6 Research Evaluation and Priority Assessment at the International Crops Research Institute for the Semi-arid Tropics (ICRISAT): Continuing Cycles of Learning to Improve Impacts

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Abstract

This chapter documents the research priority assessment methods used at the International Crop Research Institute for the Semi-arid Tropics (ICRISAT). Research evaluation and priority assessment have evolved to provide continuous cycles of learning to improve impacts. Prior to 1992, research priorities were established based on consultative meetings with ICRISAT and National Agricultural Research Systems (NARS) scientists to identify key productivity constraints and propose research themes and approaches to address them. For its 1994–1998 Medium-term Plan (MTP) cycle, ICRISAT undertook a quantitative priority-setting exercise using clear criteria for establishing choices among competing research activities. This drew on scientists' empirical and intuitive knowledge base. Research themes identified were impact-oriented, projecting clear milestones against which progress can be measured and evaluated *ex post*. This identification formed an integral part of the research evaluation process and facilitated revising priorities in the light of such experiences.

Following the quantitative priority assessment exercise, ICRISAT pursued extensive discussions with partners in the MTP 1998–2000 cycle and broad targets were identified to capture the areas of research and the nature of the benefits they intended to deliver. Hence, four targets were articulated by ICRISAT including prosperity, diversity, environment and inclusiveness. Due to time and cost constraints, simple scoring methods were used to rank identified constraints through a broader consultation between ICRISAT and all partners in the research and development (R&D) continuum. The target of inclusiveness included participatory methods that facilitate the participation of stakeholders and allow them to express their preferences. Scoring methods were used to rank priorities in the subsequent three-year MTP cycles.

In addition, ICRISAT enhanced priority assessment through institutionalization, building up a structured database serving as a benchmark of reference for future research evaluation, including qualitative impact indicators, using the results from numerous diffusion, adoption and impact assessment studies in setting priorities and mainstreaming poverty considerations. In recent years, CGIAR system priorities provided a framework in which to cast ICRISAT priorities. Strengths and limitations of the different methods are highlighted.

Keywords: Priority assessment, agricultural research, scoring

Introduction and Background

The International Crops Research Institute for the Semi-arid Tropics (ICRISAT) was established in 1972 with a mandate to improve sorghum, pearl millet, groundnut, chickpea and pigeon pea productivity in the semi-arid tropics. During the last 3 decades, ICRISAT expanded its research agenda along much of the research for development continuum. The goals and objectives of research have broadened from increased food production to include sustainable resource management, equity, gender, health and environmental concerns and farm- and policy-level implications. Along with the expansion of the research agenda, there is greater appreciation of the need for quantifying the economic returns to research investment and other dimensions of impact (social, environmental and institutional). In line with these changes, priority assessment in agricultural research has changed, with the principal focus shifting from yield and nutritional gains to achieving equity and environmental sustainability. This change is reflected in ICRISAT's evolving vision and strategy as well as research priorities.

The pursuit of a well-balanced and well-focused portfolio has become imperative. It has motivated stronger accountability mechanisms and systematic priority setting. Thus, the establishment of a transparent, consistent, objective and participatory priority-assessment process has become essential in institutional decision support and research planning. This process has prompted awareness among agricultural scientists and research managers about the expected benefits and pay-offs from research.

Research Priority Assessment at ICRISAT: Evolution from the 1980s to the Present

Research priority setting involves a process of explicitly or implicitly making choices over possible research activities. ICRISAT has conducted formal or informal priority assessment exercises to help set the research agenda, guide allocation of research resources and improve the quality and efficiency of research. The outcome of these exercises is a ranking of research programmes, projects or research themes within a programme or global theme. Research priorities are set across commodities, regions, disciplines, technology types and research problems. Priorities are set at different levels including the global, regional, national, research programme and project. Decisions about resource allocation also differ depending on the level at which priorities are set.

The priority assessment initiative at ICRISAT has been sustained by a determination to build an objective and transparent basis through its Medium-term Plans (MTPs). ICRISAT faced the challenge of a changing external environment where funds for research were declining, and pursuit of a focused research agenda became imperative.

Early Priority Assessment Approaches (1980s–1993)

During the late 1980s to the early 1990s, ICRISAT followed the CGIAR Technical Advisory Committee's (CGIAR/TAC) guidance, which identified four basic factors for identifying agricultural research priorities. These factors included: (i) comparative advantage (e.g. the advantage that ICRISAT has in undertaking projects where long-term, continuous effort is required); (ii) internationality (i.e. the existence of externalities and spillover effects); (iii) partnership (i.e. encouragement of inter–Center and Center–NARS activities); and (iv) efficiency and equity.

The fourth factor related to total potential benefits and high-expected payoffs, in consideration with the distributive consequences of successful research. This distributional element meant identifying the area (ecological and geographical regions) and people affected, the benefits of research in relation to costs, the feasibility of implementation and successful completion and the potential effects on the livelihoods of the poorer or marginalized sections.

Efforts to establish research priorities were based on consultative meetings with ICRISAT scientists and National Agricultural Research and Extension System (NARES) partners to identify key productivity constraints and propose research themes and approaches to address those. These exercises help to build consensus around important issues especially when ICRISAT resources were expanding. This approach did not provide information on trade-offs between various research undertakings.

Quantitative Priority Assessment for the 1994–1998 MTP

For its MTP cycle 1994–1998, ICRISAT undertook a more significant effort for research priority assessment. It involved application of a participatory approach and it set out on prioritizing among numerous competing research possibilities to make optimum use of scarce research funds against the background of a strategic plan. ICRISAT used an *ex ante* multi-objective framework, considering indicators for economic efficiency, equity, internationality and sustainability, for assessing research priorities. A supply-side methodological orientation was used to complement the TAC (1992) demand-side analysis. As illustrated later, the distinct advantage of the quantitative framework that was established is that at a time of intense competition for scarce funds, it made explicit the benefits that would flow from additional investments to an institute as well as the opportunity costs corresponding to reductions.

The priority-setting methodology used by ICRISAT (see Box 6.1) was found to provide clear criteria for establishing choices among competing research activities. It is more analytically rigorous, draws on scientists' empirical and intuitive knowledge base and is transparent and interactive. Research themes were identified along with expected impacts, projecting clear milestones against which progress can be measured and evaluated. The assumptions about prospective yield increases, research lags, probabilities of success and adoption lags and ceilings were tested against actual delivery of a new research-induced technology. This formed an integral part of the research evaluation process and facilitated revising priorities in the light of such experiences. This type of methodology was also later applied in other CGIAR Center (IRRI, 1997; ILRI, 1999).

