FUNGAL DETERIORATION OF COTTON CORDAGES IN SOIL

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(*Received* 17 *October* 1979 ; *revised* 10 *December* 1979)

Fungal degradation of cotton cordages was studied under soil burial conditions with soil moisture contents varying from 5 to 30 per cent. Maximum degradation was noticed in thinner cordages at 15-25 per cent soil moisture. Sixteen fungal species were isolated from soil buried cordages and their succession was studied. Half life period of cordages during soil contact condition was determined. The time of initiation of spore formation of cordage-attacking fungi was found between 48 to 168 hours.

Deterioration of cellulosic materials including cotton cordages is a major economic problem. The cordages in constant use are subjected to many climatic hazards which are partly responsible for their deterioration[1,2]. The weakening in the cordages is also caused by the action of fungi. Studies carried out in this direction have revealed that certain cellulolytic fungi are indeed responsible for deterioration of cordages particularly in hot and humid climate[3]. The most severe hazard of microbiological attack which cotton cordage is likely to encounter under user conditions is that of contact with the soil. No data, however are available in the literature to show deterioration of cotton cordages in Indian soil having different moisture contents.

MATERIALS AND METHODS

Following types of cotton cordages were taken for study :

(i) Cordage cotton grey white, circumference 0.625 cm, ply 3, singles 8.

(ii) Cordage cotton grey white, circumference 1.25 cm, ply 4, singles 7.

(iii) Cordage cotton grey white, circumference 2.5 cm, ply 4, singles 190.

The cordages were subjected to soil burial test as per ISI specification No. IS : 1389-1959. The moisture content in the soil varied from 5, 10, 15, 20, 25 to 30 per cent. Cordage pieces 1.5 m long were incubated in a Tropic Room maintained at Defence Research Laboratory, Kanpur where ideal tropical conditions were simulated on the principles given by Smith[4]. Random sampling was done after 7, 14, 21 and 28 days. The harvested samples were dipped in rectified spirit and then dried at room temperature for 24 hours. These were then subjected to tensile strength test on a Goodbrand Tensile Tester (100 cm between grips) after proper conditioning at 27—2° C temperature and 65—2% relative humidity for 48 hours. Isolation of fungi from harvested test samples was done by standard techniques using potato dextrose agar, Czapek-Dox agar and Waksman agar media. The succession of fungi was also studied on soil buried cordages. The sporulation of fungal isolates was studied on CDA medium[5] to supplement taxonomic characterisation. The cellulolytic activity of fungi was also studied by fabric test method[6].

RESULTS

The cotton cordages showed a distinct pattern of degradation with the soil moisture increasing from 5 to 30 per cent. Minimum loss in tensile strength was observed in all the cordages at 5 per cent moisture level. Thereafter the tensile strength decreased with the increase of soil moisture upto a particular optimum level after which there was again increase. The cordage of 0.625 cm circumference however exhibited changed

pattern of degradation. In this case there was first gradual decrease in tensile strength followed by slight increase and then there was decrease followed again by increase. This was observed after 21 and 28 days of incubation in 5 to 30 per cent soil moistures as shown in Fig. 1.

