance soil fertility and its productivity [2]. This increased knowledge of about the interaction between changes in the composition of organic matter and microbial populations is of vital importance. Although general tendencies with regard to thermophilic and mesophilic micro-organisms populations of have been identified during decomposition, monitoring of the microbial succession is very important in the effective management of the decomposition process as microorganisms play key role in the process and the appearance of some micro-organisms reflects the quality of maturing compost [3]. Litter decomposition by soil fungal community was excellently reviewed by [4]. In the present investigations interaction of thermophilic and mesophilic microorganism during decomposition of different plant material was studied and discussed in this communication.

MATERIAL AND METHODS

The decomposition of leaf litter of Hyptis suaveolensis orange fruit peels, wood chips paddy straw and mixed plant litter in relation to thermophilic fungi was studied. Fixed quantity of respective decomposing litter was buried in a soil by arranging wired mesh and covered by a layer of soil. The moisture of litter material was maintained by sprinkling the fixed quantity of water at regular intervals. The decomposing litters were analyzed at regular intervals for three months to investigate the fungal population by employing the petri plate method was analyzed [5], dilution plate by employing PDA medium. The paired petri plates with PDA medium thus prepared were incubated at 45± 2ºC for 5 days. The colonies appeared were picked up and sub cultured on the same medium. The purified cultures ware identified with the help of standard manuals [6, 7, 8, 9].

Simultaneously, physico-chemical changes in decomposing litter were also analyzed at 3 months intervals for one year by standard methods. Temperature, pH, ash content [10], cellulose [11], total nitrogen [10] and lignin content [12] were also determined. The number of colonies of each species appearing in a petri plate was counted from which percentage of incidence and percentage of frequency were calculated by the following formula.

$$\text{Percentage of Incidence} = \frac{\text{No. of colonies of a species in all the plates}}{\text{Total no. of colonies of all the species in all the plates}} \times 100$$

$$\text{Percentage of Frequency} = \frac{\text{No. of observations in which a species appeared}}{\text{Total no. of observations}} \times 100$$

Following methods used to check the Physico-chemical changes

pH: Ten grams of decomposing material was taken and cut into small pieces and shaken in 100 ml of distilled water for 30 minutes. The pH of the decomposing material was determined either with the help of Elico pH meter.

Moisture: Hundred grams of decomposing leaf material was dried at 105 ℃ for 48 hours and cooled in a desiccator and weighed to a constant weight and expressed moisture in percentage of weight loss.

Ash content: Total ash content of decomposing material of wood chips, orange peels and leaf material of H. suaveolensis was estimated by using two grams of oven dried sieved sample was weighed into porcelain crucible and kept in a muffle furnace at 558 ℃ for 2 hours. The ash content was weighed after cooling the sample in a desiccator and expressed in mg.

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Cellulose: Cellulose content of decomposing material was determined by weighing five grams of oven dried sample was refluxed for 1 hour with alcoholic nitric acid (10 ml of ethyl alcohol and 2.5 ml of concentrated nitric acid) in a soxhlet extractor and the residue was filtered off and heated with water for 30 minutes followed by extraction with a mixture of 4% NaOH and 4% sodium sulphite for three times for a period of 40 minutes. The residue was then dried at 105 ℃ for 20 minutes and weighed to a constant weight after cooling. The results are expressed in percentage of cellulose in decomposing materials.

Total nitrogen : Turbido metric method was employed for estimating total nitrogen of decomposing material of orange peels, wood chips and decomposing leaf material of H. suaveolensis . Hundred mg of leaf material was taken in 100 ml Kzeldahal flask to which 2 ml of digestion reagent (50 ml of concentrated sulphuric acid diluted with 100 ml of distilled water and then 1 gram of selenium-di-oxide was dissolved) was added and 2-3 glass beads were also taken and then heated until chocolate brown or pale- green solution is resulted. It was subsequently cooled and then diluted with distilled water to make 250 ml. To 1 ml of digested solution, 0.5 ml of Rochelle salts solution was added and the volume was raised to 6 ml by adding nitrogen free water. One ml of Nesslers solution was added and intensity of yellow colour thus developed was read at 480 nm in colorimeter. The amount of nitrogen was read from the standard curve. The total protein nitrogen was also calculated by multiplying the total nitrogen with 6.3.