The seminal work of Kelley *et al.* (1995) laid the groundwork for rigorous priority assessment at the institute level. The methodology was used by ICRISAT to develop its MTP 1994–1998 and is described below.

Scoring model: a weighted composite index

This methodology was developed by Kelley *et al.* (1995), and was used in setting priorities for ICRISAT's 1994–1998 MTP. It provides criteria for establishing choices among competing research activities, drawing on scientists' empirical and intuitive knowledge base. Research themes identified are impact-oriented, projecting milestones against which progress can be measured and

Box 6.1. MTP 1994–1998: Research Priority Setting Based on New 'Tandem Matrix' Management Model

The research priority-setting delivery mechanism applied a scoring method, using a weighted composite index. ICRISAT's research agenda was restructured into 22 global research projects focused on priority needs and research opportunities of the 29 production systems across the SAT. Each of the projects has a team with clearly defined objectives and milestones. The team was accountable for the development, conduct, management, resource utilization, and reporting and impact assessment of the project.

An organizational framework employing a tandem matrix was developed to facilitate the definition, development, management and conduct of projects (ICRISAT, 1992). There are two dimensions of the matrix. The original axis has four geographic regions. The geographic regions are complemented by seven disciplinary research divisions on the vertical axis that have global responsibilities. The axes of the matrix are designed to emphasize shared responsibilities, goals and outcomes through development and delivery of a relevant global research project portfolio. Research partnerships with NARS are a crucial part of the research agenda, and they have been involved in the development and conduct of these research projects.

evaluated *ex post*. The assumptions about prospective yield increases, research lags, probabilities of success and adoption lags and ceilings can be subsequently tested against actual delivery of a new research-induced technology.

A working group of scientists from across commodities, disciplines, programmes and locations was constituted to coordinate activities, exchange information and generate ideas. The group helped develop methodology and agreed upon procedures for prioritizing research themes. Four principles guided the research planning process: (i) the methodology adopted should provide clear criteria for establishing choices between competing research activities; (ii) the methodology used should be analytically rigorous and offer a consistent method for prioritization; (iii) the research plan should be based on empirical and intuitive judgements from a knowledge base within ICRISAT and NARS; and (iv) the process should be transparent and interactive with open presentations and discussions among all scientists in the organization.

These principles resulted into four major elements which characterize the process: (i) the choice of four selection criteria which reflected the mandate of the CGIAR and ICRISAT: economic efficiency, equity, internationality and sustainability; (ii) an overall score (composite index) for each potential research theme; (iii) a formalized database of primary and secondary data; and (iv) an institute-wide effort with multidisciplinary spillovers.

Relevant criteria were identified based on ICRISAT's stated mandate and objectives. A scoring method employing a weighted, additive composite index was developed to calculate an overall score for each proposed research activity or 'theme'. Subsequently, an ordinal ranking of themes and their cumulative costs emerged which defined research priorities, based on a multi-impact measure of economic efficiency, equity, internationality and sustainability. Depending on the budget available, an optimal research portfolio could be defined.

To measure economic efficiency, the expected benefit/cost ratio was estimated using a simplified version of the producer–consumer surplus approach, i.e. estimating gross welfare benefits. Equity was measured in terms of the number of poor and number of adult female illiterates in the regions where adoption is predicted. Internationality was measured using a Simpson index (Simpson, 1949) of the expected spread or spatial diversity of the problem each research theme is to address. Sustainability was measured as a subjective index from 1 to 5 in accordance with the expected contribution of the research to sustainable agriculture. These four indices were then normalized, weighted and combined into a single index (Kelley *et al.*, 1995).

Key parameters used in the scoring model

Values for these measures described above were calculated using information from research protocols ('themes') and other databases. Themes were ranked from highest to lowest with respect to one specific measure. However, since themes were evaluated for impact using multi-objective criteria, some means of integrating the various measures were indispensable.

The ideal research theme has the largest expected benefits relative to the cost of investment, affects the largest number of poor, is widely pervasive and is environmentally friendly. Satisfying the two criteria for efficiency and equity means offering a high rate of return and affecting a large number of people in poverty. This preference is depicted in Fig. 6.1 as the area that should receive strong emphasis. As noted above, those with low economic returns and which affect a low number of poor and illiterate females receive limited support. In many cases, there are trade-offs, e.g. a project may affect a large number of poor, but offer only a low rate of return on investment. These types of projects may receive emphasis, depending on the social or economic objectives pursued.

The basis for assigning weights to the criteria was transparent. After considerable discussion, and given the fact that each of the four criteria was a fundamental goal of the institution, it was decided to give an equal weight to the four criteria. Therefore the model calculated the score for each theme as follows:

$$Cli = X_{li} + 0.5X_{2i} + 0.5X_{3i} + X_{4i} + X_{5i}, \qquad (6.1)$$

where Cl_i is the composite score for theme i and X_{1i}, X_{2i}, X_{3i}, X_{4i} and X_{5i} are theme i normalized values for net benefit/cost ratio, number of poor, number of female illiterate, internationality and sustainability.

Although equal weights are applied in the scoring model, the trade-offs between the different criteria are not equal (Appendix 6.1). In order to achieve a 0.25 increase in the composite index score, a research theme would have to either: (i) increase its net benefit/cost ratio by 12.5; (ii) increase the number of poor affected by 62.5 million and the number of female illiterates affected by 75 million; (iii) increase the Simpson index of diversity by 0.25; (iv) increase the sustainability score by 1; or (v) increase any fractional combination thereof. The composite index is indifferent between those changes.

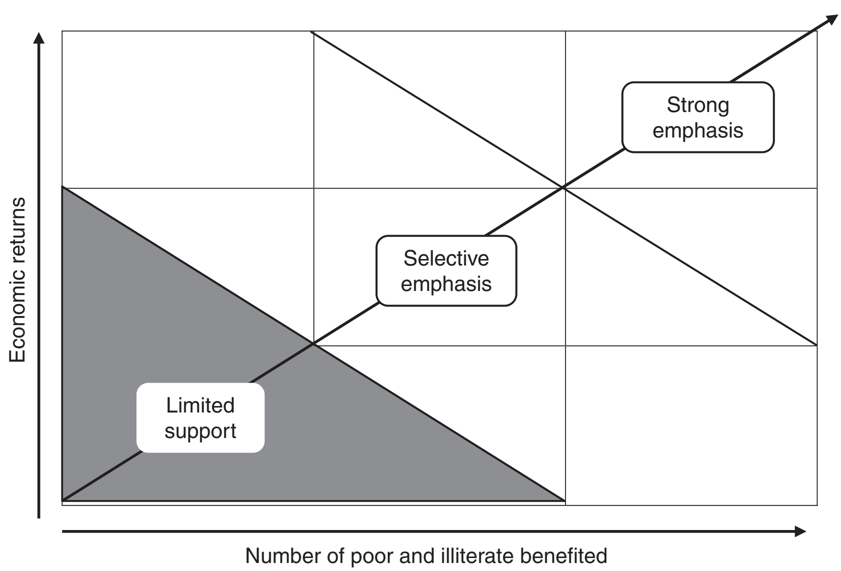

Fig. 6.1. Research portfolio selection: potential trade-offs between returns and equity.

