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Ecological problems in bamboo cultivation and indigenous technical solutions from the Himalayas

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Abstract

Bamboos play a very important role in many Asian land-use systems, contributing greatly to ecological stability and soil conservation. Despite this many natural resource managers in the Himalayas are reluctant to plant or utilise bamboos because of uncertainties concerning their life history. Not so the Himalayan farmer, whose fragile subsistence lifestyle has relied upon bamboos since time immemorial. He has developed a long-term cultivation policy which seems to have significantly reduced the degree of flowering and death in his bamboos. A strategy which has served him well could be of great benefit to others. Firstly he knows his species and varieties well. Secondly he uses vegetative propagation, thus both actively selecting clones which flower less than others, and reducing the genetic base and subsequent cross-pollination, seed production, and death. Other factors reducing the disruptive effect of flowering such as the planting of a mixture of species and the occurrence of pathogens which reduce seed production are also of benefit to him. It is suggested that studies of genetic variability in cultivated populations and fertilisation mechanisms in conjunction with advances in vegetative propagation techniques may encourage more confident management of bamboos in the next century.

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The ecological significance of bamboos

Bamboos play a very important role in many Asian ecosystems, both natural and man-made, especially in montane areas such as the Himalayas. In forest areas they provide useful products as well as valuable wildlife habitats, and annual harvesting without large machinery minimises environmental disturbance. In many rural areas bamboos are also cultivated to support subsistence agriculture through the provision of animal fodder and manure, fencing and tools, as well as housing, thus reducing pressure on forests and grazing areas. In shifting cultivation, the rhizomes allow rapid re-establishment of soil cover and fast nutrient recycling.

In steep or eroding areas their unique rhizome and rooting systems stabilise slopes and reduce soil erosion. Throughout the Himalayas and in many other areas of Asia they are actively helping to maintain the ecological balance in delicate natural and man-made environments. Because the distribution of bamboos is so concentrated on Asia, the ecology of bamboos is a subject of particular regional importance.

Ecological problems in bamboo cultivation

Despite their potential contribution to the stability of the environment there is often considerable reluctance on the part of natural resource managers to either plant bamboos or to develop more organised production and utilisation systems. The principle constraint is the unpredictable disruption of production by gregarious flowerings, and the uncertain fate of flowered clumps.

Knowledge of the life cycle and reproductive behaviour of species is fundamental to the study of their relationship to each other and to the environment, and thus is central to ecological studies. In the bamboos this knowledge has been very limited in the past, and recent important studies on reproductive behaviour need considerable reinforcement.

Thus the lack of knowledge of bamboo life-cycles, reproductive mechanisms, and population dynamics is essentially an ecological problem, and the lack of knowledge in these areas resulting in their neglect compounds the wider ecological difficulties facing Asian land-use systems in the next century.
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The problems and solutions of Himalayan farmers

While institutions have on the whole not shown a very good record in planting bamboos in the Himalayas, farmers throughout Asia have managed to plant it and use it since time immemorial. It is perhaps pertinent to examine how they have overcome the problems, as their solutions or the general approach which they have taken gives some insight into the life cycles and general ecology of cultivated bamboo populations, and highlights areas where further study is necessary.

The basic problems facing the farmer have been which bamboos to plant, how to plant them, and how to extend the life of the plants. Because of several practicalities they have adopted vegetative propagation techniques. This in conjunction with their good knowledge of local species and varieties has led to several interesting developments, and perseverance with cultivation over many generations has allowed them to rely upon bamboos with confidence.

Their basic knowledge in the areas of taxonomy, propagation and life-history has been sufficient to provide an effective cultivation strategy. If these areas were studied with all the scientific resources available, there could be equally effective solutions to the problems of professional resource managers.

Identification and flowering cycles

It is well known that the length of flowering cycles varies between species, but this is of little use until the bamboo flora is accurately documented. Most records of the flowering history of particular species are severly flawed by poor identification. In addition fertilisation mechanisms and vegetative propagation techniques vary between species. Ecology, as the study of the interrelationships of different species and the environment, cannot begin unless different species can be separated by a reliable taxonomic system.

Asian farmers often know local bamboos better than centralised institutions or the scientific world. Hopefully the bamboos of all of Asia will soon be documented for separation in the field as they have been in China, and are now being documented elsewhere.

