A PACKAGE VERSUS A GRADIENT APPROACH IN THE DEVELOPMENT AND DELIVERY OF TECHNOLOGY IN DRYLAND AGRICULTURE

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Since I have recently arrived, my field experience in India is limited. Hopefully, a candid admission of ignorance is a first step in attaining knowledge. What I can share with you are my views on a package versus a gradient approach in the development and delivery of technology. Like most of you I have carried out some adoption studies on technical packages and probably like some of you I have often thought that the package approach was often abused or that it was the wrong approach at the wrong time.

Despite strong opinions on the subject, I do not relish my assignment to appraise the package and gradient approaches. Evaluation of research and extension methodologies is a difficult if not impossible task. It is hard to pit one approach against another to determine which one is superior. Ideally, we would like to construct an experiment across research and extension programs with the two approaches as treatments. Since technical change takes time, our experiment would have to run for many years and would be most impractical. Another alternative would be to rely on historical case studies.

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We would want to compare one program using the package approach with another employing the gradient methodology. Such a with-and-without evaluation is highly susceptible to location-specific effects that confound the comparison. Another possibility is to analyze over time what happens when a research and extension program changes methodology. This type of before-and-after appraisal biases the results in favor of "the after" methodology as technical knowledge may not have been available in "the before" period. About the best we can do is to blend experience, intuition, and casual empiricism together to arrive at a judgement.

In the next section, I define both methodologies in a fairly broad context and briefly outline the history and some of the advantages of the package approach. The bulk of the paper critiques the package approach from a number of perspectives. It emphasizes how the package approach can retard adoption of recommendations and how it can dampen the development of technology. The advantages to a gradient approach are described, and priority areas for analysis are suggested when we as agricultural economists are faced with the package approach. The paper concludes strongly in favor of a balanced approach to the development and delivery of technology.

DEFINITIONS, HISTORY, AND ADVANTAGES OF A PACKAGE APPROACH

The package approach refers to the grouping of management practices and inputs into one large encompassing recommendation oriented at a broad target group of farmers. The package approach is frequently associated with ideas like the whole is greater than the sum of its parts, a large shock to the system is needed to significantly increase productivity, and new technologies require higher levels of inputs and the best practices in order to express themselves. A package approach creates the stereotype that if the farmer is to succeed he has to do a lot of things and do them all at once.

The package may focus on cropping subsystems, systems, or even observational units such as a watershed that are larger than a farm. Presumably, multiple elements of the package are different--sometimes they are sharp departures--from the practices of representative farmers in the target group (Walker and Quarles). At first blush, some differences appear subtle, but in dryland environments like the Semi Arid Tropics (SAT) of India, where mixed cropping is common, technical packages demonstrated in monoculture imply major changes for the farmer.

The gradient approach does not simply mean fewer recommendations at reduced levels of application. It is not just half a package. It also implies a set of procedures that facilitate a stepwise progression in the adaptive development and transfer of technology. The gradient approach aims at specificity in the design and delivery of technology and explicitly recognizes that some constraints, problems, and recommendations are more important than others.

National agricultural research and extension programs probably follow a combination of the two approaches that I have stereotyped. Nevertheless, I suspect that most national programs heavily lean towards the package approach.

The diffusion of maize hybrids in Iowa in the 1930s ushered in the package approach as a tool in research and extension methodology. Hybridization was a method which abruptly shifted the yield distribution and gave rise to substantial complementaries between the new seed and accompanying management practices. Researchers and extensionists found it logical to cluster the new technical relationships into a homogenous recommendation. A massive demonstration compaign was launched to promote the new technology. Since the 1930s, demonstrations organized with the package approach have

been widely applied throughout the world. IRRI used the package approach to disseminate the high-yielding, semidwarf rice varieties to many parts of Southeast Asia in the early 1960s. It has become the cornerstone for many development projects such as Caqueza in Colombia and Plan Puebla in Mexico.