Developing the plan and data requirements

In developing the research plan, the steps in conceptualizing, operationalizing and quantifying proceeded in an iterative fashion. These steps included everything from adoption domain definition to research theme development, and from the specification of scientific outputs to expected economic and social impact. The first task in developing the plan was to define the research domain, which was essential in assessing potential regional research impacts and spillovers. Production systems and yield constraints were the primary criteria for defining adoption domains.

Data requirements

Once the adoption domains were identified for each constraint, data were gathered on population, absolute numbers of poor, female literacy rate, crop production, crop production value, crop losses per constraint, economic losses, and yield and potential economic recovery through research.

Socio-economic data were derived from various sources including the World Bank (1992), UNDP (1992) and Broca and Oram (1991). World prices are used to assess the value of crop production gains and losses. Production data were obtained from the FAO (1992) and crop reports from state and regional levels of India. Crop yield losses resulting from biotic and abiotic constraints were elicited from scientists or estimated from survey results. Estimates were expressed as a percentage of average yields currently achieved in the respective country. Yield recovery or yield gain was estimated as a portion of the respective contributions from resolving each single constraint.

Research protocols

After identifying the adoption domains, constraints and associated yield losses were translated into research themes and expected outputs. From the many constraints identified, a limited number of research themes were identified. For each research theme, a research protocol was identified and generated by the respective scientists. The protocols covered 14 items which provide qualitative and quantitative information: constraint/problem, crop(s) involved, research domain, type of research, research output, research and extension lags, adoption ceilings, probability of success, senior scientist years, yield improvement expected, production costs, stability component, environmental/sustainability component and extra-capital requirement.

Measuring impact

Economic value of research

The unadjusted and undiscounted economic benefits are estimated as:

$$EB_{ikt} = [(y_{ikg}{}^{*}Pkg) + (y_{ikf}{}^{*}P_{kf}) - c_{ikt}]A_{kt}, \qquad (6.2)$$

where EB_{ikt} is the undiscounted economic benefits derived from new technology i on crop k in year t, y_{ikg} and y_{ikf} are the per hectare increment (average) in grain and fodder yield improvement expected on farmers' fields due to adoption of technology i, P_{kg} and P_{kf} their respective prices, c_{ikt} is the per hectare incremental costs associated with adoption of technology i and A_{kt} is the total area of crop k in the relevant research domain.

For each of the research theme, the economic benefits are described as the net present value (NPV) of the gross economic benefits derived from technology i on crop k in year t (NPV_{ikt}) where Pr_i is the probability of success in research leading to the development of technology i, Ad_{it} is the percentage of adoption of technology i by farmers in year t, and r is the social discount rate.

$$NPV_{ikt} = \sum_{t=1}^{n} \frac{EB_{ikt} \times PR_i \times Ad_{it}}{(1+r)^t}. \qquad (6.3)$$

This value could not be attributed solely to the research done by ICRISAT because of the contribution of other partners in the R&D continuum, such as NARS, public and private seed companies, agricultural extension and infrastructure development. Benefits were estimated as gross benefits, and investment costs were not subtracted. The single largest cost is human capital (scientists, support staff and operational costs). The discounted stream of cost flow for technology i and crop k are calculated as:

$$C_{ik} = \sum_{t=1}^{n} \frac{(SY_t \times SC) + K_t}{(1+r)^t}, \qquad (6.4)$$

where C_{ik} is the discounted costs associated with technology i on crop k, SY_t is the total number of scientist years in year t, SC standard scientist costs per year, K_t is the special capital costs in year t, $t = 1, 2, \ldots, n$; r represents the discount rate.

The net benefit/cost is the ratio between the gross benefit (Eq. 6.4) and the costs (Eq. 6.5) is

$$\text{Net } B/C \text{ ratio} = \frac{NPV_{ik}}{C_{ik}}. \qquad (6.5)$$

Equity

A combination of two poverty measures: (i) head count of poor, defined as the number of people with income below the minimum level required to maintain an acceptable calorie consumption level; and (ii) the extent of female illiteracy were used as proxies for general welfare. Data on the absolute number of poor were taken from an International Food Policy Research Institute (IFPRI) study by Broca and Oram (1991); the number of adult female illiterate from UNDP (1992), Vu (1984), UNESCO (1985) and Indian census statistics (Govt of India, 1985).

Internationality

The cross national character of a research theme was considered as a prominent feature in determining an international research institute's priorities. As a measure of internationality, the Simpson index of diversity was used:

$$D_i = 1 - \sum_{j=1}^{J} (S_{ij}/100)^2, \tag{6.6}$$

where D_i represents the diversity value ranging from 0 to 1, and S_{ij} is the share of the total production gain resulting from research theme *i* in country *j*. Higher values correspond to research themes which are more international in scope.

Sustainability

The contribution of the research theme to sustainability is difficult to measure. As objective valuation is challenging with present methods, we used a subjective scale. Themes are ranked from 1 to 5 according to the likelihood impact in maintaining or upgrading the resource base to ensure long-term productivity. A 1 indicates no, or only negligible, contribution to sustainable agriculture; a 5 indicates upgrading the resource base is the primary focus of the research. No rigorous formula is used but arguments are put forward to explain how a particular piece of research is expected to change the resource base that in turn would impact long-term productivity growth.

Consolidation, deletion and ranking

For each of the research themes, an overall score was computed using the weighted, additive composite index scoring model described earlier. Subsequently, an ordinal ranking of themes emerged.

Prior to final ranking and before the scoring exercise, senior research management scrutinized all themes for consolidation and elimination, as there were research themes for which the institute does not have a comparative advantage. After this early screening, the final consolidated research themes were developed to establish priorities for the Institute.

