Expanding the Production and Use of Cool Season Food Legumes

A global perspective of peristent constraints and of opportunities and strategies for further increasing the productivity and use of pea, lentil, faba bean, chickpea and grasspea in different farming systems

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Infrastructural support to promote farmer adoption of improved technologies

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Abstract

Adoption of technology is faster with resourceful farmers in the more productive and homogenous core areas with irrigation or assured rainfall. However, the pace of adoption is slower with the resource-poor farmers in less productive and diverse hinterlands. A decentralized research strategy is needed to develop technology suitable to diverse conditions of hinterlands. Use of farmers' indigenous knowledge and their involvement in developing and testing of technology to suit local conditions is essential. Hence, farmer-participatory on-farm research constitutes the foundation for technology adoption. Environmental factors influence adoption, but are beyond our control. Therefore, the infrastructure for adoption will be comprised of technological, institutional, socioeconomic, and human factors. Case studies from Bangladesh are given to illustrate the beneficial effects of some of the infrastructural support systems on technology adoption.

Introduction

Technology is defined as a "scientific method of achieving a practical purpose". In agriculture, improved technology usually refers to one or more crop management practices that are an improvement over traditional practices, and can produce higher yields and profits, while maintaining stability of production. Usually, most improvements are first developed in research stations, and then tested for applicability in farmers' fields. Beneficial sets of technologies are then "adopted" by farmers.

Technology transfer has been particularly successful in the green revolution era, in the highly productive and homogeneous areas called "core areas" where production is guaranteed by irrigation or assured rainfall. The physical environment in core areas is similar to that at research stations, and hence the new technologies from research stations were easily duplicated by the resource endowed farmers in these regions. At the same time adoption of technology has

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been slow in the more diverse, less productive, and more heterogeneous areas called "hinterlands" (Rambo and Sajise, 1985). The highly diverse conditions and the limited resources of farmers in the hinterlands reduced the chances of applicability of improved technologies developed on well endowed research stations. This means that a single comprehensive package of improved technologies can be designed to fit the core areas, while no single package can possibly be applicable to the diverse hinterlands. In addition, resource endowed farmers in core areas could influence the research strategies to their benefit while resource poor farmers had no means of expressing their demand for suitable technology, and consequently their needs were not addressed adequately (Chambers and Jiggins, 1986; Farrington, 1988; Fujisaka, 1989; Merrill-Sands *et al.*, 1989). This paper considers the various factors responsible for technology adoption, and suggests the infrastructures needed to hasten adoption.

Farmer participation in technology adoption

The "top-down" approach of transfer of technology (TOT) was successful in the more fertile and homogeneous areas, but not the diverse, less productive and risk-prone areas (Chambers and Jiggins, 1986). In the early 1960s farmers' ignorance and the inability of the extension service to educate farmers were cited as reasons for non-adoption of technology. In the 1970s, socioeconomic factors were advanced as the main reasons for slow adoption. In the 1980s, a more challenging interpretation was put forward which stated that the problem was not the farmer, nor the farm, but the technology itself and the priorities and processes of its generation (Chambers *et al.*, 1989; Toulmin and Chambers, 1990). The farmer-participatory approach envisages that new technology should be technically feasible, economically viable, socially acceptable, and environmentally safe and sustainable for use by the small, resource poor farmers (Batugal *et al.*, 1985). In the hinterland the agroecological complexities and socio-cultural diversities of each area require the technology to be tested and modified (adapted) to suit individual farmer or farm situations. The centrality of the farmer in the whole process becomes vital and this leads to "demand driven pull" for technology in contrast to the "technology push" in the TOT approach. Farmers have been increasingly recognized as sources of indigenous knowledge and technology and hence must be involved in the technology adoption research process (Chambers *et al.*, 1989). This involves assessing the farmer's problems, priorities, and indigenous knowledge; and use with available scientific knowledge to address identified problems – the "bottom up" approach (Norman, 1980).

On-farm adaptive research should be farmer-participatory research (Farrington and Martin, 1987) to develop a basket of technology options from which the farmer can choose practices useful and affordable (Toulmin and Chambers, 1990). As aptly put by Raintree and Hoskins (1988), "both scientists and farmers have unique areas of expertise which collectively produce a better basis for development than either alone". Therefore, for the purpose of this paper, we will consider the farmer-participatory approach in technology adoption as the foundation to build the infrastructure needed to facilitate adoption.

