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BIOLOGICAL DEGRADATION OF DATE-PALM FRONDS USED IN CONSTRUCTION

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ABSTRACT

The paper presents the decay organisms (molds, algae, bacteria, fungi, ... etc.) that attack the date-palm frond which will be used as structural materials causing biological degradation and rot. All findings of the study are reported in the paper.

The contents of this paper are extracted from a two-year research project funded by King Abdulaziz City for Science and Technology, Riyadh, Saudi Arabia. The project was aimed at investigating the various ways of developing new building materials using the fronds of date-palm trees locally available in Saudi Arabia.

Keywords: *Date-palm fronds, construction, biological degradation, algae, bacteria, fungi, molds.*

الملخص

استلت محتويات هذه الورقه من مشروع بحث – مدته سنتان – مولته مدينة الملك عبدالعزيز للعلوم والتقنيه في الرياض بالمملكة العربية السعودية. ويهدف المشروع الى البحث عن أساليب مختلفه لتطوير مواد بناء جديده باستخدام سعف النخيل المتوافر محلياً.

ستعرض هذه الورقه الكائنات الحيه (كالعفن والطحالب والبكتيريا والفطريات ... الخ) التي تصيب سعف النخيل المستخدم كمواد انشائيه مسببة إنحلالاً حيوياً وتعطناً. وستقدم جميع نتائج الدراسة في هذه الورقة.

1. INTRODUCTION

It is estimated that twelve million date-palm trees exist in Saudi Arabia. Every year, about three million trees have to be pruned. The pruning process is estimated to yield a flow of about 75,000 tons of fronds every year. Moreover, this amount is evenly distributed all over the Kingdom which makes it attractive for use in a development project that would benefit every part of the country. This is particularly true when it is known that these fronds obtained as a result of the pruning process have little economical value and are sometimes disposed off as waste.

Date-palm fronds were proposed to be used as follows:

(1) Date-palm fronds embedded in concrete in a certain manner to obtain date-palm-frond reinforced concrete beams, columns and slabs.

(2) Shredded leaves mixed with certain agents to produce heat insulating materials.

(3) Date-palm fronds covered with concrete to produce small housing modules.

What is meant by biological degradation is the retrogradation of the cut palm fronds due to microorganisms or insects manifestations. Date palm fronds, as an organic matter, are a source of food for many living creatures. Some insects, like locusts, may diet on live green leaflets. This is irrelevant to our study in contrast with other insects, such as termites, which attack dead fronds. The same circumstances apply to decay microorganisms which feed on live or dead organic matter and digest to maintain growth and activity. Eventually, there are those creatures which may not feed directly on parts of the palm frond, but extend their stingers through the xylem and suck the sap. This will weaken the whole plant, and therefore parts of this plant will die and may not be strong enough to carry loads when included in structural members.

2. METHODOLOGY

Several infected date-palm fronds were collected from the date-palm grove here at KFUPM. Half of the quantity was sent to King Faisal University in Hofouf (Al-Hasa) for studying and identifying the microorganisms attacking the fronds. The other half was studied here by a qualified technician at the sanitary lab in the department of Civil Engineering. The degradation causing agents are presented herein.

Insects and Spiders

Although palm trees and dates are attacked by numerous species and kinds of bugs, only those which attack palm fronds are discussed in this paper. A study was carried out to classify their effects. In any case, only the effects upon fronds as a structural material are being considered. The discussion is given in Table 1.

Diseases

Most of the known diseases are caused by fungi. Research concerning diseases caused by bacteria or viruses is insufficient. Again, it is emphasized that in this project only the diseases affecting the palm fronds as construction elements are considered. The disease name, the cause and its effect are given in Table 2.

Digestion by Microorganisms

Decay organisms (molds, algae, bacteria, fungi, … etc.) have certain requirements in order to digest any organic matter. Plant wastes contain complex carbohydrates, which the microorganisms digest for the energy they give. The second requirement is a source of

protein needed for their growth. This is supplied by the amount of nitrogen in the organic matter. Eventually the digestion requires water and oxygen. Reducing one or more of these four requirements will delete or delay the action of digestion. Carbon and nitrogen with different quantities exist in all cut plants. For instance, alfalfa (the richest in nitrogen) contains 3 percent nitrogen and 37 percent carbon (dry weight). Microorganisms require about 15 days (with 30 percent humidity and enough air) for the complete digestion of such organic matter.

The carbon and nitrogen contents in two sample groups of dead stems and shredded leaflets were measured in the Civil Engineering laboratories of KFUPM (groups # 1 and # 2 respectively in Table 3). To find the effect of a mixture of hydraulic Portland cement and gypsum (pH = 13) on the shredded leaflets the carbon and nitrogen contents of some leaflets extracted from concrete block were also measured, group # 3. The results are shown in Table 3. They are expressed on the basis of dry weight. That is, samples were dried at 103ºC for 24 hrs before analysis. The results shown are the average of 10 samples with a standard deviation of 0.004 percent.

From Table 3 the following remarks can be found:

a) Comparing with the alfalfa, the palm leaflets have less than 50 percent of the nitrogen content, as for the stems it has only 14 percent nitrogen content. Such small amounts of protein do not encourage microorganisms to grow. (Protein = N ∗ 6.25).

b) Group # 3, as compared with group # 2, shows dramatic reduction of the amount of carbon (71 percent) and nitrogen (31 percent) as a result of chemical reaction with the hydraulic cement components.