Within species variation in flowering and selection of superior clones

Variability in the length and synchronisation of flowering cycles has often been reported, and suggestions made for this situation to be exploited to reduce disruption caused by gregarious flowering. Himalayan farmers have long been aware of such variation. Where bamboo cultivation has been practiced for a very long time local knowledge of flowering habits in the Himalayas seems fairly consistent. Essentially the story is that forest bamboos flower regularly, produce seed, and die, while most of their own bamboos flower sporadically, often recovering after flowering, and some of their species never flower at all.

When asked why their bamboos flower less than forest bamboos the reply is that they pick out non-flowering clumps to plant vegetatively after bamboos flower. In this way they have actively selected strains with abnormal flowering habits, sometimes for thousands of years, and have multiplied those to produce clones which flower less frequently, less intensively or possibly not at all.

Implementing and testing a scientific selection program to select non-flowering clones would obviously take an immense amount of time. Maybe the industrious Asian farmers have already completed the task in some species. Is it just coincidence that the most common vegetatively propagated species, *Bambusa vulgaris*, has the reputation of flowering so infrequently ?

Self-incompatibility as a barrier to fertilisation

Another reported reason given by farmers as to why their bamboos flower and die less than forest bamboos is that they do not plant too many bamboos together, or plant mixtures of species. Apparently, when clumps are on their own they do not produce so much seed, and consequently they have enough reserves left over to recover vegetative growth after flowering. The superior production of seed from gregarious flowerings compared to sporadic flowerings has often been reported by foresters. Self incompatibility seems to be a possible explanation for this. This would mean that if the genetic base in stands were reduced substantially then cross-pollination, seed production, and subsequent death would also be reduced.

Studies of incompatibility mechanisms are now advanced in many plants. The long flowering cycles in many bamboos obviously deter such investigations, but if cross-breeding programs can be undertaken in China then detailed studies of fertilisation mechanisms should also be possible.

Should the hypothesis of self-incompatibility prove to be true then large scale efficient vegetative propagation could have great benefits, and micropropagation or true tissue culture would be the way forward, rather than propagation from seed or embryogenic callus. Such self-incompatibility could also explain why leptomorph *Phyllostachys* species, in which one genotype can cover a large area, tend to recover after flowering, while pachymorph species tend to die.

Pathogenic and chemical interference in flowering

Other factors can also be involved in seed production and clump recovery. Interruptions to normal flower production have been witnessed in the Himalayas. Insect damage to *Dendrocalamus hamiltonii* flowers has prevented seed production in some clumps in eastern Nepal. Fungal damage in flowers of a variety of *Bambusa tulda* invariably occurs in central Nepal. This variety has never been seen to produce seed, nor to die after flowering. Moreover the disease occurs wherever and whenever this variety flowers, suggesting a common second host. Manipulation of disease, hosts or susceptibility could be another avenue to explore.

In other monocotyledonous crops chemicals are sometimes used to good effect to control flowering. In sugarcane the sugar content of culms is maintained by applying chemicals to inhibit flowering. Such techniques may also be of value in bamboos.

Vegetative regeneration of flowered clumps

The fate of flowering clumps is often influenced by the Himalayan farmer. The effect of prolific flower or seed production on the rhizomes' reserves is readily appreciated, and flowering culms are quickly cut by many farmers. Manure is also often applied if the clump is valued, and together these techniques can allow the clump to regain vegetative growth. The value of fertilizing flowered bamboos has been clearly demonstrated in China. The experience of farmers in the Himalayas supports the value of such procedures.

Interruption of production during flowering

While the Himalayan farmer has managed to reduce the chances of his bamboos dying, he cannot exclude the possibility. Protection against this eventuality is provided by planting a mixture of species, often as many as five or six. The chances of all clumps flowering together are thus greatly reduced. In this way the flowering of a single species can pass almost unnoticed to the casual observer, and causes little hardship to the farmer.

Conclusions

It would seem that despite important work on the ecology and life cycles of bamboos already undertaken, especially in Japan and China, there are still fundamental gaps in our knowledge of the Himalayan bamboos. The Himalayan farmer has arranged a system whereby the consequences of the lack of knowledge are minimised and his strategy deserves closer attention. Further study of his bamboo varieties backed up by fundamental studies in the physiology of flowering and seed production may allow more widespead and confident use of bamboos in Asia. Using the farmers perspective and following his chosen course of vegetative propagation of well known varieties, but using more sophisticated techniques of micropropagation or tissue culture, in combination with thorough taxonomy and record keeping, may be an appropriate strategy for ecologically sound Himalayan bamboo cultivation in the next century.