Seed-Production Mechanisms

Proceedings of a workshop held in Singapore, 5–9 November 1990

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SEED PRODUCTION AND DISTRIBUTION MECHANISMS

A Review Paper

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Abstract

Crop improvement through breeding is a principal strategy in improving food security for resource-poor farmers. However, farmers do not necessarily adopt the new variety or technology made available to them. Is this because of a lack of awareness of potential benefit, or because the technology does not fit the farming system? Do farmers use different evaluation criteria from those used by breeders?

Formal dissemination assumes that adoption of a new technology is desirable, and that there will be a measurable benefit. While it is possible to define dissemination mechanisms and their components, different degrees of formality among them almost certainly mean that no single one would fully account for the adoption noted. Few programs or projects attempt to quantify the contribution of different mechanisms to dissemination, or, ultimately, adoption by the farmer.

Several projects reviewed note the unique circumstances of each that contributed to, or constrained, successful dissemination. Involvement of the farmers themselves in seed production is often a key to success, including the establishment of community-level seed businesses.

Successful donor-funded seed programs have been characterized by good management, prior experience with seed, and good demand for seed. Rigid government controls are likely to limit success in production and dissemination. Seed programs for marginal agricultural populations require a greater level of effort than those targeted at commercial operations.

1. Introduction

Seed is fundamental to agriculture. It is both the means of transference of genetic information from one crop generation to another, and the basis of economic yield of the majority of crops. Through selection processes practised by farmers over centuries, many crops have become adapted to specific growing conditions, and have evolved qualitative and other characteristics that mirror the preferences of the growers. It is only in the last century that plant breeding has become a scientific process largely out of the hands of the farmers. This has resulted in large-scale changes in the characteristics of some crops, and in the methods of seed production for future crops. Agriculture in many countries is no longer a cyclical process that is contained within the boundaries of the farm.

Plant breeding has developed at the same time as other crop sciences. Much of the improvement attained through breeding and selection is dependent on other agronomic elements, such as fertilization and pest control. Thus, while the seed contains the potential for improved crop yield (or whatever the breeding objective was), the potential may not be achieved without other inputs. Most plant breeders test their crosses and selections under specific conditions. These are often the conditions recommended to farmers for the management of their crop. However, the closely controlled conditions of test plots are generally not duplicatable on-farm, and crop output will vary according to within and between farm conditions.

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Very often, therefore, the crop does not achieve the potential described for it by the breeder.

The resource-poor small farmer is even more at the mercy of natural forces. Normally unable to provide extra inputs, the farmer's system would revolve around whatever natural fertility is present in the soil, plus whatever the farmer can return to it in the form of animal and crop residues. Variable weather and pest cycles will interact with these resources for the overall definition of growing conditions. Under such uncertain conditions, the farmer will need very strong convincing of the desirability of changing his or her crop or crop variety. This small farmer is thus normally conservative, with a range of reasons for retaining current varieties or production methods. In such conservatism is security.

2. Our Hypothesis

As breeders or other crop scientists, we believe that improving the characteristics of a crop is one of the main ways of improving food security and general welfare of individual farm families and communities, whether the crop is grown for home consumption, or some is to be sold. Through the Green Revolution we have seen the potential of this approach, where the output of crops such as rice and wheat have increased significantly. Yet this again required the provision of other inputs, something of which not all farmers were capable, or to which they may not have aspired. As a result, the poorer farmers have tended to become marginalized, even though there is a technological basis for increasing crop production.

In many cases, the market may not be equivalent to the potential of the technology, i.e., prices paid for the crop do not cover the input costs, especially where marked increases in yields depress prices. In such situations, lower-cost production alternatives are usually sought, with concomitant reduction in yield. However, institutions may still recommend production practices that assume little or no marketing constraint. Small farmers who accept production credit under such conditions run the risk of not being able to repay, and incurring long-term indebtedness.