The research portfolio plan

The ranked research themes and their estimated costs for ICRISAT's MTP exercise are given in Appendix 6.1. The final research portfolio largely depends on final budget allocation. Totally 110 research projects were selected, several of which could not have been included if there had not been special funding. The results also illustrated the opportunity costs of budget cuts at the margin. For example, if the budget decreases from a US$19.7 million to US$19.0 million, the foregone benefits would be those for research themes 55–57. The NPV from these three themes was US$35.7 million which represented the potential benefit stream lost if an additional investment of US$0.70 million for core budget was not made available to ICRISAT.

Scoring Approaches from 1999–2007

In the follow-up MTP cycle for 1998–2000, ICRISAT pursued extensive discussions with partners in which broad targets were identified that captured the areas of research and the nature of the benefits they intended to deliver through these partnerships during the MTP period. Four scoring criteria used by ICRISAT include prosperity, diversity, environment and inclusiveness.

1. *Prosperity*. Poverty is a fundamental cause of hunger, disease, environmental degradation and a host of other afflictions. Since the majority of the poor in the Semi-arid Tropics (SAT) are engaged in farming or other agriculturally related enterprises, the road to prosperity lies in the development of more productive and efficient agricultural systems.
2. *Diversity*. Poor farmers with small landholdings cannot afford the risk of being overly dependent on just a few crops or cropping systems. Diversity creates options; it spreads risk; it evens out peaks and valleys in labour use and income; and it enables the creation of added value by expanding the application of farmers' management skills to new enterprises. More diverse, complex cropping systems are usually more robust and stable, and sustainable over time.
3. *Environment*. Environmental resources are the fundamental inputs of agriculture. The conscious or unconscious abuse of these resources can throw entire societies into poverty. This target has particular relevance to the SAT where poverty is a driving force behind short-term exploitation of the environment to satisfy pressing food needs.
4. *Inclusiveness*. Research products must be understood and valued by those who use them if they are to have impact. It is difficult to achieve this unless stakeholders are involved in the identification of relevant research priorities, and in the research process itself.

The target of inclusiveness appealed to participatory methods to support the priority-setting process and decision-support tools that facilitate the participation of stakeholders, allowing them to express their preferences.

Subsequent three-year MTP cycles followed, and the criteria used to rank priorities were more or less maintained. The criteria were broadened to include equity, efficiency, internationality sustainability, new science opportunity, relevance to NARS priorities and future trends (Deb and Bantilan, 2001). The strategies and priority guidelines offered by the CGIAR TAC (later called Science Council) were influential in this evolution. Notably, major efforts continue to be launched to consult NARS partners and other stakeholders in the setting of priorities. The approaches to strategic planning and priority assessment in the CGIAR continued to advance in the last few years, where the basis of priority assessment not only became more inclusive and participatory, but also increasingly appealed to process plans for strategic planning, impact pathways, situation and outlook analysis, periodic commodity and sector reviews, and more systematic understanding and foresight of the external environment and mega trends (see Box 6.2). These

Box 6.2. ICRISAT: Understanding the External Environment – SAT Futures Approach

The agricultural environment in the SAT is constantly changing, in terms of cropping patterns, income opportunities, trade regulations and other factors. In order to remain relevant, ICRISAT monitors these changes and their implications for priorities of its research agenda. This monitoring process was formalized as a global research theme in the early 2000s (one of six themes at ICRISAT at that time) titled *SAT Futures and Development Pathways*. This global theme has three broad objectives: (i) to track changes in the external environment and better understand the factors driving these changes; (ii) correspondingly, to review (and adjust where needed) ICRISAT's research agenda, priorities and funding allocations among alternative research areas; and (iii) to provide an analytic, objective basis for research management decisions, i.e. a decision-support system for senior management.

The SAT Futures project includes strategic socio-economic research in specific areas: commodity trends and market outlooks; input supply and access constraints; patterns and determinants of technology adoption; institutional innovations; and dynamics and determinants of poverty. These studies identify technological, policy and institutional alternatives and development pathways to enhance the livelihoods of smallholder farmers in the SAT. They also inform and direct ICRISAT's research investment towards the most crucial areas.

The project uses a participatory approach. ICRISAT organized a series of brainstorming meetings to discuss poverty-related problems and their implications for research priorities. Many key stakeholders are involved to ensure that the final outputs reflect a diversity of views and experiences. These include national and international institutes, development investors, universities, the private sector, extension, non-governmental organizations (NGOs) and farmer organizations. The broad involvement also enables tapping of a large, multidisciplinary pool of expertise in policy and planning, sustainable development, rain-fed agriculture, agricultural economics, farming systems research, germplasm enhancement and environmental conservation. Simultaneously, focus group meetings were also conducted in each region (East Africa, West and Central Africa, Southern Africa, South Asia, South-east Asia), involving scientists from ICRISAT and partner institutions.

The SAT Futures approach in strategic planning and priority setting follows a systematic procedure: literature survey, data analysis, stakeholder consultations and synthesis of the major issues. It seeks to identify the unique features of the SAT, and understand the differences in agricultural trends between the SAT and other regions of the developing world. During ICRISAT's 2006 research priority setting and visioning exercise, the process was supported by a review of major trends in SAT agriculture using available long-term time series data from the 1960s. The review summarized the major constraints limiting income growth, poverty alleviation, food security and environmental sustainability now and towards 2020, the implications for future R&D strategies and priorities for the SAT and the roles for ICRISAT, NARS, NGOs and the private sector in implementing these R&D strategies.

In sum, these initiatives led to: (i) development of guidelines to enhance participation in research; (ii) clear identification of key issues and external factors affecting SAT agriculture, emerging challenges and opportunities and strengths as well as gaps in existing research systems; (iii) documentation: synthesis report summarizing responses from the baseline survey, as well as collation of relevant literature from other sources (e.g. World Bank and FAO); (iv) development of a framework that underpins the critical issues in SAT agriculture, linking productivity, food security and poverty reduction; (v) update and analysis of micro-level data and macro-level statistics (both demographic and agricultural) to support research decision making; (vi) design of research for development strategies for the SAT; and (vii) publication of several important strategy documents: (a) Future challenges and opportunities for agricultural R&D in the SAT; (b) Future of agriculture in African SAT; and (c) Vision on SAT agriculture for Asia.

Continued

Box 6.2. Continued

The SAT Futures project, too, has evolved, in response to this consultative exercise. Research has been refocused on three areas: (i) strategic assessments for agriculture and economic growth in the SAT of Asia and Africa and implications for agricultural research priorities; (ii) development pathways and policies for rural livelihoods; and (iii) synthesis studies: lessons learnt from impact studies, institutional arrangements and implications for research spillovers across regions.

