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Agroforestry trees: to domesticate or not to domesticate?

The improvement of agroforestry is as much a social and political challenge as a biological one. To encourage tree planting amongst a diverse client group of resource-poor farmers requires better understanding of farmers' decision-making processes. The modest resources for domestication efforts will have to be focused on priority species which have been determined following objective methodologies. Common to the domestication of all species is a need to accelerate the process to deliver appropriate improvement early on. The proactive multiplication of germplasm is required to reduce the lag phase between identification and adoption of improved material.

Introduction

Following the resurgence of interest in agroforestry, agriculture and forestry are no longer thought of as mutually exclusive landuse activities. Yet the resources attributed to crop domestication dwarf those available for domestication of agroforestry trees. Conventional teachings on agricultural crop improvement converge on the date of 8000 BC to define when humans began deliberate selection of desired variants in cereal species. Tree species, however, are more recent subjects of selection. Even in commercial forestry, fewer than 40 taxa have genetic improvement programmes under way and most of these are less than 50 years old (Barnes and Simons, 1994). Domestication of agroforestry trees has received substantial recent interest following a number of articles and conferences (e.g. Leakey and Newton, 1994). In its development context, tree domestication is more than just breeding and selection. For some it has an undeservedly dull reputation.

Domestication

To domesticate is to naturalize to human conditions and involves change in the genetics and management of a plant. Put simply, it means to bring into human use. In genetic terms, domestication is accelerated and human-induced evolution but it is also concerned with management. Selection can be deliberate or inadvertent. Deliberate choices might be made for fruit characters, growth rate, form, etc., whereas inadvertent selection could be for insect resistance, tolerance of selfing, etc. The manner in which domesticated trees diverge from their aboriginal stocks will depend upon the size of the population, heritability of traits under selection, the mating system, the intensity of selection and the inherent variability of the traits. The level of intensity of domestication activity will ideally be dictated by a combination of biological, policy, market and social factors (Simons, 1996).

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With forested areas declining to accommodate agricultural expansion, and with human populations rising, the logical endpoint must be a choice between more people moving into the forest or for more trees to move out of it onto farmers' lands. Extractivism from forest areas is often a form of tree domestication in that vegetation is cleared around target species or that natural regenerants are transplanted or nurtured. The primeval richness of forests that allowed low intensity of utilization, however, is unlikely to be able to support larger scale extractivism. Consequently, forest trees must evolve into agroforestry trees.

Agroforestry trees

It should not be forgotten that a tree is a mode of growth, not a botanical class of plants. There is no necessity of design for them to be the size or shape that they are. A fundamental question then emerges: "are trees optimally fit for their role in agroforestry systems?" Natural selection has endowed trees in closed forests with great heights to be able to compete for light against their peers. Size, however, is not a structural necessity but rather an evolutionary response to competition from

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other trees. Therefore, in ecological terms it is likely that they are not optimally fit for their new functions in agroforestry systems. It is intuitively obvious that a tree when placed in a field does not need to reach 37 m in order to compete with surrounding annual crops. Since the modification of ecological functioning will be driven by alteration of the genetic constitution of a tree, this explains the relevance of selecting within the intraspecific diversity that is present in virtually all species.

Notwithstanding further discoveries and taxonomic debates, we are driven to conclude that there are 50 000 extant tree species. More than 2 500 of these have been described for use in agroforestry systems. The assertion that untapped potential exists is unequivocal, but the question remains of how to prioritize and best allocate scarce resources amongst such a plethora of species.

What is a priority species to one farmer may not be so for another and the need to identify clearly the target group for whom species are being chosen is apparent

Priority species

Research priorities among tree species have been determined largely by researchers alone. Such subjectivity has led to sub-optimal use of resources although this does not mean that no successes have occurred (Simons, 1996). Rigorous priority setting, however, requires understanding of user needs and preferences, technological opportunities and systematic methods for ranking species (Jaenicke *et al.*, 1995). The recently published guidelines on species priority-setting represent a great advance in procedural methodology (Franzel *et al.*, 1996). The process described involves seven stages at which the number of species under consideration is consecutively reduced. It is an extremely expensive exercise to carry out the range-wide exploration and collection required for ecogeographic evaluation and only after a species has proven itself is this justified. The paradox is that a species may not prove itself until its full intraspecific variation has been tested (Dunsdon and Simons, 1996).

