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Setting Research Priorities for Agronomic Research: A Case Study for Wheat in Chalco, Mexico

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Contents

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Abstract

Although identifying crop production problems, setting research priorities, and identifying appropriate technological alternatives are fundamental to the success of a research program, these activities rarely receive the attention warranted. In this Wheat Special Report, a simple three-step procedure for defining research needs is illustrated using a case study for wheat production in the High Valley of Mexico. The major agronomic limitations identified were soil fertility, variety, weed control and plant stand. Analysis of the problems highlighted that additional research was not always necessary to recommend changes in cultural practices. For example, problems of variable plant stand and high seeding rates could be directly reduced by changing the method of seed incorporation. The methodology highlights the advantages of a multidisciplinary approach to ensure priority problems are selected based on a predetermined set of criteria, namely: problems 1) are of economic and/or social importance, 2) are relevant to the client (i.e., the farmer), 3) consider environmental and long term issues, and 4) have viable solutions.

Acknowledgments

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Introduction

Most crop production areas have agronomic problems. The yield gap (i.e., the difference between yields observed on research stations and those in farmers' fields) offers a challenge to researchers to find appropriate technologies that will help farmers improve both their profitability and yields. Identifying and solving such production problems and planning ahead are the functions of a good research program. However, the resources available for such research in many developing countries are often limited. Thus, the research undertaken must: 1) be focused on priority issues that offer good probabilities of success, 2) produce technologies that are accessible to the farmer, and 3) offer suitable environmental protection.

Despite its importance, the problem identification and prioritization process is often inadequately done in agricultural research. In addition, a number of factors complicate the process. For example, what might be identified as a problem to the researcher may not look like one to the research authorities or to the farmers of the area. Conversely, sometimes the authorities and farmers may incorrectly perceive a factor as being an important limitation, and thus request research from the scientists. In addition, there may be insufficient time or resources for the researcher to work on a problem or the problems may not have viable solutions. Clearly, investigation into problems with no viable solution constitutes a waste of resources. For these, and other reasons, it is important to follow a process for problem identification and problem solving that considers all factors that will affect the likely success of the program.

A great deal of literature exists on on-farm research with a farming systems perspective (OFR/FS) (e.g., Zandstra et al. 1981, Gomez and Gomez 1983, CIMMYT 1988), but less on problem identification and planning research (e.g., Tripp and Woolley 1989, Macagno et al. 1992). This wheat special report documents a simple approach used by CIMMYT staff in maize and wheat crop management training programs for the identification and prioritization of production problems and the selection of research options. The methodology is demonstrated using wheat production in the High Valley of Mexico as a case study.

Site Description and Secondary Data

The "Chalco" study area covers an area of approximately 25,000 ha largely about the town of Juchiltepec, Mexico (**Figure 1**). Altitude ranges from 2200 to 2900 masl. Average rainfall for Juchiltepec (2300 masl) is 782 mm. Rainfall is distributed in a normal pattern starting about the end of May and finishing in mid- to late October. Considerable variation in precipitation exists, however, throughout the zone, as rainfall is chiefly from convective storms. Average maximum and minimum temperatures vary little during the growing season (May-October) being 25.2 and 6.6 ^{o}C, respectively for Juchiltepec. Frosts often occur in November. Soils range from sandy loams to clay loams. The average soil properties for 50 fields throughout the region were pH, 5.9 (range, 5.6-6.4); soil organic matter, 2.12% (0.80-5.68); N, 0.114% (0.050-0.240); Ca, 1037 ppm (450-1935); Mg, 151 ppm (54-398); K, 229 ppm (68-638); and P (Bray), 25.7 ppm (4.6-69.2).

A 1989 formal survey of 50 farmers showed the following primary data relating to practices. Land preparation involved disk plowing and 1-3 passes of a disk harrow during the dry season. At the onset of the rains, a final disking is done to prepare the seedbed and control the initial flush of weeds.

The primary wheat varieties grown are Pavon F 76 (approximately 56%) and Salamanca (22%). Only some 10% of sown seed is certified, the rest is either seed kept by the farmer or seed purchased from neighboring farms. All noncertified seed is untreated, but the germination is generally high (i.e., > 90%). In the cooler higher areas, seed is sown from May 15 to June 15, while in the warmer lower areas, the planting dates range from June 1 to July 15. Seed is sown primarily broadcast and incorporated by disk harrow or tine cultivation. The average seed rate is high (256 kg ha^{-1}; range 175 to 440 kg ha^{-1}).

