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Crop Variety Mixtures in Marginal Environments

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This Gatekeeper Series is produced by the International Institute for Environment and Development to highlight key topics in the field of sustainable agriculture. Each paper reviews a selected issue of contemporary importance and draws preliminary conclusions of relevance to development activities. References are provided to important sources and background material.

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CROP VARIETY MIXTURES IN MARGINAL ENVIRONMENTS

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Intensive agriculture supported by good infrastructure has in recent decades come to be associated with uniform monocultures of crop varieties. These varieties are chosen for their characteristics of adaptability and stability[1] under conditions of high inputs of labour and chemicals. As a result significant widespread increases in yield and harvest stability have been achieved.

Yet in marginal environments the situation is quite different. Here the variability between production sites is high, climatic conditions are erratic within seasons and between years, and infrastructural development is poor. Farmers often respond by enhancing diversity, both of crops and of varieties of crops. Diversity allows versatility; it also contributes to greater household security.

Until now the importance of between species diversity has been well recognised. But the value of varietal mixtures has largely been ignored. This is because conventional breeding goals aim to select out variability and adaptability in order to exploit the potential of intensive and uniform agriculture. Such strategies are quite inappropriate for marginal environments, and alternatives are urgently required.

Alternative Breeding Strategies

In these marginal environments, where production conditions vary in time and space, there are four reasons why we need to look at new breeding strategies:

- Research capacity is limited: approaches like Rapid Rural Appraisal, Farming Systems Research and Farmer Participatory Research are valuable in making the most out of limited resources of time and money for research. However, even using these approaches, researchers are unlikely to be able to define the characteristics of more than a handful of specific environments adequately enough for scientific breeding purposes. There are similarly limited possibilities for research subsequently to evaluate the stability and adaptability of new cultivars for these environments.

- Marginal environments can be extremely variable; micro-variations in production conditions across space together with instability in conditions through time make the task of evaluating different cultivars difficult. This is a problem which is unlikely to be speedily resolved.

1. A variety is said to be stable if, at a given location, its yield varies little from year to year; a variety is said to be adaptable if its yield, expressed as an average yield over years at a given location, varies across locations

Multilocation and multi year trials in marginal environments pose particular technical and managerial problems. In particular it is difficult to choose local controls where farmer assessment of performance is tied to particular sets of weather, site and consumer preference variables specific to a season. There is also usually a lack of prior scientific knowledge of the physiologically important variables at a given site, plus a lack of good time series data for calculating probabilities of extreme events. It is difficult to ensure that trial sites are sufficiently representative of the variation in sites and climates experienced by the farming population. Finally the costs of managing and maintaining dispersed trials are of course greater.

- There is little prospect of modifying the conditions; major investment in modifying these environments is unlikely. This is partly because public and private investment is not economically attractive as these areas contribute relatively little to market surplus and world trade, and partly because the majority of the 400 million or so people who live in these environments do not have the means to make such investments themselves.

- Variety mixtures fit the local processing technology and household needs; the technological processes and processing equipment for the majority of crops grown in these environments are adapted to the characteristics of the varieties grown, and to the small batches grown of each variety. A range of household needs is met by extracting as much usable biomass as possible. This goal is pursued because manufactured goods cannot be obtained reliably and at an affordable price.

The Diversity Value of Mixtures

Farmers in unstable and variable environments experience two acute pressures: limited sources of power and labour; and, in many cases, limited time within the single short growing season of erratic rainfall. One of the keys to surviving these pressures is the maintenance of versatility in juggling labour availability and production opportunities. Mixtures maintain biological diversity. Biological diversity allows versatility in the management of labour and the maintenance of a capacity to respond to inter-annual and inter-seasonal fluctuations in the timing and intensity of rains, and fluctuations in the soil conditions, incidence of pests and diseases, and temperature.

There are three main ways in which farmers can maintain biological diversity: by using mixtures of different species, mixtures of different varieties of the same species, or varieties whose genetic composition is itself variable.

Mixtures of Different Species

Mixtures of species make an important contribution in unstable and variable environments to harvest security and nutritional balance. In some cases they also yield a higher total usable biomass than monocrops and increase the sustainability of the yield (Clawson, 1985; Francis, 1986). Plant populations in tropical interspecies mixtures have a wide range of adaptations to day length, make efficient use of growing time, and are diverse in the effects of sowing time on their plant form. These three features offer a considerable buffer to rainfall and temperature variability and to the constraints on timeliness of labour inputs.

Mixtures of Different Varieties

Variety mixtures offer additional diversity, in the timing of germination, flowering, growth, seed-filling and harvest. In a study of agriculture in a cluster of villages in central Sierra Leone, Richards (1987) noted how farmers used this diversity by drawing on a portfolio of different species and variety mixtures to suit the different conditions of different sites along the slopes. He comments: "The point of having such an integrated set of varieties is that it allows for maximum flexibility in adapting to climatic contingencies and adapting to constraints on labour supply."

The maintenance of large inventories of different varieties also helps satisfy different household needs. Since a number of desired and less desirable criteria usually are associated with each variety, choice of varieties involves trade offs, for example between hard-to-cook but early maturing, or between slow-to-cook but good storage. The time trade offs are the critical ones in variable environments, as the choice must be made between satisfying the immediate needs of the household or storing the crop to satisfy future needs. A spread of varieties ensures that there is an adequate range of desired traits to draw on to meet varying needs (Ferguson and Sprecher, 1987).