It should be emphasized that the number of priority species should not be restricted to only a handful of species. In priority-setting in the Peruvian Amazon where individual farmers were asked to name their top ten species, more than 200 species were recorded (ICRAF, 1996). Clearly, what is a priority to one farmer may not be so for another. In the Sahelian zone of Niger, 470 farmers were polled for their priority trees and it emerged clearly that different sectors of the community had different priorities. Women were different from men in their preferences, whilst old men were different from younger men (ICRAF, 1996).

The need to identify clearly the target group for whom species are being chosen is apparent. Enhanced geographic information system (GIS) technologies allow better estimation of the impact of various technologies or species. The delineation of extrapolation domains allow determination of the land area or population that will be affected by given agroforestry interventions. Such research permits greater precision in selection of appropriate trees to domesticate for areas of both high and low impact potential.

Which species to domesticate will depend on the objectives of domestication, and will differ if it is for income generation, germplasm conservation, forest conservation or farm diversification. No studies are available which combine the economic, social and environmental benefits and costs to compare the merits of domesticating various species in the forest or on the farm (Simons, 1996). Until this knowledge imperfection is addressed, species priority-setting will continue to be influenced most by the more readily available information relating purely to biological and social considerations.

Domestication strategy

Amongst trees, which are the largest and oldest living things, what we have are wild prototypes. As with domesticated species of crops we need to see adaptation to man's use. The domestication strategies for crops, however, may not be applicable to agroforestry trees (Simons *et al.*, 1994). Further, as agroforestry trees differ in functional use, life history traits, mating systems, economic value, native status, history of use and partitioning of genetic variation, it is clear that no single strategy for domestication will suffice. Consequently, the emphasis of ICRAF's approach to domestication is on developing objective decision-making frameworks which firstly ascertain whether domestication should proceed, and then determine in which way and at what level. In addition, ICRAF and our partners will never be able to advance domestication of all agroforestry species. Accordingly, ICRAF uses a number of species in the six eco-regions as case studies in order to build and optimize the decision-making framework. This, together with the strategies and techniques for capturing and using genetic variation (Leakey and Simons, in press) can be used as a model by other organizations who wish to domesticate other species.

Perhaps the most important aspect in the domestication of agroforestry trees is that it must be done in a participatory way with farmers rather than provision of cultivars or germplasm developed on-station. The domesticates of agroforestry tree species have the primary purpose of enhancing the productivity and sustainability of agroforestry systems. In turn, it is envisaged that the domesticates may also contribute to the conservation of genetic resources of such species and in turn the preservation of natural habitats (e.g. rainforests, woodlands or savanna) in which their progenitors reside. It is further desired that the provision of improved germplasm will accelerate adoption and expansion of agroforestry technologies.

Demand and supply of agroforestry trees

Demand for germplasm of a particular species in agroforestry development projects has often been stimulated by the provision of incentives (such as cash, livestock, food or fertilizer). In these instances, it is difficult to dissociate the real demand from that created by the incentives. Knowledge of the supply of germplasm of agroforestry trees is also imperfect. To fill a void in operational and policy aspects of tree germplasm, ICRAF is to hold a workshop on this subject in Nairobi during 6-8 October 1997.

Understanding that germplasm availability (improved or not) is often cited as a constraint to increased tree planting, ICRAF is using a number of case studies to examine how much germplasm will be needed, by whom, when, and for how long. It is crucial that this demand is real and not just perceived.

If improved germplasm is to be provided to farmers, what are the delivery pathways currently available or in need of creation to ensure availability of improved germplasm? Very little information is available for agroforestry trees on the supply side parameters. We would be in a far better position to have an impact with domestication efforts if we had a better understanding of the pathways of germplasm delivery, namely:

- **distribution** (to NARS, NGOs, communities, private sector),
- **dissemination** (to farmers); and
- **diffusion** (farmer-to-farmer exchange)

The link between the demand and supply of germplasm of a species determines the efficiency with which improved material is used. The demand side of germplasm delivery is being assessed by ICRAF at three levels, namely that of (a) the farmer; (b) the disseminator (e.g. NGOs, community programmes); and (c) the distributor (such as NARS or international projects). Demand from farmers is being determined using farmer surveys. These examine aspects that are both qualitative in terms of the useful traits they desire and quantitative in terms

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The supply side of germplasm is being examined by compiling a list of suppliers of germplasm in collaboration with FAO and IUFRO. This is being put into a database that links species information with individual suppliers. Easy-to-fill-out questionnaires have been sent out to several hundred suppliers. Surveys of large- and small-scale tree nurseries are also being carried out in several countries. Further, the possibilities of private sector involvement and contract multiplication and delivery are being investigated by ICRAF and its partners.

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