The average fertilizer rate is 112:53:0 ($N:P_2O_5:K$). Weeds are controlled by 2,4-D, and manual control for *sicius* sp. Both aphids and diseases (e.g., *Fusarium, Septoria* and *Gaeumannomyces*) are present, but no chemical control is used.

Setting Priorities and Selecting Research Options

The procedure used involves:

- Problem identification and analysis,
- Selection of priority problems

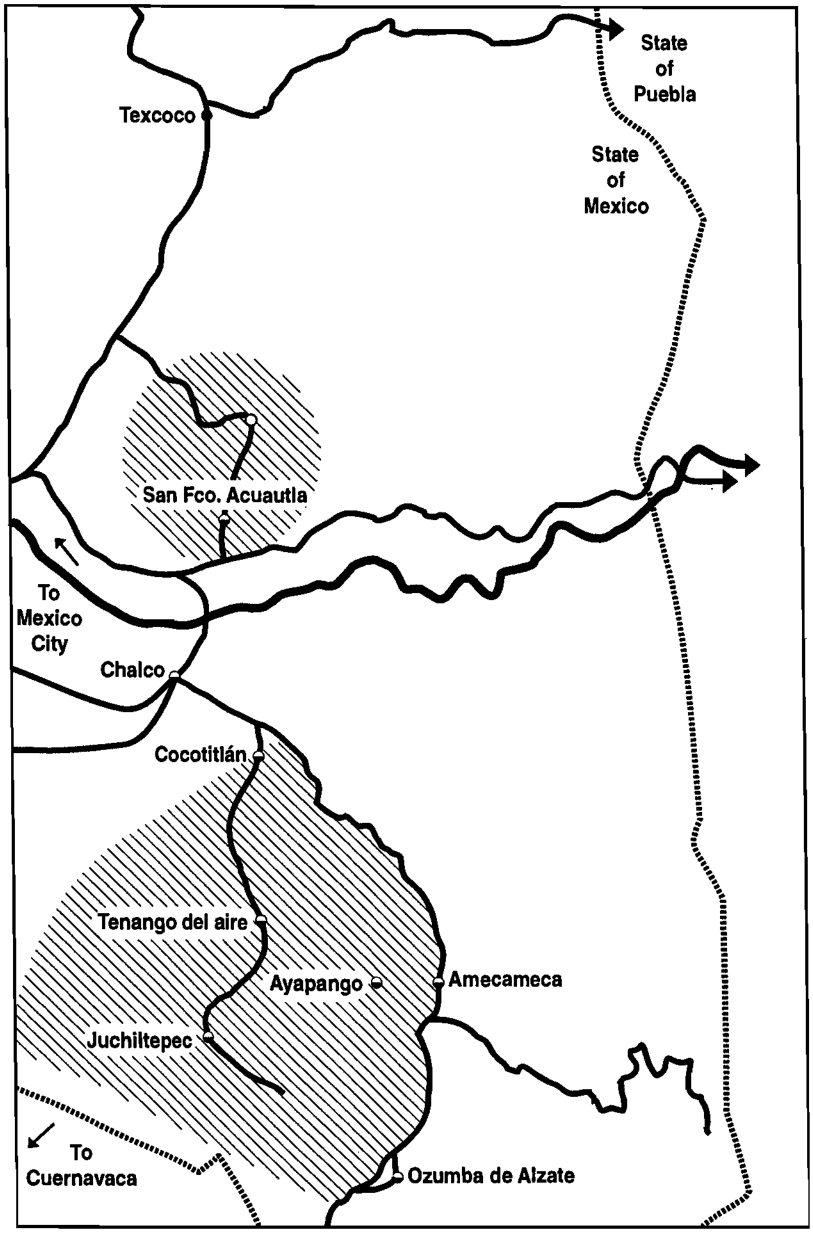

Figure 1. Map of study area. Shaded areas show major concentration of trials.

• Evaluation of alternative solutions.

