第三届国际非木材纤维制浆造纸会议论文集

THIRD INTERNATIONAL NON-WOOD FIBER PULPING AND PAPERMAKING CONFERENCE

PROCEEDINGS
(Supplementary Volume)

October 15-18, 1996

International Academic Publishers

THIRD INTERNATIONAL NON-WOOD FIBER PULPING AND PAPERMAKING CONFERENCE

PROCEEDINGS
(Supplementary Volume)

October 15 - 18, 1996
Beijing, P.R.China

Sponsored by:

China Technical Association of the Paper Industry (CTAPI), Beijing, P.R.China

Co - Sponsored by:

United Nations Industrial Development Organization (UNIDO), Vienna, Austria

The Technical Association of the Pulp and Paper Industry (TAPPI), Atlanta, GA, U.S.A.

Pulp and Paper International (PPI) Brussels, Belgium

Pulp and Paper Industry Research Institute of China (PIRIC), Beijing, P.R.China

Organized by:

China Technical Association of the Paper Industry (CTAPI)

China International Conference Center for Science and Technology (CICCST)

International Academic Publishers

图书在版编目(CIP)数据

非木材纤维制浆造纸：第三届国际非木材纤维制浆造纸会议论文集：英文/中国造纸学会编. -北京：万国学术出版社，1996.10
ISBN 7-80003-382-1

I. 非… II. 中… III. ①非木材纤维-制浆-国际学术会议-文集-英文②非木材纤维-造纸工艺-国际学术会议-文集-英文 IV. TS7-53

中国版本图书馆 CIP 数据核字（96）第 13444 号

Published and Distributed by
International Academic Publishers
137 Chaonei Dajie, Beijing 100010
The People's Republic of China

First edition 1996

Proceedings of the Third International Non-Wood Fiber Pulping and Papermaking Conference (Supplementary Volume)

ISBN 7-80003-382-1/TS·1

Printed by the Printing House of China Building Industry Press

CONTENTS

(Supplementary Volume)

KENAF FARMING FOR MARKET PULP PRODUCTION IN THE NORTHERN TERRITORY, AUSTRALIA

Alfred Wong
Arbokem Inc.
Vancouver, Canada

ABSTRACT

In 1986-89, a major agronomic and technical study project was initiated by the Northern Territory (Australia) Government to establish the practicality of growing kenaf under local dryland farming conditions, and viability of establishing a kenaf market pulp mill in the region.

Preliminary agronomic study showed that the "Top End" region near Darwin in the Northern Territory may be ideally suited for kenaf cropping. Arable land is abundantly available. The climate is sub-tropical. Rainfall is plentiful and highly predictable in a well-defined period of November to March. The following 7-month dry season provides a convenient opportunity to harvest and store the kenaf crop efficiently.

Under rainfed growing conditions. The typical yield of whole stem would be 10 dry tonnes per hectare. The farm-gate cost is estimated to be about A$114 per dry tonne. Kenaf cropping could become more competitive under certain circumstances such as growing under irrigated conditions and chemical pulping to higher yields. In all cases, the economics of kenaf pulp production would require the usage of the whole stem.

INTRODUCTION

Kenaf (Hibiscus cannabinus) is a herbaceous plant which has been grown as a fibre crop for many generations in sub-tropical and tropical regions of the World. The plant is a dicotyledon in which the bark (25 to 30%) contains relatively long fibres and the core (70 to 75%) contains relatively short fibres. The critical climatic factors for efficient kenaf cropping are timely precipitation and warm temperatures during the 100- to 120-day growing season.

In developed countries, kenaf pulp could be produced competitively under certain circumstances. Some of the key success elements required would include:

a) achieving maximum biomass yield without irrigation and minimal fertilizer input,
b) usage of fibres available in the whole plant, and
c) judicious choice of appropriate pulping and bleaching technology.

During the late 1980's,Arbokem was a technical advisor to the Northern Territory Government on the kenaf pulp development project. Although the Northern Territory Government has not actively pursued the project for several years,Arbokem has decided to continue the project study,albeit on a less intense basis,for the comparative assessment of kenaf fibre as a viable subsidy-free crop.

