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JUTE PRODUCTS RESEARCH

DP/BGD/75/013

BANGLADESH

Technical report: Chemistry of Lignin, with Special Reference to the Jute Fibre and the Photochemical Yellowing upon Exposure to Sunlight*

Prepared for the Government of Bangladesh
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of K.V. Sarkanen
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CONTENTS

MISSION SUMMARY

The following Summary covers both the activities of the Consultant in Dhaka during the period October 18 to December 17, 1985 and the results from research at the University of Washington on photochemical yellowing of jute, carried out between October, 1984 and April, 1986.

1. Work on stabilization of jute against photochemical discoloration by Dr. Abdullah at BJRI has resulted in the development of a nickel complex stabilizer for application to dyed jute fabrics. It is recommended that detailed application studies be continued on pilot plant scale to demonstrate the suitability of this highly promising method for mill scale application. Additionally, sulfur containing antioxidants are being tested as photostabilizing agents with promising results. It is proposed that additional laboratory equipment be aquired to facilitate progress in this research activity.
Work at the University of Washington (Annex I) has likewise been directed towards sulfur-containing antioxidants with main emphasis on polymeric stabilizers exemplified by polymethylene sulfide (PMS). It has been demonstrated that PMS additives combine moderate bleaching action with color stabilization, eliminate largely strength losses caused by phototendering and probably also act as fungicidal agents. Application of these stabilizers to both bleached and unbleached jute products deserves consideration and consequently, expanded research activity is recommended in this problem area.

2. A new research program was initiated jointly with Dr. Aminul Islam and Professor M. Mosihuzzaman (Chem. Dept., Dhaka University) to determine the chemical characteristics of lignins present in jute fibers and -sticks.

3. Research on the effects of sulfonation on the properties of jute fibers, initiated during the previous visit, continues as a part of Mr. Mohammad Ali's PhD thesis work.

4. The Consultant had frequent discussions with DR. Mohiuddin concerning research on the microbiological softening of jute cuttings. A novel design for the piling chamber for jute cuttings, proposed in the previous report, was being constructed under the direction of Mr. Ataur Rahman, S.S.O.

5. The Consultant acted as an Outside Examiner for the PhD thesis of Mr. Nurul Amin (Chem. Dept., Dhaka University, Thesis Advisor: Professor Jabbar Mian), covering the effect of urea-formaldehyde- and melamine resins on the properties of jute fabrics.

6. At the end of the visit, the Consultant composed a draft for the proposed Phase II Program at BJRI (Tech.) for submission to UNIDO.

I. INTRODUCTION

The purpose of the mission was to continue work started during two earlier visits to BJRI (Tech.), described in the First Technical Report (DP/ID/SER. A/511, dated 2 May, 1984) and in the Technical Report DP/ID/SER. A/548), dated 5 November 1984.

The Consultant arrived to Bangladesh on October 18, 1985. The originally planned 6-week visit was extended by two weeks with approval by UNIDO in order to enable the Consultant to prepare a draft plan for the proposed Phase II program. A copy of this draft is appended as Annex II.

The report consists of two parts

A. The Consultant's activities in Bangladesh during the period October 18 to December 17.

B. Short summary of research results on the photostabilization of jute and chemimechanical pulps at the University of Washington between October, 1984 and July, 1986.

A. ACTIVITIES IN BANGLADESH

1. Photostabilization of Bleached Jute. Research and development work in this area is the responsibility of Dr. A.B.M. Abdullah and his group. The two main directions of current research are the following:

a. Photostabilization of dyed jute products by the application of nickel complexes.

b. Stabilization of bleached, white jute fabrics by antioxidants.

The first method, based on the discovery of Dr. Abdullah in connection with his Ph.D. research conducted in the UK, has been tested on pilot plant scale by treating one hundred yards of bleached jute cloth with the nickel complex. The industrial feasibility of the method had been further demonstrated by converting samples of dyed cloth to various finished products such as wall coverings and table cloths. The quality of these products appears very promising.

It appears that a similar approach towards the commercial utilization of the nickel complex method is called for as was recently performed in connection with the jute blankets developed at BJRI. However, this activity has not yet been initiated.

The stabilization of white jute fabrics is now being explored using commercially available antioxidants currently in use in synthetic polymer and wool industry. Several sulfur-containing anti-oxidants have been found promising, in general accordance with similar studies carried out at the University of Washington. The results of these studies were presented by Dr. Abdullah at the International Jute Conference at BJRI in October, 1985.

The second program area appears promising for future industrial application and deserves to be encouraged. As it is, the testing methods being used are not sufficiently reliable due to the lack of adequate equipment, such as irradiation and whiteners measurement instruments.

2. Jute Lignin Research. Together with Dr. Aminul Islam (BJRI) and Professor M. Mosihuzzaman (Chem. Dept., Dhaka University), a joint research program was set up to characterize the lignin components in jute fibers and sticks. Milled wood lignin and soda lignin preparations were successfully isolated and characterized by various analytical and spectral methods. The remaining analytical and ^{13}C-nmr determinations are now in progress in Professor Theander's laboratory in Sweden. The results will be published during the coming fall.

3. Sulfonation of Jute Yarns. Jointly with Dr. A. Rahman (Chief, Chemistry and Biochemistry Division) and Mr. Mohammad Ali, S.S.O., a series of experiments was conducted on the sulfonation of jute fibers. It was demonstrated that sulfonation is superior to alternative methods of partial delignification in producing a light-colored, soft and bleachable fiber. Work on jute sulfonation continues in the form of Mr. Mohammad Ali's Ph.D. study under the direction of Professor Ali Naob (Chem. Dept., Dhaka University).

4. Pile Softening of Cuttings. The Consultant had frequent discussions with Dr. G. Mohiuddin and was well impressed by his investigations, specifically on the pectinase activities of thermophilic microorganisms. The proposal made in the previous report of constructing a softening chamber with forced circulation of the pile atmosphere in order to maintain uniform temperature and maintain content throughout the pile, was followed up by Mr. Ataur Rahman, S.S.O. The construction of a chamber unit for this purpose was nearing completion at the time of the Consultant's departure.

5. Improvement of the Resiliency of Jute Fibers by Cross-linking. The Consultant acted as Outside Examiner for the Ph.D. thesis of Mr. Nurul Amin at the Chemistry Department of Dhaka University. The thesis advisor for this study was Professor Jabbar Mian. This valuable and well-performed study covers the effects of urea-formaldehyde- and melamine resins on the properties of jute fabrics. The results are promising enough to encourage application to such products as jute carpets. The success of the project encourages further cooperative activities between BJRI and Dhaka University.

6. Composition of the Draft for the Phase II Program at BJRI (Tech.) In composing the program draft, the Consultant started from the idea that the Phase II Program will be task- rather than training-oriented. In cooperation with the Chiefs of the individual departments, Mssrs. Rahman, Lodi, Salam and Alam, the goals and functions of the departments were defined and the approximate costs of implementation were estimated. A copy of the draft document is appended as Annex II to this report. Based on the drafted plan, the cost of implementation of the Phase II Program will be approximately two million U.S. dollars.