The application of these steps is shown in the following sections.

Problem identification and analysis

The first step is to list <u>**ALL**</u> of the possible problems limiting or affecting production (including relevant economic and political limitations as well as the agronomic and environmental limitations). It is better to spend a few hours listing all possible problems at the beginning, rather than to start work on problems that may not be really important, or to overlook more important problems.

Methodology--Survey work, be it informal or formal (e.g., Byerlee et al. 1980; Carruthers 1980-81), at this stage of the research process is essential. Both agronomic and socio-economic problems and the interaction between these must be considered. Without field observation and farmer contact, proper identification of problems, their causes, and their priorities cannot adequately be done. Farmer interviews are critical to helping understand why certain problems arise (e.g., weed problems may arise due to a shortage of labor at critical times). Such cause-effect relationships will help with the subsequent identification of suitable solutions. Where possible, farmer interviews should occur in the production field being surveyed. **Tables 1** and **2** present examples of the types of lists of observations that can be made for field and farmer surveys. The survey team should, if possible, be multidisciplinary (e.g., agronomists, pathologists, economists, etc.), and modify the observations to be made based on experience and on the characteristics of the zone.

Every effort should be made to be aware of what farmers (often women) and other researchers know and are thinking. The important point to remember is that, within certain limits, the more people involved in identifying the problems, the better the understanding of the system and of its problems. In addition, by involving people in the diagnostic and priority setting phases, the work is more likely to have the support of these people when research begins.

It is important to note that the farmer often already knows what the problems are. However, the researcher often has to determine the true cause of the problem. For example, farmers often have problems identifying the cause of symptoms as a result of disease and nutrient imbalances. This is where the use of a multidisciplinary team is particularly

Table 1. Field sheets used in field surveys.

Farmer	//	//	//
1. Soil			
pH	/	/	/
Compaction (present?)	/	/	/
Soil depth	/	/	/
Slope	/	/	/
Texture	/	/	/
Crusting	/	/	/
Structure	/	/	/
Plant residues	/	/	/
Sample for analysis	/	/	/
2. Crop			
Stage	/	/	/
Variety purity	/	/	/
Productive tillers m^{-2}	/	/	/
Tillers $plant^{-1}$	/	/	/
Grains $spike^{-1}$	/	/	/
3. Crop health			
General			
Uniformity	/	/	/
Whole plant	/	/	/
Flag leaf	/	/	/
Nutrition			
Symptoms	/	/	/
Disease (Infection rating)			
Rust (0-100%, response;	/	/	/
Other (0-9)	/	/	/
Insects			
Type	/	/	/
Damage	/	/	/
Control effectiveness	/	/	/
4. Weeds			
Types	/	/	/
Extent	/	/	/
Control effectiveness	/	/	/
5. Irregular crop patches			
Size (% of field)	/	/	/
Likely cause	/	/	/
6. Other			
(e.g., climatic stress?)	/	/	/
7. Primary production problem			
	/	/	/

important to ensure the problem is correctly diagnosed. In addition, the process of integration across disciplines ensures the development of a balanced research program that focuses on the priority problems and not just on the skills of the researcher who will be primarily involved in the research.

Table 2. List of questions to ask farmer in formal and informal surveys.

Farmer	//	//	//	//
1. Area sown to wheat	/	/	/	/
2. Variety sown and date	/	/	/	/
3. Fertilizer applied				
How	/	/	/	/
When	/	/	/	/
What	/	/	/	/
4. Herbicide used				
How	/	/	/	/
When	/	/	/	/
What	/	/	/	/
5. Insecticide used				
How	/	/	/	/
When	/	/	/	/
What	/	/	/	/
6. Cropping pattern	/	/	/	/
7. Land preparation				
How	/	/	/	/
When	/	/	/	/
What	/	/	/	/
8 Seeding				
Rate	/	/	/	/
Seed source	/	/	/	/
Method	/	/	/	/
9. Land leveling or drainage	/	/	/	/
10. Disease awareness	/	/	/	/
11. Availability and types of inputs	/	/	/	/
12. Source of information on practices and inputs	/	/	/	/
13. Reasons for practices	/	/	/	/
14. Machinery availability	/	/	/	/
15. Announced price	/	/	/	/
16. Climatic stresses	/	/	/	/
17. Credit	/	/	/	/
18. Markets	/	/	/	/
19. Primary production problem	/	/	/	/
20. Other	/	/	/	/

Appendix 1 lists some references to field guides found to be useful in agronomic survey work.