LOCATIONAL ASPECTS

Land Base

There are basically four main areas in the Northern Territory in which kenaf cropping can be undertaken. As shown in Figure 1,the main regions are Koolpinyah (east of Darwin), Douglas-Daly Basin (south of Darwin),Katherine (south of Darwin) and the Keep River District (along the Western Australia border). The estimated total area available in these four regions for kenaf cropping is more 340,000 hectares. At present,these areas are used mainly for mixed farming activities.

Both Douglas-Daly and the Katherine districts have been evaluated extensively as prime kenaf-growing areas. Computer modelling studies and field trials have been made.

Climate

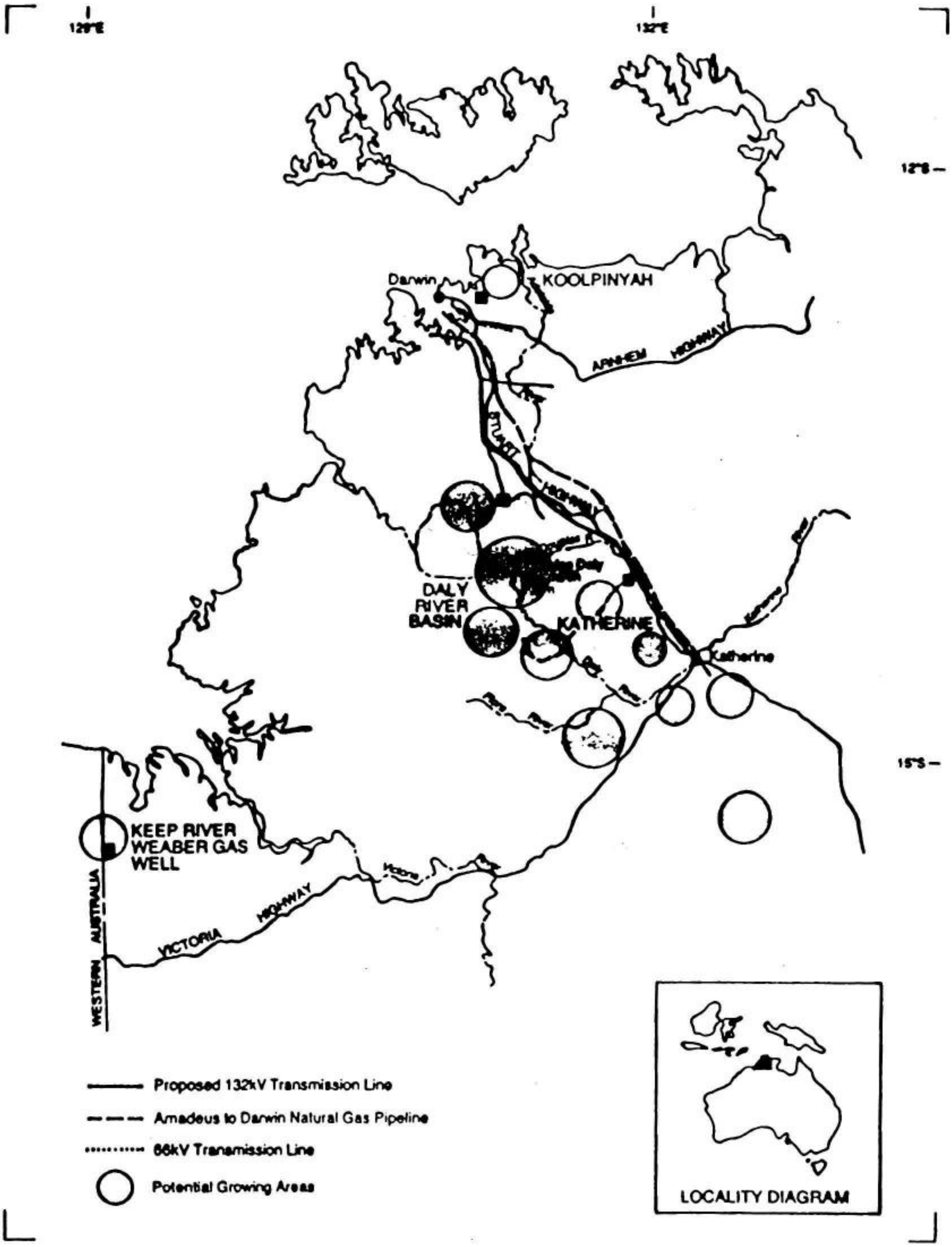
The seasonal average rainfall in these candidate regions is 1,000 to 1,200 mm. Approximately 90% of the rain falls in the five-month period of from November to March. This highly predictable rainfall period provides a reliable means to plan the critical sowing activities. The mean daily maximum temperature can exceed 30 deg. Celsius throughout the year.