Infrastructural Support for Adoption of Technology

Adoption of technology is a continuous process and takes places at varying degrees depending on the crop, technology, and the locations where adoption is occurring (Feder *et al.*, 1981). Grigg (1984) reported that during the 18th century new technologies in Europe spread at about a mile (1.6 km) each year. In the 20th century with improved transport facilities and communication links we would expect a faster adoption rate. However, several studies on innovation adoption among farmers have shown that there is a considerable lag period (5 to 8 years) between the first adoption and majority adoption (Jones, 1967).

Infrastructure refers to the "basic framework of a system or organization". We have already indicated that the farmer-participatory approach of technology adoption forms the foundation to build the infrastructure. In the present context we will consider infrastructure to be the organizational structures and policies needed to facilitate adoption of improved technology. In this paper we will attempt to ascertain the factors responsible for the lag period in adoption and suggest ways to improve the conditions to hasten adoption.

Factors Affecting Adoption of Technology

Farmers make choices to exploit available technology based on environment and the resources. Farmers who make correct choices will survive and prosper, and over time their successful production practices will become institutionalized (Rambo, 1983). A knowledge of the factors responsible for adoption of technology will enable agricultural scientists and planners to identify strategies to overcome some of the bottlenecks slowing adoption. These factors can be grouped into: environmental, technological, socioeconomic, institutional, and human.

Environmental or climatic factors include topography, soil, rainfall, temperature, and natural hazards. The resource poor farmer has little, if any, control over these factors even though they have a major influence on adoption in diverse, risk-prone, and unpredictable environments (Chambers and Ghildyal, 1985; Chambers and Jiggins, 1986; Rambo and Sajise, 1985). Despite their importance and although they must be kept in mind we will not discuss environmental factors as they go beyond the scope of this paper. We will discuss the technological, socioeconomic, institutional, and human factors as they form the framework for the infrastructural support.

Technological Factors

Technology development is a continuous process, and is essential for success of any adoption process. Components of technology include:

Indigenous Knowledge Base

Farmers are always experimenting and making small changes in the course of their normal agricultural activities. Farmers therefore naturally can contribute their indigenous knowledge in planning on-farm trials designed for adoption of improved technology in their area. Incorporation of results, experiences, and suggestions from these farmers will make improved technology more responsive to local conditions and also gain tacit support of the farming community who feel they own the new technology (Maurya, 1989; Toulmin and Chambers, 1990).

Research Support

Each country should have a dynamic backup research program to hasten and assist the adoption process by supporting (1) technology generation, (2) technology adaptation, (3) technology verification, and (4) technology dissemination. All these four stages of technology adoption are interlinked and need a concerted effort by scientists to provide the research backup. Countries with a poorly developed research program are likely to take more time for adoption than countries with a strong research base.

Systems Approach

Integration of disciplinary research and commodity research into a systems approach is a prerequisite to ensure the success of a technology adoption program. Scientists in individual disciplines tend to emphasize the importance of their own area of research, and are sometimes intolerant of the importance of other disciplines. Establishing a systems perspective can eliminate these biases and allow scientists to work as a team. Integration of on-station and on-farm research improves the capacity to respond to the client group, i.e., the resource poor farmer (Merrill-Sands and McAllister, 1989; Holden and Joseph, 1991). Policy changes (as discussed elsewhere in the paper) by governments are needed to get the systems perspective incorporated into the existing system.

Monitoring and Evaluation

Monitoring and evaluating the adoption process ensures that field staff and extension personnel get moral support, and provides the direction needed for making adjustments. Evaluation provides feedback that can be used to modify the strategy or technology so that they better suit the farmers' conditions.

Information Exchange

A strong information network can help in the exchange of knowledge and proven technologies between farmers, researchers, and extension staff in a region, and in other regions (Biggs and Farrington, 1991).

Socioeconomic Factors

Studies on technology adoption have emphasized the importance of socioeconomic factors. An apparently profitable technology may be rejected because of high input costs or because of increased risks associated with the new technology (Rambo, 1983). Following are some socioeconomic considerations:

Resources

Resource-poor farmers must make difficult decisions about how they allocate their resources which include land, labor, draft-power, and equipment. Security of tenure or land ownership is a necessary pre-condition before farmers feel safe to invest in long term management practices needed for adopting many new technologies (Chambers *et al.*, 1989) because the share of profit to a tenant is low. Most improved technologies require added labor, which may conflict with other essential farm operations. Similarly, the draft power required may be more than the farmer can provide. In such cases technology must be designed to reallocate labor and draft power efficiently. Equipment (planter, sprayer, etc.) needed for new technologies can be made available through policies which enable the hiring or cooperative ownership of equipment (Duwayri *et al.*, 1988; Grenoble *et al.*, 1990).

