Discussion Paper No. 13

AN ECONOMIC GUIDELINE FOR APPLIED AGRICULTURAL RESEARCH 'MINIMUM YIELD INCREASE REQUIREMENTS' (MYIR)

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International Center for Agricultural Research in the Dry Areas

(ICARDA)

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A. PURPOSE

The purpose of this paper is to present a method with which the economic viability (ex ante and ex post) of a certain class of agricultural experiments can be evaluated using farmer costs and prices.

B. JUSTIFICATION

The starting point is that most research at the international agricultural research centers is applied. In other words, such research is conducted with a view to rapid transfer of results to farmers.

This is why centers like ICARDA with a farming systems perspective emphasize the technical and economic viability of research results under farmer conditions.

In this paper a criterion for evaluating the economic viability of certain experiments is presented. It is hoped that it will be honed to be utilized by researchers to critically evaluate experiments and projects.

C. **THE METHOD:** "Minimum Yield Increase Requirements" (MYIR)

1. We start with the following assumptions:

   (a) In all experiments, there is either a "check" component which represents the average farmers' practices, 1/ or

   (a') Researchers have a fairly good idea of the average farmers' practices and yields to conceptually have a "check".

   (b) Through primary and secondary sources of data, there is sound and up to-date information available on costs of inputs and practices as well as output prices at the farmer level.

   (c) These costs and prices are constant for a given period and location.

   (d) Research, especially agronomic research, can identify the yield effects of (i) individual components of experiments and (ii) the yield effects of interactions between clusters of components, rather than producing a total effect for the experiment as a whole.

1/ Other reference points are also possible.

2. The method can then be described in the following manner:

(a) Each new input or practice, to be called a technological component or component from here on, implies that additional costs be incurred by the farmer.

(b) These additional costs have to be met with additional (i.e., increased) returns. With constant output prices, increased returns are possibly only with increased yields.

(c) Unless the additional costs of a new component are matched by additional returns (which can clearly be attributed to it), the probability of its adoption by farmers is very low and most probably zero.

(d) The minimum yield increase necessary to exactly pay for (i.e., break-even) a new component can be calculated by dividing the additional costs per unit area by the price of the output. We will call this the MINIMUM YIELD INCREASE REQUIREMENT (MYIR) to pay for the new component. 1/

1/ For the total cost of the experiment, we can drop the "INCREASE", i.e., the "I" in MYIR and talk about the MYR, i.e., the break-even yields.

(e) The higher the possible yield increase as compared to MYIR, the higher is the chance of adoption for the component. Such a comparison will allow researchers to identify the "best bet" components and to focus on such components.

3. Mathematically, MYIR is based on the principles of marginal analysis.

Let us define the following:

X_i = the amount of the ith component per unit area, $i=1.....n$

p_i = the cost per unit of the ith component.

Then, the cost of production per unit area is:

$$C = \sum_{i=1}^{n} p_i X_i$$

Let us say that now, we are introducing a new component j with a unit cost of p_j at an amount of X_j per unit area.

This will increase costs per unit area by:

$$C_j = p_j X_j$$

to a total cost of

$$C' = \sum_{i=1}^{n} p_i X_i + p_j X_j$$

If the unit price of the output Y is p_y, then

$$MYIR = C_j / p_y$$

4. A simple example (not that we think the real word is this simple...): ISATSO in HYPOTHETICA.

Let us say that in the country of Hypothetica, the basic staple is granis vulgaris, locally named "subsista". Local farmers perform one tillage, broadcast the seeds and then cover the seeds with another tillage. There is no weed control or fertilizer use. The average yield, under average weather conditions is 1000 kg/ha. The International Subsistence Agriculture Training and Service Organization (ISATSO) is conducting research and trials in Hypothetica with the purpose of developing higher yielding technologies than can be adopted by farmers. In its initial plans ISATSO consider adding on to the local practices and devises the following agronomic trial among others. As standard,

a) There will be one tillage before planting,

b) Local seed will be broadcast, and

c) The seeds will be covered by discing.

Then the following will be included in a factorial design:

P0. 0 kg/ha P_2O_5

P1. 60 kg/ha P_2O_5

N0. 0 kg/ha N

N1. 60 kg/ha N

H0. No herbicide

H1. Herbicide at 100 gms/hg (active ingredient OKKL).

The price information is as follows:

a) P_2O_5 costs 2.0 Hypothetical Liras (HL)/kg
(cheap due to locally available phosphate rocks).

b) N costs 5.0 HL/ka
(expensive because it is imported).

c) Herbicide (QKKL) costs 500.0 HL/kg
(again expensive because it is imported).

d) Subsista has a minimum government support price of 2 HL/kg.

The additional costs of each level of the trials and the implicit MYIR are given in the following table.