The package approach has some positive features and many advocates. It particularly appeals to agronomists and natural scientists who sometimes err on the side of always giving technology the best opportunity to express itself. The approach is congruent with many agronomists' perceptions of synergistic effects among practices. A package lends itself to project planning by international donors. It offers the hope that significant increases in productivity can take place in a few years. It clearly responds to short-term goals. It is relatively easy to administer, carry out, and evaluate.

Examples like maize hybrids in Iowa, dwarf wheat in the Punjab, and improved rice varieties in parts of Southeast Asia are some of the prominent success stories with the package approach. In each case, success hinged on an agroclimatically and economically assured, relatively homogenous production environment and on a major breakthrough in technology. In dryland agriculture in the SAT, success stories are rare.

Adoption research, such as the studies presented by many of you at the AICRPDA/ICRISAT Yield-Gap Conference last year, invariably shows that different components of a package are adopted at markedly different rates over time and plateau at ceiling levels that are also significantly different. Reasons for nonadoption are also specific to each recommendation in the package. Most studies report a bottom line that reads "no one adopted the complete set of recommendations in the package."

EXTENSION OF TECHNICAL PACKAGES AND ADOPTION

Many economists and other social scientists are not comfortable with the package approach because it conflicts with their findings on human behavior in the adoption of technology. Based on a review of hundreds of adoption studies, Rogers found that attributes of innovations as perceived by potential adopters strongly influence adoption. Some of the important attributes that are often mentioned by Rogers and others in the literature are relative advantage, compatibility, simplicity, trialability, observability, and congruence (Lowdermilk). Aggregating many practices into one all-embracing recommendation enhances relative advantage but sacrifices the other attributes.

Moreover, a package approach contradicts what has been confirmed in many studies about the dynamics of adoption, i.e. farmers adopt recommendations sequentially and usually proceed through stages of awareness, interest, evaluation, trial, and ultimately adoption. It is natural to expect that different elements of the package will go through the dynamics of the adoption process at a different pace.

At its best, the package approach is a set of mutually reinforcing incentives to adopt technology. At its worse, it ignores sequentiality in the adoption process and encourages incompatibility, complexity, indivisibility, blurred vision, and incongruence.

The package approach also assumes that the socioeconomic and agroclimatic characteristics of the target group are relatively uniform. This assumption at least for dryland agriculture is often incorrect. Farmers possess different abilities to process information, have different market access, may perceive risk differently, face different costs of capital, and are located in varying agroclimatic environments. It is useful to dwell on each of these aspects to understand how a package approach may retard adoption.

Information

The information requirement of a package approach is sometimes prodigious. A package approach provides many opportunities for faulty communication between researchers and extensionists. Information can also be transformed into misinformation to farmers (Gladwin). Such mistakes may lead to rejection of recommendations and to unfair tests of the more viable practices in the package.

Many adoption studies conclude that few farmers in the target group know all the recommendations in the package. Even farmers who demonstrated the package may not remember everything they demonstrated from one year to the next (Walker et al.). Plant protection and plant population practices are two repeated examples where packaged recommendations are very often either not known or misunderstood.

As the complexity of the package increases, a greater burden is placed on the ability of farmers to process information. Farmers with less ability to process information might have adopted more recommendations sooner if a more incremental approach had been followed.

Risk

At least in theory, the package appraoch attempts to minimize yield risk. What it does not reduce is financial risk. Applying more inputs at higher levels implies costlier technology that generates larger financial losses when crops fail or when yields are low which are not atypical events in dryland agriculture of the SAT. Even if yield risk is reduced, financial risk may be greatly increased. A more sequential approach could hasten the adoption of leading practices that do not entail greatly increased financial risk and allow farmers more time to adjust to the rapidly changing conditions resulting from the adoption of new technologies.

