THE FIBRES OF AUSTRALIMUSA

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1. INTRODUCTION

Australia is a section of the genus house in which it is planned here to utilise the world-renowned australind fibre, valued particularly for marine work because of its immense strength and resistance to the corrosive action of sea water.

The main area of production of Manila hemp in the Philippines which still maintains a virtual monopoly regardless of the world's increased demand for the crop in Central America, South America and North America. Previous attempts to introduce absence to other tropical areas have proved unsuccessful. This is probably due to the varying soil and climatic requirements of the species and the high cost of production of the fibre, particularly when labours are unskilled in handling the crop.

Abaco, it may safely be concluded, has only been confined to the Philippines. It has consisted mainly of artificial hybridization between varieties. A recent study in relation to absence breeding is that of Basili and Valdez (1961), in which absence, pacol and cotton were studied with a view to determining whether they were cross-fertile. It was hoped that hybrids might be produced which would have the immunity to bunt and mosaic of pacol and cotton while still retaining the desirable fibre qualities of absence. Results showed that absence and pacol were interfertile while absence x cotton and pacol x cotton were incompatible. These results are not surprising in view of the fact that pacol is a hybrid and cotton is a sterile hybrid (Em. 20), between pacol and absence, (Australia, 2n = 20); (Chinaman, 1960). It seems unlikely that pacol and cotton will prove useful in an absence improvement programme. In fact, the only alternative, or adjunct, to variety improvement is the use of other Australinds in a hybridization programme with absence.
1. INTRODUCTION

*Australimus* is a section of the genus *Musa* in which is placed *Musa textilis* Née, abaca or Manila hemp, the world's foremost cordage fibre, valued particularly for marine work because of its immense strength and resistance to the corrosive action of salt water.

The main area of production of Manila hemp is the Philippines which still maintains a virtual monopoly regardless of successful cultivation of the crop in Central America, Sumatra and North Borneo. Previous attempts to introduce abaca to other tropical areas have proved unsuccessful. This is probably due to the exacting soil and climatic requirements of the species and the high cost of production of the fibre, particularly where labour is not skilled in handling the crop.

Abaca breeding has previously been confined to the Philippines. It has consisted mainly of artificial hybridization between varieties. A recent study in relation to abaca breeding is that of Umali and Valdez (1951), in which abaca, pacol and canton were studied with a view to determining whether they were cross-fertile. It was hoped that hybrids might be produced which would have the immunity to bunchy-top and mosaic of pacol and canton while still retaining the desirable fibre qualities of abaca. Results showed that abaca and pacol were interfertile while abaca x canton and pacol x canton were incompatible. These results are not surprising in view of the fact that pacol is *M. balbisiana* Colla, (*Musa*, 2n = 22), while canton is a sterile hybrid (2n = 21), between pacol and abaca, (*Australimus*, 2n = 20): (Cheesman, 1949). It seems unlikely that pacol and canton will prove useful in an abaca improvement programme. In fact, the only alternative, or adjunct, to variety crosses is the use of other *Australimus* in a hybridization programme with abaca.
This has now been realised by the Filipinos and at least one Australimusa, *M. lolodensis* Cheesman, is being used in their programme of hybridization with a view to obtaining mosaic resistant plants. *M. lolodensis* is highly resistant to mosaic (Kent, 1954).

Among the collection of *Musa* at the Imperial College of Tropical Agriculture are several Australimusas, and hybrids of them between each other and with *M. textilis*. Their fibre characteristics are described in this paper, the work having been planned as a preliminary investigation into the possibility of improving abaca by interspecific hybridization.
2. MATERIALS AND METHODS

The tensile strength and thickness of their fibres have been determined for the following Australimusa species and species hybrids:

M. *textilis* Née - cultivated clones:

a) Tangongon (I.R. 240)
b) Libuton (I.R. 239)
c) St. Vincent (I.R. 71)

