



CIMMYT Economics Working Paper 91/03

**Extension of On-Farm  
Research Findings:  
Issues from Experience  
in Southern Africa**

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**Abstract.** This paper draws on the experience of on-farm research (OFR) projects in Swaziland and Zambia, in which Training and Visit (T&V) extension methods have been employed. Despite the claims that both OFR and T&V procedures strengthen links between research and extension, the OFR projects in Swaziland and Zambia experienced serious problems with the transfer of some types of information generated by OFR. This paper suggests that improved technology developed by OFR requires a more flexible extension approach, different to that used to extend "correct husbandry practices." Both OFR projects adopted measures to overcome the emerging communication difficulties, and these are among the potential remedies reviewed in the final sections of the paper.

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# **Extension of On-Farm Research Findings: Issues from Experience in Southern Africa**

## **Introduction**

Poor information transfer between research and extension has been identified as a major factor limiting the supply of appropriate new technology to resource-poor farmers in the developing world (USAID 1982, IBRD 1985, FAO 1984, Kaimowitz et al. 1989, Lele et al. 1989). The on-farm research (OFR) approach is expected to help bridge the information gap between research and extension (McDermott 1987) and improve information transfer in two ways. First, OFR improves the compatibility between the information that research provides and what extension and farmers need by basing research agendas on problems identified in the fields of target groups of farmers (Norman and Collinson 1985, Merrill-Sands 1985, Byerlee and Tripp 1987). Second, OFR encourages contact between researchers and extension agents in the field (Palmer et al. 1982, Tripp 1982, Collinson 1984). However, experience indicates that the use of OFR results by extension continues to be a problem (Sutherland 1988, Ewell 1989, Waterworth and Muwamba 1989).

This paper draws on the experience of OFR projects in Swaziland and Eastern Province, Zambia, both of which have employed Training and Visit (T&V) extension methods, to identify reasons for problems in transferring information generated by OFR. The types of improved technologies developed by OFR require a different, more flexible extension approach to that used to extend "correct husbandry practices." Some potential remedies for these communication problems are reviewed in the final sections of the paper.

## **Research and Extension in Zambia and Swaziland**

### **The Incorporation of OFR and T&V into Research and Extension Systems**

On-farm research and T&V were introduced to overcome certain weaknesses that had been perceived in research and extension systems. Research and extension systems based on technologies developed on research stations with the goal of maximizing yields or economic returns (Pickering 1989) were often poor at serving the needs of small-scale, resource-poor farmers. The OFR methodology is designed to produce technologies that are relevant (that address farmers' priority production problems or opportunities) and appropriate (that fit with farmers' operational circumstances and objectives) (Byerlee et al. 1982). On-farm research is expected both to select and adapt existing technology for specific targets/problems, and to help set the agenda for commodity research.

The T&V system was introduced in response to the realization that extension efforts were often poorly focused and loosely organized and managed. Farmers were not receiving relevant technical information on a timely and regular basis. The T&V system aims at upgrading the technical content of field extension activities and improving extension agents' accessibility by making their contacts with farmers more predictable (as well as more easily enforced by ministry supervisors) (Benor and Harrison 1977, Moris 1983). The major elements of T&V are:

- A regular schedule of visits by the extension agent to contact farmers.
- Regular training of extension agents to provide them with relevant and timely technical information.
- Restriction of extension activity to technical production advice and demonstrations (i.e., removal of administrative and statistical tasks).
- Regular contact between extension workers and researchers through workshops to discuss the messages to be extended and farmers' response to previous messages.
- Identification of key "impact points" on which to focus extension contact.

**Zambia**—On-farm research was introduced in Zambia in 1982 through the formation of the Adaptive Research Planning Team (ARPT), whose status equalled that of commodity and specialist programs in the research department. A coordinating unit was formed at headquarters and OFR teams comprising from one to four technical and social scientists were located at the provincial level. The T&V system was implemented in Central Province in 1979 and in Eastern Province in 1982.