Access to Inputs

The package approach can easily lead to an "all-or-nothing" mentality which can have an arresting effect on adoption particularly in areas where marketing infrastructure is deficient. When a farmer encounters a technical package, there is a natural tendency to think "If I do not follow all the recommendations, the technology will fall apart". Frequently, the same farmer does not have timely access to inputs and his thinking turns into a self-fulfilling prophecy as he does not adopt the technology. A better, more flexible approach would give the farmer some options that he can follow when contingencies arise.

Location Specificity

The location specificity of technology greatly weakens the package approach. The concensus from many adoption studies in the 1970s is that recommended practices are not accepted because they do not significantly increase yield under farmers' conditions (Perrin and Winkelmann). Location-specificity is usually the reason why recommended practices do not measure up to expectations in terms of profitability. A single-interview survey is a notoriously poor instrument for capturing the expected profitability of various practices in the package; therefore, we tend to underestimate location-specific problems in our adoption studies.

Some practices such as fertilizer recommendations are extremely sensitive to soil, water, and climatic gradients. Other recommendations are more robust and hold up across more environments. This differential sensitivity to soil and agroclimatic factors is displayed in Figure 1 where R1, R2, R3, and R4 represent four recommendations grouped into a package. Because of site specificity, the complete package may "work" on only a small area of its intended range of action.

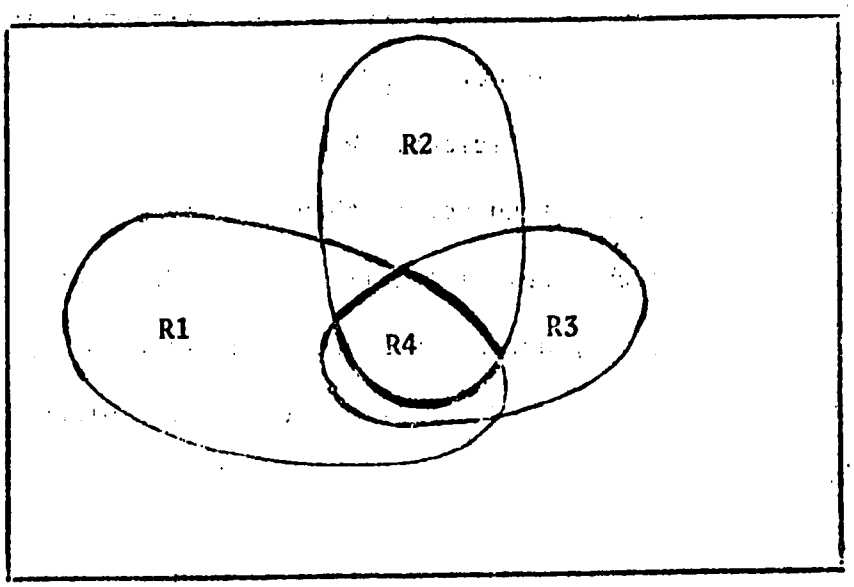

Figure 1

Source: Adapted from Binswanger et al.

Figure 1 is not far-fetched. Packages are often developed in production environments that may be atypically favorable. Production conditions in experimental stations, where most packages are developed, change over time particularly with reagrd to soil fertility and weed, insect, and disease populations. What starts as a representative production environment, may gradually change into an unrepresentative one. Packages are seldom validated in a rigorous program of on-farm testing. The net result is that some practices (R1 and R2) are widely applicable, others (R4) are extremely site-specific.

Rather than provide the farmer with information on the applicability of different recommendations, the package leaves the farmer to find out for himself. A more flexible approach would rely more on base-data analysis and on-farm testing to allow for location-specificity in the formulation of recommendations.