3. Adoption

If adoption can be described as the uptake of a new technology by a producer, the fact that farmers, especially small farmers, often do not immediately adopt technology on a wide-scale (e.g. Anon, 1987) poses a problem for crop scientists. Often this is assumed to be a consequence of the intractability of the peasant, who, because of poor education, knows no better. However, there are many factors at play in this process, and it is often the case that small-farm communities do have persons willing to adopt new technology (Fairlie et al., 1990), but who are cognizant of factors not necessarily clear to the scientist behind the technology, factors that may nullify any advantage in adoption.

It is not always easy to measure adoption, because this is not a one-time affair. Thus, a new variety may be tried one year, but, for different reasons, may not appear on the same farms each year over successive years. The farmer's production resources may change from year to year, forcing or requiring some change in what is grown and how it is grown. However, the farmer will be cognizant, if the extension services have done their work, of what is available to him, and how to use it.

One measure of adoption is the index of acceptability, which is calculated as the percentage of farmers who continue to use the technology (A), multiplied by the percentage of their crop on which the technology is applied (C), over 100:

$$IA = \%A \times \%C \ / \ 100$$

This index has been helpful in evaluating the acceptability of new technology (Dardon, 1982), though it should only be used on farms which conducted tests, i.e. it should not be extrapolated to a wider population. This author notes that in Guatemala an index of 25 in regions of traditional agriculture was considered good for the adoption of improved maize varieties. An index of this type offers a means of quantifying adoption, though explains none of the underlying reasons (which may be both for and against); it should be noted that an identical value for IA could be calculated by reversing the values for A and C.

Adoption, then, is one of the factors that anyone involved in technology development must consider closely. Current farming-systems methodology includes technology testing and validation as key components of the transfer process. Plant breeders are no less responsible for assuring themselves of the appropriateness of their outputs than is any other agricultural scientist. If a farmer appears indifferent to a new variety, what is the reason? Is it a question of not understanding potential advantages of the new variety? Is there an aspect of changing varieties of which the breeder is unaware, but which to the farmer represents an obstacle? Is the farmer using different evaluation criteria than the breeder, such that the material is seen differently? The literature is full of references to lack of adoption, yet the reasons are rarely elucidated.

While farming-systems approaches have been widely adopted in, for instance, the development of improved agronomic practices, there has been more resistance to their inclusion in breeding programs and varietal development. Yet there is evidence (e.g. Wooley, 1986) that such an approach is no less critical in the latter activities. Some work in Colombia indicated that the order of superiority among ten improved lines of beans was very different between on-station and on-farm tests, and that local conditions could be such that there was no correlation between yields in the two cases. In his writing, Wooley effectively asks the question 'what would the on-farm yields have been of the varieties eliminated in the process of selecting the ten elite on-station lines?' Even if this latter concern is ignored, to what extent would a solely on-station program have resulted in potentially lower levels of adoption of a new bean variety? Would a breeding program conducted primarily on-farm result in a significantly different result from one almost wholly station-oriented?

Farmer evaluation and adoption can speed up the process of varietal release. Wooley (1986) again cites the case in Colombia where farmers were already disseminating seed of a bean line under test by the third year of such testing. This acceptance, accompanied by evidence of significant increases in yield and disease resistance when compared to the traditional variety, forced the breeding institution into immediate formal release. Cock (1986) suggests that farmers are capable of managing a low-cost trial network, an innovation that would certainly add much debate to the evaluation process.

Douglas (1980) has attempted to list in generic terms the factors that farmers consider when deciding whether to adopt a new variety. These are over and above the institutional and market factors that may influence seed availability and quality. He describes them as follows:

1. **Relative advantage.** This is the degree to which the new variety will raise benefits, lower costs, compared to benefits or costs associated with current varieties. It may also take the form of a difference in effort, risk, prestige or social approval.
2. **Reliability.** The new variety will consistently produce the minimum crop needed to feed his family and provide the income normally received from sales.
3. **Simplicity.** The ease of use.
4. **Compatability.** With respect to needs, values, past experience and the farming system.
5. **Visibility.** With respect to the results of the new variety in the eyes of the farmer and others.
6. **Divisibility.** The perception that the innovation can be tried on a limited basis.
7. **Independence.** That the variety can be adopted without consulting anyone else.