Figure 1 depicts the effect of incorporating the ARPTs and T&V into the Zambian research and extension structure. Before, the development and delivery of extension messages had followed very much the line of command, as indicated by the open lines. Extension messages were developed by research at headquarters and then sanctioned by research and extension, also at headquarters. Production guidelines on how to obtain high yields were developed for separate commodities and packaged into recommendations for broad agroecological zones. Field staff were trained at the district level by subject matter specialists of the extension service on an *ad hoc* basis, or at district meetings where policy directions, production drives, and strategies for combatting pest outbreaks and other problems were passed down from headquarters.

Since the introduction of the ARPT, both the development and delivery of extension messages have tended to follow the flow of the solid lines in Figure 1. Two major changes are evident. First, diagnostic activities in OFR provide feedback from farmers to researchers. Second, extension messages are developed, theoretically at least, at the provincial level in a forum which involves field extension staff, subject matter extension specialists, and on-farm researchers.

**Swaziland**—OFR and T&V have been incorporated within existing structures. Since 1978 extension has been organized within the Rural Development Areas (RDAs). Work programs for extension officers are developed in conjunction with the general development program of the RDA. The RDA project manager sets targets for specific crops or the adoption of certain practices and develops the visit schedules for extension workers around these targets. Subject matter specialists operate at the district level and may cover two to four RDAs. An agricultural information section at headquarters develops production guidelines and trains extension workers in how to deliver messages from these guidelines to farmers.