CROP PRODUCTION AND MANAGEMENT

Land Preparation and Sowing

Using conventional methods of land preparation,the establishment of kenaf can best be obtained by using a fine seed bed. Ideally the seed should be sown at 25 mm depth with a precision seeding equipment. At a field emergence rate of 80%,the anticipated plant density should be of the order of 250,000 plants per hectare at harvest. In field trials,it found that row spacing between 280 mm and 750 mm have no appreciable effect on yield. In the Northern Territory,a mulch cover is needed to reduce high soil temperatures which can adversely affect seedling emergence and crop establishment.

Initial screening of the cultivars showed that "Guatemala 4" gave the best overall results.



Map of the Top End (lower latitudes) of the Northern Territory with schematic representations of potential growing areas for kenaf.

Yield

Because of the very seasonal nature of the rainfall period,the sowing date is very important. As shown in Table I, late plantings within the wet season (e.g.,January-February) provides lower stem yields.

Table I - Whole Stem Yield as Affected by Planting Date (under rainfed conditions)

	Darwin	Douglas-Daly	Katherine
Sowing Date	Dec 2/87	Nov 18/87	Nov 13/87
Stem Yield,kg/ha	9,400	9,200	11,700
Sowing Date	Jan 8/88	Dec 17/87	Dec 1/87
Stem Yield,kg/ha	7,200	7,100	10,200
Sowing Date	Feb 16/88	Jan 8/88	Jan 5/88
Stem Yield,kg/ha	3,600	7,000	`6,000

The simple reason for the higher yield with earlier planting is that there was a longer growing period after flowering.

Fertilizer Requirements

In the Northern Territory,kenaf whole stem yield up to 10 tonnes per hectares had been achieved conservatively under rainfed growing conditions,with the typical application of following fertilizers:

Phosphorus	30 kg P/ha
Sulphur	30 kg S/ha
Potassium	50 kg K/ha
Nitrogen	230 kg N/ha
Zinc	5 kg Zn/ha
Copper	3 kg Cu/ha

Subsequent field trials have shown that nitrogen fertilizer application could be reduced to the range of 100 kg N/ha without any adverse effect on whole stem yield. Table II illustrates some of the experimental results.

Table II - Effect of Nitrogen Fertilizaer Application Rate on Whole Stem Yield in Katherine Test Plots

	Whole Stem Yield,dry kg/ha			
	Nitrogen Applied,kg N/ha			
	0	60	120	240
Irrigated	20,300	22,190	22,170	18,610
Rainfed	12,430	11,060	13,440	13,890

The apparent lack of response to nitrogen fertilizer application might be attributed to the increased accessibility of nutrients and water by the large root system through the clay loams and sandy soils of the Northern Territory test sites.

It is interesting to note that the yield of kenaf whole stem could be effectively doubled if irrigated conditions were available. In many countries including Australia,water is a valuable resource. There are the political,moral and economic questions about using scarce water supply for fibre production instead of food (grain) production.

Weed,Pest and Disease Control

Weed control was found to be critical during the first 3 weeks of growth. However,early rapid growth of the kenaf palmt will shade out the weed competition.

In the Northern Territory field trials,only the looper catepillars were noted to cause significant leaf damage. As in most other kenaf crooping in other regions of the World,root damage by nematodes (Meloidogyne spp.) is a serious problem. It is generally recognized that sustainable farming practices through crop rotation can alleviate the nematode problem.

FARM ECONOMICS

Assumptions

The establishment of a new kenaf farm in the Douglas-Daly Basin was chosen as the base case. This area is presently dominated by the cropping of sorghum,maize,sesame, mung bean and peanuts. Cattle production has become important in recent years.