Components (kg/ha) P_2O_5	N	Herbicide	Additional costs over the basic minimum practices (HL)	MYIR kgs of subsista/ha
60	0	0	120	60
0	60	0	300	150
0	0	0.1	50	25
60	60	0	420	210
0	60	0.1	350	175
60	0	0.1	170	85
60	60	0.1	470	235

The research scientists at ISATSO look at these figures and compare them with their achievements, experiences and expectations. After considerable thought and soul searching they make the following statement:

"Experiments indicate that under conditions similar to Hypothetical farming conditions, the present state of the arts can raise yields by around 10 percent, i.e., to 1100 kg/ha. We cannot realistically expect to increase yields by more than this. It appears that the complete package we are envisaging will cost more as it requires a MYIR of 235 kg/ha. This arises due to the high price of nitrogen. Unless the pricing policies for N change, we will emphasize the P_2O_5 and herbicide components of technology with which we can achieve a 5.8 percent increase. These

components have lower MYIR and we can expect to achieve such yield increases. Consequently, we will conduct trials and try to develop demonstrations so that the farmers can adopt, depending on their financial capabilities, the practices below in the given order:

(i) Herbicide application,

(ii) Phosphate application, and

(iii) Herbicide and phosphate application.

We will continue to conduct N trials with the purpose of showing the national authorities what can be achieved. If we are successful beyond our expectations and achieve significantly higher yield increases, maybe the national authorities will consider reductions in the price of N desirable from the point of their food security policy."

D. CAVEAT

To present cost increases of technological components in physical yield terms, rather than money terms or any other terms, will be useful in enabling the biological scientists, especially agronomists, in visualising the concrete implications of research. If some trials imply prohibitively high cost increases that cannot be matched by yield increases under the current state of the arts -- or rather science -- then it may be worth considering not

allocating resources to such trials. This will allow applied research to be really applicable.

MYIR calculations are examples of the use of relative prices. The use of relative prices is at the heart of many economic calculations. Economic calculations are not in the exclusive domain of economists. For example, there is substantial evidence that farmers delve in such calculations too...

Some words of caution are necessary however,

1. The marginal yield increase of a specific component depends on the stage at which it is being added on to another set of practices. At earlier stages and with simpler technologies marginal effects are usually higher and can more than match the MYIR. However, at higher levels of technology, the marginal effects are usually lower due to diminishing returns and limits imposed by agro-climatic constraints and it may not be possible to match the MYIR.

   On the other hand, if interaction effects are significant then marginal effects may be higher at higher stages of technology.

2. When looking at the effects of inputs such as fertilizer, the usual procedure, as exemplified in

fertilizer response curves, is to relate the effects of fertilizer to yields. This approach usually ignores the costs of application and looks only at the cost of the inputs. Despite the fact that our example above does ignore application costs for the sake of simplicity, in practice these costs should obviously be included in the calculation of MYIR.

3. Higher yields usually mean higher harvesting, storage and transportation costs due to the larger volume of the product that needs to be processed. If estimates of such costs are not readily available, one can make a simplifying assumption and increase MYIR by a reasonable amount to account for them.

   If they are available, one can account for the increased harvesting and post-harvesting costs in the calculation of MYIR.

   Let v stand for harvesting and post-harvesting costs per unit of output. Then break-even occurs when

$$\sum_{i=1}^{n} p_i X_i + vy = p_y y$$

where y is the yield per unit area of the output Y. In other words, for break-even, costs per unit area should equal the returns per unit area.

Rearranging, we have:

$$\frac{\sum_{i=1}^{n} p_i X_i}{(p_y - v)} = y$$

For a new component j, used at amount X_j per unit area and with price p_j, MYIR can be calculated as

$$\frac{p_j X_j}{(p_y - v)} = \text{MYIR}$$ 1/

4. A new component, while implying additional costs, may also imply savings in other respects. This is especially so for components which are substitutes for some other practrices. For example, while drilling

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1/ Actual harvesting and post-harvesting cost functions may be non-linear and possibly step functions. Furthermore, there may be switches from manual harvesting to mechanical harvesting at some point of technological change.

implies additional costs by itself, it eliminates the costs of broadcasting and the tillage to cover the seeds. Under those circumstances, the net additional costs should be used in the calculation of MYIR.

5. MYIR is an optimistic first approximation for a measure with which to evaluate the feasibility of improved technology components and to identify the best bet ones. MYIR does not take into consideration the effects of factors such as risk, management (especially differences in management between experimental and farm conditions), and variability due to agro-climatic differences.

   In actual use, it would be wise to be cautious and revise MYIR upwards to account for such factors. 1/

   One can observe that the optimistic MYIR is nothing more than the level of yields which will ensure a marginal benefit-cost ratio (MBC) of 1. Considering that MBC ratios need to be more than 1 to make the proposition of adoption attractive, the wisdom of adjusting MYIR upwards become clearer.

1/ It is entirely possible that the effects of those factors will change the ordering of MYIR of different practices. This requires further study of the problem especially in specific locations.

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