The key question is: 'How can agricultural research improve the pay-offs to diverse and changing investment opportunities?' The ultimate objective is to steer research direction and development towards a pathway that better addresses poverty and environmental degradation.

approaches shaped the current ICRISAT research priority assessment effort, and were found to be consistent with the current CGIAR research priorities and regional research priority assessment by regional bodies such as West and Central African Council for Agricultural Research and Development (CORAF/WECARD), Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) and Southern African Development Community (SADC).

In particular, with increasing pressure resulting from dwindling core funding in the period from 1999 to 2002, time and funds involved in implementing the rigorous priority assessment approach used in the 1994–1998 cycle were not available and hence a simpler scoring method was used. In this case, a range of constraints was first identified through a large consultation process with partners in the R&D continuum through a survey of significant constraints and opportunities in the semi-arid tropics. The results were shared in a series of consultative meetings at the regional level in West and Central Africa, Southern and Eastern Africa and Asia. During these meetings, constraints and opportunities were translated into research themes. Using a matrix format, a simple mean-scoring method was used to rank the relative importance of these research themes.

Continuing Enhancements to Priority Assessment at ICRISAT

Structured database

Systematic calculation of the measures of the various priority-setting criteria requires a structured database. The database developed from the research evaluation and impact assessment (REIA) project of ICRISAT contains comprehensive information on variables including research objectives, target research domains, estimated yield losses, expected yield gains, probability of success, adoption rates and ceiling levels, research and adoption lags, expected output and manpower and capital requirements. This database serves as a benchmark or reference for research evaluation of future projects. This database is regularly updated through impact monitoring.

Institutionalization

ICRISAT research management instituted a continuous cycle of priority assessment with a defined and regular interval to provide an avenue of feedback and timely redirection of research. Establishing such a mechanism (Joshi and Bantilan, 2001) required the following essential steps: (i) adaptation of a uniform methodological framework to assure comparability and consistency of identified priorities; (ii) regular annual database updates; (iii) establishment of a monitoring process for performance, adoption and impact; and (iv) training to develop the capacity of scientists associated with priority assessment. Training is essential not only to undertake priority assessment consistently and objectively, but also to achieve transparency and active participation within the organization. Finally, in order to facilitate organizational priority-setting processes, a monitoring and evaluation (M&E) scheme was institutionalized by ICRISAT Governing Board in 2004, whereby M&E should be written into research proposals such that movement along the research evaluation and impact pathway continuum can be monitored, any necessary mid-course adjustments could be made and *ex post* impact assessments properly done.

Inclusion of qualitative impacts in priority assessment

Since research evaluation and priority assessment involve the process of making choices in the context of scarcity, most of the earlier efforts have placed emphasis on the economic principles of efficiency and on the costs and benefits that can be expressed in monetary values. The latter raised concerns about qualitative aspects associated with externalities (Bantilan and Davis, 1991; Brennan and Bantilan, 2003), gender and distributional effects and longer-term impacts which tend to be neglected with such an emphasis.

For inclusion of qualitative impacts in priority assessment, a systematic documentation of the impact pathways has been useful in identifying the sources of the qualitative effects of technology adoption (Bantilan *et al.*, 2005). The pathway helps in clarifying the nature of impacts by considering whether or not the expected changes due to technology adoption can be valued using conventional markets, and therefore identifying variables that have market impacts and those that relate to non-market effects. A listing of the potential positive and negative effects aids in the analysis of the market and non-market impacts of alternative technology options. This analysis is particularly useful for assessing qualitative effects and relative preferences among alternatives. It records the market impacts reflecting yield gains or reduced yield losses and changes in unit cost. The measurement of environmental effects in monetary terms within the context of economic surplus draws from changes in the social marginal cost of production (i.e. product supply) and the demand for the marketed product. The inventory of non-market effects may be substantial, e.g. significant positive effects may result in longer-term yield stability, or increased resource availability in the future. A detailed account of the analysis of possible market and non-market impacts is presented in Bantilan *et al.* (2005). This study explains how conventional calculations that exclude environmental effects can skew measures of the full potential benefits from an improved technology.

Using the Results of *Ex post* Impact Assessment in Priority Assessment: Learning Cycles and Feedback Process

The process of assessing impact *ex post* can generate insights that can help to better inform *ex ante* priority assessment and provide grounds for additional investment in the resultant research portfolio (Bantilan and Ryan, 1996). For example, data from primary field studies provide a good basis for reasonable estimates of parameters, which are used in the priority-setting exercise, such as: (i) levels and speed of adoption and reasons for non-adoption of technology; (ii) farmers' perceptions of desirable traits or features of technology options; (iii) on-farm gains due to alleviation of biotic and abiotic constraints; and (iv) infrastructural, institutional and policy constraints in facilitating technology exchange.

Two categories of impact data may be developed. The first is a set of primary data on adoption and related variables generated from formal and informal on-farm surveys. The second is a set of secondary data based on input from partner agencies. On-farm reconnaissance and formal surveys may be primarily aimed at continuously assessing the extent of adoption of improved technology from the secondary database. This confirms the extent of utilization of improved technologies by farmers in the target regions. Research lag is a major parameter determining the present value of research, and the cost of miscalculating it in terms of erroneous priority ranking can be substantial. Verification of research and adoption lags used can be accomplished by cross-checking *ex post* data from various sources.

Farmers' opinions on important constraints as well as their perceptions of desirable cultivation and management technology options may also be generated from primary surveys. These farmers' perspectives provide the following information: (i) they identify the constraints and research opportunities; (ii) they provide an empirical basis for the expected ceiling levels of adoption, i.e. technologies introduced in an environment characterized by significant bottlenecks to adoption cannot be expected to have high adoption ceilings unless these constraints are addressed; and (iii) they identify the research options that directly address the users' needs and are most likely to be adopted.

Estimates of yield losses due to important constraints and on-farm gains due to improved technology are also vital pieces of information for deciding research priorities. Impact studies can be used to validate estimates of expected yields. Furthermore, the estimates generated from these surveys (i.e. yield gains or unit cost reductions) also provide a way of predicting the potential supply shift, a necessary parameter for estimating potential impacts in cost/benefit analyses.

Another important outcome from impact studies is the assessment of researchers' perceptions or constraints, which can be technological, institutional, infrastructural and policy-based. Two aspects are relevant for seed policy and priority assessment: (i) standard variety release procedures of breeders' selection of materials that can make it through the formal release system; and (ii) criteria for varietal release do not necessarily match farmers' needs and preferences.