It is not clear whether such an analysis has any practical value in promoting adoption, though the first two points obviously reflect on the economic advantage conferred (through both increased returns and stability of return). The other points reflect more on socio-cultural issues which may influence adoption. Perceptions of the intended recipient can be very significant - Douglas (op. cit.) again cites an instance where the perception of attributes explained more than half of the variance in the rate of adoption.

The issue of adoption suggests that the breeder must be more than just a breeder. Experience is needed in on-farm evaluation techniques, in knowing how to interact with farmers, in understanding local marketing issues (whether of seed or the harvested crop), in crop processing, in the cultural and social characteristics of the target population, etc.. If the breeder has not the social science skills necessary for some of these areas, then crop improvement becomes an inter-disciplinary effort, involving more than one scientist. In other words, the research effort requires more than the release of a new variety.

Then, of course, once the farmer is convinced that he or she wants to use the new variety, it must be accessible. The seed must be available.

4. Dissemination Mechanisms

The dissemination process could be considered to have two components, the apprising of the farm community of the new technology (hopefully, the involvement of the community in its development), and the delivery of the new technology. It is possible for a single channel to serve both functions. Where large volumes of material are involved, there may be steps in the dissemination process which do not involve the farming community, but which eventually target this group. Equally, there may be mechanisms which impose controls on this process, either to protect the end user, or even the originator of the technology.

Dissemination assumes that adoption of a new technology is desirable, that there will be a measureable benefit. Much of the emphasis will therefore be on the characteristics of the technology that will impart this benefit. Traditional approaches centred on demonstration techniques, which were considered to show the advantages to be gained by the new technology. To the scientist, this was often a black-and-white issue, with perhaps a single indicator, e.g. crop yield, being used as the basis for decision-making. However, traditional farmers may have had a multitude of factors to take into account, rendering an evaluation much more complex. Modern farming-systems work recognizes this complexity, and includes the farmer in the adaptative processes necessary to ensure that the technology is transferable. However, most dissemination carried out world-wide is still traditionally oriented, using the less-effective demonstration techniques under scientist-controlled conditions.

Table 1 suggests the types of dissemination approach, and the components of these, commonly employed. There exist different degrees of formality at each level, such that no single approach or component would generally account for the adoption achieved, e.g. a formal Government program based on demonstration plots will soon be confounded by discussions between farmers and the informal interchange between them of seed. This means that success in dissemination cannot necessarily be ascribed to the mechanism used by the institution or the researcher to reach the farming community.

Waugh (1982) notes that the activities of different groups involved in dissemination must be coordinated. This requires that responsibilities and objectives in the program be clearly understood, and that each group or agency must support the others. He points out that adoption will not be successful if the seed promoted by extension is not available at the time the farmer needs it. There is a danger that demonstration events based on materials not yet in the multiplication stage will discourage farmers, and they may well have forgotten about the new variety by the time it appears on the market two or three years hence.

Table 1. Dissemination approaches and components

Approaches	Components
Formal programs through extension services	Demonstration plots
	Field days
Formal delivery through community/farm organizations	Extension agents
Formal delivery through private sector contracts	Agreements or contracts
	Revolving funds
Informal delivery by breeder, including during FSR process	On-farm trials
	Minikits
Farmer exchange	

On-farm trials overcome a lot of these problems, placing the new material directly in the farmers' hands. The availability of minikits at a field day stimulate the farmers' interest in the new variety, as he or she will almost certainly plant the material with current varieties for comparison. Such mechanisms also overcome the financial constraints small farmers have: as Martinez (1982) suggests, why should farmers pay for seed when they can produce their own? why should they spend money on a variety they do not know? and why make a trip to town, which would be an additional expense?