Lignin content: The lignin content of decomposing material was estimated by weighing one gram of oven dried sieved leaf material was extracted for 6 hours using ethanol: benzene (1:1) solvent. The residue was washed thoroughly with hot water using suction pump and then dried. The dried material was taken in a glass crucible to which 13 ml of 72% H_2SO_4 was added for hydrolysis. It was diluted and refluxed on hot water both for 6 hours. The residue was washed with hot water several times and dried at 105 ℃ for 24 hours and then weighed to a constant weight after cooling in desiccator.

Results and discussion

The succession of thermophilic and thermotolarent fungi in decomposing leaf litter of Hyptis suaveolensis was studied and results are presented in table 1.

Table 1 and fig 2 reveals that the incidence of different fungi in decomposing leaf liter of H. suaveolensis varied with the progress of decomposition. In all ten fungal species representing 3 genera of fungi could be recorded. A. fumigatus was dominant while reverse was true with A. nidulans and A. terreus as their population increased with the progress of decomposition leaf liter of H. suaveolensis. A. flavus and A. fumigatus were with high incidence during early phase of decomposition, but disappeared at later stages. Thermomyces lanuginosus and Humicola gresia became dominant during active decomposition as a result of increased temperature. Voriskova and Baldrian [13], observed rapid successional changes in decomposing of leaf litter studied by them.

Table 1: Succession of thermophilic fungi in decomposing leaf litter of Hyptis suaveolensis

	Incubation period (four months interval)							
	November 2025		February 2026		May 2026		August 2026	
Name of the fungus	P.I	P.F	P.I	P.F	P.I	P.F	P.I	P.F
Aspergillus fumigatus	84.0	73.0	20.0	2.0	30.0	20.0	10.0	5.0
A. nidulans	5.0	10.0	50.0	30.0	20.0	40.0	20.0	50.0
A. terreus	3.0	1.0	10.0	25.0	10.0	5.0	50.0	10.0
A. flavus	2.0	12.0	--	--	32.0	15.0	--	--
Aspergillus fumigatus	2.0	0.5	9.0	25.0	8.0	20.0	--	--

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Aspergillus niger	2.0	1.0	5.0	5.0	--	--	--	--
Aspergillus spp.	2.0	2.5	5.0	7.0	--	--	--	--
Thermomyces lanuginosus	--	--	1.0	3.0	--	--	10.0	20.0
Humicola gresia	--	--	--	--	--	--	10.0	15.0