Taking the above results into consideration, different experiments were carried out in order to evaluate the effect of humidity and time on the different parts of palm fronds at various conditions. Five groups of samples were tested. The first one contained shredded palm leaflets which would be used in various structural members. Since the leaflets will be used with cement, the second group contained leaflets extracted from concrete blocks. Stems were tested in three cases. In the first case stems without any treatment were considered. Since a cut in the vein exposes its core to outside conditions, stems were varnished at the exposed end in the fourth group. The last group contains stems which are completely coated with wood varnish as a water repellent. One set of the samples was exposed for 5 months to humidity of 20 percent. The samples in the other set were exposed to humidity of more than 70 percent. The samples were observed for apparent attacks of molds, algae or fungi. Table 4 shows the time at which such biological development is observed.

It is obvious from the table that the shredded leaflets, when mixed with concrete, need not to be pretreated or coated, while stems should be coated with a water-repellent agent.

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Table 1: Deterioration due to Insects

No.	Species	Family	Name	Effect	Discussion
1	Orthoptera (Locust)	Acrididae	Schistocerca gregaria, Forsk	Attacks in great numbers.	It decreases the amount of leaf crop. But it causes no harm to leaf-built structures.
2	Isoptera (Termites)	Termitidae	Microcerotermes Diversus (silveatri)	Attacks live and dead wood, stems, veins, and eats their cellulose.	Since termite live in mud tunnels and cannot attack concrete. Palm fronds in structure members in contact with soil should be completely covered with cement.
3	Homoptera (Plant Bugs)	Cicadidae	Parlatoria blanchardi, Targ.	Appears on the green veins and leaflets. Sucks the sap and weakens the plant.	It is very easy to observe the gray traces of the insect on the leaves and veins. Use of such veins should be avoided since their strength might be reduced.
4	Homoptera (Plant Bugs)	Tropiduchidae	Ommatissus Libycus, Berg.	Sucks large amount of sap from leaflets. Secretes large amount of viscous liquid.	The infected trees are weak. It is not recommended to use their fronds. It is easy to distinguish the struck leaflets since the secreted viscous liquid is very obvious.
5	Lepidoptera	Nemobiidae	Phonopathe forntalis, Fahr	This insect drills tunnels in the veins and secretes large amount of sticky liquid that kills the insect.	Veins with hollow cores, tunnels or spots of sticky liquid should be avoided.
6	Coleoptera (Beetles)	Cerambycidae	Apatophysis Larbara, Lucas	The larvae of this insect drill holes in the veins.	The holes are obvious and hence infected veins should not be used in the concrete.
7	Coleoptera (Beetles)	Curculionidae (Weevils)	Motesiapis	This insect makes holes along the veins.	Infected veins with holes should not be used.
8	Coleoptera	Curculionidae (Weevils)	Oryctes elegans, Prell	Insect drills large holes in the live or dried veins.	This insect is found in Al-Hasa region. It lives on decomposed organic matter of the veins after drilling the holes. Same precaution should be taken as in 1 and 7.
9	Arachinda (Spiders) Acari (Acarida) Ticks & Mites	Tenuipaloidae, Acarina	Tenuipalpus eriophoides (Baker)	It attacks the leaflets and sucks the sap. It leaves light colored spots that can be recognized.	If the infection is intensive and the leaflets are to carry heavy loads (leaflets will be used to carry shear forces in beams) infected leaflets should not be included in the structure member. The insect attacks the xylem cells (load carrying elements).

Table 2: Deterioration due to Diseases

No.	Name	Cause	Effect	Discussion
1	Bayyoodh	Fusarium Oxysporum, Schlecht, Var. albedinis (Killisn & Maire) Malencon	This fungi attacks first the live leaflets then the whole frond. Cross-sections will show reddish black color.	The infected leaflets are white and the cross-sections of the veins show dark reddish black color. Hence, it is easy to recognize the diseased fronds.
2	Graphiola Leaf Spot	Graphiola phoenicis (Moug.) Poit.	Black spots cover the leaflets and the veins. It attacks young trees and kills the fronds.	Since it attacks only young trees whose fronds touch the ground surface. The fronds of such trees should be inspected for black spots and discarded.
3	Diplodia	Diplodia phoenicum (sacc.)	Kills the new fronds. Yellowish black lines (15 to 120 cm) shown on the veins.	In general small, young and new fronds should not be used in building construction. Only old pruned fronds should be used.
4	Dry Bone	Bacterial infection	Spots and white lines are observed on the leaflets and veins. The infection is very shallow.	Cutin layer and lower epidermis are attached by this bacteria. Since these layers are not to carry any load such attack is overlooked.
5	Al-Wijam	Viral infection	Exists mainly in Al-Qatif and Al-Hasa. It causes a general weakening of the tree growth.	A long faint yellow line can be seen along the vein. The use of these veins may be avoided.

Table 3: N and C Contents

	Group # 1	Group # 2	Group # 3
Total Nitrogen %	0.40	1.37	0.95
Total Organic Carbon %	23.00	27.30	7.79

Table 4: Effect of Humidity on Palm Fronds

Sample #	Conditions	Humidity	
		20%	70%
1	Shredded leaflets	14 days	4 days
2	Shredded leaflets from concrete	No growth	No growth
3	Veins	No growth	6 days
4	Veins with varnished ends	No growth	25 days
5	Veins coated with varnish	No growth	No growth

3. RECOMMENDATIONS

(1) If stems are used alone (not mixed with concrete), they should be coated with a water-repellent agent.

(2) Shredded leaflets and/or stems when mixed with concrete need not to be pretreated or coated.

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REFERENCES

1. Al-Juruf, R. S., H. H. Abdelrahman, F.A. Ahmad and I. A. Alam, "Development of New Building Materials Using Date-Palm Fronds," Final report submitted to King Abdulaziz City for Science and Technology (KACST), April, 1998.