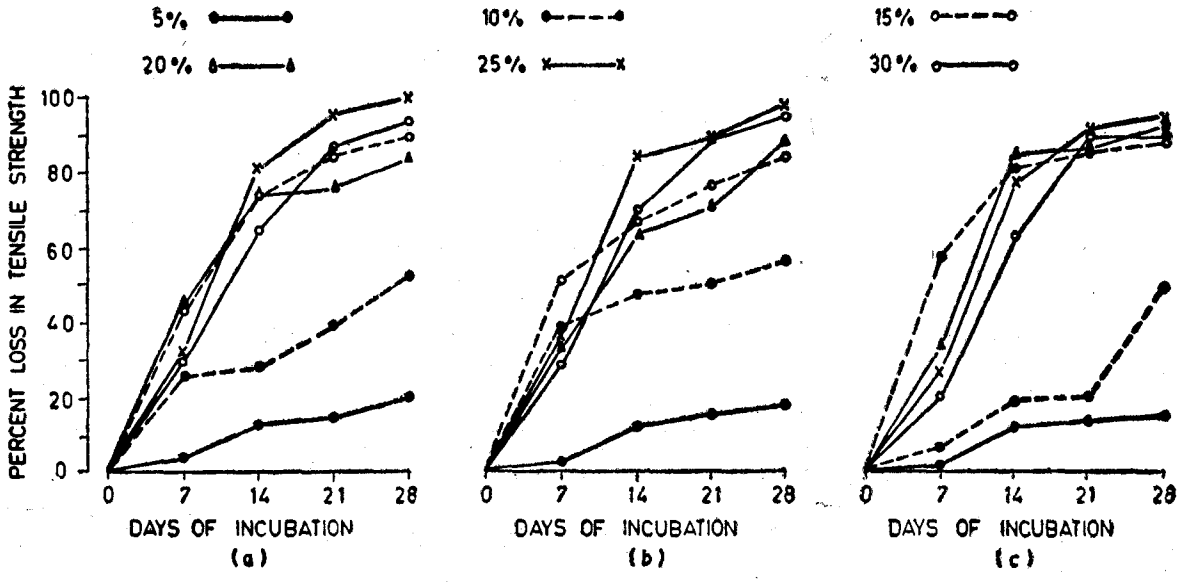

Fig. 1—Rate of fungal degradation of cotton cordages in soil under different moisture contents; cordage circumference (a)=0.625 cm. (b)=1.25 cm & (c)=2.5 cm.

The pattern of gradual decrease in tensile strength of different cordages under different soil moisture contents has been mentioned below. The values under same bar did not show significant differences :

Cordage	Tensile strength in decreasing order in following soil moisture percentage					
2.5 cm	5	10	30	25	20	15
1.25 cm	5	10	20	30	15	25
0.625 cm	5	10	30	20	15	25

The moisture optima for maximum loss in tensile strength of cordages was found to be 25 per cent except in case of 0.625 cm cordage where it was 15 per cent.

The data of retention of tensile strength in all the cordages were statistically analysed individually and variation due to moisture vs control, moisture, days and moisture X days were found highly significant. The inverse relationship between retained tensile strength of cordages and percentage loss in tensile strength was statistically substantiated by negative value of correlation coefficient (−0.99). Thus minimum retained tensile strength simultaneously showed maximum loss in tensile strength.

The fungal susceptibility of cordages was found as under in decreasing order—Cord. 0.625, —Cord. 1.25, —Cord. 2.5 cm.

The mean values of tensile strength of all the cordages were maximum on the first sampling day and decreased with the increase in the incubation period till last sampling day. Statistically significant variations were observed in the tensile strength of nearly all the cordages on all the four sampling days.

Resistance of cotton cordages under soil burial condition was also assessed in terms of number of days taken to reduce the original strength to 50 per cent level. Half reduction of tensile strength is meant to denote the life of cordage till the strength is reduced to half of the original strength. It reflects the period of serviceability or useful life of the material. It was calculated from the graph plotted for percentage loss in tensile strength against the days of incubation. It was found that 50 per cent reduction in strength of cordages

does not occur at 5 per cent soil moisture till last sampling day. In soil having 10 to 25 percent moisture the time taken in 50 per cent reduction of strength was relatively lesser than in 30 per cent soil moisture.

Mould growth on cordages was recognised by the presence of stains, discolouration or mildew spots. No apparent mildew symptoms were observed on any cordage in 5 per cent moisture. At 10-25 per cent moisture black, orange and red mildew spots were observed. At 30 per cent moisture red and green mildew spots along with general yellowing were observed. The mildew spots, on isolation, yielded several species of fungi given below.

In all, sixteen fungal types were isolated from cordages.

POORLY CELLULOLYTIC
Aspergillus flavus
A. nidulaus
Penicillium sp.
Paecilomyces varioti
HIGHLY CELLULOLYTIC
Phoma sp.
A. terreus
Penicillium thomii
Memnoniella echinata
Cladosporium herbarum
Curvularia lunata
C. pallescens
Fusarium chlamydosporum
F. moniliforme
NON-CELLULOLYTIC
Rhizopus nigricans
A. niger
A. sydowi

As regards successional pattern of fungi on soil buried cordages three categories of fungi were recognised. First category consisting of *Rhizopus nigricans, Aspergillus flavus, A. nidulans, A. niger, A. sydowi, Penicillium* sp. and *Paecilomyces varioti* appeared on cordages during early period of degradation but their persistence period was very short. The second category which included *Phoma* sp., *A. terreus, Penicillium thomii, Curvularia lunata, C. pallescens, Fusarium chlamydosporum* and *F. moniliforme* appeared quite late and persisted till the end. The third category of fungi including *Cladosporium herbarum, Memnoniella echinata* and *Rhizopus nigricans* colonized the cordages at no definite stage of degradation and these were sporadic showing no sequence. In the entire pattern no fungus was found to be restricted on a particular type of cordage.