M. *lolodensis* Cheesman - I.R. 247, the type clone from Halmahera, Indonesia.

M. *peekelii* Lauterbach - I.R. 229, from New Ireland.

M. *maclayi* F.v. Mueller - I.R. 200 and 201, from Solomon Islands, type clones of M. *erecta* Simmonds.

M. *angustigemma* Simmonds - I.R. 194 and 395, from New Guinea, the former the type clone.

M. *lolodensis* x M. *textilis* - a triploid, LLT.

M. *textilis* x M. *lolodensis*

M. *lolodensis* x M. *peekelii*

M. *peekelii* x M. *lolodensis*

M. *peekelii* x M. *angustigemma*

M. *textilis* x M. *peekelii*

M. *textilis* x M. *angustigemma*

Similar examinations have been made of M. *violascens* Ridley - I.R. 108, from Malaya (*Callimusa*, 2n = 20), and the Eumusas, M. *balbisiana* Colla, several clones of various origins; M. *basjoo* Sieb. - I.R. 78A, from Liuki Archipelago, Southern Japan; M. *itinerans* Cheesman - I.R. 185, the type clone, from
Northern Burma and hybrids between *M. violascens* and some *Australimusas*.

Mature pseudostems were harvested. Tuxies were prepared from the outer edges of each leaf sheath. Well-cleaned fibres were obtained by removing the excess pulpy material from the tuxies in a hand hagutan. (Fig. 1).

A metal knife is attached to a 3 x 2 inch wooden cross-arm suspended at its central point from a 4 x 4 inch wooden upright. A weight on the opposite end of the cross-arm forces the knife against a smooth wooden block. A treadle, attached by a wire to the cross-arm, allows the knife to be drawn away from the wooden block to facilitate the insertion of the tuxies (Fig. 2).

When the treadle is released the tuxies become clamped between the knife and the wooden block. Sufficient force is exerted by the weight to allow the pulpy material to be removed from the tuxies when pulled evenly over the knife. (Fig. 3).

The fibre from each species was sun-dried and then sampled until sufficient material was obtained for testing. Only the middle section, 25 cm. long, was used. From each sample twenty-five fibres were selected so that they constituted a size range from the finest to the coarsest. Single fibres were mounted on wooden blocks with the aid of cold-water glue which was allowed to harden overnight. Wooden pegs of $\frac{3}{16}$ inch diameter were inserted through holes in each block and a full turn of the fibre was taken around each peg. (Fig. 4).

One block was attached to a cup-hook screwed into the bench, the other to a cup-hook attached to the end of a steel-yard. The steel-yard was made from a V-shaped steel girder 210 cms. long. The girder was graduated in decimetres and nicks were cut at suitable intervals so that it might be placed
accurately upon a knife-edge as fulcrum. The knife edge was supported, at a height of 12 inches above the bench, by clamps attached to two retort stands. (Fig. 5).

The apparatus allowed for adjustment of the fibre-fulcrum distance. Tension on the fibre was obtained by moving a kilogram weight in a distal direction along the steelyard. Weaker fibres were broken with the girder supported at its central point. For stronger fibres the girder was supported at a fibre-fulcrum distance of 80 cms. or 60 cms. Graphs of distances and breaking strengths were constructed from a knowledge of the weight and length of the girder. When the fibre snapped the distance from the fulcrum of the kilogram weight was noted and the breaking load was read directly from the appropriate graph. The diameter of each broken fibre was measured on a binocular microscope and the cross-sectional area computed. Most of the fibres measured were circular in cross-section but the remainder showed varying degrees of flattening. The approximate cross-sectional area of such fibres was calculated by measuring the long and short axes and using their mean as a measure of the fibre diameter.

The mean thickness of fibres from each species and hybrid was determined by measuring the diameters of a sub-sample of 100 fibres.
3. RESULTS

The relationship between the size and strength of fibres was determined by constructing graphs for all species and hybrids. The breaking load, L, (g. x 100) of each fibre was plotted against its cross-sectional area, A, (sq. mm. x 1000). The scatter diagram for M. textilis clone Tangongon is shown in Figure 6; the other plants studied all gave similar scatters.

Figures 7-11 illustrate the relationships between the strengths of Australimusas and their hybrids. Figure 12 shows the graphs for some miscellaneous species. Figures 13 and 14 illustrate the relationships between the strengths of M. textilis and M. violascens and hybrids and M. lolodensis and M. violascens and hybrids.