P.I = Percentage of incidence; P.F. Percentage of frequency

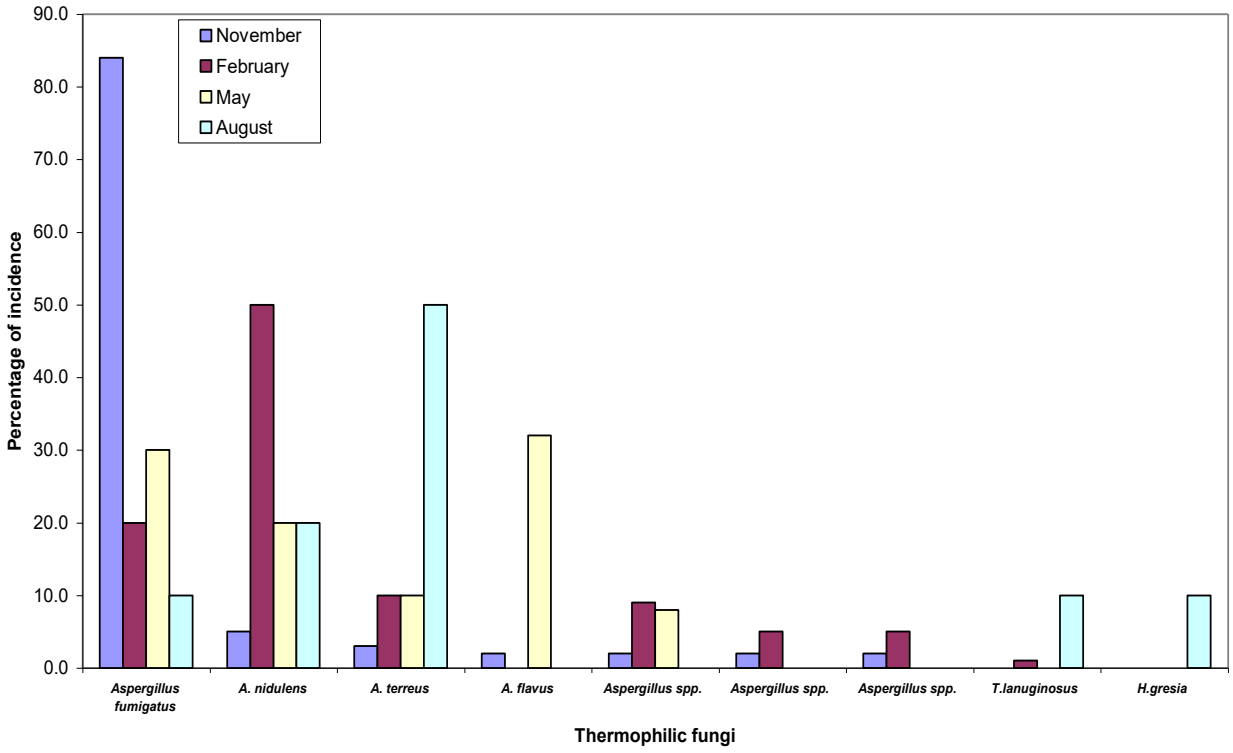


Fig 2. Succession of thermophilic fungi in decomposing leaf litter

From table 2 it is clear that the pH of the decomposing leaf material changed with the progress of decomposition period. The pH changes were within the range of 4.5 to 6.0. The pH which was 5.8 at 0-day rose to 6.0 by 3rd month which, however, remained almost constant up to 6th month. The acidity increased after 9th month and pH recorded was 4.5 by the end of the decomposition period. The comparison of pH changes with the fungal population in leaf litter of H. suaveolensis revealed no positive correlation. The moisture content of decomposing leaf litter decreased with the progress of incubation. However, by the end of leaf litter decomposition, the moisture content of decomposing leaf litter of decreased to a minimum. Ing general the ash content decreased with the progress of leaf decomposition. The cellulose content of decomposing leaf also decreased with advancement of leaf decomposition. Similar was the case with the lignin. The decrease in lignin content was insignificant in the later stage of decomposition. It was observed that total nitrogen and protein nitrogen content decreased gradually with the progress of decomposition.

Table 2. Physico-chemical changes in decomposing leaf litter of Hyptis succlensis

Month	pH	Moisture (in %)	Ash content (in mg)	Cellulose (per 1 gr)	Lignin (per 1 gr)	Total Nitrogen	Protein Nitrogen
Control	5.8	5.20	0.84	1.75	1.50	0.32	1.70
November, 2025	6.0	2.76	0.75	1.50	0.92	0.28	1.40

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February, 2026	5.8	1.85	0.69	1.36	0.87	0.24	0.98
May, 2026	5.2	1.45	0.63	1.10	0.74	0.18	0.81
August, 2026	4.5	0.84	0.49	0.81	0.48	0.09	0.59

The succession of thermophilic fungi and thermotolerant fungi and physico-chemical changes in decomposing orange fruit peels were recorded in table 3and 4 respectively.

Table 3 reveals that the incidence of different fungi varied with the progress of decomposition of orange fruit peels. In all eight species representing four genera of the fungi could be recorded in decomposing orange peel. Incidence of A. nidulans increased up to the 6th month of decomposition period, which gradually decreased in later part of period of decomposition. Chrysosporium spp could be detected from the initial stage of decomposition period up to 8th month, while H. gresia was recorded on the 12th month of decomposition period only. On the other hand, T. lanuginosus was detected during early stages of decomposition and again at the end. The maximum percentage of incidence of H. lanuginosus was at 6th month of decomposition period and again significant at the end of 12th month of incubation. A. nidulans was recorded with maximum percentage of incidence at the 4th month of decomposition period, which decreased with the progress of observation period.