B. PHOTOSTABILIZATION STUDIES AT THE UNIVERSITY OF WASHINGTON, October, 1984 - July, 1986.

A Ph.D. thesis work on the sulfonation, bleaching and stabilization of jute fibers against photoinitiated discoloration was started in the beginning of 1984, and completed in April, 1986, by Mr. Hossein Resalati. Reference to the early part of this work was made in the previous report. The later part of the thesis, focussed on photodiscoloration and its inhibition, is the subject of this report. A copy of the full thesis was mailed to Mr. Eranova, UNIDO, in April. Dr. Resalati's thesis summary is appended to this report as Annex I. The general conclusions based on this research project are the following:

1. On account of high brightness values that can be achieved by the use of hydrogen peroxide at relatively low application levels (1-3%), this bleaching method is clearly superior to other methods, including hypochlorite. Peroxide bleaching does, however, accelerate both photodiscoloration and phototendering, emphasizing the need for developing effective methods for the inhibition of these phenomena.

2. A broad study conducted on various methods to retard photodiscoloration in jute and in high-yield paper pulps suggested that many of the approaches taken earlier, such as the use of ultraviolet absorbers or blocking the phenolic groups in the lignin component, did not warrant further exploration. Even borohydride reduction of jute was found to be inefficient in retarding photodiscoloration, in contradiction with studies performed elsewhere. The most promising approach was found to be in the use of sulfur-containing antioxidants - a conclusion similar to that reached in studies carried out at BJRI.

3. Of low-molecular weight antioxidants, 1-thioglycerol and glycoldimercaptoacetate were found to be the most effective. The photostabilization effect of the former antioxidant is illustrated in Figure 1. It can be seen that less than 5 percent addition to the jute fiber is sufficient to eliminate most of the photoinduced discoloration.

Low molecular weight antioxidants are, however, water-soluble and are therefore removed from the fiber by water extraction with accompanying loss of photostabilization. Alternative, water-insoluble antioxidants were consequently tested. Among these, polymethylene sulfide (PMS) was found specifically effective in retarding photodiscoloration. This polymer is readily prepared either by an acid-catalyzed reaction between formaldehyde and hydrogen sulfide, or by reacting formaldehyde with ammonium hydrosulfide.

The effect of PMS-additions to peroxide-bleached and unbleached jute fibers are illustrated in Figures 2 and 3, respectively. It should be noted that unbleached jute fibers do not undergo significant photodiscoloration. In this case, the addition of PMS induces a slight photobleaching effect amounting to 10 brightness units whereafter the color remains stable (Fig. 3). Likewise, when PMS is applied to sulfonated jute fibers, irradiation causes bleaching rather than discoloration and the increased brightness remains unchanged upon continued irradiation.

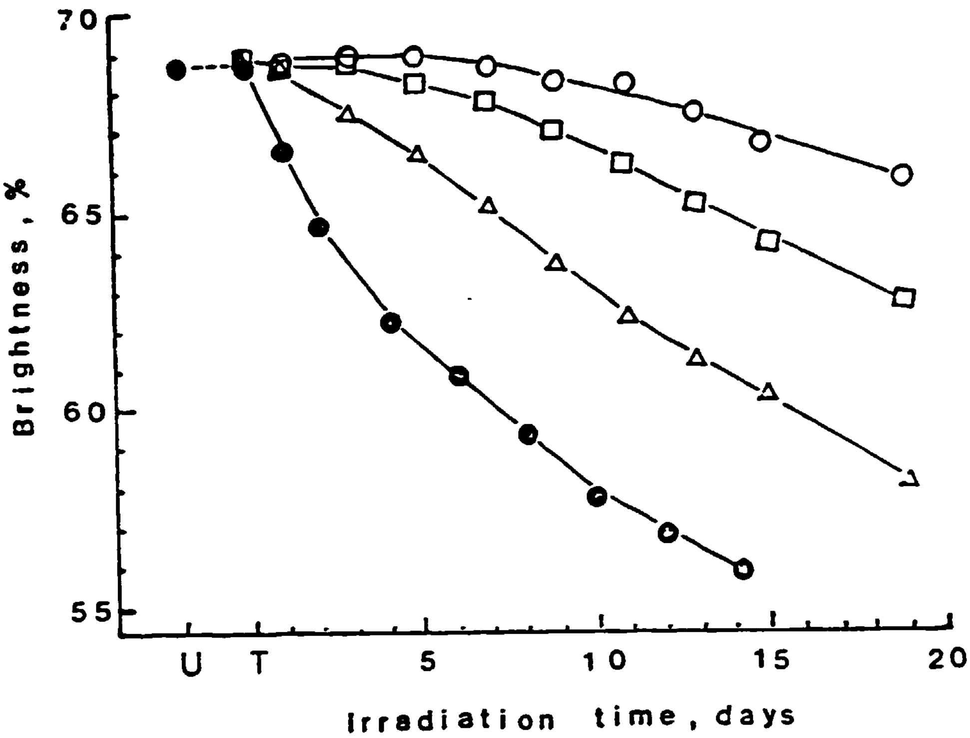

Figure 1. Effect of 1-thioglycerol concentration on light-induced discoloration of peroxide bleached jute fibers; U = untreated; T = treated: control (●), 1.5% (Δ), 3% (□), 6% (O).