Application to Chalco--Based on field and farmer surveys and after consultation with as wide a range of people as possible, a list was developed of all of the problems observed, the basis for believing the problem to exist and whether the cause is agronomic, economic or political/policy. The first three columns of **Table 3** show the process as conducted for

Table 3. Problem listing sheet.

Problem	Evidence+	Problem type (APE)++	Economic importance	Number of ha's (% of zone) or farmers affected*	Priority (H,M,L)+	Primary criteria why problem rated high, medium or low.
1. Erosion	FO	A	L	S	M	Limited area affected, but long term costs
2. Land preparation	FO	A/E	L-M	S	M	Interaction with plant stand, cloddy bed
3. Planting date	FO/FI	A	L-M	S	M	Unknown importance
4. Seed supply	FI	P/E	L	M	L	Farmer seed reasonable quality
5. High seeding rate	FI	A	L	M	L-M	No research required
6. Seeding method	FI/FO	A/E	L	M	M	No research required
7. Plant stand	FO	A	M	M	H	Widespread
8. Plant tillering	FO	A	L-M	S	M-H	May be fertilizer, variety or sowing effects
9. Variety	FO	A	M-H	A	H	No research, easy returns, disease losses
10. Quality	FI	A/P	L	M	L-M	Payment based on yield
11. Disease	FO	A	M	M	M-H	High incidence
12. Fertility	FO	A	M	S	M	Unknown importance
13. Weeds	FO	A	H	M	H	High number of infested fields
14. Moisture stress	FO	A	L	S	L-M	Limited periods only
15. Rotation	FI/FO	A	L	M	L-M	Market dependent
16. Credit	FI	P/E	M	M	M	
17. Marketing	FI	P/E	M	M	H	Middleman problems
18. Field accessibility	FO	P/E	L	M	L-M	Wet weather access to fields
19. Harvesting	FO/FI	P/E	M	M	H	Large field losses due to rented combines
20. Machinery availability	FI	P/E	M	S	L-M	

+ FO = Field observation, FI = Farmer Interview;
++ A= Agronomic; P = Political/Policy; E = Socio-economic
* S = Some fields visited, M = Many fields visited, A = All fields visited;
H = High; M = Medium; L = Low.

the area of Chalco. As no prior agronomic research had been conducted in the area, all problem identification was based on survey work and researcher expertise.

Selection of priority problems

The next step after problem identification is to prioritize the problems. Selecting problems to work on is often done in a very unsystematic manner. A researcher is often in the position of working with limited resources, and on whatever problem appears to be important on a particular day. This means that some important problems never really get adequate attention. Alternately, a researcher may try to work on too many problems at one time and have little impact on any of them.

Methodology--The first step in setting priorities is to select those problems that arise due to agronomic problems (column three in Table 3); this does not mean that economic and policy issues are discarded, but rather their solution will normally be pursued through channels other than research (Thus they are noted to ensure that any economic or policy problems that may prevent development or inhibit success of the research program can be taken into account). It is worth noting that, at times, the economic and policy issues may actually be the primary cause of the agronomic problems themselves. For example, plant fertility problems may be due to logistical problems in fertilizer distribution, credit, and marketing (i.e., socio-economic and/or policy issues). Thus, an awareness of the interaction between socio-economic and political circumstances with agronomic problems is critical for generating appropriate recommendations and for changing off-farm policies that may adversely affect production. Also, research may actually help to change policy. For example, fertility trial results may be useful for changing government policy on fertilizer availability or imports.

For the agronomic problems, the criteria listed in **Table 4** should be considered to help set the priorities. The list should be appended based on knowledge of the local area. Three basic questions, however, tend to dominate the prioritization process, namely:

- What is the economic importance of the problem (both short and long term) (i.e., what is the economic cost of the problem on a per field and regional basis)?
- Can the problem be fixed (i.e., is there a likely solution)?
- Do sufficient resources and time exist to resolve the problem?

Table 4. General criteria that can be used to help set research priorities.