Cost of Capital

Rural capital markets in developing countries do not work well (Adams). Interest rates are artificially low in regulated institutional markets. Low interest rates give rise to an excess demand for formal credit. In order to minimize risk, capital is rationed to the "surer bets" or large farmers who have collateral and are judged creditworthy. Small borrowers have to rely on the informal market. Even if small borrowers had access to institutional credit, the non-interest rate borrowing costs for small loans may make their real borrowing costs significantly higher than those faced by large borrowers. Fragmented capital markets translate into cheap capital for large farmers and expensive capital for small farmers. Institutional considerations such as land tenure may also cause a divergence in the rate of return on investment that farmers are willing to accept. For example, recommended practices may need to generate a significantly higher rate of return for adoption by sharecroppers than for acceptance by owner operators (Herdt and Mandac, Flinn et al.).

Partial budgeting of experimental data clearly suggests that the marginal rate of return on investment varies sharply across the components of most technical packages (Ryan and Sarin). The package approach provides a minimal amount of information on the marginal rate of return of different investments in the package. Even farmers confronted with severe capital constraints could benefit by adopting the higher-return recommendations if they in advance are made aware of the higher yielding investments in the package. By not focusing on individual recommendations, the package approach compells the farmer to sort out the productivity question through trial and error. Once again the farmer has to find out for himself.

One can only speculate on the rate of adoption of recommended practices if a gradient approach had been used instead of the package approach. The arguments presented in this section and results from a study by Ryan and Subrahmanyam suggest that the costs of the package approach in terms of output forgone may not be inconsequential. The package approach also has equity implications. The package approach appears to discriminate against farmers who are located in more marginal production areas, have limited ability to process information, have less access to inputs, confront higher costs of capital, and have few mechanisms available to adjust to risk. To the extent that these characteristics describe lower-income farmers, the package approach can have a negative impact on equity.

TECHNOLOGICAL PACKAGES AND AGRICULTURAL RESEARCH

The package approach fosters the impression that technology may be parachuted from above with little regard to what is happening below. The approach is not conducive to ranking research priorities since it attempts to solve in one instant a host of problems caused by widely differing constraints. The package approach addresses the overall problem of low-resource productivity, but it does not generate relevant information on the reasons underlying low productivity. As such, a package approach is not geared towards problem-oriented research.

At times, researchers in their enthusiasm over new findings or in response to pressure from policy makers tend to integrate their results into a technological package without adequately testing and sorting out effects at the component level. This problem is endemic to technological packages where new cultivars are the leading elements. Procedures are established in most national programs for rather rigorous and formalized cultivar selection and testing. In contrast, research on appropriate management practices may be

in an embroyonic state when the cultivar is available for release. When the package is demonstrated the farmer receives a mixed product. Some components have undergone intensive testing; others are relatively untested. In some cases, only after the package is extended after a number of years do researchers arrive at a sound understanding of what conditions the performance of the package.

In a package approach, responsibilities are clearly defined. One group of scientists develops the package, a second group transfers it, and a third evaluates it. When results do not measure up to expectations, the evaluators, who are usually economists and other social scientists, frequently blame the researchers. A repeated refrain in many studies starts with "If they had only considered...." (Gladwin). (In many cases even with the best crystal balls, astrologers, and economists available, natural scientists could not have predicted what would have been the performance of the package.) Meanwhile, the developers of the package often fault the extension effort or attribute the failure of the package to an unresponsive socioeconomic environment. Such a dialogue is not healthy. Over time it erects barriers to effective communication between researchers and extensionists and between biological and social scientists. It further impedes multidisciplinary cooperation on problem-oriented research (Galt and Stanton).

THE GRADIENT APPROACH

Over the last ten years there has been a growing disenchantment with the package approach. One increasingly hears of "intermediate technology", "steps in technology", "best-bet alternatives," "clusters of practices", and "diamonds" to describe concepts embodied in a gradient approach (Winkelmann, Ryan and Sarin, CIMMYT, Mann and Somil, and Gerhart). These terms convey the idea that the generation and extension of technology should be a sequential

process--roughly in the same way that farmers adopt technology.