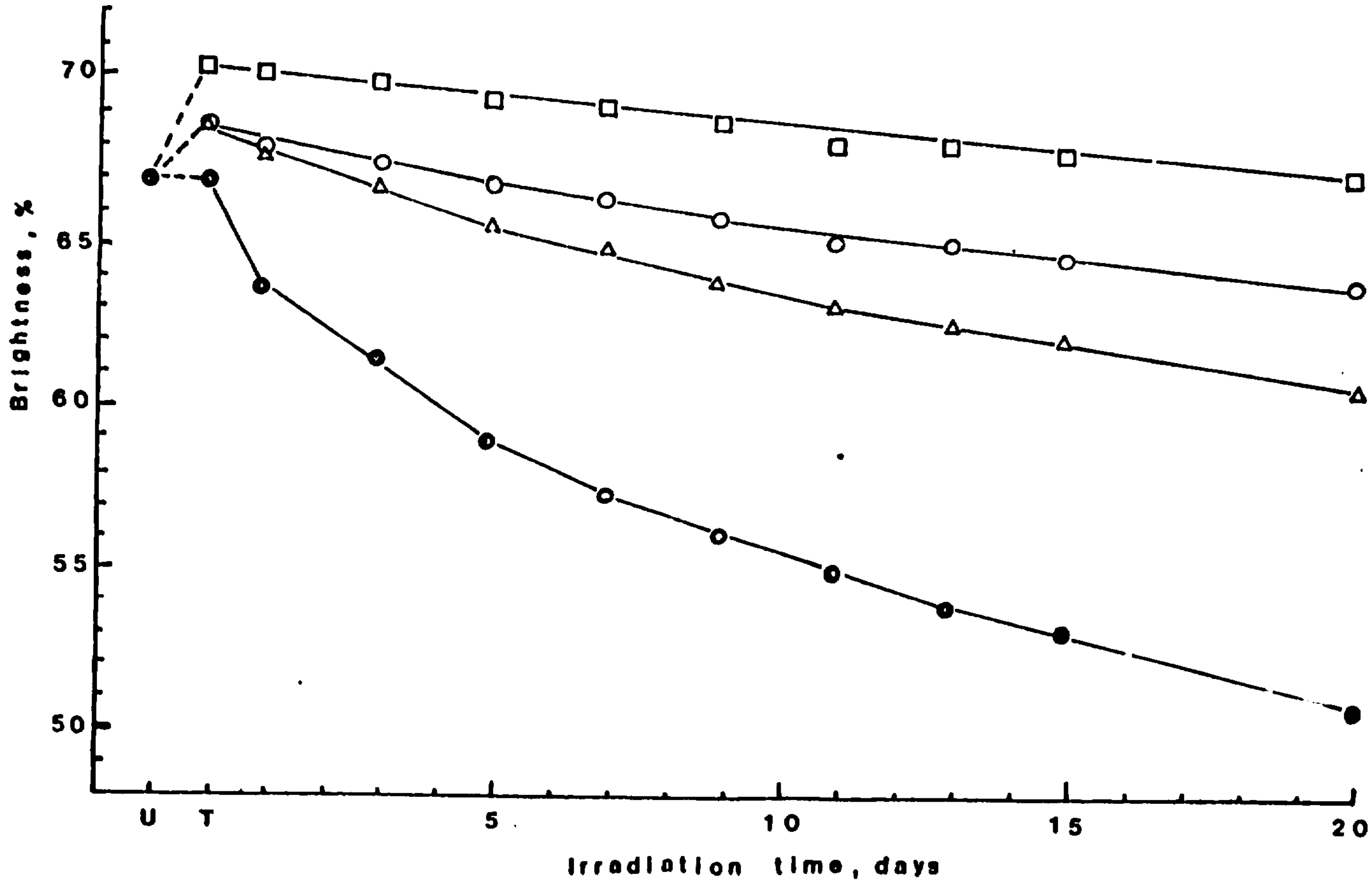

Figure 2. The effect of PMS-C on light-induced discoloration of peroxide bleached jute fibers. U = untreated; T = treated: control (●), 2.2% (Δ), 4.45% (O), 6.7% (□).

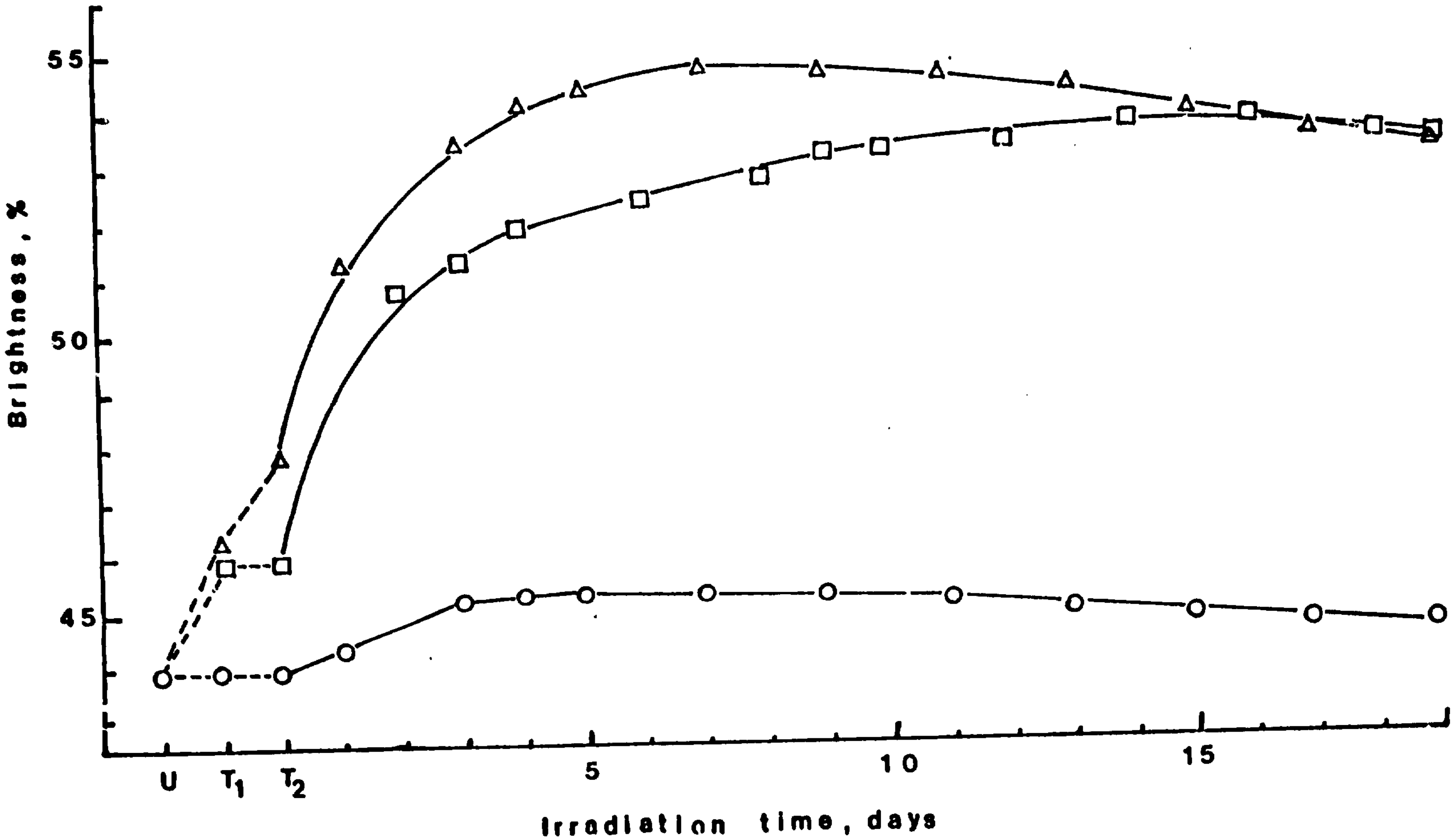

Figure 3. The effect of PMS-C on photostability of unbleached jute fibers as such and pretreated with DTPA. U = untreated; T = treated: control (○), 7% PMS-C (□), DTPA-7% PMS-C (△).

Particularly interesting results were obtained in determining the effect of PMS on the phototendering of jute yarns, measured as the degeneration of the tensile strength (Figure 4). It should be noted first that phototendering, in general, was observed to be a linear function of irradiation time. Significant as the phototendering is in unbleached jute yarns, its rate becomes more than tripled after peroxide bleaching. In both cases, however, PMS-addition essentially eliminates the phototendering phenomenon.

4. Dr. Resalati was not able to pursue the highly promising polymethylenesulfide studies in greater detail, because he had to return to his native Iran and accept duties as a professor at the University of Tehran. Photodiscoloration studies have later been continued in the context of cottonwood chemimechanical pulp by Barbara Cole and in application to softwood chemimechanical pulps by Judith Hooper. A short summary of these studies is given in the following:

In general, a complete correspondence was established for the photostabilization effects of various antioxidants on jute, on one hand, and cottonwood chemimechanical pulps, on the other, although the required chemical charges for equivalent stabilization were somewhat larger in the latter case. Initial efforts towards the continuation of the PMS studies were concentrated on the development of proper synthetic methods for obtaining polymethylene sulfide preparations suitable for conversion to water-soluble cationic polyelectrolytes. It was hoped that the cationic PMS could be equally applicable for padding of jute fabrics and as headbox additive in paper manufacture. Difficulties were encountered, however, in obtaining PMS-products that were sufficiently soluble for successful reaction with dimethylsulphate. Work along the PMS line was therefore temporarily discontinued in favor of a systematic study on the functional groups responsible for photostabilization. A large number of low-molecular weight compounds containing thiol-, thioether- and disulfide groups were either acquired or synthesized and tested as photostabilizing paper additives. It was found that the photostabilizing action is strongly dependent on a., other functional groups present in the molecule and b., the molecular weight and steric effects.