Table 3. Succession of thermophilic fungi in decomposing orange fruit peel

	Incubation period (average of three months interval)							
	November, 2025		February, 2026		May, 2026		August, 2026	
Name of the fungus	P.I	P.F	P.I	P.F	P.I	P.F	P.I	P.F
Aspergillus fumigatus	30.0	5.0	10.0	5.0	5.0	25.0	15.0	5.0
A. nidulans	20.0	50.0	60.0	80.0	5.0	25.0	30.0	40.0
A. terreus	15.0	10.0	--	--	5.0	12.0	--	--
A. flavus	20.5	5.0	--	--	5.0	12.0	25.0	20.0
Chrysosporium spp	--	3.0	--	--	--	--	10.0	5.0
H. lanuginosus	5.0	20.0	30.0	15.0	20.0	6.0	--	--
H. gresia	--	--	--	--	--	--	10.0	20.0
T. lanuginosus	9.5	7.0	--	--	--	--	10.0	10.0
Sterile mycelium	--	--	--	--	60.0	20.0	--	--

From Table 4 it is clear that the pH of the decomposing orange peels changed with the progress of incubation. The pH changes were within the range of 3.8 to 5.5. The pH of orange peel at the 0 day was acidic (4.8), which changed to pH 5.0 by 3rd month of incubation period. A gradual increase was recorded up to 6th month and final pH recorded was 5.5 at the end of the incubation period. The moisture and ash content of the decomposing orange peels decreased with the progress of the decomposition, and final contents of these decreased significantly by the end of the decomposition.

The cellulose and lignin content of decomposing orange peels also decreased with the advancement of decomposition. Total nitrogen content decreased during the progress of decomposition of orange peels. The same trend was observed in protein nitrogen of decomposing orange peels.

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Table 4. Physico-chemical changes in decomposing orange fruit peel

Month	pH	Moisture (in %)	Ash content (in mg)	Cellulose (per 1 gr)	Lignin (per 1 gr)	Total Nitrogen	Protein Nitrogen
Control	4.8	5.00	0.96	1.60	1.70	0.34	1.80
November, 2025	5.0	4.40	0.91	1.38	1.38	0.28	1.50
February, 2026	5.5	3.80	0.87	1.28	1.20	0.24	1.25
May, 2026	4.0	3.40	0.82	1.00	1.10	0.13	0.98
August, 2026	3.8	2.80	0.65	0.75	0.81	0.10	0.68

Succession of thermophilic and thermotolarent fungi and physico-chemical changes in decomposing wood chips was investigated and the results are presented in table 5 and 6 respectively.

Table 5 reveals the incidence of different fungi in decomposing wood chip material changes with the progress of decomposition. A total ten species representing four genera were recorded in decomposing wood chip material. Incidence of Absidia corymbifera increased up to 8th month of decomposition and decreased subsequently. A. thermophila and A. terreus could be detected throughout the decomposition period observed. A. flavus and A. ochraceus were recorded only during early and later stage of decomposition period. H. stellata was detected only in initial stage of decomposition period, while H. lanuginosus was recorded up to 4th month of decomposition.

Table 5 : Succession of thermophilic fungi in decomposing wood chip

Name of the fungus	Incubation period (average of three months interval)							
	November, 2025		February, 2026		May, 2026		August, 2026	
	P.I	P.F	P.I	P.F	P.I	P.F	P.I	P.F
Absidia corymbifera	20.0	10.0	30.0	25.0	40.0	30.0	27.0	25.0
Acremonium thermophila	13.0	15.0	10.0	20.0	12.0	10.0	20.0	10.0
Aspergillus terreus	5.0	40.0	35.0	20.0	12.0	15.0	23.0	20.0
A. flavus	25.0	20.0	--	--	--	--	10.0	10.0
A. ochraceus	10.0	5.0	--	--	--	--	5.0	10.0
A. niger	12.0	3.0	20.0	5.0	16.0	10.0	10.0	5.0
A. nidulans	--	--	--	--	--	--	5.0	20.0
A. fumigatus	--	--	--	--	20.0	35.0	--	--
H. lanuginosus	10.0	2.0	5.0	30.0	--	--	--	--
Humicola stellata	5.0	5.0	--	--	--	--	--	--