In extension methodology, the Benor and Harrison Training and Visit System, which emphasizes simple, low-cost recommendations based on existing information has recently received favorable reviews (Singh). With this approach, "practices are at first recommended on only a small part of the farmers' land so that they do not appear unduly risky, and so that their results can be compared with those of traditional practices in farmers' own fields (Singh, p.24).

The gradient approach should emphasize on-farm testing and problem identification at the farm level. It should start with the farmer and should view him as an integral participant in the process of technology development. The approach stresses smaller changes in a sequential fashion. It aims at increasing the specificity and the applicability of recommendations. It relies heavily on factorial experiments to evaluate the separate contributions of recommendations or subsets of recommendations in a technical package.

THE PACKAGE APPROACH, ADOPTION, AND AGRICULTURAL ECONOMISTS

While the gradient approach is an ideal to strive towards, it is time consuming and resource intensive. With the gradient approach, a premium is also placed on institutional stability. While some forms of a gradient approach will probably increase in popularity in the future, the package approach will remain the norm in many national programs.

How can we as economists contribute when the package approach is used? We can do at least three things. First, we can develop and maintain detailed agronomic and socioeconomic profiles of practices that are presently used in cropping systems of interest. By a detailed profile, I mean a careful documentation of practices over time and space. For instance, the

the profile would contain input information on fertilizer type, date of application, rate of application and form of placement. Such profiles would serve as basic points of reference to gauge what changes representative farmers have to make in their cropping systems to adopt potential packages.

Secondly, we can adopt the principle of divide and conquer--split the package into its component parts, see where complementaries are likely to arise, regroup the recommendations into subsets, and use our intuition based on knowledge of the target group and the proposed technical package to predict the sequence of adoption by subset. A good example to follow is Mann and Somil. For example, plant protection practices usually run up against information, capital, marketing, and location specific constraints. In contrast, a simple recommendation like seed treatment is a candidate for early adoption since it violates few constraints. We should write up our predictions and circulate them to researchers and extensionists for comments. The results from the adoption study are used to revise our predictions and alert us to special problem areas. Such an iterative procedure should sharpen our intuition and result in a more efficient flow of information. It may even stimulate researchers to make predictions to extensionists, and extensionists to farmers, on the more "adoptable" parts of the package.

Lastly, we can develop historical profiles of commodity recommendations. We would probably be surprised at how slowly recommendations change over time. We would also learn if recommendations from our adoption studies had any impact on policy.

CONCLUDING COMMENTS

While I have recommended a gradient approach throughout the paper, I should place my endorsement in a balanced context. A strict adherence to the gradient approach may degenerate into "rates and dates" agronomy or research

on minute changes in existing cropping systems. Presumably, farmers can answer such microscropic research questions on an informal trial-and-error basis. They do not need researchers to do it for them. We should never lose sight of the fact that what is urgently needed in dryland agriculture are new cultivars and practices.

When we use a gradient approach, we should also resist the temptation to try and develop fundamentally different technologies for different socio-economic classes of farmers. As Binswanger has stated, "it clearly makes no sense to advocate the development of technologies so that small farmers adopt the low-yield, low-risk ones and large farmers adopt the high-yield, high-risk ones (p.30)." Differences among farmers in terms of risk attitudes and factor resource endowments are simply not great enough to merit targeting more basic research efforts at different types of farmers (Binswanger, Rathore and Ryan). The emphasis in the gradient approach is on opening up the spectrum of technological options so that farmers have a wider range from which to choose. If the gradient approach is guided by the misconception that we have to develop a new and different technology for each socioeconomic class in the target group, it has no hope for success and becomes a bankrupt methodology.

There are also rare occasions when a package approach is decidedly superior to a gradient approach. A significant breakthrough in basic research may suddenly move potential yield distributions and thus pave the way for the appropriate use of the package approach. We need vision to adopt a package approach when these precious opportunities present themselves and perseverance to follow a gradient approach when they do not.

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