Mainstreaming Poverty Considerations in Priority Assessment

Mainstreaming poverty considerations is an important issue in ICRISAT priority assessment (Bantilan and Keatinge, 2007) in the light of recent developments in the global research agendas of international organizations, which have identified poverty eradication as a common goal (UN, 2002; CGIAR, 2005). Mainstreaming poverty recognizes that there are at least five ways by which agricultural research can benefit the poor: (i) increasing poor farmers' productivity; (ii) greater agricultural employment opportunities for small farmers and landless workers; (iii) higher wages and growth in adopting regions; (iv) lowering food prices; and (v) greater access to nutritive crops.

Ryan (2004) identified the following considerations in relation to poverty-targeted agricultural research priority assessment: (i) it is not necessarily given that research investments targeted at the locations of the poor will achieve maximum impact on the resident poor. Many factors mediate this relationship and make it difficult to argue that priorities at the macro level should be primarily based upon the location of the poor. These factors include price effects, migration and research spillovers in other regions. However, as Fan and Hazell (2000) have shown, the marginal returns to research are higher in less-favoured environments and also the effect of this on poverty alleviation is greater. Therefore it is not clear that it is appropriate to neglect the less-favoured areas and allow 'trickle down' forces from more favoured areas to equilibrate the benefits; (ii) wage and employment effects of targeted research can be counter-intuitive. In particular, if labour-intensive commodities have non-responsive demands, then research on those commodities could lead to mechanization or to their substitution in production of less labour-intensive commodities; and (iii) growth linkages between agricultural and nearby rural industry can generate significant multiplier effects, benefiting the poor most when agricultural income is a high proportion of total income.

By analysing a typology of agricultural regions based upon agroecological zones and socio-economic factors that condition the size and distribution of benefits from technological change, five broad areas of focus for a pro-poor research agenda have been identified (Haddad and Hazell, 2001): (i) increasing productivity in less-favoured lands, especially in heavily populated areas but also in high-potential lands constrained by poor infrastructure and market access; (ii) increasing production of staple food in areas where food price effects are still important and/or in areas that have a comparative advantage in growing these crops; (iii) helping smallholder farms to diversify into higher-value products, especially in areas where market prospects are good; (iv) increasing employment and income-earning opportunities for landless and near-landless workers in labour-surplus regions; and (v) nutritional enhancement of diets by investing in agricultural technology that reduces the price of micronutrient-rich foods; increases physical access in remote rural areas, or increases the nutrient content of food staple crops via traditional or transgenic technologies.

Reflections and Ways Forward

The environment facing publicly funded international agricultural research centers such as ICRISAT has changed significantly over the past two decades (Byerlee, 2000; ICRISAT, 2002). One important dimension of the changing agricultural research environment is the increased emphasis that is now given to food security and poverty alleviation. The CGIAR explicitly recognizes that investments in international public goods-oriented research must have poverty and impact foci (GFAR & iSC, 2002). ICRISAT has embraced this perspective and is renewing its research efforts to give greater priority to problem-based, impact-driven science and output delivery (ICRISAT, 2002).

This changing context of agricultural research also implies that approaches to setting research priorities at ICRISAT must adapt to these changes. The 2002 ICRISAT vision and strategy internalizes these changes. Recent CGIAR emphasis on a regional approach to agricultural research in order to better address poverty, food security and the environment in developing countries is being assumed by ICRISAT through its regionalized research and its administrative empowerment of the regions.

The ICRISAT Vision and Strategy (ICRISAT, 2002) as well as the 2003–2005 MTP have adapted to the CGIAR's new vision, and ICRISAT has initiated steps to institutionalize regional research planning and priority assessment. ICRISAT's current research strategy is addressed in four global themes and implemented through regional projects that are based on strategic regional priorities. However, to implement regional consultative priority assessment, exercises must be done systematically at a regional level to support planning and resource allocation decisions.

Currently, the CGIAR system priorities identified by the CGIAR Science Council (described in Chapter 12, this volume) provide a framework for 80% of ICRISAT's priorities. Precedence models are used to allocate resources. In effect, the level of funding in the previous year is the basis for the following year's allocation of resources to project themes and projects. Research resources are increased or decreased marginally depending on the overall funding situation. Changes in total resources available are usually allocated in equal proportion across research themes. This approach is simple and quick and has minimal data requirements. It can also provide long-term continuity in funding of research themes and projects. One disadvantage of this model is that it can continue allocating resources to research areas that have reached the limits of their productivity and for which changing research environment mean that they are not even high-priority activities anymore. Precedence models are also not forward looking since funding decisions are based on past levels of resource allocation rather than on research investments that are likely to give the greatest impact. It is therefore difficult to use this model for introduction of new research areas.

Conclusions

ICRISAT has pursued a range of priority assessment exercises over the last three decades. The 'scoring model approach: weighted composite index' to setting priorities has its advantages. It made explicit the benefits that would flow from additional investment to the institute as well as the opportunity costs corresponding to specific reductions in research funds. It generated milestones by which research outputs can be evaluated *ex post*. However, it involved significant time and financial costs. The degree of scientific subjectivity is also significant with this approach. In addition, scientists and managers expressed concerns about the lack of simple and transparent procedures for priority assessment and resource allocation. However, there is a need for a certain level of scientific rigour to priority assessment, so as to incorporate basic economic principles. Thus, efforts to search for simple ways to prioritize research themes and resource allocation at ICRISAT continue.

Regional priority assessment is currently pursued and appears to be more appealing to partners, given the participatory nature of priority assessment across regions. However, the need for clarity over the linkages between priority assessment, research planning (including M&E), and budgeting and resource allocation continues to be a big challenge.

References

Bantilan, M.C.S. and Davis, J.S. (1991) Across-commodity Spillover Effects of Research and Opportunity Costs in a Multi-product Production Environment. ACIAR/ISNAR Project Paper No. 30. Australian Center for International Agricultural Research, Canberra, Australia/ International Service for National Agricultural Research, The Hague, The Netherlands, 24.

Bantilan, M.C.S. and Keatinge, J.D.H. (2007) Considerations for determining research priorities: learning cycles and impact pathways. Chapter 3. In: *Agricultural Research Management*. Springer, 32.

Bantilan, M.C.S. and Ryan, J.G. (1996) Using Impact Assessment in Research Priority Setting: Developments at ICRISAT. Paper presented at the International Conference on Global assessment for science policy, 26–28 August 1996, Melbourne, Australia.