Mixtures of Unstable Varieties

The additional benefits which mixtures of unstable varieties might confer have not received much attention. Their use has been widely observed, even where stable varieties are available to farmers. Recent surveys of variable common bean (*Phaseolus vulgaris*) varieties in Malawi indicate that "the mixtures planted by farmers are comprised of both higher yielding but probably susceptible and the lower yielding but drought tolerant components. This is one explanation why Malawian farmers grow bean mixtures. They appear to want to maximise seed yields during good years by planting higher yielding types while at the same time minimising yield losses, in the event of a drought, by including drought tolerant types" (Mkandawire, 1988).

Further evidence from Malawi, Kenya, and Burkina Faso suggests that farmers may be able to manipulate blends of unstable varieties so that over time the blends continue to display desirable traits. But it is not known which strategies are the most likely to encourage the acquisition of desired characteristics within the blend: renewal of diversity by new acquisitions, outcrossing and further hybridisation between the new combinations, or fertilization by wild or weedy relatives.

Martin and Adams (1987a; 1987b), reporting on another study of common bean in Malawi in areas where beans are commonly intercropped with maize, found that beans were generally grown as variety mixtures. The blends ranged from simple physical mixtures of a few unrelated types to complex mixtures of biologically dynamic populations. The blends were found to be drawn from large inventories of named types. The composition of the blends was diverse, and interestingly the more widely dispersed types occurred only rarely. Bean growers could also identify their named varieties and associate visible characteristics with desired traits.

In addition to deliberate selection by farmers, agronomic and genetic factors also contribute to the maintenance of the variability and of desired traits within the blend. Agronomic trials indicate that a blend can display a high potential for stability across sites and years. Both the genetic make-up of the individual varieties in a blend and the very fact that it is composed of diverse varieties possibly contribute to the stability.

Pasture Environments

Variety mixtures are sometimes used in industrial and irrigated agriculture for specific purposes. Take the seeding of pastures with perennial ryegrass mixes: grown over a wide range of environments, the versatility of ryegrass mixes is derived from the careful selection of a large range of stable types, maybe fifty cultivars in a mix, each of which has been thoroughly tested in multilocation trials to establish its range of adaptation.

In unmanaged pastures in marginal environments, it makes sense to aim to create as much genetic variation as possible in pasture sowings through deliberate incorporation of variability in the varieties (Hopkinson, 1985). There are a number of reasons why this is worthwhile:

- the range of conditions is large,
- there is only limited opportunity to modify them,
- researchers have neither the resources to get to know the conditions well nor to evaluate cultivars thoroughly in more than a small fraction of them,
- relatively pure lines are unlikely to give efficient adaptation to the variation present in the environment.

In Queensland, Australia, researchers are setting out to create pasture mixes which blend variable *Stylosanthes* varieties for conditions in which one head of cattle per 3 hectares of improved pasture is considered an achievement. They have selected *Stylosanthes* types by working with material that mostly contains a high degree of natural variability, choosing mixes that differ in flowering time and other physiological responses, and for resistance to anthracnose (a serious fungal disease).

But there are advantages and possible hazards in such a strategy. The suggested advantages are:

- much greater adaptive versatility than single cultivars, leading to wider and faster naturalisation and spread.

- generation of wide range of resistance to anthracnose, slowing down the spread and reducing the destructive risk of anthracnose.
- greater adaptiveness to the emergence of new races of pathogen.

The possible hazards are:

- a potential increase in unpalatable types: so far it is not known if unpalatable types exist - all types tested by grazing so far have been eaten.
- creation of biological pathways across which anthracnose itself could diversify.

In the *Stylosanthes* species under investigation in Queensland, adaptability appears to be a characteristic of single varieties. For example, *Stylosanthes scabra* Seca has proved very diverse. When first released, it was late flowering and thus useful only for the tropical parts of Queensland. In the sub-tropical areas the tops were killed by frost before seed was produced so Seca persisted no longer than the life of the original plants. But then certain seed crops of Seca changed into early flowering lines. These were tried in the sub-tropics with success and are proving highly popular. If conventional seed assessment and certification practices had been followed, the deviant crops would have been rejected and never introduced into working pastures (Hopkinson, pers. comm. Sept 1988).

Implications for Breeding Strategies

Crop variety mixtures provide farmers in marginal environments with the capacity to adapt their production to the variable and unstable conditions. Farmers in these environments often have detailed knowledge of the different varieties and the locations and weather patterns to which they are suited. The case for producing mixes of crop varieties is, at present, clearer than the case for retaining unstable varieties within particular blends of crop varieties.

However, there are a few guidelines for researchers who might wish to formulate new variety mixtures, select additions to existing blends, or evaluate the results. A great deal of progress could be made in this direction if researchers were to seek greater farmer participation and help empower farmers to improve their own manipulation of the varieties at their disposal.

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Sustainable Agriculture and Rural Livelihoods Programme

The Sustainable Agriculture and Rural Livelihoods Programme

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