P.I = Percentage of incidence; P.F. Percentage of frequency

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The pH of the decomposing wood chip material changed significantly during the decomposition period (table 6). The pH changes were within the range of 2.8 and 6.5. At the 0-day the pH recorded was 6.5 which decreased slightly by 3rd month of decomposition period. The sudden decrease was recorded in 3rd month of decomposition and it was strong acidic pH 2.8 which drifted to 5.0 by 7th month of decomposition. However, it was pH 4.6 by the end of decomposition period (9th month). The moisture content decreased drastically by 4rd month of incubation period. Insignificant change was observed at 9th month of incubation period. Ash content of decomposing wood chips decreased gradually with progress of incubation period. The cellulose content also decreased with the progress of incubation period. During the early stages the cellulose content decrease was slow but decreased significantly with the advancement of decomposition. Lignin content did not change much between 3rd and 6th month of decomposition period but it decreased significantly by 9th month of decomposition period.

Table 6. Physico-chemical changes in decomposing wood chip

Month	pH	Moisture (in %)	Ash content (in mg)	Cellulose (per 1 gr)	Lignin (per 1 gr)	Total Nitrogen	Protein Nitrogen
Control	6.5	7.20	0.98	2.70	2.10	0.28	1.52
November, 2025	6.2	4.80	0.83	2.10	2.10	0.12	1.20
February, 2026	2.8	4.00	0.71	1.40	0.71	0.08	0.09
May, 2026	5.0	3.25	0.51	0.68	0.59	0.07	0.06
August, 2026	4.6	2.20	0.41	0.21	0.25	0.02	0.02

Succession of thermophilic and thermotolerant fungi and physico-chemical change in decomposing paddy straw was investigated and the results are presented in table 7 and 8 respectively.

Total nine fungal species representing four genera were recorded (table 7). A. corymbifera could be detected throughout the decomposition and its incidence was highest at very early stage of decomposition. A. terreus, A. flavus, A. fumigatus, Chrysosporium spp and H. gresia were conspicuous by their absence during early stages of decomposition. Chrysosporium spp was detected only on 8th month of decomposition period. H. gresia detected in early stage to 6th month of decomposition period.

Table 7 : Succession of thermophilic fungi in decomposing paddy straw

Name of the fungus	Incubation period (average of three months interval)							
	November, 2025		February, 2026		May, 2026		August, 2026	
	P.I	P.F	P.I	P.F	P.I	P.F	P.I	P.F
Absidia corymbifera	80.0	40.0	10.0	5.0	75.0	32.0	25.0	10.0
Aspergillus nidulans	5.0	20.0	35.0	55.0	2.0	28.0	25.0	40.0
A. terreus	--	--	15.0	10.0	6.0	15.0	25.0	14.0
A. flavus	--	--	20.0	5.0	1.0	5.0	20.0	26.0
A. fumigatus	--	--	5.0	5.0	1.0	5.0	5.0	10.0
A. niger	50.0	20.0	10.0	15.0	5.0	10.0	--	--
Chrysosporium sps	--	--	--	--	10.0	5.0	--	--
H. gresia	10.0	20.0	5.0	5.0	--	--	--	--

P.I = Percentage of incidence ; P.F. Percentage of frequency

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pH of the decomposing rice straw material changed significantly during the decomposition period (table 8). The pH changes were within the range of 4.8 to 6.0. At the 0-day the pH recorded was 6.0 which turned to slight acidic by 3rd month of decomposition period. The gradual decrease was recorded by 6th month of decomposition and pH was 4.8 by the end of decomposition period (9th month).

The moisture content decreased drastically by 4th month of incubation period, which this progressively decreased with the advancement of incubation period. Ash content of decomposing paddy straw material decreased gradually with progress of incubation period. The cellulose and lignin content also decreased with the progress of incubation period.