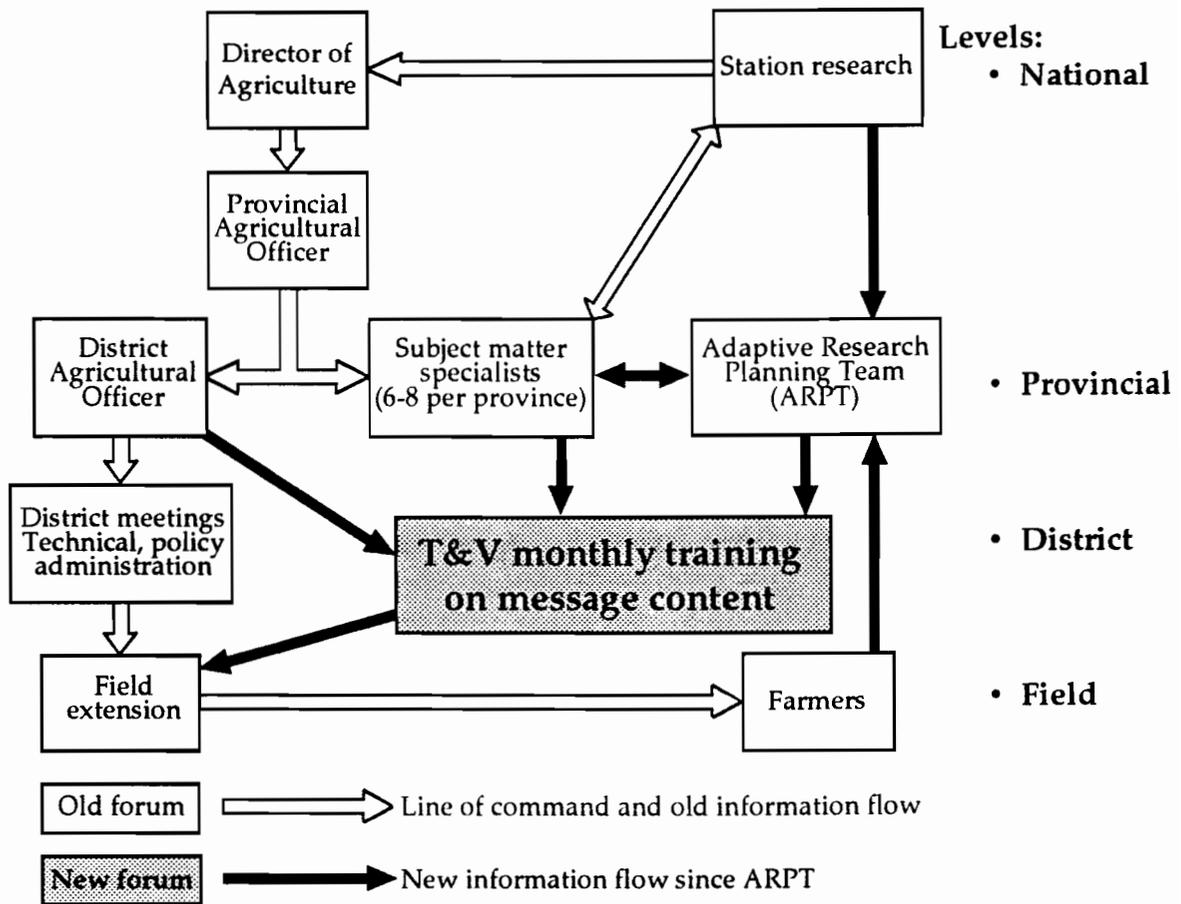


Figure 1. Research and extension structure, Zambia.

## The OFR Projects, Study Areas, and Research Strategies

### The OFR Projects

Adaptive research in Zambia's Eastern Province began in mid-1982 as part of the five-year Eastern Province Agricultural Development Project, whose main task was to introduce the T&V system of extension. This project required updated crop recommendations for smallholders for the whole province.

In Swaziland, the Cropping Systems Research and Extension Training Project, which also started in 1982, had as its main goal "to increase the economic viability of farming on Swazi Nation Land" (USAID 1981). It was expected that research would begin to develop relevant extension messages and that, in the meantime, the extension staff would receive training on how to deliver those messages most effectively. The T&V approach was introduced as a separate initiative, designed to improve the management of message delivery.