Results are summarised in Tables I and II. Length of mature pseudostem refers to the distance between its base and the point of emergence of the inflorescence. The breaking load corresponding to the mean cross-sectional area of fibres is given as the mean breaking load. The tensile strength was computed from the formula:

\[
\text{Tensile Strength (Kg./mm.}^2) = \frac{\text{Mean Breaking Load (Kg.)}}{\text{Mean Cross-sectional Area (mm.}^2)}
\]

The upper limits of breaking load and fibre diameter are given.

Table I shows that the Tangongon and Libuton clones of M. textilis have the coarsest fibre and highest mean and maximum breaking loads. The St. Vincent clone has the highest tensile strength but its fibres are finer than those of the other abacá clones. Those interspecific hybrids which have M. textilis as the female parent have tensile strengths and fibre diameters not far removed from those of the Tangongon and Libuton clones of abacá. The fibres of M. peekelii x M. angustigemma have a
### TABLE I

Pseudostem length and diameter and strength of fibres of Australimusas and hybrids.

<table>
<thead>
<tr>
<th>Species or Hybrid</th>
<th>Pseudostem Length</th>
<th>Mean Diam. of Fibre</th>
<th>Mean Breaking Load of Fibre</th>
<th>Tensile Strength of Fibre</th>
<th>Upper Limits of Diameter</th>
<th>Breaking Load</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>M. textilis</em> clone St. Vincent</td>
<td>18 dm.</td>
<td>0.135 mm.</td>
<td>1000 g.</td>
<td>69.4 Kg./mm.²</td>
<td>0.185 mm.</td>
<td>1670 g.</td>
</tr>
<tr>
<td><em>M. textilis</em> clone Taneoneon</td>
<td>40</td>
<td>0.165</td>
<td>1305</td>
<td>60.1</td>
<td>0.238</td>
<td>2360</td>
</tr>
<tr>
<td><em>M. textilis</em> clone Libuton</td>
<td>34</td>
<td>0.163</td>
<td>1170</td>
<td>56.2</td>
<td>0.172</td>
<td>1980</td>
</tr>
<tr>
<td><em>M. peekelii</em></td>
<td>49</td>
<td>0.116</td>
<td>540</td>
<td>50.9</td>
<td>0.172</td>
<td>800</td>
</tr>
<tr>
<td><em>M. angustigemma</em></td>
<td>40</td>
<td>0.127</td>
<td>600</td>
<td>47.2</td>
<td>0.228</td>
<td>1150</td>
</tr>
<tr>
<td><em>M. lolodensis</em></td>
<td>34</td>
<td>0.143</td>
<td>720</td>
<td>44.5</td>
<td>0.185</td>
<td>1030</td>
</tr>
<tr>
<td><em>M. maclayi</em></td>
<td>49</td>
<td>0.146</td>
<td>620</td>
<td>37.1</td>
<td>0.211</td>
<td>970</td>
</tr>
<tr>
<td><em>M. textilis</em> (St. V.) x <em>M. peekelii</em></td>
<td>34</td>
<td>0.138</td>
<td>850</td>
<td>56.6</td>
<td>0.199</td>
<td>1330</td>
</tr>
<tr>
<td><em>M. peekelii</em> x <em>M. angustigemma</em></td>
<td>37</td>
<td>0.122</td>
<td>660</td>
<td>55.0</td>
<td>0.145</td>
<td>910</td>
</tr>
<tr>
<td><em>M. textilis</em> (Tang.) x <em>M. angustigemma</em></td>
<td>40</td>
<td>0.144</td>
<td>830</td>
<td>51.2</td>
<td>0.236</td>
<td>1410</td>
</tr>
<tr>
<td><em>M. textilis</em> (St. V.) x <em>M. lolodensis</em></td>
<td>21</td>
<td>0.148</td>
<td>860</td>
<td>50.0</td>
<td>0.264</td>
<td>1460</td>
</tr>
<tr>
<td><em>M. lolodensis</em> x <em>M. textilis</em> (St. V.)</td>
<td>37</td>
<td>0.129</td>
<td>620</td>
<td>47.7</td>
<td>0.238</td>
<td>1800</td>
</tr>
<tr>
<td><em>M. peekelii</em> x <em>M. lolodensis</em></td>
<td>40</td>
<td>0.134</td>
<td>620</td>
<td>43.6</td>
<td>0.264</td>
<td>840</td>
</tr>
</tbody>
</table>
TABLE II
Pseudostem length and diameter and strength of fibres of some Musa species and hybrids.