The Ph.D. work of Barbara Cole is now completed and she will join the Chemistry Department of the University of Maine as an assistant professor. Work on photostabilization will be continued by another graduate student, Judith Hooper, for the next two years under financial support from the Weyerhaeuser Company.

Earlier results of the work at the University of Washington were presented by the Consultant at the International Jute Research Conference at BJRI in October, 1985.

On the basis of the research findings to date, it is the Consultant's opinion that it will be possible to develop industrially applicable photostabilizers for jute within the foreseeable future. Suitably modified polymethylene sulfides appear presently the most promising candidates in this respect. It should be noted that the potential application of these chemical agents is probably not limited to fully bleached jute fabrics - they may also find use in improving the quality and useful lifetime of such common jute products as sacking and wool packs. The beneficial effects in the latter case consist of the following:

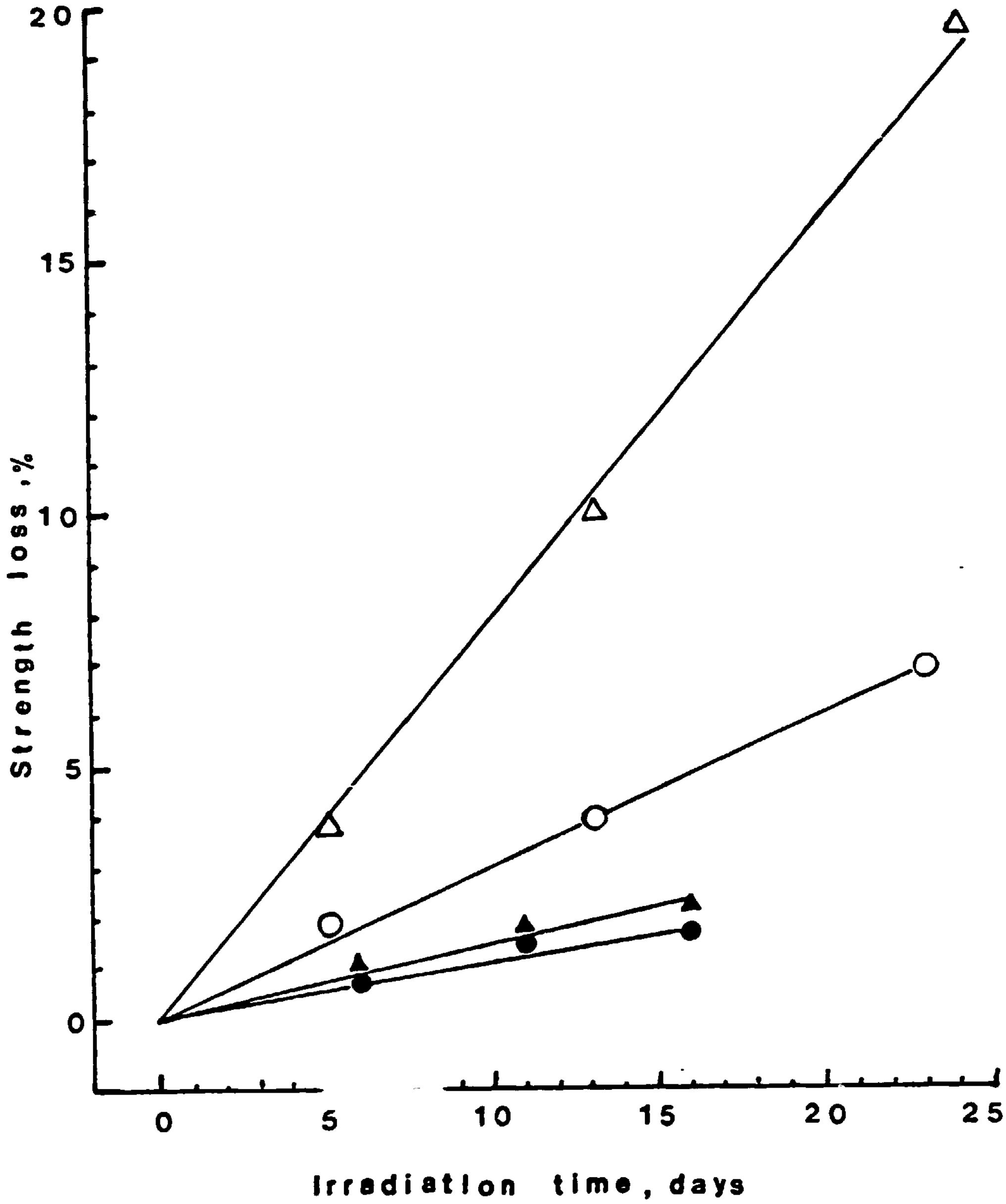

Figure 4. The effect of PMS-C (6.5% based on OD yarn) on phototendering (tensile strength loss) of unbleached and peroxide bleached jute yarn. Unbleached yarn (○), bleached yarn (△), treated unbleached yarn (●), treated bleached yarn (▲).

1. PMS-additives combine moderate bleaching action with photostabilization.

2. Strength losses as a consequence of phototendering (and possibly by other oxidative processes) are reduced.

3. According to literature information, PMS-derivatives probably are effective in reducing fungal degradation.

Opportunity for the continuation of jute studies at the University of Washington may become possible in the context of the training mission by Mr. Momen Miah and Mr. Anwaral Islam, scheduled to start in October, 1986. Also, increased emphasis on photostabilization is recommended for the projected research program at BJRI. The Consultant is interested in continuing cooperation with BJRI in terms of information exchange and possible additional visit (most convenient time: May, 1987.)

ANNEX I

Summary from Ph.D. thesis by Hossein Resalati, entitled "Stabilization of Jute Fibers Against Photodiscoloration by Antioxidants."

Chapter V - Summary

The objective of this research was to stabilize bleached and unbleached jute fibers, with or without partial delignification, against photo-induced discoloration. The major findings are summarized as follows:

1. By using common bleaching agents, hypochlorite and chlorine dioxide, approximately 40-45% of lignin can be removed from jute yarn without significant loss in wet strength.
2. Alkaline sulfite treatment strongly deteriorates the wet strength of jute fibers, causing approximately 70% reduction in wet strength at about 50% delignification level.
3. In sodium sulfite treatment, the degree of delignification of jute fibers, is directly proportional to both weight loss and strength loss and is independent of the reaction temperature.
4. Sulfonation of jute fibers improves fiber flexibility and softness, but accelerates the photodiscoloration. At the same level of initial brightness, it affords higher sensitivity to discoloration as compared with either hypochlorite or hydrogen peroxide bleached fibers.