- Is there good evidence that the problem exists?
- What is the relative importance of the problem to the farmer?
    - What is the economic importance of the problem?
    - How many people are affected by the problem?
- What will happen if nothing is done about the problem?
- Does the problem have a solution?
    - In terms of time available for research?
    - In terms of known, available, and economical technological solutions?
- Are there barriers to prevent work on the problem e.g.,:
    - policy,
    - people,
    - lack of time or interest,
    - conflicts with other responsibilities,
    - lack of resources?
- Will people with influence on your job agree that the problem is a priority?
- What will be required to solve the problem?
- Other?

In establishing these priorities, it is extremely useful to list for each field surveyed, the major problem identified. Such an exercise helps to quickly identify which problems are predominant and therefore likely to be the priority problems for a region. When setting research priorities, patterns in the distribution of problems should also be identified (e.g., disease may be a greater problem only in wetter parts of the district); this helps with identifying the economic importance of a problem, and helps focus research where it is needed.

As for problem identification, it is important when setting priorities to involve people who work in the area (i.e., farmers, researchers, and extension officers), and discuss options with many people so that their reactions can be considered. Involving the people and groups that can influence the success of the research program, and giving them a chance to have input into the priority setting process, will likely improve their support for the project and thus improve the probability of project success.

Field experimentation itself, can be a critical tool in setting priorities. For example, the 2^n factorial trial (usually involving 3-4 key production factors at two levels) shows the relative importance of factors in the yield gap, and identifies if any interaction occurs between the factors (important in determining recommendations). Through these trials, the economic importance of limiting factors can be clearly identified. In addition to research conducted in the zone, research or experience from similar areas often proves useful. Such revision means: 1) better identification of key issues, 2) better identification of proven and possible options, and 3) avoidance of wasteful repetition.

In summary, selecting the priority research problems, the process involves:

- List the primary agronomic problems for each field.
- Estimating the economic importance of the different types of problems, (In the present situation an economic value indicating the importance of the problem could not be given. Therefore, qualitative estimates (i.e., High, Medium, Low) were made).
- Estimating the number of farmers and area affected by each problem (If the area is large, then a problem may be critical in part of that zone only, and thus priorities should be set accordingly--i.e., recommendation domains (Harrington and Tripp 1984) should be identified).
- Establishing the primary criteria for evaluating the problem as high, medium or low.

Application to Chalco--The remaining columns in Table 3 show how the relative priorities were set for Chalco. As there had been no previous research in the zone, priorities were set on a combination of field and farmer observations, plus experience of the researchers in other similar areas. For Chalco, the priority **agronomic** problems identified were weed control, soil fertility, variety and plant stand.

Evaluation of alternative solutions

Most problems can be solved in a number of ways. It is the responsibility of the agronomist to choose the most appropriate solution. For example, if weeds are seriously affecting yields, there are several possible solutions to this problem. One could:

- use herbicides,
- investigate crop rotations,
- use biological control,
- study land preparation.
- increase seeding rate.

All of these solutions would be likely to decrease or eliminate weed competition, however, they will not all equally address the cause of the problem.

Methodology--In assessing priorities, the researcher must decide what problems are related, and what problems truly need research. For example, Table 3 shows the wide range of problems identified at Chalco. However, an analysis of the problems suggested that seeding method, seeding rate, plant stand, and tillering were all potentially related, at least for many fields. For example, farmers incorporated seed with a deep disk--this necessitated high seed rates, but also meant deep incorporation of a high percentage of the seed with resulting low tillering and poor plant stand. Not only were these factors related, but researchers also felt that these problems could be solved primarily without research or at least could be evaluated whilst researching other factors. Thus, a key point in evaluating solutions is to determine whether a solution already exists (and thus whether research is actually necessary). To reiterate, in the case of poor plant stand and high seed rates, it was felt that the solution depended more on the method of seed incorporation and that further research was not required. Equally, even if research is considered necessary, research conducted in areas with similar climate, soils and problems may mean that solutions are already known; thus only technology demonstration and not development may be required.