There is certainly a major question about the efficiency of extension services in the technology dissemination process that is particularly important when it comes to small farmers and seed. Typically, extension agents are not trained to deal with the input-variable mixed-systems of the small farmer. Most extension agents are trained in the T and V approach, which has, to date, pushed simplified technology based on fixed inputs. The dynamics of small-farm agriculture, which is subject to major risks and constraints, has resulted in the farmers developing many risk-aversion strategies, including varietal mixtures. Small farmers will evaluate a new variety themselves in this way, and, obviously, if the new variety competes well, and survives the environmental stresses placed upon it, it will be a significant component of the farmers' harvest. Invariably, lower levels of inputs are used by the farmer than extensionists recommend, rendering the evaluation process even more rigorous.

How can the extension process be improved to make it more effective in dissemination under these conditions? There clearly has to be implicit recognition of small-farm production strategies. One possible approach is to train some of the farmers themselves as part-time extension agents. This has been tried, and found to be successful (Martinez, 1982) in Guatemala. Certainly, extension agents must be made to be aware of social and community issues which influence farmers' interest in new technology. They should have the conviction themselves that there is added benefit in adopting what they are recommending. It is questionable whether this will always come about through centralized classroom-training programs.

Many agencies have attempted to establish revolving funds as a component of a seed multiplication and dissemination program. Invariably, seed production costs are higher than originally expected when this is conducted by the public-sector, and marketing problems may add to the financial burden if seed quality is not high. A revolving fund needs high standards of management if it is to be sustainable, with effective means of generating sufficient income to cover its own costs.

5. Some experiences

This workshop intends to review your experiences, and to attempt to draw out the important lessons relating to your successes in dissemination. However, there are many projects world-wide dealing with similar attempts either in plant breeding, or in the general area of increasing agricultural productivity, though in many countries public-sector seed production activities are restricted to the provision of material for commercial-scale crops. Only a small proportion of projects deal with the marginal crops grown by resource-poor farmers. The experiences of these projects are varied, but where institutional approaches to managing the seed production and dissemination process are described, it is clear that there are some valuable lessons to be learned. Some innovative projects are in fairly early stages, and the results are not yet available. Unfortunately, few projects detail the amounts of seed that pass through different channels.

1. Henderson and Singh (1990) describe efforts by the Government in the Gambia to provide seed to farmers. The principal approach was to establish, in 1972, a Seed Multiplication Unit to provide the nucleus of a seed industry. Various donor assistance was obtained for the different parts of the program. High multiplication costs resulted in a change in policy, such that the unit became responsible for seed testing and certification. It was also supposed to act as a distribution outlet for foundation seed to private contractors for multiplication. However, the responsible research units have not provided the general volumes of seed required for the unit to function properly in this way. A seed revolving fund set up to facilitate

the purchase of seed by the unit's contractors declined in value by almost two-thirds in the first two years due to bad debts.

NGOs have become important in the Gambia in seed production and dissemination. They now act as the main contracting agents for multiplying up seed each year. Training is provided by the unit to NGO personnel. A particular advantage to working with NGOs is their geographical spread into areas which Govt services find difficult to reach. The NGOs regularly meet with the unit to review progress on seed production activities. In some cases, NGOs have been selecting high-performing types from individual farms in order to multiply them up, and make them available to farms or villages with similar conditions.

2. The same authors describe work ongoing in Ethiopia, where an NGO is attempting to establish a model for local seed enterprises. The characteristics of the current local seed system are described as:

    1. Recurrent shortages of seed at the household level.
    2. Most seed transactions take place between neighbours, or through purchase at local markets.
    3. The price of seeds at the time of planting can be as high as 30-100% more than the grain price at harvest.
    4. Farmers generally cultivate 4-5 varieties of each of the main crops.
    5. Farmers practice seed replacement after about 5 years.
    6. Socio-economic interactions in the community do not necessarily allow seed borrowers to shop around on the basis of field performance of the standing crops.

    As a result of this appraisal, the NGO is attempting to develop a model based on the Ethiopian Service Cooperative, which is currently the only local operational and development entity.