5. Hydrogen peroxide bleached fibers have a similar tendency to photodiscoloration as hypochlorite bleached fibers, at the same level of initial brightness.
6. Reduction of bleached or unbleached jute fibers with sodium borohydride provides only modest stabilization. This degree of stabilization is even lower than that of fibers bleached with sodium chlorite.
7. Thiol containing antioxidants, such as 1-thioglycerol and glycol dimercaptoacetate, effectively stabilize jute fibers against photo-induced discoloration. However, the photostability of the treated fibers is eliminated when the fibers are washed with water prior to irradiation.
8. Treatment of jute fibers with excess ethylene sulfide in vapor phase at temperatures ranging from 65 to 100°C, provides considerable photostabilization at near-neutral pH values. When the jute fibers are wetted with water prior to ethylene sulfide treatment, a higher degree of initial brightness increase is obtained followed by improved photostabilization.
9. About 50% initial ethylene sulfide charge is sufficient to achieve photostabilization equal to that of 1-thioglycerol.
10. Ethylene sulfide treatment at near-neutral pH also results in an increase of the fiber wet strength.

11. Treatment of jute fibers with polyethylene glycol improves slightly the photostability of bleached jute fibers.

12. Out of three different types of polymethylene sulfide (PMS) synthesized from formaldehyde solution, only that produced in an acidic medium, PMS-C, was found to be an efficient antioxidant in photostabilization of jute fibers.

13. Treatment of jute fibers with PMS-B affords satisfactory stabilization. However, an initial drop in brightness after polymer addition appeared unavoidable.

14. Treatment of peroxide bleached jute fibers with PMS-C not only results in an increase of initial brightness but also affords a significant stabilization against light-induced discoloration.

15. Photo-induced discoloration of peroxide bleached sulfonated jute fibers can also be prevented by treatment with PMS-C.

16. When unbleached jute fibers are treated with PMS-C, the initial brightness is increased, approximately 2 units, and the treated fibers are further photobleached, up to 8.0 units, even after 20 days of irradiation.

17. Treatment of sulfonated jute fibers with PMS-C not only prevents photodiscoloration but also results in a

significant increase in brightness, due to photobleaching, even after 20 days of irradiation.

18. Hydrogen peroxide bleaching of jute fibers increases the photosensitivity and also accelerates considerably their phototendering.

19. Phototendering of both peroxide bleached and unbleached jute fibers can be practically eliminated by treatment with PMS-C.

PRELIMINARY DRAFT FOR THE UNDP/UNIDO
PHASE II ASSISTANCE PROGRAM TO THE
BANGLADESH JUTE RESEARCH INSTITUTE (TECH.)

Introduction:

This Consultant spent the period October 18 to December 17, 1985 at the BJRI (Tech.). The main purpose of the visit was to participate in the development of a research and development program on the lowering of the photochemical yellowing tendency of jute yarns and textiles. This activity was one of the technical projects associated with the final phase with the UNDP/UNIDO project DP/BGD/75-013 aimed at strengthening the research capabilities of the Technological Research Wing of Bangladesh Jute Research Institute (BJRI). During the course of the UNDP/UNIDO Project, the desirability of follow-up project-"phase II Program" - had been contemplated. However, it was not until October 1985, when the Government of Bangladesh made a formal request to UNDP/UNIDO for the establishment of such a project, with an approximate budget of 4.5 million US dollars for a five-year period. At the time of this writing, UNDP has given an indication of a necessity of substantial reduction of the budgetary request and what the final allocation will be is not known at the moment.

This decision of the Bangladesh Government to recommend the establishment of a Phase II project generated an immediate and urgent need to define the scope of this project, for approval by UNIDO. In this context, the Consultant agreed to compose, in addition to his other duties at the BJRI, a preliminary draft document describing the salient aspects of the Phase II project.

The purpose of the draft document is to form the foundation for the final plan for the Phase II project which, in due time, would be submitted to UNIDO for approval.

In view of the very short time that could be made available for the composition of the draft document, extensive corrections, revisions and complementations will be necessary, before the document will reach the state appropriate for submission to UNIDO.

Phase I Program:

The project "Jute Products Research", DP/BGD/75/013 was initiated in October, 1978 with the immediate objective "to develop the capability of BJPI(Tech.) to carry out technological research and development work for the benefit of the Bangladesh Jute Industry on a scale appropriate to the size and economic importance of the industry". The program was completed, after a nine-month extension, in June, 1985. At this time, the total UNDP project input amounted to $ 3,045,311. During the course of the project, altogether three evaluations were carried out. Of the last evaluation (May, 1984), two reports are available:

A. Evaluation Report prepared by Dr.J.J.Willard, UNIDO Consultant, and submitted in June 29, 1984.

B. In-Depth Evaluation Report of the UNDP Project, Jute Products Research, prepared jointly by Ayubur Rahman, M.A.R.Talukder M.M.M. Rahman and A. Mumin, and completed in August, 1984.

Both of the reports mentioned rated the jute products Resear project as highly succesful in fulfilling the goals initially set forth for the program. The specific areas that received favourable evaluation included a balanced research program consisting of ten main areas, acquisition of appropriate machinery and laboratory instrumentation and training and study tours of research staff. The second, more comprehensive evaluation report singled out the following achievements as significant research and development outputs of the Institute:

1. Development of a method to spin light-weight (2.0-2.5 count) jute yarn.
2. New technique to test the durability of jute fabric under soiling conditions.
3. Demonstration of the suitability of domestic raw materials (Potato, sweet potato) for the production of sizing agents for jute.
4. Progress made in improving the fire resistance of jute carpets and wall coverings.
5. Improvement of bleaching and dyeing methods.
6. Improvement of carpet yarn resiliency by jute-acrylic blends.
7. Development of a yarn abrasion tester.
8. Progress made in chemical methods to soften jute cuttings and to improve the quality of jute yarns by partial delignification.
9. Development of a branding ink formulation from domestic raw materials for marking of jute bags.

Although both reports gave an overwhelmingly positive evaluation of the success of the UNDP/UNIDO Project, a need was nevertheless envisaged for a Phase II project, supported by the same agencies for an additional five-year period. Dr. Willard's report only states broadly the need of strengthening the capabilities of the Institute to carry out research and development work in the area of textile blends of jute with other natural and synthetic fibres and products developed therefrom. A slightly more detailed description of the envisaged Phase II project is given in the second evaluation report and consists of four areas of financial support. A cursory list ofneeded machines and laboratory equipment is provided with no cost estimates, however. The needs for short-term consultants and experts is estimated to amount to 50 man-months and that of training fellowships abroad, to 125 man-months. In addition, 50 man-months are proposed for specific study tours abroad. Thus the program, as envisioned by the Evaluation Report, would essentially be a continuation and expansion of the Phase I-project.

It is to be noted, however, that the views of UNIDO are not in accord with this concept. In their view, the Phase I project whose expressed aim was " to provide assistance to develop the capability of BJRI (TRW) for technological research and development work related to the products of the jute manufacturing industry" is completed and finished. Therefore the Phase II program, if implemented, ought to be much more specific in nature. In a nutshell, the design of a viable Phase II program would require, in the first place, answers to be given to the following questions:

1. What specific aspects in the capabilities and present and planned research programs of BJRI (TRW) need strengthening ?

2. In which manner assistance by UNDP/UNIDO can be made instrumental in aiding and facilitating these strengthening activities ?