Once problems not requiring research have been eliminated, the researcher then must analyze the best possible (short, medium and long-term) solution(s) for the remaining priority problems. Criteria for evaluating the alternative solutions therefore need to be developed. Some factors to consider are listed in **Table 5**. Identification of the dominant cause of the problem is critical to the identification of possible solutions. For example, the problem of weeds may be due to insufficient labor at critical times for weeding. However, alternately it may be due to the use of inappropriate products for the weed species present (e.g., 2,4-D for grasses). The most appropriate solution will depend on the cause. In addition, solutions must be screened as to which is the best (i.e., which are potentially more economic or more compatible with the farming system). Choosing the best solution depends on many factors. The list in Table 5 should be appended based on knowledge of the research area.

The methodology for evaluating technologies consist of 6 basic steps, namely:

- Identify priorities,
- Identify causes,
- Identify potential solutions,
- Evaluate suitability of solutions,

Table 5. Factors to consider in selecting alternative solutions for research problems.

Does a solution already exist?
Is it compatible with the farming system?
What is the fastest solution?
What is the most cost-effective solution?
What is the most practical solution?
Do you have the power to carry it out ?
Will you get backing from your supervisor?
How much time do you have to solve the problem?
What is the level of Farmer's skill?

- Identify resources required to conduct research,
- Re-evaluate the technology.

These steps are illustrated in the following section using the Chalco data.

Application to Chalco--Initially, the problems were rated as either high, medium, or low priority (Table 3). Obviously, given limited resources, research will focus on the high priority problems for which technology is not already known (i.e., experimentation is needed). Of these problems, those requiring research are listed. In the case of Chalco, the priority problems were identified as weed control, variety, fertility, and plant stand. Factors interact, however, and, for example, in establishing variety recommendations, both planting date and possible interactions with weeds and disease need to be considered. Three sheets can be used to help develop and evaluate appropriate solutions for the problems of interest.

The first form considers the most probable cause of the problem, possible solutions, the selected solution, and why it is felt to be the most appropriate solution (i.e., what was the criteria used). **Table 6** presents an example for weed control in Chalco. One sheet per problem can be used, writing the problem at the top of the sheet. Below this there is a space to indicate what is the probable principal cause (or causes) of the identified problem. Then, in the first column write down all possible solutions. At this stage, the researchers should use their imagination. A solution that appears unfeasible at first glance may, in fact, have some potential. In the next column indicate reasons for the assessment. In the last column rate the solutions as "Best, Good, or Not Good". All solutions being listed as best can be included in the trial as treatments.

The second and third sheets are used to help further evaluate the suitability of the proposed solution(s).

Table 6. Selecting and evaluating alternative solutions for weed control.

Problem: Weed control		
Cause(s): Weed species tolerant to primary form of control (i.e., 2,4-D)		
Solutions	Evaluation	Rating+
Herbicides	Products available, farmers already using pesticides	B
Rotations	Market dependent, lowers weed numbers, but does not remove need for control	G
Manual weeding	Labor availability and costs	NG
Delay seeding date	Lose yield, weeds still germinate	NG
Increase seeding rate	Seed rate already high, wheat not very competitive with weed species present	NG
Biological control	Technology not available	NG

+ B = Best solution, G = Good solution, NG = Not a good solution.

To evaluate the applicability of the proposed solutions, it is necessary to determine what resources are required to investigate the identified problems. Additionally, the availability of the desired inputs to the farmer, and thus the applicability of the technology to the farmer must be considered (remembering that new inputs may become available based on the research results). **Table 7** shows the major inputs that were required for research in Chalco for the top three problems and whether these inputs were available to farmers.

Finally, **Table 8** demonstrates how to define the problems and assess the suitability of proposed technology. The top three or four problems are analyzed according to aspects that will affect whether a technological change is likely to be adopted. For example, low risk, high profitability, and relatively easy application all favor the adoption of technological changes. Table 8 then is essentially a summary sheet of the previous tables and is used to help develop the researchers line of thinking. It is important to remember that these tables are a guide and must be used along with the experience of the researchers and the agronomic and economic knowledge of an area.

Table 7. Assessing input availability.

Problem	Materials required for research	Availability+ of materials to:	
		Farmer	Researcher
Variety	New varieties	Low	High
Weed control	New herbicides	High	High
Fertility	Fertilizer	High	High

+ An input could be considered for research, even if not presently available. For example, the product/input could become available due to profitability, business enterprise, changes in Government policy, etc..