Table 8. Physico-chemical changes in decomposing paddy straw

Month	pH	Moisture (in %)	Ash content (in mg)	Cellulose (per 1 gr)	Lignin (per 1 gr)	Total Nitrogen	Protein Nitrogen
Control	6.0	5.50	0.88	1.60	1.20	0.30	1.50
November, 2025	5.8	2.80	0.70	0.95	0.86	0.24	1.00
February, 2026	5.1	2.50	0.64	0.65	0.63	0.18	0.90
May, 2026	5.0	1.20	0.57	0.32	0.50	0.14	0.80
August, 2026	4.8	1.00	0.51	0.20	0.22	0.10	0.50

Succession of thermophilic fungi and physico-chemical change in decomposing mixed litter was investigated and results are presented in table 9 and 10 respectively.

Table 9 and Fig 3 reveal that during decomposition period the incidence of different fungi varied. Total ten fungal species representing five genera were recorded. A. corymbifera, Acremonium thermophila, A. terreus, A. flavus, A. fumigatus and A. nidulans were recorded throughout the decomposition period. A. corymbifera, A. fumigatus were recorded with maximum incidence on 9th month of decomposition period. H. stellata was recorded only during early stages of observation, while H. lanuginosus was detected at end of the decomposition period observed.

Table 9: Succession of thermophilic fungi in decomposing mixed litter

Name of the fungus	**Incubation period (average of three months interval)**							
	November, 2025		February, 2026		May, 2026		August, 2026	
	P.I	P.F	P.I	P.F	P.I	P.F	P.I	P.F
Absidia corymbifera	25.0	10.0	35.0	15.0	5.0	8.0	20.0	10.5
Acremonium thermophile	20.0	12.0	25.0	10.0	5.0	16.0	10.0	8.0
Aspergillus terreus	10.0	5.0	10.0	12.5	--	--	5.0	2.5
A. flavus	5.0	15.0	5.0	10.0	5.0	4.0	5.0	9.0
A. fumigatus	5.0	18.0	15.0	30.0	--	--	20.0	40.0
A. nidulans	20.0	20.0	5.0	12.5	10.0	2.0	15.0	20.0

A. niger	--	--	--	--	35.0	40.0	5.0	5.0
Sporotrichum sps.	5.0	10.0	--	--	40.0	30.0	10.0	3.0
H. stellata	10.0	10.0	5.0	10.0	--	--	--	--
H. lanuginosus	--	--	--	--	--	--	10.0	2.0