As a matter of fact, considerable thought has been given by the BJRI (TRW) personnel to the needs of the strengthening activities after the completion of the Phase I project. In a workshop on Agricultural and Technological Research on Jute (April 12-24,1985), valuable suggestions were obtained from representatives of the Bangladesh Jute Industry. The potential implementation of these and other suggestions has been elaborated in a specific document (Project Proforma of Strengthenin of Technological Research on Jute,July,1985). The areas that were considered to require strengthening are briefly summarize in the following:

A. Up to the present, BJRI(TRW) has not given sufficient attention to improving currently practiced mill production methods. By specific research projects and by applying innovations developed elsewhere in the textile industry to jute processing, BJRI(TRW) can perform valuable service to the jute industry by:-

- Developing engineering modifications for currently utilized machines in order to maximize production rate, reduce labor input and improve product quality.

- Generating modernized process control methods and instrumentation to improve product uniformity.

B. The development of standard testing methods for jute and jute products has been an activity performed largely outside of BJRI(TRW). It is now proposed that BJRI would assume leadership in fulfilling the needs of jute industry in this area.

C. The Evaluation Report by Ayubur Rahman et al (P.8) recognizes the need for improvement in the management of individual research projects, as reflected in the following statement.

"The research efforts (at TRW have not been) systematic, properly organized and directed............ and the organization (has been) lacking in leadership to achieve the desired objectives".

The weaknesses in project planning and management system are also brought forward emphatically by the UNIDO Expert Report submitted in June,1985 by B.N. Iliev who also gives guidelines for eliminating these weaknesses.

The internal evaluation conducted during 1985 demonstrates clearly that although the Phase-I program was instrumental in creating the basic foundation for productive research and development work, additional efforts will be required to upgrade the activities of BJRI (TRW) to a level where it can efficiently serve the needs of the Bangladesh jute industry. It is also clear that the personnel at BJRI is thoroughly aware of the current shortcomings and is making efforts to rectify them. Consequently assistance by UNDP/UNIDO Phase II program in order to accelerate these developments appears appropriate.

PLAN FOR THE PHASE-II PROGRAM.

General:

The goals of the Phase-II project will deviate significantly from those of the first program. While the latter program has the broad objective of developing the over-all capability of BJRI (TRW) for technological research and development, the Phase-II project will be strictly task-oriented. Consequently, any acquisitions of machinery and laboratory equipment need to be justified in terms of applicability to current or future industrial operations. Visits abroad cannot any more be considered as training missions, but require the completion of a specific task such as gathering important information or performing research for which the home-base is not adequately equipped. Likewise, task-orientation needs to be emphasized in the selection of visiting foreign experts.

It should also be noted that the Phase-I program made no provision for the use of domestic consultants. This oversight ought to be corrected in the context of the Phase-II program. There is is a great deal of expertise in Bangladesh both in jute technology and - science that could benefit the BJRI (TRW) activities. It is therefore proposed that the UNIDO consultantships should include a selected number of Bangladeshi experts, such as university professors, industrial engineers on professional leave or prominent retired jute industry executives. In the following outline for the Phase-II program, six program area are separately considered:

1. Upgrading of cuttings and low-grade jute.
2. Development of spinning and weaving technology for conventional and new jute products, including blends with other natural and synthetic fibres.
3. Bleaching and photostabilization methodology.
4. Dyeing,printing and finishing technology.
5. Chemical modification of raw jute, jute yarns and fabrics.
6. Needs for additional testing and laboratory research equipment.
7. Technical and extension service for jute Mills.

The following section will outline current and planned activities in each of the above program areas. In the context, appropriate forms of assistance by the Phase II program are outlined.

<u>Upgrading of Cuttings and Low-grade Jute</u>:

The problem of low-quality cuttings, representing the fibres from the bottom part of the jute plant, is as old as the jute industry itself. Extensive research activities to solve this problem have met with limited success only. Thus,addition of microbial nutrients to batching emulsion shortens the softening period significantly and the method has gained wide-spread use in jute mills. However, significant improvement of the softening effect is not achieved. A crude enzyme method developed in India, however, has been claimed to be more successful in this respect and significant improvements in the softening of cuttings have been observed in mill-scale experiments.

Regardness of these partial successes in the cuttings technology, the problem of upgrading this material which represents approximately 25% of the total jute harvest remains perhaps the most important problem facing the industry. It is also to be observed that the jute industry as a whole is eager to implement any improvements that may be developed in the handling of cuttings because of the substantial economic gains that may be realized. Therefore, research work in cuttings technology must remain one of the topics of foremost importance in the research program of BJRI (TRW). To make future progress in this area, three alternative approaches need to be considered:

a. Improvement of retting technology at the farmers' level
b. Development of uniform and controllable batching methods at the mill.
c. Manufacture of products not requiring high quality jute, such as geotextiles or paper pulp.

In the first area, that of retting technology, several improved methods have been developed, but they have all failed to gain acceptance by jute farmers. Consequently, emphasis in continuing efforts ought to be placed on <u>practical field studies</u> rather than laboratory investigations. The questions to be answered by field studies are the following:

- What kind of improved retting practice will be acceptable to jute farmers ?

- In which way economic incentive can be provided to the farmers to deliver cuttings of improved quality ?

- Can the collection of protein rich jute leaves for cattle food supplement be integrated with the jute harvesting practice ?

For this part of the program, the meaningful input by UNDP/UNIDO would be the provision of adequate transportation facilities. During the Phase-I-program, the provision of two micro-buses with drivers proved to be insufficient for effective mill visitation program. It is proposed that a third car(jeep) with driver be added to transportation facilities.

In mill batching studies conducted at BJRI(TRW), micro-biological investigations suggest strongly that the softening action during the process is mainly caused by pectinases generated by certain thermophilic bacteria with a temperature optimum at 65 to 70°C. This important work deserves to be encouraged. Its application to practical batching process is, however hampered by two factors. First, the batching facilities at BJRI fail to produce a realistic peak temperature. Mill batching which is currently being studied is non-uniform in terms of moisture content and temperature and can not be utilized to determine the effect of thermophilic bacteria under optimized conditions. For this reason, the construction of a pilot size batching apparatus (25 kg capacity) has been initiated in which the temperature- and moisture conditions can be precisely controlled. Another rotating drum type batching apparatus is under planning. The ultimate goal of these studies is to design an improved and controllable batching facility and-technology for indusfrial treatment of cuttings.

The current estimate for the construction of the two types of Pilot-size batching units is $ 45000. It is proposed that funding for this development work be provided by the Phase II program.

The third alternative to solve the cuttings problem is to utilize this material in an application not requiring the qualities of long jute. A novel product of this nature has recently materialized in the form of geojute. This product consists of loosely woven fabric of thick yarns and can be manufactured entirely of cuttings and other low-grade jute fibres. It is used to stabilize steep slopes in road-and canal construction against erosion during the period of the establishment of vegetative cover. A similar material developed in Eastern Europe consists of a non-woven web made of cuttings fibre and caddies.

It is clearly indicated that the world-wide market for geojute is an expanding one and could potentially consume a large portion of cuttings fibre. It is therefore of utmost importance that the Bangladesh jute industry becomes tooled up for the manufacture of this product at an early date. Obviously, BJRI (TRW) should play a leading role in this endeavour. It is proposed that the Phase II program finance a 3-month study tour of an experienced technologist to collect information on the world-wide market potential of geojute and its manufacturing and application details. Simultaneously, the production of experimental quantities of geojute should be initiated at the pilot plant of BJRI.