Bantilan, M.C.S., Anupama, K.V. and Joshi, P.K. (2005) Assessing economic and environmental impacts of NRM technologies: an empirical application using economic surplus approach. Chapter 11. In: Shiferaw, B., Freeman, H.A. and Swinton, S.M. (eds) *Natural Resource Management in Agriculture: Methods for Assessing Economic and Environmental Impacts*. CAB International, Wallingford, UK.

Brennan, J.P. and Bantilan, M.C.S. (2003) Price and yield effects of spillovers in international agricultural research: evidence from ICRISAT and Australia. *Agricultural Economics* 28(2), 87–97.

Broca, S.A. and Oram, P. (1991) Study on the Location of the Poor. Paper Presented for the Standing Committee for Priorities and Strategies of TAC/CGIAR. IFPRI, Washington, DC.

Byerlee, D. (2000) Targeting poverty alleviation in priority setting for agricultural research. *Food Policy* 25, 442.

CGIAR (Consultative Group on International Agricultural Research) (2005) *Agricultural Research Matters – Achieving the Millennium Development Goals*. CGIAR, Washington, DC. Available at: http://www.cgiar.org/pdf/cgiar_mdgs_brochure_2005.pdf

Deb, U.K. and Bantilan, M.C.S. (2001) Spillover Impacts of Agricultural Research: A Review of Studies. Socioeconomics and Working Paper Series No. 8. International Crops Research Institute for the Semi-arid Tropics Patancheru 502 324, Andhra Pradesh, India. 32.

Fan, S. and Hazell, P. (2000) Should developing countries invest more in less-favoured areas? an empirical analysis of rural India. *Economic and Political Weekly* 35(17), 1455–1464.

FAO (1992) *Production Yearbook 1991*. FAO, Rome, Italy.

GFAR and iSC (2002) Regional Priority Setting. Agenda Item During the Stakeholder Meeting, 30–31 October 2002. Annual General Meeting, 2002. Manilla, The Phillippines. 180.

Govt of India (1985) *General Population Tables. Census of India 1981*. Registar General and Census Commissioner, New Delhi, India.

Haddad, L. and Hazell, P. (2001) CGIAR Research and Poverty Reduction. Paper prepared for the Technical Advisory Committee of the CGIAR. International Food Policy Research Institute, Washington, DC.

ICRISAT (International Crops Research Institute for the Semi-arid Tropics) (2002) *ICRISAT Vision and Strategy to 2010*. ICRISAT, Patancheru 502 324, Andhra Pradesh, India.

ILRI (International Live Stock Research Institute) (1999) *Making the Livestock Revolution Work for the Poor*. ILRI, Nairobi, Kenya.

IRRI (International Rice Research Institute) (1997) *Annual Report 1995–1996: Listening to the Farmers*. IRRI, Metro Manila, The Philippines.

Joshi, P.K. and Bantilan, M.C.S. (2001) Institutionalization of research prioritization, monitoring and evaluation. In: Suresh, P. and Joshi, P.K. (eds) *Priority Setting, Monitoring and Evaluation in Agricultural Research*. National Center for Agricultural Economics and Policy Research, New Delhi, India, pp. 65–81.

Kelley, T.G., Ryan, J.G. and Patel, B.K. (1995) Applied participatory priority setting in international agricultural research: making trade-offs transparent and explicit. *Agricultural Systems* 49(2), 177–216.

Ryan, J. (2004) Agricultural Research and Poverty Alleviation: Some International Perspectives. ACIAR Working Paper no. 56, Australian Center for International Agricultural Research, Canberra, Australia.

Simpson, E.H. (1949) Measurement of diversity. *Nature* 163, 688.

TAC (Technical Advisory Committee) (1992) *A Review of CGIAR Priorities and Strategies* (Advanced Draft – Rev. I). CGIAR Technical Advisory Committee Secretariat, FAO, United Nations, Rome, Italy.

UN (United Nations) (2002) *The Millennium Development Goals and the United Nations Role*. UN, New York. Available at: http://www.un.org/millenniumgoals/MDGs-FACTSHEET1.pdf

UNESCO (United Nations Educational Scientific and Cultural Organization) (1985) *Statistical Yearbook 1985*. United Nations Educational Scientific and Cultural Organization, Paris.

UNDP (United Nations Development Programs) (1992) *Human Development Report 1992*.

Vu, M.T. (1984) *World Population Projections*. The World Bank, Washington, DC.

World Bank (1992) *World Bank Development Report 1992. Development and Environment*. Oxford University Press, Oxford.

Appendix 6.1

Example of research themes ranked by composite index. (From Kelley *et al.,* 1995.)

			Efficiency			Research cost		Equity					
Rank	Program	Constraint/theme	NPY ($mil)	Net B/C (ratio)	IRR (%)	First year ($mill)	Average 94–98 ($mill)	Poverty (million poor)	Gender (million fem. ill.)	Inter-nationality (index)	Sustain-ability (index)	Composite index	Cumulative cost ($mill)
Core	funding												
1	GRU	Germplasm evaluation	79.1	101.9	–	0.19	0.13	397.0	378.0	1.00	4	5.21	0.19
2	GRU	Germplasm collection	24.5	40.7	–	0.14	0.12	397.0	378.0	1.00	5	4.24	0.33
3	LGM	Drought-CP	265.2	113.7	47.3	0.48	0.42	60.6	119.5	0.55	3	3.64	0.81
4	GRU	Germplasm maintenance	15.3	35.5	–	0.10	0.09	397.0	378.0	1.00	3	3.63	0.91
5	LGM	Ascochyta blight-CP	73.2	134.7	64.0	0.14	0.09	9.9	74.4	0.57	1	3.48	1.05
6	LGM	Rust-GN	80.9	47.9	33.0	0.33	0.28	337.0	310.0	0.70	3	3.35	1.38
7	LGM	Aflatoxin-GN	7.6	23.1	29.3	0.05	0.04	248.2	298.6	0.82	5	3.28	1.43
8	LGM	Late leaf spot-GN	32.7	12.4	24.9	0.43	0.36	329.0	302.0	0.84	4	3.00	1.86
9	LGM	Aflatoxin (MGT)-GN	19.7	6.4	23	0.56	0.47	360.0	308.0	0.60	5	2.96	2.42
10	LGM	Insect damage-CP	76.1	78.5	47.2	0.25	0.16	88.2	107.9	0.26	4	2.94	2.67
11	LGM	Wilt-CP	63.9	114.2	57.0	0.14	0.09	88.2	107.9	0.26	1	2.90	2.81
12	RMP	Adopt. asses./imp. evl.	–	–	–	0.62	0.52	75.9	114.1	0.00	3	–	3.43
13	RMP	Res. resource. alloc'n	–	–	–	0.21	0.11	397.0	378.0	1.00	4	–	3.64
14	RMP	Soil nutrients	130.3	35.9	43.4	0.54	0.45	167.9	162.2	0.49	5	2.81	4.18
15	LGM	Early leaf spot-GN	9.1	4.4	21.3	0.45	0.37	345.0	313.0	0.70	4	2.75	4.63
16	LGM	Genetic poten'l yld-PP	64.0	63.5	41.5	0.13	0.11	125.2	168.2	0.23	3	2.53	4.76
17	LGM	Yield potential-GN	29.6	12.3	23.4	0.44	0.37	234.2	363.4	0.71	3	2.53	5.20
18	CRL	Striga-SG	78.7	41.4	46.2	0.28	0.23	31.5	43.8	0.80	4	2.51	5.48
19	LGM	Drought-GN	14.5	5.2	20.3	0.50	0.42	331.8	326.0	0.62	3	2.43	5.98
20	LGM	Root rots-CP	41.3	70.3	49.1	0.14	0.09	88.2	107.9	0.33	2	2.34	6.12
21	LGM	Bud necrosis virus-GN	1.0	1.2	13.9	0.13	0.11	298.9	328.1	0.66	3	2.33	6.25
22	CRL	Grain & stover yld.-SG	47.1	16.6	31.7	0.68	0.57	180.8	169.2	0.85	3	2.33	6.93
23	RMP	Soil fertility	86.4	21.1	29.1	0.58	0.48	16.8	37.9	0.76	5	2.28	7.51
24	LGM	St. mosaic/Fu. wilt-PP	58.5	40.4	33.5	0.21	0.17	125.2	168.2	0.12	4	2.21	7.72