P.I = Percentage of incidence; P.F. Percentage of frequency

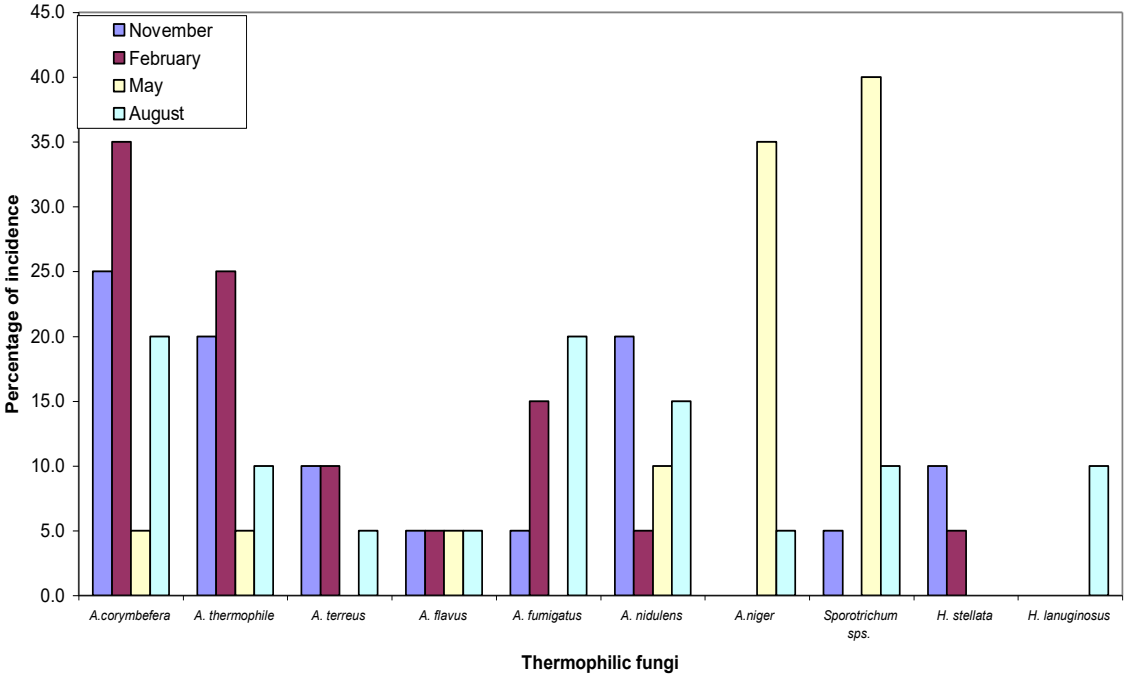


Fig 3. Succession of thermophilic fungi in mixed litter

From table 10 it is clear that the pH of the decomposing mixed litter changed with the progress of incubation period. The pH changes were within the range of 5.0 to 6.2. The pH which was 6.2 at 0-day gradually decreased from the 4th month onwards and it reached to pH 5.0 at the end of incubation period. The moisture content of decomposing mixed leaf litter decreased with the progress of incubation period. However, by the end of decomposition period the moisture content decreased to very low level. In general the ash content decreased with the progress of decomposition. The cellulose and lignin content of decomposing litter showed decreasing trend with the advance of decomposition. The decrease in lignin content was insignificant in the later stage of decomposition. It was observed that total nitrogen and protein nitrogen content decreased gradually with the progress of decomposition.

Table 10. Physico-chemical changes in decomposing mixed litter

Month	pH	Moisture (in %)	Ash content (in mg)	Cellulose (per 1 gr)	Lignin (per 1 gr)	Total Nitrogen	Protein Nitrogen
Control	6.2	5.80	0.92	2.72	2.20	0.45	1.90
November, 2025	5.8	2.50	0.80	1.82	1.21	0.26	1.20
February, 2026	5.4	2.00	0.70	1.22	0.98	0.21	0.80
May, 2026	5.0	1.63	0.61	0.61	0.51	0.09	0.65
August, 2026	5.0	0.98	0.42	0.21	0.21	0.03	0.31

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CONCLUSION

The present study demonstrates that thermophilic and thermotolerant fungi contribute significantly to the decomposition of diverse organic litter materials, including Hyptis suaveolens leaf litter, orange fruit peels, wood chips, paddy straw, and mixed plant litter. The fungal community exhibited distinct successional patterns during decomposition, with the occurrence and incidence of individual species varying according to the nature of the substrate and the stage of decomposition. Fungi such as Aspergillus, Absidia, Acremonium, Thermomyces, and Humicola were observed at different stages, indicating their potential roles in the degradation of complex organic constituents.

The physicochemical analysis revealed progressive changes in pH, moisture, ash, cellulose, lignin, total nitrogen, and protein nitrogen during decomposition. A general reduction in cellulose and lignin content indicated the breakdown of plant structural components, although the extent and rate of degradation varied among the litter materials. Changes in pH and moisture content further reflected the dynamic nature of the decomposition process and its influence on fungal succession.

Overall, the findings highlight the importance of fungal diversity and succession in organic matter decomposition and nutrient transformation. Understanding these microbial interactions can support the development of improved composting strategies and the efficient utilization of agricultural residues. Furthermore, litter-decomposing fungi represent a promising resource for the production of industrially important enzymes, including cellulases, ligninases, pectinases, and amylases, through solid-state fermentation using low-cost agricultural substrates. Further studies involving quantitative enzyme assays, molecular identification, and controlled decomposition experiments would help establish the specific contributions of individual fungal species and their potential applications in sustainable waste management, compost production, and agricultural biotechnology.

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