B. Research in Spinning and Weaving for the Improvement of Conventional Processes and for the Development of New Jute Products, in Blends with Synthetic Fibres.

The basic spinning and weaving machinery at BJRI (TRW) was acquired at an early stage. Later, the capabilities of the pilot plant were complemented by special machines to produce low-count yarns. The current operation has been highly successful in not only clarifying operational problems in conventional jute processing but also in exploratory work to develop new products, such as those based on the use of union fabrics with cotton warp.

As mentioned earlier in this outline, current plans for strengthening the operation of BJRI(TRW) call for increased emphasis on industrially oriented project work, in part in cooperation with a new Engineering Department, to be initiated in the near future. This development phase does not however, require assistance from the Phase II program.

On the other hand it must be recognized that the world market for conventional jute products has been shrinking year by year and this regrettable trend will probably continue.

Consequently it is of utmost importance, for the Bangladesh jute industry in particular, to diversify its production to new, preferably high-value, products for export. The BJRI(TRW) has responded to this trend by exploring a whole spectrum of novel jute products. Of these, jute blankets consisting of a blend of woollenized jute with wool and acrylic fibre, have shown the best market potential. Large-scale consumer test of these blankets is now in progress.

However, the current facilities at BJRI are quite limited for processing jute blends with synthetic fibres. This fact was emphatically brought forward by the Technical Report of B.N. Iliev (June,1985). It seems logical that providing BJRI (TRW) with the capability of spinning and weaving jute blended with synthetic fibres ought to be one of the principal goals of the Phase-II program.

The machinery envisioned to fulfill the current needs is outlined in Table-I. It should be noted that the planned program does not include jute-cotton combinations, in order not to overlap with research in progress at BCSIR. Rather, the focus will be on blends consisting of flax-type jute and synthetic staple fibres.

In the weaving area, the main current need is to acquire machinery for the optimization of the blanket manufacturing process (items 2 to 5).

It is felt that project work for Bangladesh carpet industry can be best performed using idle machinery in existing mills. For the development of more competitive carpet products, both tufting and felting capability are necessary:

Table-I: REQUESTED MACHINERY FOR COMPLEMENTING EXISTING SPINNING AND WEAVING CAPABILITY.

	App. cost in U.S.$:
Spinning:	
1. Stapling machine	1,000.00
2. Card for Flaxtype Man-made fibre	150,000.00
3. Intersecting Drawing I	25,000.00
4. Intersectiong Drawing II	30,000.00
5. Combing Machine	35,000.00
6. Ring Spinning (Sliver spinning)	100,000.00
7. Scroll type Winding Machine	20,000.00
8. Reeling Machine	40,000.00
9. Hank-to-cone Winding Machine	25,000.00
Weaving:	
1. Bobbin-to-bobbin sizer	30,000.00
2. Blanket loom	8,000.00
3. Pirn Winding	1,000.00
4. Raising Machine	60,000.00
5. Overedge Sewing machine	1,000.00
Carpet & Non-Wovens:	
1. High Speed Tufting Machine	60,00.00
2. Combined Sheet forming, laying & felting machine	100,000.00
	6,86,000.00

C. Bleaching and Photodegradation studies:

No extensive activity is expected in bleaching of yarns and fabrics where optimal reactants (H_2O_2 or hypochlorite-H_2O_2) and conditions are well-known. In the pilot plant, the acquisition of a Hank Bleaching/Dyeing Machine (200-250 kg capacity, approximate cost $ 12000) is required for efficient yarn bleaching.

In contrast, two recent discoveries made at BJRI(TRW) in preventing photochemical yellowing require vigorous development work. The first of these discoveries is based on the quenching of photo-excited groups in bleached jute fabrics by certain nickel complexes. The light stability of fabrics treated with such complexes has been convincingly demonstrated not only on laboratory but also on pilot plant scale. What remains to be done, is the optimization of the process for such applications as wall coverings, furniture cloth and curtains. After extensive testing and optimization work has been completed, textile mills both in Bangladesh and abroad should be approached for industrial application of the photostabilization treatment.

The nickel complex method does not lend itself to the photostabilization of bleached white fabrics, because the complex itself is slightly colored. For this case, a promising line has been established in the addition of selected antioxidants to peroxide-bleached jute. Wash resistant antioxidants can be incorporated in jute fibres by either using insoluble polymers such as polymethylene sulfide or by reacting jute fibre with ethylene sulfide. The ongoing laboratory work will require approximately a six-month period, before a realistic pilot plant program can be designed.

The two discoveries mentioned place the BJRI (TRW) in a position of leadership in the jute photostabilization field. It is therefore important that further work towards the development of industrial scale photostabilization technology is pursued effectively. In order to implement this activity, the following assistance from the Phase II - program is required:

a. Additional instrumentation is needed for equipping the newly remodelled laboratory for bleaching, photostabilization and dyeing studies. Most of the essential instrumentation is already available at BJRI - such as the Xenotest apparatus. The urgently needed additional instrumentation is outlined in Table-II. It should be noted, that BJRI(TRW) has been inadequately equipped in terms of such items as optical instrumentation and even pH meter.

TABLE-II. EQUIPMENT NEEDED FOR PHOTOSTABILIZATION STUDIES.

Item:	Appr. cost in US $:
1. Reflectnance Spectrofotometer with Recorder.	10000
2. Two UV Rediation Lamps.	1000
3. Microscope.	3000
4. Photovolt Brightness Tester.	2000
5. Tensile Strength Tester for yarn.	1000
6. Ditto, for Fabric.	1000
Total	18000

b. Travel support is requested for the following purposes:

i. A tour to selected domestic and foreign jute-and textile mills in order to provide information on new photostabilization methods and to encourage their industrial application.

ii. A six-month visit by a BJRI (TRW) scientist to a foreign university to carry out a research program on the photostabilization of jute fibres by antioxidants.

D. Dyeing, Printing and Finishing.

During the past years, BJRI (TRW) has accumulated extensive experience in the three operations mentioned and also developed a meaningful research activity in this area. Further demands on these capabilities will be placed by the increasing orientation in the direction of fibre blends, in which the individual components respond in varying ways to dyes.

The existing laboratory - and pilot plant equipment is not adequate for the planned research and development activity. A list of needed instrumentation and machinery is presented in Table III for which funding is requested from the Phase-II program.

Table -III. Needed Equipment for Dyeing, Printing and Finishing Research.

Item:	Appr. cost in US $:
A. Laboratory equipment:	
1. Three bowl lab. padding machine	7000
2. Lab. size screen printing machine, flat	7000
3. High speed stirrer for print paste	1000
4. Colour Atlas	3000
5. Centrifuge	3000
6. Electronic balance (capacity 200g, 4-digit precision)	1000
B. Pilot plant machinery:	
1. Singeing machine	7000
2. Flat screen printing machine	25000
3. Full-width Steamer	2000
4. Cylinder drier	7000
5. Measuring and folding/rolling machine	5000
Total:	68000

E. Chemical Modification of Raw Jute, Jute Yarns and - Fabrics.

The chemical modification treatment which has been studied most extensively at BJRI(TRW) is based on the use of concentrated sodium hydroxide solutions at ambient or slightly elevated temperature. Mercerization of jute at ambient temperature produces "Woollenized" fibre which has been tested in several experimental applications including the blankets now undergoing consumer acceptance test. More recently, extensive studies have been performed on the effects of urea - and melamin-formaldehyde resins on the rheological properties of jute fabrics. These studies are now ready for continuation on pilot - plant scale. In addition, cross-linking studies using epichlorohydrin have been initiated.