25	RMP	Soil structure	29.4	5.9	22.8	0.74	0.62	167.9	162.2	0.46	5	2.18	8.46
26	LGM	Leaf miner-GN	5.7	6.0	20.8	0.19	0.16	195.7	268.6	0.46	4	2.17	8.65
27	LGM	Biolog. N fixation-CP	9.6	16.6	30.4	0.10	0.09	88.2	133.7	0.43	5	2.16	8.75
28	LGM	Leaf miner (MGT)-GN	4.8	4.5	21.3	0.23	0.19	195.7	268.6	0.46	4	2.14	8.98
29	RMP	Water deficit	122.8	19.1	32.9	0.95	0.79	154.4	151.4	0.34	4	2.03	9.93
30	LGM	Spodoptera-GN	0.7	0.9	13.3	0.14	0.12	174.7	247.6	0.40	4	1.93	10.07
31	LGM	Peanut clump virus-GN	5.7	4.9	21.0	0.23	0.19	114.3	124.0	0.84	3	1.87	10.30
32	LGM	Posette virus-GN	20.8	8.6	23.1	0.53	0.39	71.9	71.4	0.89	3	1.82	10.83
33	LGM	Helicoverpa (MGT)-PP	26.0	23.8	29.7	0.17	0.14	98.2	136.4	0.17	4	1.82	11.00
34	CRL	Stem borer-SG	8.4	1.6	16.1	0.76	0.63	232.7	191.2	0.75	2	1.82	11.76
35	CRL	Grain mold-SG	66.0	21.5	32.2	0.45	0.38	51.2	57.2	0.68	3	1.81	12.21
36	LGM	Millipedes-GN	3.0	8.0	23.8	0.04	0.03	27.3	37.2	0.77	4	1.80	12.25
37	RMP	Water deficit-PM,SG,GN	22.0	3.9	19.4	0.83	0.69	24.1	42.6	0.76	4	1.71	13.08
38	RMP	Tech. adopt./imp/eval.	–	–	–	0.29	0.24	24.1	42.6	0.83	2	–	13.37
39	RMP	Agroforestry	16.7	3.5	17.7	0.60	0.55	24.1	42.6	0.76	4	1.70	13.97
40	RMP	Char'n of prod'n envi't	–	–	–	0.72	0.60	24.1	42.6	0.76	3	–	14.69
41	LGM	Nematodes-GN,PP,CP	15.1	5.9	21.3	0.41	0.34	179.7	263.9	0.27	3	1.69	15.10
42	LGM	Termites-GN	2.3	2.4	16.7	0.11	0.09	27.3	37.2	0.77	4	1.68	15.21
43	LGM	Suboptimal yield-CP	0.9	0.5	12.6	0.25	0.21	88.2	133.7	0.52	4	1.68	15.46
44	CRL	Low temperature-SG	1.6	9.6	13.4	0.19	0.17	32.7	11.8	0.60	4	1.63	15.65
45	LGM	White grubs-GN	1.3	1.6	15.8	0.11	0.09	27.3	37.2	0.72	4	1.62	15.76
46	CRL	Head bug-SG	12.8	7.1	24.7	0.27	0.22	43.3	74.8	0.76	3	1.61	16.03
47	LGM	Drought-PP	19.7	7.7	24.0	0.41	0.35	98.2	136.4	0.28	4	1.61	16.44
48	CRL	Anthracnose-SG	13.5	4.6	25.5	0.43	0.36	126.7	110.8	0.82	2	1.60	16.87
49	CRL	Midge-SG	14.4	4.1	19.4	0.52	0.43	56.6	47.1	0.82	3	1.59	17.39
50	RMP	Char'zation of environ.	–	–	–	0.25	0.21	75.9	114.1	0.00	3	–	17.64
51	RMP	Microecon studies	–	–	–	0.41	0.41	–	–	–	–	–	18.05
52	RMP	Natural resources	–	–	–	0.60	0.50	75.9	114.1	0.00	5	–	18.65
53	RMP	Supply & demand	–	–	–	0.21	0.17	75.9	114.1	0.00	4	–	18.86
54	RMP	Farmers' preferences	–	–	–	0.14	0.12	75.9	114.1	0.00	3	–	19.00
55	RMP	Beneficial organisms	27.3	11.3	27.4	0.41	0.34	62.4	104.9	0.27	4	1.55	19.41
56	RMP	Plant nutr'n-SG/PM/FM	4.5	13.0	29.0	0.08	0.07	32.1	12.4	0.70	3	1.54	19.49
57	LGM	Peanut mottle virus-GN	3.9	3.5	19.6	0.21	0.18	147.3	138.7	0.91	1	1.51	19.70