<table>
<thead>
<tr>
<th>Species or Hybrid</th>
<th>Pseudostem Length</th>
<th>Mean Diam. of Fibre</th>
<th>Mean Breaking Load of Fibre</th>
<th>Tensile Strength of Fibre</th>
<th>Upper Limits of:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>dm.</td>
<td>mm.</td>
<td>g.</td>
<td>Kg./mm.²</td>
<td>Diameter</td>
</tr>
<tr>
<td>M. balbisima (Eumusa)</td>
<td>46</td>
<td>0.114</td>
<td>410</td>
<td>39.8</td>
<td>0.172</td>
</tr>
<tr>
<td>M. violascens (Callimusa)</td>
<td>12</td>
<td>0.108</td>
<td>500</td>
<td>55.5</td>
<td>0.145</td>
</tr>
<tr>
<td>M. acuminata x M. textilis (St. V.)</td>
<td>21</td>
<td>0.110</td>
<td>645</td>
<td>67.2</td>
<td>0.158</td>
</tr>
<tr>
<td>M. peekolii x M. violascens</td>
<td>24</td>
<td>0.118</td>
<td>705</td>
<td>64.1</td>
<td>0.172</td>
</tr>
<tr>
<td>M. violascens x M. textilis (St. V.)</td>
<td>18</td>
<td>0.114</td>
<td>585</td>
<td>58.3</td>
<td>0.146</td>
</tr>
<tr>
<td>M. textilis (St. V.) x M. violascens</td>
<td>18</td>
<td>0.136</td>
<td>825</td>
<td>56.9</td>
<td>0.158</td>
</tr>
<tr>
<td>M. violascens x M. lolodensis</td>
<td>21</td>
<td>0.118</td>
<td>585</td>
<td>53.7</td>
<td>0.158</td>
</tr>
<tr>
<td>M. lolodensis x M. violascens</td>
<td>18</td>
<td>0.112</td>
<td>480</td>
<td>49.5</td>
<td>0.158</td>
</tr>
<tr>
<td>M. violascens x M. angustigemma</td>
<td>27</td>
<td>0.116</td>
<td>525</td>
<td>49.1</td>
<td>0.158</td>
</tr>
</tbody>
</table>
high tensile strength but are very fine. *M. lolodensis* x *M. textilis* is a triploid of composition LLT. It has fine weak fibres. *M. peekeli* x *M. lolodensis* has weak fibres. The fibres from all species and hybrids have satisfactory colour and sheen.

Table II shows that *M. basjoo, M. itinerans* and *M. violascens* have strong but very fine fibre. *M. basjoo* is cultivated in southern Japan for its fibre (Baker, 1893).

*M. acuminata* x *M. textilis* has strong, fine fibre. The most promising hybrids from the point of view of both tensile strength and fibre diameter are *M. textilis* x *M. violascens* and *M. peekeli* x *M. violascens* but neither are robust plants. In fact none of the hybrids in Table II compare favourably with the best Australimusa hybrids of Table I.

That a breeding programme involving the use of wild relatives of *abe¿ is necessary is evidenced by the fact that the recovery of the *Philippine* abaca fibre production to its pre-war level has been severely retarded by disease, particularly by mosaic. (Julián, 1951). Plantations in North Davao are suffering from bunchy top infestation (Anon., 1953). Abaca grown in Central America is free of virus but other troublesome diseases (Robinson & Johnson, 1953) are proved to be controllable by the synthesis of disease resistant clones.
4. CONCLUSIONS

Although none of the hybrids mentioned in this paper will be ignored in further investigations, the results indicate that the species which will prove most useful in abacá improvement programmes are *M. peekelii*, *M. angustigemma* and *M. lolodensis*. Although hybrids between these species and *M. textilis* produce weaker and finer fibres than would be acceptable to the cordage trade it is probable that several generations of backcrossing to a vigorous clone of *M. textilis* would give improvement of the fibre sufficient for it to compare favourably with commercial grades of Manila hemp.