BJRI (TRW) has also developed a novel approach to chemical modification, based on partial delignification by sodium sulfite solutions at 160°C. The method has the advantages of low chemical consumption, improved softness and bleachability, when compared with mercerization treatments. Lack of adequate autoclaves has so far prevented the work to be carried out at BJRI and all experiments to-date have been performed in the laboratories of BCSIR.

It is therefore essential that the lack of Pressurized equipment is corrected at BJRI (TRW.),especially since the same equipment will be needed for meaningful cross-linking studies.

Table IV gives the suggested list of laboratory - and pilot plant scale pressure equipment for which funding is sought from the Phase-II program. It is to be noted that the equipment finds also use in jute lignin studies and can potentially be utilised to study the conversion of jute waste to paper pulp.

Table IV. Necessary Autoclave Equipment for Chemical Modification Studies.

Item:	Appr. cost in US $
1. Six lab. size autoclaves, 250 ml volume, a $ 400	$ 2400
2. Rotating pressure autoclave, 20 liter capacity	$ 20000
3. Stationary, pilot plant-scale autoclave with forced circulation and control accessories	$ 90000
Total	112400

F. Needs for Additional Testing and Laboratory Equipment.

There are three separate factors which cause a need for substantial augmentation of currently available testing equipment at BJRI (TRW):

i. Some instruments, such as the Instron machines are old and out-of-date and spare parts are not any more available.

ii. BJRI will assume the responsibility of developing standard methods for the Bangladesh jute industry. Additional testing capability is required for this purpose.

iii. Expansion of development activities to fibre blends requires the acquisition of testing equipment for fibres other than jute.

Three items on the testing equipment list are somewhat tentative and their acquisition should be decided upon at a later date: Weather-O-meter (Item 32), Crock meter (33) and "WRONZ" (38).

Table V. Required Additions to Testing and Laboratory Equipment.

Testing Equipment:	App. cost in US $:
1. Two Instron Testers	20000
2. Conditioning Cabinet	5000
3. Air-Conditioning Unit (4-6 tons)	7000
4. Research Microscope with accessories for polarization, interference, phase contrast and ultraviolet microscopy together with photomicrography assembly	20000
Fibre testing:	
5. Photoelectric stapler (for fibre length measurement up to 18 inches)	5000
6. Sledge Sorter (for frequency diagram)	5000
7. Fibre Sampler	5000
8. Hardy microtome	400
9. Reflection microscope	1000
10. Bursting energy tester for jute reeds	1000
11. Ultrasonic apparatus with sound level meter	1600
12. Torsional rigidity analyzer	3000
13. Fibre melting point apparatus	3000
14. Hot stage microscope	1000
15. Mounting, sectioning and casting kit	500
16. Fibre staining kit	200
17. Thermal balance	1000
18. Thermal analyzer	1000

Yarn testing:

19.	Electronic wave length analyzer	1000
20.	Imperfection indicator	1000
21.	Inspection winder	1000
22.	Viewing cabinet	500
23.	Yarn slub counter	500

Fabric testing:

24.	Drape meter	1000
25.	Pilling tester	1000
26.	Snagging tester	1000
27.	Seam slippage tester	1000
28.	Shrinkage tester	1000
29.	Static electricity tester	1000
30.	Staining tester	1000
31.	Colour meter	15000
32.	Weather-O-meter	50000
33.	Crock meter	6000
34.	Flammability and flame toxicity testers	20000

Carpet and non-woven testing:

35.	Carpet static voltage tester	2000
36.	Tuft length block	500
37.	Caster chair	2000
38.	Wool tester "WRONZ" (New Zealand)	15000
39.	Carpet thickness gauge	1000
40.	Rubbing fastness tester	1000
41.	Togmeter, for measuring insulation values of felts	20000

Maintenance equipment:

42.	Digital multimeter	1500
43.	Oscilloscope	1500
44.	UV exposure and etching	500
45.	Microdrill	500

General laboratory equipment:

1.	Abbe refractometer	1000
2.	X-ray diffractometer	20000
3.	Two digital pH-meter	2000
4.	Shearing viscometer	6000
5.	Two rotary evaporators	700
6.	High vacuum pump	700

7.	Ball mill assembly	3500
8.	Vibratory ball mill	1500
9.	Recording UV spectrofotometer	10000
10.	IR spectrometer with "Wiggee ba" grinder and pellet press	20000
11.	Proton nmr spectrometer	30000
12.	Capillary gas chromatograph with integrator	12000
13.	High pressure liquid chromatograph	25000
14.	Scanning electron microscope	80000
15.	Video-cassette camera with accessories, for audio-visual presentations	3000
16.	High-speed video camera, for spinning process studies	15000

As far as the general laboratory equipment list in table II is concerned, items 1 to 10 and 12 represent straight-forward needs for studies on cellulose, lignin and hemicellulose. The real need for the high-cost instrumentation (items II, 13 and 14) should be scrutinized. If an arrangement can be made for the convenient use of coresponding instruments at Dhaka University and other governmental laboratories, their acquistion by BJRI may not be urgent.

G. Technical and Extension Service.

Almost all visiting UNIDO experts have pointed out the unsatisfactory contact and cooperation of BJRI (TRW) with the Bangladesh jute industry, and currently, definite measures are being taken to improve the situation. In this activity, support by the Phase-II program can be of importance. Three separate areas ought to be considered in this context:

i. Upgrading the library at BJRI to become an adequate source of information for Institute scientists and for the industry.

ii. Organization of annual meetings with representatives of industry and also,periodic international jute symposia..

iii. Regular publication of an informative news letter for the needs of industry.

Specifically, the library needs to increase its collection of books, journal subscriptions and abstract collections. Presently, the library has no system of obtaining copies of publications and patents from abroad. It is proposed that the library should acquire a telex-number to facilitate ordering copies of published papers and patents from abroad. It is difficult to give realistic cost for achieving this goal. It would appear that the sum of $ 10000 (including the cost of needed xerox-copiers) would not be excessive for this purpose.

The organization of annual meetings as well as symposia would involve, in addition to organizational expenditures, the travel cost of invited speakers. The proposed amount of assistance is, in this case, $15000 for the five-year period.

A monthly or quarterly newsletter has been found to be an outstanding tool of transmitting information to manufacturing units. This activity has become common in many central research institutes analogous to BJRI. It is proposed that at least one man-month of foreign consultants' time be assigned to the initiation of this and other publishing activities.

Foreign and Domestic Consultants.

Need for outside consultants (either foreign or domestic experts) is foreseen at least in the following areas:

1. Blending of natural and synthetic fibres.
2. Chemical modification of jute
3. Estimation of the cost of manufacturing processes (presentation of a short course to Institute personnel desirable)
4. Development of pilot plant - and full scale industrial processes starting from the results of laboratory-scale research.
5. Recent innovations in textile machinery.
6. Resin treatment and cross-linking of textile fabrics.
7. Dyeing and printing technology.

It is estimated that effective consulting activity will require a total of 60 man-months, domestic consultants inclusive.