Inputs

Inputs such as seeds, fertilizers, pesticides, and fungicides must be available for many improved technologies (Dei, 1981; Feder *et al.*, 1981; Chambers and Ghildyal, 1985; Chitnis and Bhilegaonkar, 1987; Heinrich, 1991). In such cases non-availability and high cost of inputs can slow down their adoption. Necessary inputs can be made available when needed and at reasonable prices through government organized agriculture input and service organizations. Farmer cooperatives and non-government organizations (NGO) have arranged the supply of essential inputs which has lead to success in adoption of technologies dependent on inputs (Montemayor, 1987). Quality of inputs (e.g., genuineness of pesticides) should be guaranteed for the success of a technology dependent on the input.

Finances

Cash for inputs, equipment, machinery, and other services, beyond the resources of the farmer can be a major bottleneck to adoption (Conteh, 1986; Chitnis and Bhilegaonkar, 1987; Cruz, 1987; Duwayri *et al.*, 1988). Low-rate credit facilities through banks, cooperatives, and financial institutions can help farmers buy the needed inputs (Krause *et al.*, 1990). Repayment should be made easy. Subsidizing input costs is practiced in some countries but is not favored in others because of the negative effects it can have when the subsidy is withdrawn.

Markets

Market intervention can help speed up adoption (Miller and Trolley, 1989). Encouraging small and large scale industries to increase the demand for a product has accelerated adoption of technology associated with that product. Support price, guaranteed procurement, and other government policies that ensure remunerative prices to farmers can provide strong motivation for adoption (Cruz, 1987). This must be coupled with the establishment of rural markets and a good network of roads to ensure accessibility to markets. For example, in Nepal the area under groundnut has not increased despite heavy demand for groundnut oil because of poor roads and few markets for selling the crop.

Insurance

Risk and uncertainty substantially affect farmers' decisions to adopt improved technology (Feder *et al.*, 1981; Nygaard and Basheer, 1981; Kelley and Walker, 1991). Hence, reducing risk through crop insurance schemes can provide the needed moral support for farmers to accept a new technology (Knight *et al.*, 1989).

Institutional Factors

Institutional factors can have a greater effect than resource constraints on technology adoption (Merrill-Sands *et al.*, 1989). These are discussed below:

Policy

Success of technology adoption in a country depends largely on the policies adopted by the government. Some of these have been discussed above under technology and socioeconomic factors. Senior administrators and policy makers should be knowledgeable about on-farm adaptive research, show commitment towards such projects, and provide leadership and support through suitable policies. A national coordination committee or council to plan, coordinate, and provide guidance has been found effective (Merrill-Sands and McAllister, 1988; Axinn, 1991). Farmer-participatory research and farming systems perspectives need to be emphasized in formal agricultural education (Axinn, 1991).

Resources

Allocation of resources for on-farm research can facilitate adoption. Funds also are needed to recruit new staff, provide them with vehicles and fuel to visit and monitor trials to ensure that farmers are provided with timely advice and assistance in adopting the technology. Often this includes training new staff and providing new facilities in areas targeted for adoption. Sustained involvement of social scientists at all stages of adoption brings a social science perspective (Merrill-Sands *et al.*, 1989).

On-Farm, On-Station Links

There can be conflicts of interests between on-farm and on-station researchers. To prevent these conflicts, opportunities for collegial interaction should be given to allow frank discussion and free flow of information (Axinn, 1991). The on-farm researcher who is posted in remote areas can feel neglected, while the on-station researcher can feel superior. Joint planning and allocation of responsibilities can lead to a feeling of mutual success (Merrill-Sands *et al.*, 1989). A system of monetary incentives can be set up to reward those that use the farmer participatory adoption process (Axinn, 1991).