A crop rotation pattern of kenaf-kenaf-kenaf-fallow was the basis of analysis. It is possible that other croping activities instead of fallow might a sustainable alternative.

A separate economic analysis of the farm size has shown that a 500-hectare cropped area provides the highest cropping yield and operating efficiency in the Douglas-Daly Basin. Because of firebreak requirements,topography,soil conditons,etc.,a total farm area between 2,000 to 4,000 hectares was considered essential. The total fixed capital costs of establishing a 500-hectare kenaf farm was estimated to be about A$960,000. The actual farm area would be 4,000 hectares.

Economic Analysis

The basic analysis was first made in 1988-89 by officials of the Department of Primary Industries and Fisheries (DPIF) [1]. We have updated the data to late 1995 using economic indicators published by the Government of Australia [2]. As shown in Table III,the break-even farm gate cost of whole stem kenaf was calculated to be about A$114/dry tonne. This cost presents a moderately interesting fibre supply source for paper industry development. In comparison, the delivered cost of softwood chips for many inland pulp mills in Western Canada is the order of equivalent A$100 to 150 per dry tonne.

Lauhaussois and Kyrklund [3] have previously estimated the farm-gate cost of whole stem kenaf to be about A$58/dry tonne (US$44/dry tonne,in 1988) for a whole stem yield of 6 dry tonnes per hectare. The cost estimate was based on field data from Pakistan and Thailand. More recenty,Parsad et al. [4] have reported that the minimum cost of growing kenaf in Georgia,USA to be US$50 to 60 per dry ton (A$70 to 84 per dry tonne) at an expected yield of 6 dry tons of whole stem per acre (13.4 dry tonne per hectare). Harvesting cost does appear to have been included. If the Douglas-Daly Basin data were projected to the same whole stem yield level,the revised farm-gate cost for kenaf cropping in the Northern Territory would be about A$83/dry tonne.

The competitiveness of the manufacture of kenaf pulp is worsen if only kenaf bark is used. The fibrous cost could increase to over $300/dry tonne,if there is no compensating credit for the secondary use of the separated core material. The distinct technical advantage of kenaf bark pulp over northern bleached softwood kraft pulp has yet to be established in the market place. Therefore,it is not likely that the kenaf pulp price could command a premium pricing on the basis of technical merits alone.

Table III - Economic Analysis for a 500-Hectare Rainfed Kenaf Farm in the Douglas-Daly Basin, Northern Territory

	Total A$
A. Variable Costs	
1. Land preparation	0
2. Weedicide spraying (twice) @9.36 ha/hr x $16.25/hr	1,736
3. Planting @6.3 ha/hr x $24.81/hr	1,969
4. Aerial top dressing (twice) @$14.85/ha	14,850
5. Insecticide aerial spraying @$14.85/ha	7,425
6. Seed @15 kg/ha x $4/kg	30,000
7. Fertilizers	
* Triple superphosphate @157 kg/ha x $629.92/tonne	49,449
* Urea @200 kg/ha x $541.66/tonne	54,166
* Muriate of potash @60 kg/ha x $484.51/tonne	14,535
* Sulphur @20 kg/ha x $833.76/tonne	8,338
8. Weedicides @$77.66/ha	38,831
9. Insecticides (allowance) @$54.50/ha	27,250
Pre-harvesting variable costs	248,549
10. Harvesting and baling @$25.34/ha x 10 tonnes/ha x 500 ha	126,698
Total variable costs	375,247
B. Fixed Costs	
1. Farm establishment at $958,470 amortized over 20 years at 8% interest rate per annum	95,847
2. Farm maintenance and overheads	98,174
Total whole stem costs at the farm-gate (or about A$114/dry tonne)	569,268

The apparent high cost of the fibrous raw material may be surmountable under some specific circumstances. For example, kenaf cropping could be made under irrigated conditions. The farm-gate economics would be changed considerably. Table IV shows that the farm-gate income could exceed A$1 million annually. It should be cautioned that the actual gross receipt may vary as there is no relationship between price and cost in the free-market society.