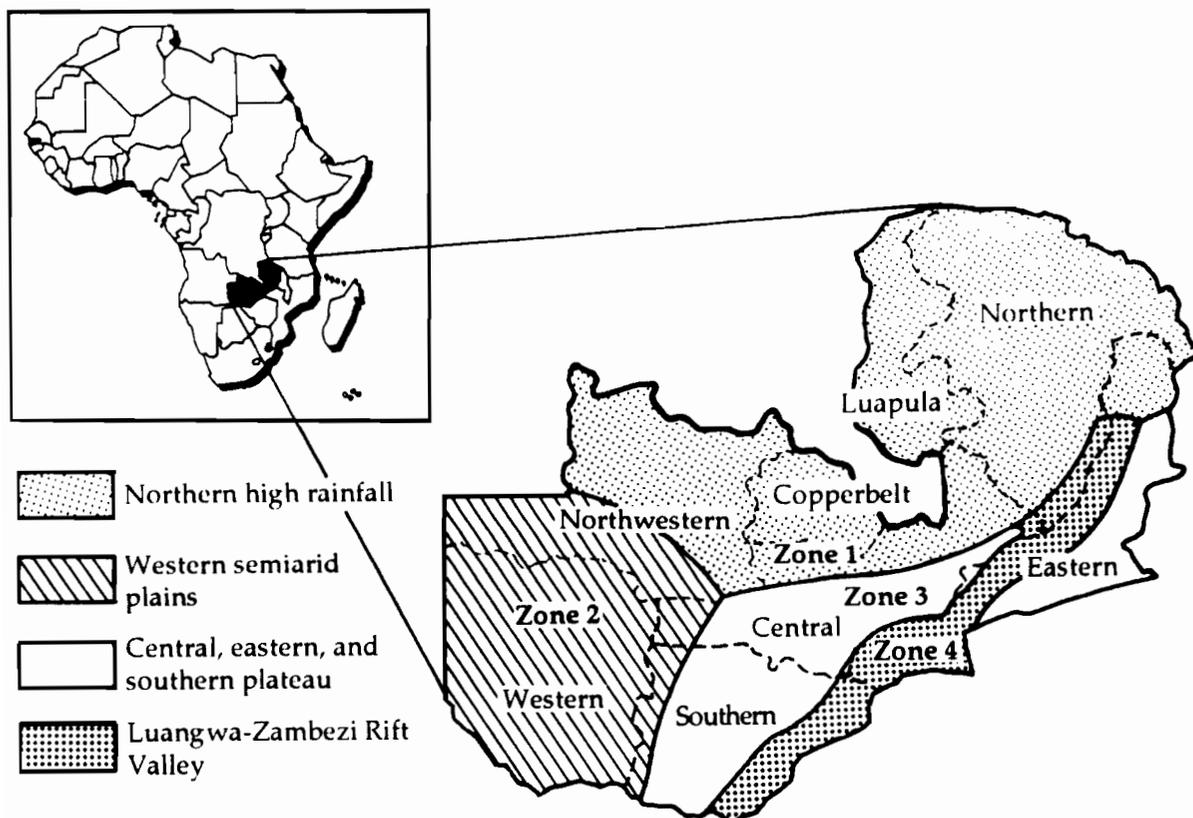
Unlike most OFR and T&V projects implemented in southern Africa or elsewhere (Ewell 1989), these projects implicitly recognized the complementarity of research and extension. In Zambia's Eastern Province, research was part of a wider rural development and extension project, which foresaw that developing extension and support infrastructure and capacity would not have much impact if the messages extended to farmers were irrelevant. In Swaziland, the situation was seen the other way around: appropriate messages coming out of research would not be very valuable unless an effective dissemination system was in place. The important point is that these complementarities were built into the projects from the start.