Technology Adoption System

Among countries there is a wide variety of systems for technology transfer and adoption. Most countries have an extension service, and some have on-farm research groups. The basic objective is to assist farmers to increase their agricultural production and income. The World Bank has financed the training and visit system of extension workers in about 40 countries. This system has been effective by increasing the farmer orientation of research through feedback to the system (Benor, 1987). However, the links among the different agencies need to be strengthened for the agencies to be effective in serving the farmers. McDermott (1987) suggests that there should be no clear distinction between extension and research, and that extension should provide the technical liaison between the farmer and researcher needed to support adoption activities. Some reorganization and reorientation of policies and procedures are needed. For example, in countries that have used cooperative farming, a sudden shift to individual farming can lead to unclear job goals for the extension staff. Formerly the extension system was paid by the cooperatives they were helping. With the new system such payments no longer exist, and the expected goals of extension system become unclear.

Authority

Decentralization of power and delegation of decision making can strengthen the effectiveness of adaptive on-farm research (Axinn, 1991). A rigid and inflexible bureaucratic setup can negatively effect the adoption processes because scientists or extension staff located in remote villages cannot always wait for decisions to be made by the headquarters (Merrill-Sands *et al.*, 1989). Although the local staff is usually better able to judge the situation, and make appropriate and timely decisions, such decentralization sometimes attracts local political pressures, and can lead to disruption of planned programs. Effective mechanisms to link with NGO's and farmers' organizations can also help the adoption process (Axinn, 1991).

Communication

Better communication links to assist in contacts between field staff and senior administrators can assist the adoption process.

Feedback

An effective feedback system from farmers, extension staff, and on-farm research scientists can help develop a meaningful research agenda to sustain the adoption process. Direct interaction between the farmer and scientist is better than indirect contact through the extension service (Chambers and Jiggins, 1986). Feedback systems need strong support from senior management and institutions (Merrill-Sands and McAllister, 1988; Axinn, 1991).

Human Interactions

The human interactions are basic to technology adoption. Those in the technology adoption process – the research scientist, the extension worker, and the farmer – should interact as joint partners. The level of interaction and linkage affect the adoption process. Collegial researcher-farmer interactions can improve adoption (Lightfoot *et al.*, 1989). To ensure that new technology is appropriate, scientists should avoid the resource-rich farmer and work with the representative groups of resource-poor farmers (Chambers and Jiggins, 1986). However, resource-rich farmers are in a better position to test and adopt new technologies which means that they could act as "models" to disseminate the new technologies (Feder *et al.*, 1981). Involving farmers' groups and rural leaders in the decision to adopt a technology can provide a firm basis for the adoption of that technology (Kean. 1988; Norman *et al.*, 1988). Farmer to farmer interaction then becomes important (Dequito and Abansi, 1987; Chambers *et al.*, 1989).

Sustaining the farmer's involvement in the adoption process helps research address the needs of the resource-poor farmer. For example, identification of priorities is an interactive process and can be best accomplished by continuous interchange between researcher and farmer (Merrill-Sands *et al.*, 1989). Communication between scientists and farmers is an art requiring an expertise which many biological scientists do not have (Rhoades *et al.*, 1985). Experience indicates that maintaining the involvement of social scientists improves communication between farmers and research scientists. Another approach is for national programs to train their scientists to have a social scientist's perspective.

The role that women play in participatory on-farm research and technology adoption has been overlooked. Most technology adoption programs have a male-bias, although several activities involve women. The gender issue becomes particularly critical when the decision maker or user of technology is not consulted. Recent studies have re-emphasized the important role women can have in the adoption of technology (Chambers *et al.*, 1989; Axinn, 1991).

All the factors discussed above affect the pace of technology adoption. Therefore, the infrastructure needed must be designed to facilitate the removal of bottlenecks, and provide for the congenial conditions necessary for rapid adoption. Many of these are interrelated, and sometimes interdependent. A marginal positive change in any factor can hasten the adoption process substantially.

Technology Adoption in Bangladesh

Case studies from Bangladesh are given below to illustrate how technology adoption can be successfully achieved. The examples given below illustrate the positive effects of some of the infrastructural systems described above in enhancing adoption.