The desirable characteristics of the Australimusas have not yet been completely investigated. It is known, however, that at least one of them, *M. lolodensis*, possesses resistance to abacá mosaic (Kent, loc. cit.). Simmonds (1956) has reported the apparent drought tolerance of the *M. textilis* x *M. peekelii* hybrid growing at the I.C.T.A., Trinidad. *M. peekelii*, *M. lolodensis* and *M. angustigemma* are vigorous and in this respect are more valuable than *M. maclayi* which, although robust, is not vigorous, and the Callimusa *M. violascens* which is a weakly species.

That a breeding programme involving the use of wild relatives of abacá is necessary is evidenced by the fact that the recovery of the Philippines Manila hemp production to its pre-war level has been severely retarded by disease, particularly by Mosaic. (Juliano, 1951). Plantations in North Borneo are suffering from bunchy top infestation (Anon, 1955). Abacá grown in Central America is free of virus but other troublesome diseases (Robinson & Johnson, 1953) may prove to be controllable by the synthesis of disease resistant clones.
5. SUMMARY

1. The diameter and strength of fibres of Australimusas (and some other Musa species) and hybrids have been determined.

2. Results indicate that interspecific crosses of M. textilis with M. peekeli, M. angustigemma and M. lolodensis may be of value in abaca improvement programmes.
6. LEGEND TO FIGURES

Figure 1: The hagutan used for extraction of *Musa* fibres.

Figure 2: The treadle of the hagutan is depressed to allow the tuxy to be inserted.

Figure 3: The treadle is released and the tuxy is cleaned of pulpy material when pulled between the metal knife and wooden block.

Figure 4: A mounted fibre ready for breaking.

Figure 5: The steel girder supported at its central point.

Figure 6: Breaking load - cross-sectional area scatter diagram of *M. textilis* clone Tangongon.

Figures 7-11: Illustrations of the relationships between fibre strengths of Australimusas and their hybrids.

Figure 7: *M. textilis* (St. V.), *M. peekelii* and *M. textilis* x *M. peekelii*.

Figure 8: *M. textilis* (Tangongon), *M. angustigemma* and *M. textilis* x *M. angustigemma*.

Figure 9: *M. textilis* (St. V.), *M. lolodensis* and *M. lolodensis* x *M. textilis* and *M. textilis* x *M. lolodensis*.

Figure 10: *M. angustigemma*, *M. peekelii* and *M. peekelii* x *M. angustigemma*.

Figure 11: *M. lolodensis*, *M. peekelii* and *M. peekelii* x *M. lolodensis*.

Figure 12: Comparison of fibre strengths of *M. textilis* clone Libuton, *M. balbisiana*, *M. basjoo*, *M. itinerans* and *M. maclayi*. 
Figures 13 and 14: Illustrations of the relationships between fibre strengths of some *Musa* species and their hybrids.

**Figure 13:** *M. textiliis* (St. V.), *M. violascens* and *M. textiliis* x *M. violascens* and *M. violascens* x *M. textiliis*.

**Figure 14:** *M. lolodensis*, *M. violascens* and *M. lolodensis* x *M. violascens* and *M. violascens* x *M. lolodensis*.
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*Colonial Developm.* No. 24: 30-2.

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A study of the mosaic disease of abacá, or manila hemp plant (*Musa textilis* Née), with special reference to sources of inoculum and possible transmission of the virus by mechanical means.

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Abacá. *A Cordage Fibre.*

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*Philipp. Agric.* 35: 171-185.
Figure 5.
Figure 6. M. textilis clone Tangongon
Figure 9.
Figure 11.
Figure 13.