3. In Nepal, a new strategy is being applied to overcome the problems of limited and uncertain seed supply, lack of adapted materials, high transportation costs, and low quality seed for the farmers (Rana and Bal, 1982). The plan includes developing a seed multiplication system in the hills, with the farmers being encouraged to produce seed for local distribution. At each hill site, a small seed house facility for processing and storing 40 to 50t of seed is being established; outlets for seed and fertilizer are also being established at strategic points to aid the flow of inputs; hill farmers are being trained in the production of quality seeds; a credit program and the extension service support the activities associated with the local production, storage and processing of seed.

    Under Nepalese conditions, it was found that any effective strategy would have to take into account several factors, many of them unique. Some are: the use of porters and mules for transportation; solar energy as the only source available for seed drying; lack of awareness of seed quality; lack of land for seed production in food-deficit areas; difficulty of encouraging agronomists and extensionists to live in remote areas; current cooperatives not in a position to play a leadership role in seed development.

4. In Guatemala, the inability of the existing seed industry to meet the high level of demand from small farmers, led the National Crop Services Agency to develop small-scale seed production and distribution among resource-poor farmers (Ortiz, 1989, reported in Ortiz, et al., 1990). Extension agents

appear to have been the main agent in this process, supporting the farmers in their seed production activities. Table 2 indicates their production in 1988.

Table 2. Small-scale seed production and distribution by resource-poor farmers in Guatemala, 1988

Crop of	No of seed plots	Production area (ha)	Seed produced (t)	No of farmers receiving seed
Maize	194	19.5	23.5	6227
Beans	153	23.6	29.5	7406
Wheat	204	13.2	29.5	3595
Potatoes	161	7.1	126.9	3635
Faba beans	6	0.2	0.4	166
Rice	1	0.7	1.4	16
Totals	719			21045

Source: Ortiz et al., 1990.

Linkages between the public and private sector in the seed industry differ from country to country. There is a general consensus that where there is heavy public-sector investment, the private sector will be discouraged. Marginal crops, of course, pose a special risk to the private sector, due to marked differences in demand from year to year. Unsold seed represents a high risk for small commercial firms.

Guatemala appears to have developed strong links between the public and private sector in the seed industry (Velasquez, 1982). In order to encourage private industry, ICTA, the national agency responsible for crop improvement, produces basic seed of most crops and offers its drying and processing facilities as a paid service to the small seed industry. ICTA also produces, processes and distributes relatively small quantities of seed in an effort to establish a quality standard and a guideline for contracting and selling prices. The strategy includes: contract seed production with carefully selected farmers at a favourable price to the producer; training of the contract producers in seed production; encouraging the producer to seek his own marketing channels rather than selling back to ICTA; provision of basic seed by ICTA, and the provision of drying, processing and bagging services for the qualified producer who wished to sell his own seed; increasing retail prices to increase the margin between the production price and the retail price of the final product.

In some cases, an excessive number of institutions appear to become involved in seed production schemes, such as examples from Alvarez (1986) and Garcia (1986). While neither author sees this as a constraint, there is a hidden cost in such top-down involvement which must, at some point, impact on the viability of the process. While mainly intended for small-farm beneficiaries in each case, the thousands of hectares planted and thousands of tonnes harvested clearly imply that the farmer is responding to institutional targets rather than to community needs.

A more producer-driven approach, where farmers participate in the definition of both the constraints and potential solutions (e.g. Gomez, 1986), suggests longer-term viability through at least partial ownership by the beneficiaries of the ideas and effort applied. The latter example is one where, with some security, one can say that it is possible to establish community-level seed businesses, managed by one or several farmers. Such businesses generally require technical assistance during their development, and are very dependent on flexible credit sources. Small farmers need seed at low-cost, a clear signal that only low-cost seed production systems will be sustainable without continuous external support.