Table 8. Summary sheet used to evaluate suitability of research program design.

	Problems identified in the field:			
	Problem	Problem	Problem	Problem
	Variety	Weed control	Fertility	
Ranking of problem** (1 - 4)	2	1	3	
Possible solutions Experimental Variables	New varieties	Chemical control	Fertilizer N, P, K	
Accessibility and availability of required inputs*	High	High	High	
Expected Profitability*	Medium	High	Medium	
Risk (Probability of failure)*	Low	Low-Medium	Low-Medium	
Divisibility+ of technology*	High	High	High	
Complexity@*	Low	Medium	Low	
Compatibility with farmers system*	High	High	High	

** Rank problems in terms of their importance (i.e. 1=highest priority problem, 2=next major problem, etc.)
* H = high ; M = medium ; L = low
+ Can the technology be divided into simple steps?
@ Is the technology difficult to understand?

Program Development

Once investigation has begun, trial results and continued field observation and farmer contact must be used to re-prioritize and re-shape (if necessary) the research program (i.e., keep the program dynamic). Continual review ensures that the truly important problems are being addressed (especially if new problems arise). **Table 9** shows how the program in Chalco developed with time, and **Table 10** summarizes the principal findings. In the initial years, recommendations for the key production factors were developed and tested. Each year's trial design was modified based on the previous season's results. Once answers to the farmers' immediate production questions were developed, studies were initiated to study the longer term issues of land preparation, erosion, and tillage cost reductions.

Table 9. Summary of research and research variables studied during four years of on-farm experimentation in Chalco, Mexico.

Trial factors	# sites	Experimental variables
1987		
Date of planting	2	3 dates x 3 varieties
Fertility	5	5 x 5 (N x P) incomplete factorial + K satellite[@]
Herbicide	3	9 broadleaf control products + check
Production	5	2 levels of N, P and broadleaf weed control
Variety	5	6 bread wheats, 2 Triticale, 2 Barley
1988		
Fertility	4	5 x 2 (N x P) complete factorial + K satellite
Herbicide	2	9 broadleaf control products (focus on *sicius* sp. control) + check
Production	3	2 levels of N, plant density and broadleaf weed control
Variety	5	7 bread wheat, 2 triticale, 1 durum wheat
1989		
Fertility	5	10 treatments - focus on N levels and management (timing) + satellite micronutrients
Herbicide	5	New product testing, and broadleaf and grass control
Production	4	2 levels of N, broadleaf and grass control
Variety	5	7 bread wheat, 2 triticale, 1 durum wheat
1990		
Tillage	3	2 levels of tillage, N, straw and weed control

[@] Satellite treatment is a high level of other test factors (N and P here) plus a K treatment

Table 10. Summary of principal research findings during four years of on-farm experimentation in Chalco, Mexico.

Trial factors	Principal results
1987	
Date of planting	Optimum date from late May to early June
Fertility	Large N effect, No P or K responses
Herbicide	2,4-D adequate except where *sicius* sp. present - then Brominal required
Production	N effect dominant except where *sicius* sp. present
Variety	Superior varieties identified
1988	
Fertility	Confirmed N effect, and no responses to P or K
Herbicide	Refined *sicius* sp. control options
Production	Demonstrated N effect and no need for high seed rates
Variety	Continued identification of superior varieties
1989	
Fertility	Refined N management options - no P, or micronutrient responses
Herbicide	Tested new products for weed control
Production	Tested economics of grass control (problem arising in wheat monoculture fields)
Variety	Continued identification of new and superior varieties.
1990	
Tillage	Focus on long term issues (erosion) Demonstrated economic feasibility of reduced tillage.

Conclusions

Given the wide range of problems that generally occur in a production zone, a researcher must often work outside his area of expertise. Thus, CIMMYT has stressed the need to work in multidisciplinary teams when identifying production problems and setting research priorities (Bell et al. 1993). The procedure outlined in this paper has been found to be useful for helping to identify problems and set priorities. Through survey work and the multidisciplinary approach, a focused and appropriate research program can be developed. Finally, trial results must constantly be used to update priorities and re-evaluate the focus.

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