fruitbodies have been placed into one of the three following species: *Morchella elata, Morchella deliciosa, Morchella esculenta* var. *crassipes / angusticeps*. Cultures were obtained and added to our large collection of Australian and overseas Morel isolates. Further collections will be done in 2001.

A specific phase of the Morel life cycle is the production of sclerotia. Stimulation of sclerotial size may enhance fruit body production. To determine optimal conditions for sclerotial production, studies have been initiated on a range of different media and in dual cultures with microorganisms.

Specialty Gourmet and Medicinal Fungi Group
Tasmanian Institute of Agricultural Research
New Town Laboratories
13 St. Johns Avenue, New Town TAS 7008
Tel: (03) 6233 6862 Fax: (03) 6233 6145

Caroline and Karen

E-mail: karen.stott@dpiwe.tas.gov.au
E-mail: Caro.Mohammed@utas.edu.au

IMPROVED MANAGEMENT PRACTICES FOR CULINARY BAMBOO SHOOTS – LOCAL AND EXPORT MARKETS (Project UCQ-9A)

David J. Midmore and Volker Kleinhenz

From this research project a series of practical recommendations can be made with the proviso that they should be locally tested for their relevance and validity, given that management by environment interactions are known to exist for many plant species of economic importance.

The setting up of both the Bamboo Society of Australia and the Australian Commercial Bamboo Cooperation (ACBC) has been key to the interaction between growers and others interested in bamboo. The current www site for the BSA (http://www.bamboo.org.au/) contains information on both the BSA and ACBC, and provides the relevant contacts to which to direct oneself for membership details. Both the BSA and the ACBC are vibrant, with a healthy membership; the former with a regular newsletter and the latter with greater than 70 registered commercial members. These will underpin the success of bamboo as a plant species of great interest and commercial relevance.

The collation of relevant literature on bamboo shoot and timber production has led to a publication in volume 74 of *Advances in Agronomy* (2001), and strengthened the position of CQU as a focal point for research and information exchange on bamboo. A post-doctoral fellow (funded by ACIAR) and a PhD student both currently work full-time on bamboo at CQU, and on an ACIAR-funded collaborative project with growers in NSW, Queensland and the Northern Territory, and with the NTDPIF and various organisations in the Philippines coordinated through the Philippines Council for Agricultural Research and Development is currently providing further useful information on optimum field production practices.

Our data on water use by *Bambusa oldhamii* show that higher application rates can induce earlier shoot production, but yields even on clumps of 9 years of age only

Continued Next Page

CQU researcher Volker Kleinhenz watching Martin Hartmann harvest Dendrocalamus latiflorus in northern NSW. Note the low culm density in each plant.

reached 2.5 t ha^{-1}. These clumps had not received irrigation until the experiment began, when the clumps were 6 years old. In contrast, for *Phyllostachys pubescens*, without irrigation and only little rainfall, shoot numbers were greater with less drainage but better supply of underground water during the first 2 years of the study.

With irrigation in the following years, bamboo shoot numbers and weight were much better under better-drained conditions with less supply of underground water. In those years, torrential rainfall and erratic irrigation negatively affected bamboo growth through over-wet soil conditions. Shoot production was superior under better-drained soil conditions with little precipitation, and evenly distributed application of non-excessive amounts of irrigation water. Optimum soil water conditions were especially important during the shoot season and in the A soil horizon. Under those conditions, plants showed less water stress under high irrigation, and there was a significant response to application of higher rates of nitrogen.

Studies on bamboo nutrient use in the field focused on nitrogen (N), while a large-scale pot trial allowed us to determine that bamboo supplied with N in the NH_4-N form enhanced water uptake (and by implication, growth). The rates of N:P:K extracted from nutrients applied to young bamboo plants supplied with nutrient solution was 1:0.4:1.3, notably highlighting the importance of sufficient K reserve in the field for bamboo.

Both over-wet and too dry conditions limited the ability of *P. pubescens* to respond to externally added N, but under ideal soil moisture applications of 130, 250 and 500 kg N ha^{-1} $year^{-1}$ supplied yields of 6, 8-9 and 11-12 t ha^{-1} shoot yield. These figures will vary in other sites in accordance with the natural soil fertility and rate of soil mineralisation of N. In clumps not harvested for their shoots, higher N rates promoted the production of more, smaller diameter culms.

In order to circumvent the need to test for soil N, we developed a Diagnostic Recommendation Integrated System (DRIS) for N in bamboo. Our suggested optimum of 3.0% total leaf N represents a value above which plants only respond slightly to externally added N, while below which bamboo plants have a greater affinity for N. This value appears to be robust enough to be applicable across all the species studied, and lead to a balanced set of both number and diameter of new shoots.

Our studies on culm management focused on *B. oldhamii*, comparing constant numbers of culms of each age class (1-1-1, 2-2-2, 3-3-3 and 4-4-4 culms of 1-2-3 years of age). There was a trend that the yield of fresh edible shoots was promoted by lower standing-culm density, but yields overall were low in this exponent over the three years that it ran (it is still continuing). However, when optimising bamboo shoot and timber yield, the 3-3-3 ratio was most suitable. Older culms apparently contributed less to stump productivity (based upon data for photosynthesis), and a ratio of 4-3-2 of 1-2-3 years old culms may indeed be superior to the 3-3-3, but this remains to be proven.

Post-harvest studies concentrated on determining the relationships between shoot weight and external dimensions on cooling (most effectively done by hydrocooling). Factors investigated included: a) the contribution of cut surface versus remaining surface of shoots to weight loss (both contributed equally); b) storage temperature (weight loss was least at 1°C and greatest at 25°C); and c) packaging materials (weight loss least by heat sealed PVC film or low density polyethylene (LDPE) bags). However, the latter two materials also induced most internal condensation, with a deterioration in visual quality within 14 and 21 days, respectively. Shoot respiration was, as expected, greater at 20°C than at 2°C, accounting for 18% and 34% total weight loss for shoots stored in LDPE film at 2°C and 20°C respectively, but only 4-6% of total weight loss of open-stored shoots.

Visual quality of shoots stored at 8°C declined after 6 days of storage, while that of those stored at 1°C was not notable even after one month's storage. Based on these experiments, optimum packaging temperature was 1°C with semi-permeable materials (micro-perforated LPDE bag or LPDE film) in which shelf life could be extended beyond 28 days.

Some of the discolouration was due to the presence and growth of bacteria and fungi, as with other fresh vegetables. We found contamination of shoots (leaf sheaths, cut ends and internal tissue) by several species of *Bacillus*, several genera of moulds including *Fusarium*, and the presence of some coliform bacteria was also indicated.

Overall, the studies reported in this publication add to the body of knowledge upon which a successful bamboo industry will be established. Reference to the outputs of a parallel project (UQ-87A) on market opportunity assessment should be made before prospective growers invest in the industry, for the fresh shoot market in Australia is currently limited, and very small compared to the overseas export potential.

School of Biological and Environmental Sciences
Central Queensland University,
Rockhampton, Qld 4702, Australia.
Fax: +61 7 4930 9255
Tel: (07) 4930 9770
E-mail: d.midmore@cqu.edu.au
www: http://science.cqu.edu.au/psg/

Professor Midmore