Importance of Indigenous Knowledge

The Bangladesh Innovative Farmers' Workshop (BIFW) is an example of the collegiate participation where scientists work with farmers to strengthen farmers' own informal research and development systems. The methods used to identify farmer's innovation include field visits, unstructured surveys, farmers' meetings, and field days. The BIFW organized by ERP (Extension and Research Project-the forerunner of On-Farm Research Division [OFRD], of the Bangladesh Agricultural Research Institute [BARI]) met to learn about the value of new processes. spread new technological innovations widely among potential users, and plan further research for refining these technologies. Started in 1982, with farmers as resource persons, these workshops are now common. So far a total of 43 innovations have been presented. These workshops have helped the ERP improve its research agenda and also provided a forum for informal exchange of information. For example, farmers participating in the Innovative Watermelon Farmers' Workshop provided valuable ideas for the quick sprouting of watermelon seeds. In the Innovative Wheat Farmers' Workshop scientists were told about relay cropping of wheat with transplanted aman rice (main rice crop – which is usually harvested during the first half of December), which helped OFRD scientists design experiments for wheat production under minimum tillage (Jabbar and Abedin, 1989). This reversal of the roles that research and extension workers normally have with farmers has encouraged interaction and improved the relation between the participants, thereby strengthening the technology adoption process. This arrangement has also been an effective means to hasten the transfer process.

Successful On-Farm Research Program in Bangladesh: Homestead Vegetable Gardening

Homesteads occupy about 5% of the total cultivated land of Bangladesh. About 56% of the households have around 400 m^2 of land. Although there are about 13 million homesteads in rural Bangladesh, the consumption of vegetables is only 28 grams per person per day. As a result, an estimated 30,000 children are becoming blind due to vitamin A deficiency each year. If homestead areas could be properly utilized, vegetable production would increase and malnutrition decrease. The Homestead Vegetable Production and Utilization Research Project was initiated in 1985 with USAID assistance at the Farming Systems Research Site, Kalikapur, Ishurdi in north Bangladesh (Hossain *et al.*, 1990).

Technology Generation

Improved vegetable production technology consisted of five vegetable cropping patterns with 14 vegetable crop combinations. About 200 kg of fresh vegetables could be produced each year in a 6 m × 6 m plot which provided the total vitamins A and C and iron needed by a family of five. In addition the homestead garden generated cash income for resource-poor farmers. A unique feature of this technology was the participation of women of landless households and marginal farms.

Adoption of Technology

The program for the adoption of technology to permit homestead vegetable production (HVP) was initiated in October 1989. It was coordinated in 20 upazilas (sub-districts) by the Bangladesh Agricultural Research Council (BARC) in collaboration with BARI and the Department of Agricultural Extension (DAE) with USAID funding.

On-farm research was conducted with landless and marginal farmers, with practical training on vegetable production, pest management, and water management. Each trainee was provided with an instruction manual and seeds of vegetable cultivars. Monitoring and evaluation of homestead gardens by researchers and extension personnel facilitated their interaction with farmers and aided the diffusion of technology. The technology was so successful that the program was extended to 100 upazilas in 1990.

Lessons Learned

The activities of the homestead vegetable production (HVP) is in its second year. Its initial success has led to plans to cover most of the districts in Bangladesh within the next 5 years (BARC, 1991). Success of the HVP technology may be attributed to:

i) Initiatives taken to strengthen extension-research links achieved through District Technical Committees, Regional Technical Committees, Internal Review Workshops, joint field visits by researchers and extension workers, and participation by farmers.
ii) Sharing by administrators, researchers, extension staff, and farmers of the common objective to improve homestead vegetable production.
iii) Elaborate planning, adequate monitoring, and supervision of the program.
iv) Clear institutional policy and donor support in a well defined area of research and development.
v) Inclusion of women as participants which enhanced the effectiveness of adoption.

It can be seen from these examples that an infrastructure to support successful farmer adoption of improved technologies requires input and committment at all levels from policy makers to administrators, scientists, extension workers, and farmers.

Concluding Remarks

Farmer adoption of technology has been generally good in the more productive and homogeneous "core lands," but slow in the less productive, diverse, and risk prone "hinterlands". To improve adoption in the hinterlands, the emphasis of administrators and scientists in each country should be to decentralize the research process to permit development of location specific technologies. Advantages can be gained by combining indigenous technical knowledge with scientific innovations to develop appropriate technologies for the resource-poor farmer. The centrality of the farmer in on-farm research and adoption of technology is of great significance. Therefore, the farmer participatory approach forms the foundation for the infrastructure needed for technology adoption. Infrastructural support itself involves the technology base, socioeconomic factors, institutional policies, and human interactions. A strong technology base is needed in each country to provide a research backup to support technology generation, testing, adaptation, and be responsive to feedback from farmers. Institutional changes and policy decisions act as vehicles, and socioeconomic factors provide the needed pull for adoption. Among all the factors, improved human interactions play the most important role in adoption of technologies. National governments and administrators should endeavor to provide these infrastructural supports needed to enhance technology adoption.

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