Donor agencies have had varied results in supporting seed production programs. Successful programs were generally characterized by good management, prior experience with seed, and a good demand for seed (e.g. the World Bank's Tarai Project in India). The converse, of course, is that new seed projects in areas where there is no experience, and no initial demand for seed, will struggle for success. The Bank notes (Brown, 1982) that success is more easily achieved with relatively flexible and dynamic management than under a government or quasi-government agency in which autonomy is restricted.

IDB experience in Latin America in general, apart from observations on the inadequacy of most programs in targeting the small farmer, and in using innovative techniques, also shows the following (Ampuero, 1982):

1. With respect to seed organizations, there are few distribution mechanisms for reaching distant areas, seed quality suffers in storage and during transportation, and inflexible and rigid seed regulations reduce the amounts of seed available.

2. With respect to seed policy, governments generally do not provide incentives to stimulate seed production and establish the seed industry, policy does not clearly distinguish the roles of public and private organizations in seed production and distribution, and there are excessive bureaucratic controls in seed quality programs.

The IDB also notes that many times regulations from developed and industrialized countries have been adopted. These are often difficult to meet, and may impede the production and supply of seed to farmers. Poey (1986), in a review of some donor experiences notes that many agencies show a preoccupation with maintaining seed prices low through subsidies in order to help small farmers, though rarely is this end result achieved.

Out of these examples come some general points:

1. Some government programs are not sustainable, especially where budgetary restrictions occur and suitable trained staff cannot be retained.
2. Agencies that operate informally at the local level provide a means to support the channeling of quality seed to small farmers, and may even act as contractors in seed multiplication.
3. Seed dissemination programs for marginal agricultural populations require a greater level of effort than those targeted at more commercial operations.
4. The characteristics of seed programs, including any legislative component, should be tailored to the intended beneficiaries. Any constraints of the latter should be noted, before inflexible systems have a chance of becoming established.
5. Few programs have targeted the empresarial spirit of the small-farmer, and searched for ways to support the development of local, or community-level, seed businesses.

6. Legislation

Legislation covering seed production and dissemination varies widely. Much of it appears to be targeted at controlling this process, to ensure that genetic standards are maintained, and that seed sold to the farmer is of good quality. Some of the examples quoted above, however, suggest that legislation can act against an efficient, and, perhaps for the small farmer, an appropriate, seed industry. Certainly some authors (Douglas, 1980; Garay, et al., 1990) suggest that legislation should be the last step in the development of integrated seed programs, precisely because the controls that legislation introduces operate against efficiency and entrepreneurism. Rather than control, it is suggested that agencies responsible for seed certification should act in technical assistance roles, and that legislation should only be effected when the seed industry is operational. This is a marked contrast to the approach the World Bank has taken in most of its large seed projects.

Equally, the issue of plant breeders' rights is one that is not of equal priority throughout the developing countries. In some, PBRs do not exist, in others they are part of the legislative package at the institutional level. Few individual breeders in the LDCs would consider that effective PBRs exist, or that they benefit in any way from them.

The Technical Advisory Committee to the IARCs believes that PBRs should only be introduced after the seed industry is well along the development path (Anon, (1986), IARC position paper). It is concerned that there is ample scope for misappropriation of material emanating from the IARCs, but believes that a degree of control can be assured through provision of seed samples and varietal descriptions to certification agencies. The TAC believes that the introduction of PBRs should be left up to individual governments, and would not specifically make any recommendations in their favour.

7. Final remarks

This paper has reviewed in general terms, the principal issues that relate to seed production and dissemination, and, ultimately, adoption. While there has been a large number of seed projects, and most countries have seed programs, the actual successes of these, as they affect the small farmer, appear relatively limited, and the processes by which seed reaches the farming community are not well documented. The papers to be presented at this workshop offer an opportunity to examine this latter aspect in detail, and I hope that we will be able, as a result, to determine those strategies which have been particularly successful. There exists an opportunity to increase the impact of future breeding programs by elucidating effective dissemination mechanisms. The resource-poor small-farmers are particularly at risk from ineffective dissemination and extension methods, and we have a small opportunity to show how such methods might be improved.

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