Table IV - Projected Farm-Gate Income as Afected by Whole Stem Yield

Yield, dry tonnes/ha	Product Income, A$/tonne	Gross Income A$
8	100	400,000
10	100	500,000
12	100	600,000
20	100	1,000,000
8	120	480,000
10	120	600,000
12	120	720,000
20	120	1,200,000

Anoher example is the judicious selection of appropriate manufacturing technology to provide higher yield chemical pulp [5,6]. Table V illustrates the economic benefit of higher-yield alkaline sulphite pulping of kenaf whole stem (chips) over kraft pulping of softwood chips.

Table V - Pulping Economics from the Perspective of Fibre Costs.

Basis: Whole Stem kenaf chips at A$120/dry tonne
Softwood chips at A$100/dry tonne

Process	Est. Pulp Yield,%	Fibre Cost, A$/ODMT Pulp
Alkaline Sulphite	60.0	200.00
Kraft	48.0	208.33

It can be argued that chemithermomechanical pulping might even be better for the utilization of the "high-cost" kenaf whole stem. Unfortunately,high-yield "mechanical-type" pulping generally provides a pulp product of lesser technical and economic value. The optimum pulping yield for kenaf whole stem is likely to be the one that provides a fully bleached chemical pulp.

CONCLUDING REMARKS

Northern Territory,Australia has the available land and appropriate climatic conditions for the cropping of kenaf. The basic cost of kenaf cropping is moderately favourable under rainfed growing conditions. The typical yield of whole stem would be 10 dry tonnes per hectare. The farm-gate cost is calculated to be about A$114 per dry tonne. Because of the lack of distinctive technical merits,kenaf pulp can be considered only as a direct substitute for conventional wood pulp for paper production. Higher pricing for kenaf pulp can not be realistically expected.

Kenaf cropping could become more competitive under certain circumstances such as growing under irrigated conditions and chemical pulping to higher yields. In all cases,the economics of kenaf pulp production would require the usage of the whole stem.

ACKNOWLEDGEMENT

The permission of the Northern Territory Government to publish its 1987-89 study results is greatly appreciated. The comments and technical assistance of Messrs. Huyn Ngo and Wayne Mollah of the Department of Primary Industries and Fisheries are grately acknowledged.

AK14554

LITERATURE CITED

1. Anon.,"Kenaf Production and Pulping un the Northern Territory - Preliminary Assessment",Department of Primary Industries and Fisheries,Northern Territory,Australia,1989.

2. Annon.,Australian Commodity Statistics,Canberra,1995.

3. Lahaussois,J.C. and Kyrklund,B.,"An Economic Review of the Use of Kenaf for Pulp and Paper",Proc. 1st International Non-Wood Pulping and Papermaking Conference,CTAPI,Beijing, China,July,1988.

4. Parsad,B. et al.,"Georgia Kenaf Project",Proc. Tappi Pulping Conference,Chicago,USA,October,1995.

5. Wong,A.,"Technical and Economic Obstaclkes Affecting the Early Commercialization of Kenaf Pulp Manufacture in Developed Countries,Proc. Tappi Pulping Conference, Atlanta,USA,October,1991.

6. Wong,A.,"New Direction in Industry Development and Environmental Protection for Non-Wood Pulp Mills in Developing Countries",Proc. 2nd International

Sugar Cane Bagasse Lignin: Characterization and Use as a Controlled Release Device for 2,4-D and Its Biodegradation

Nelson Durán, Josefina A. de Souza
Instituto de química, Biological Chemistry Laboratory
Universidade Estadual de Campinas
C.P. 6154, Campinas, CEP 13083-970, S.P. Brazil
and
André Ferraz
Biotechnology Departament
Engineering Chemistry Faculty
Lorena, S.P., Brazil

ABSTRACT

2,4-D degradation free and inside of a controlled release device formulated from steam-exploded sugar cane bagasse lignin and the possible device biodegradation by fungi were studied. The lignin device was partially altered by *Phanerochaete chrysosporium* at the studied periods. Free 2,4-D under fungal treatment, a 58% was degraded to 2,4-dichlorophenol, meanswhile in the lignin device a 46% was degraded. An increase of 35% of 2,4-D release after fungal treatment was observed. Apparently no correlation between the activities present of lignin peroxidase and manganese peroxidase in the fungi during the contact with the lignin device was found.