It was also found that most of the fungal types were sporadically distributed and occurred in all the ranges of soil moisture. The number of fungal types flourishing in 5-10 per cent soil moisture were comparatively higher than in 15-30 per cent moistures in each cordage. At 5-10 per cent moisture the predominant fungi were some phycomycetous forms and few species of *Aspergillus, Penicillium* and *Paecilomyces.* At 15-25 per cent moisture levels few more types consisting of species of *Phoma, Memnoniella, Curvularia, Cladosporium* and *Fusarium* were recorded. High moisture status (30 per cent) however prevented the advent and growth of fungi in all the cordages. Species of *Phoma, Penicillium* and *Fusarium* were only present at 30 per cent.

The time for initiation of spore formation of fungal isolates was studied and was found as under.

Time for initiation of spore formation (hours)	Fungal types
0—24	None
25—48	*Rhizopus nigricans, Aspergillus niger*
49—72	*A. flavus, A. nidulans, A. terreus, Paecilomyces varioti*
73—96	*A. sydowi, Penicillium* sp., *P. thomii, Cladosporium herbarum, Curvularia lunata, C. pallescens*
97—120	*Fusarium chlamydosporum, F. moniliforme*
121—144	*Phoma* sp.
145—168	*Memnoniella echinata*

DISCUSSION

Cotton cellulose being the basic constituent of cordages is most vulnerable to attack and degradation by microorganisms especially fungi from atmosphere and soil. The soil fungi are active causing destruction of cellulosic materials during soil contact conditions.

It is evident from the data that moisture contents of the soil play an important role in degradation process by soil fungi. The soil moisture enhances the growth and activity of fungi as long as there is no waterlogging[7]. Best growth of soil fungi has been observed at 20-25 per cent moisture[8]. During present investigation 5-25 per cent soil moisture increased the population of cellulolytic fungi. Consequently it caused gradual decrease in tensile strength of cordages. Further increase in soil moisture above 25 per cent has been found harmful for soil mycoflora. With soil's limited capacity for aeration, the oxygen supply is frequently at critical level. 30 per cent moisture status of soil possibly reduced aeration and resulted into high multiplication of facultative anaerobic bacteria and this in turn disfavoured the growth of fungi. However the reason for the presence of certain fungal species at 30 per cent moisture level may be attributed to the ability of these fungi to withstand oxygen tension in the soil. The reason for occurrence of many fungal types both in low and high soil moisture levels, may be attributed to the capacity of these fungi to withstand desiccation.

The rate of degradation of most of the cotton cordages has been found optimum at 25 per cent soil moisture except in case cordage having circumference of 0.625 cm where the optimum degradation is at 15 per cent soil moisture. Behaviour of different cellulose decomposers at different moisture levels is reported to be different[9]. In 0.625 cm cordage the soil conditions due to one or the other reason and microbiological component possibly showed abrupt changes in degradation of the cordages at different periods and, therefore, a deviation in the pattern of degradation has been observed.

Thinner cordages are found more susceptible to fungal damage than thicker ones. In the former the fungal penetration is quicker followed by early decomposition of the materials with apparent loss in tensile strength.

It is revealed that among the fungi incident on cordages, members of Fungi Imperfecti constitute the overwhelming majority. It is due to their greater tolerance of desiccating conditions coupled with their high cellulolytic activity and wide range of nutritional adaptibility[7].

Fungi occur abundantly in soil in an unstable equilibrium condition. Whenever a cellulosic substrate is inserted in soil, the equilibrium is disturbed with the specific fungi migrating to the substrate for growth and attack[10]. On introducing cotton cordages in the soil, it becomes subjected to the series of waves of colonization by fungi present in the soil. These waves overlap and succeed each other. The cordages are first occupied by fungi of high competitive saprophytic ability to utilize the less complex nutrients of substrate. The primary colonizers include both non cellulolytic as well as poorly cellulolytic species. The activities of these initial fungal colonizers lead to change in the environment such as decrease in simple nutrient supply, alteration in *p*H or in the appearance of toxic metabolic products. In the altered environment the early colonizers are less well adapted and these are replaced by another group of highly cellulolytic secondary colonizing fungi. The latter fungi increase rapidly until they become dominant. The secondary colonizers in fact release simple form of nutrition which serve as substrate for the primary poorly cellulolytic fungi. On depletion of simple nutrition, the primary colonizing fungi disappear completely. Few highly cellulolytic forms developed quite early due to most ideal growth conditions in the soil.

Variation in the time of initiation of spore formation in fungi may be due to the cumulative effect of nutrition and specific nature of fungi themselves. It is evident that spore formation in highly cellulolytic fungi does not take place before 96 hours.

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