INTRODUCTION

2,4-D biodegradation were mainly studied by bacteria (Haugland et al. 1990), however, the biodegradation of 2,4-D by ***P. chrysosporium***, although limited, were also studied (Yadav et al. 1993; Paszczynski et al. 1995).

Many controlled release devices were used for the herbicides, but with lignin as support were initiated very recently. Lignin was previously used as controlled release device by Brazilian and English researchers (Da Silva and Wilkins, 1992; Cotrim et al. 1993; Souza et al. 1996; Ferraz et al. 1996). In previous results on the characterization of the best low release device, the steam-exploded sugar cane bagasse lignin as a polymeric matrix for obtention of controlled release formulation of 2,4-D was found and it showed that the chemical composition of lignin from bagasse exhibited 93.4 ± 0.5% of Klason lignin and 4.1 ± 0.2% soluble lignin, 1.9 ± 0.01% ash with a low carbohydrate and total acids contents (0.39 ± 0.07% and 0.18 ± 0.03%, respectively)(Ferraz et al. 1992). The functional groups in the bagasse lignin were the following: 14.7 ± 0.9% MeO, 13.0 ± 1.9% total OH, 1.9 ± 0.1% aromatic OH, 10.1 ± 2.2% aliphatic OH, 3.3 ± 0.1%

C=O, and 0.1 ± 0.1% sulfur. A molecular mass (Mw) of 4364 Da with a polydispercity (Mw/Mn) of 10.3 was found. The elemental composition showed values of 62.89% C, 5.78% H, 0.13% S and 30.49% O (Da Silva et al. 1996).

The aim of this work was to compare the 2,,4-D/ steam-exploded sugar cane bagasse lignin (2,4-D/Lignin) before and after biodegradation and how this affect the controlled release of the 2,4-D in order to extrapolate to these results to the soil.

EXPERIMENTAL PART

Fungal Growth: *P. chrysosporium* (ATCC 24725) was maintained on 2% malt agar slants. In a solid state growing the method of Esposito et al. (1991) was followed, and in the liquid culture the methodology of Linko and Zhong (1987) was followed. Glucose Determination: The DNS method was followed (Miller, 1959). 2,4-D Addition to Culture Medium: After glucose consumption in the presence of fungus, 2,4-D at different concentration was added. Determination of 2,4-D Metabolites: The 2,4-D/lignin was destroyed by ultrasom and the free 2,4-D and metabolites were extracted with methanol and analyzed by HPLC (Column Merck RP-18, 200 x 4.6 mm (10 μm) with UV detector at 280 nm. Column temp. 45°C. Acetonitrile/acetic acid(1%) (3:8) in a flow rate of 1.0 mL/min). Formulation 2,4-D/Lignin and 2,4-D Release: The methodology of Ferraz et al. (1996) was followed. Enzyme Determination: Mn-peroxidase (Kuwahara et al. 1984) and lignin peroxidase (Tien and Kirk, 1984) were measured by standard procedure.

RESULTS AND DISCUSSION

In order to compare the 2,4-D degradation by *Phanerochaete chrysosporium* in the lignin device, the degradation of 2,4-D free in solution was studied. At different 2,4-D concentrations (5-100 ppm) (free) the fungal degradation in the presence of oxygen was studied (TABLE 1).

TABLE 1. 2,4-D Degradation (4 days) by *P. chrysosporium* (1.65×10^7 spores/mL) in 0.02 M tartrate buffer at pH 4.0 , 37°C.

[2,4-D] ppm	5	10	20	60	80	100
% Degradation	12	45	58	30	30	22
Lignin peroxidase (U/L)	0	40	25	0	0	0
Mn-peroxidase (U/L)	1	1.7	0.5	0.2	0	0

The high 2,4-D degradation by the fungus was at a concentration of 10-20 ppm, in which was also the high peroxidases activities of the fungus. The product isolated and characterized by HLPC was the 2,4-dichlorophenol.

In an experiment with infrared spectra of the lignin device showed that during the *P. chysoposrium* interaction (till 7 days), the lignin device appeared partially altered specially at the carbonyl regions (not showed). Then, it was important to study the 2,4-D degradation inside of the lignin device, in order to understand the possible role of the microbiological degradation on the device and in which extension this could be affected the 2,4-D low release to the soil.

The 2,4-D releasing in the control sample (2,4-D/lignin/water) was around 23%, but after fungal treatment a 58% was reached. This fact corroborates the infrared spectra changes. O course, this effect is amaximum one, since the conditions were selected for optimal growth and enzyme production of *P. chrysosporium* and this is not a real situation in the soil.

The results on the 2,4-D degradation in the 2,4-D/lignin device are showed in TABLE 2.

TABLE 2. Quantitative Analysis of 2,4-D degradation on a 45.9% formulation of 2,4-D/Lignin devise(average values of 2 indepenedent samples).

Miligrams of 2,4-D/lignin (in parenthesis days degraded)	Initial 2,4-D in 2,4-D/Lignin (mg)	Final 2,4-D in the culture media (mg)	Residual 2,4-D in 2,4-D/Lignin (mg)	Average Percentage of 2,4-D-degraded (%)
3.70(4 days)	1.70(20 ppm)	0.25	0.71	43.6 ± 0.1
6.40(4 days)	2.90(40 ppm)	0.42	1.16	46.0 ± 0.7
9.80(4 days)	4.50(60 ppm)	0.86	1.70	43.1 ± 0.1
3.60(7 days)	1.70(20 ppm)	0.33	0.60	44.7 ± 0.9
6.80(7 days)	3.10(40 ppm)	0.50	1.03	49.7 ± 1.3
9.90(7 days)	4.50(60 ppm)	0.89	1.31	49.3 ± 3.4

The 2,4-D degradation was similar for the different days (4 or 7) and also for different 2,4-D concentrations. In this case no correlation on the lignin peroxidase and Mn-peroxidase presence with the 2,4-D degradation in the 2,4-D/lignin devide (TABLE 3).The Table 2 showed that the 2,4-D degradation by *P. chrysosporium* was extremely sensitive to the 2,4-D concentration. The enzyme also showed this sensitivity. However, in the presence of the lignin device, the same type of interaction does not exist anymore. Then, the permeability or adsorption of the enzyme in the device surface can reach a maximum value of interaction with 2,4-D.

Studies in this direction with purified enzymes are actually in progress and probably will give us some answers to this question.

TABLE 3. Ligninolytic enzymes in the *P. chrysosporium* acting on 2,4-D/Lignin Device.

Time of degradation (days)	Initial 2,4-D Concentration (ppm)	Lignin peroxidase (U/L)	Mn-peroxidase (U/L)
4	20	17.5	0.0
4	40	3.0	0.0
4	60	0.8	4.3
7	20	12.4	4.5
7	40	0.0	2.3
7	60	6.2	4.5

In summary, the results from fungal attack on bagasse lignin device for low release of 2,4-D, showed that the device protected partially to the microbial degradation (this must be considered as maximum effect), then keeping a good condition for the active action of 2,4-D as herbicides at low concentrations. Studies of the microbialdegradation in soil is actually in progess.

Acknowledgement: Supports from CNPq, CAPES, FINEP and FAPESP are acknowledged.

REFERENCES.

- Cotrim, A.R., Souza, J.A., Ferraz, A., Da Silva, F.T. and Wilkins, R. (1993). The infleunce of different lignins on the controlled-release of 2,4-D and Ametryn herbicides. Proc. 3th. Braz. Symp. Chem. Lignin and Other Wood Comp. (D. Piló Veloso and Reinaldo Ruggiero, Eds.) Belo Horizonte, Brazil. 4. 278-281.
- Da Silva, T.F. and Wilkins, R.M. (1992). Use of lignins as support to herbicides in controlled release formulations. Proc. 2nd. Braz. Symp. Chem. Lignin and Other Wood Comp. (N. Duran and E. Esposito, Eds.) Campinas, Brazil. 3, 165-172.
- Da Silva, F.T., Ferraz, A., Souza, J.A., Rocha, G.J.M., Cotrim, A.R. and Schuchardt, U. (1996). Obtention of alkali lignin from steam-exploded sugar