### Farming Systems and Research Strategies

Similar researchable problems were identified by OFR in Eastern Province and Swaziland. However, the different situations in the two areas gave rise to different research objectives as well as to distinct trial agendas. In Eastern Province, trial programs were developed for specific agroecological zones. Since over 83% of the households in the province were located on the plateau,<sup>1</sup> a decision was made to focus much of the research on the eastern plateau zone (Map 1). Table 1 lists some characteristics of the three study areas in the zone. In Swaziland, research initially focused on Mahlangatsha, Northern, and Central RDAs (Map 2). Some relevant characteristics of these three areas are given in Table 2.

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1 The plateau comprises much of inland southern Africa and is distinct from the lower valley, coastal, and intermediate escarpment areas.

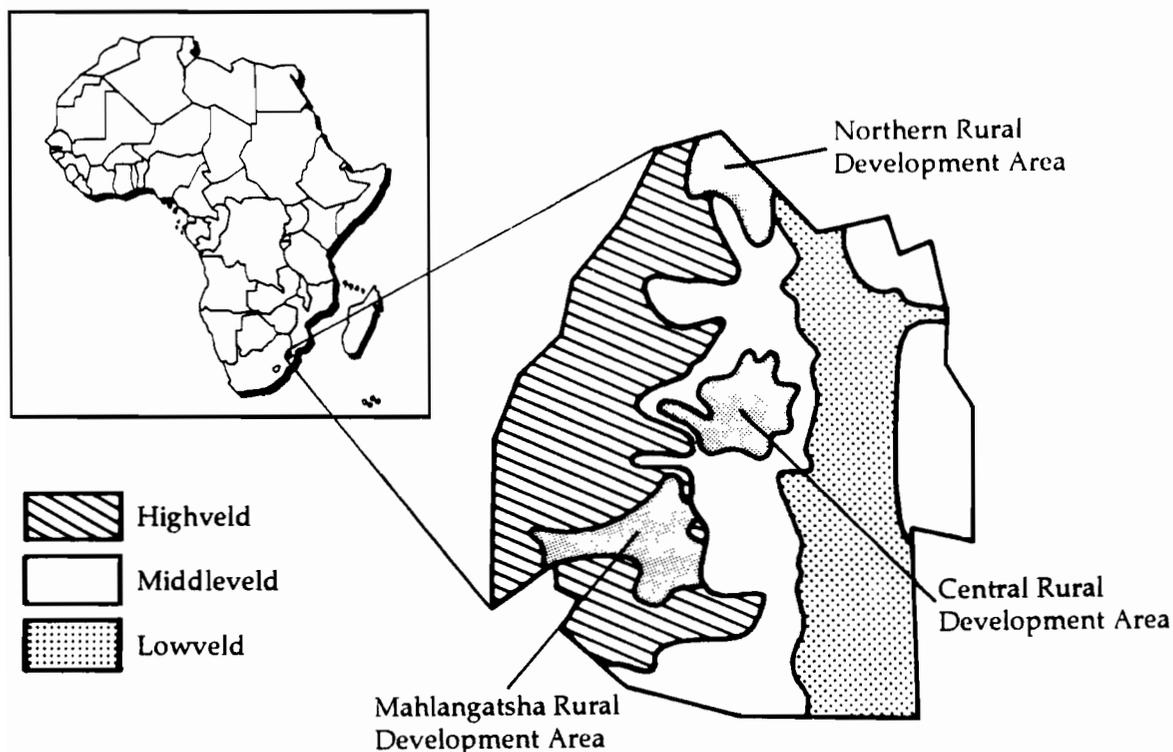


**Map 1. Agroecological zones and study areas, Zambia.**

**Table 1. Major characteristics of plateau farming systems, Eastern Province, Zambia**

Characteristic	West	North	Central
Mean annual rainfall (mm)	900-950	850-1,000	850-1,050
Mean growing season (days)	125	135	140
Soils	Clay-loam	Sandveld	Clay-loam
Percent farmers growing (ha sown to):			
• Local maize	94 (1.6 ha)	100 (1.5 ha)	96 (0.8 ha)
• Hybrid maize	24 (1.7 ha)	31 (1.5 ha)	13 (0.8 ha)
• Groundnuts	75 (0.2 ha)	52 (0.5 ha)	50 (0.2 ha)
• Finger millet	--	8 (0.4 ha)	--
• Sunflower	--	2 (0.8 ha)	17 (0.3 ha)
• Beans	--	21 (0.2 ha)	--
Percent plow with oxen	33	54	16
Percent use inorganic fertilizer	45	74	39

Source: Waterworth (1990).



Map 2. Agroecological zones and study areas, Swaziland.

Table 2. Major characteristics of three Rural Development Areas, Swaziland

Characteristic	Mahlangatsha	Northern	Central
Mean annual rainfall (mm)	1,020	960	910
Agroecological region	Highveld	Middleveld	Middleveld
Soils	Clay-loam	Clay-loam	Clay-loam
Percent farmers growing (ha sown to):			
• Local maize	67 (0.7 ha)	70 (0.9 ha)	37 (1.2 ha)
• Hybrid maize	89 (0.8 ha)	84 (0.7 ha)	85 (0.4 ha)
• Groundnuts	2 (0.1 ha)	15 (0.2 ha)	7 (na)
• Tobacco	11 (0.2 ha)	--	--
• Beans	37 (0.1 ha)	16 (0.4 ha)	47 (na)
Percent plow with oxen	100	100	100
Percent use basal fertilizer	97	80	96
Percent use topdress fertilizer	84	55	45
Percent use ox planter	95	18	73

Source: Freund and Maphalala (1983).  
na = not available.

In Swaziland and in Zambia's Eastern Province, households have individual rights to arable land and communal rights to grazing land. All households in the rural areas have access to arable land and most of the farming is done with own-family labor. A small amount of labor is hired and exchanged between farming households within an area. The major crop and basic staple food in both Eastern Province and Swaziland is maize.

A major factor influencing cropping practices within Zambia's plateau zone is the use of oxen or a hand hoe for land preparation and weeding. Farmers with access to oxen tend to grow more hybrid maize and sunflowers and to use more inorganic fertilizer than hand-hoe cultivators. Hand-hoe cultivators grow more of their maize intercropped with beans. Research in Eastern Province is aimed at updating existing recommendations for the plateau zone and targeting them at the two subgroups (ox and hand-hoe cultivators).

In Swaziland differences in cropping practices between households were related to factors such as the availability of family labor, cattle ownership, soil type, wage employment, and off-farm income. The use of improved technology (improved seed, machinery, fertilizers, pesticides) was significantly lower in Eastern Province than in Swaziland, although in Swaziland there existed substantial variation in the levels of the inputs used and how they were managed. Unlike the Zambian OFR program, the Swaziland OFR program made no attempt to develop sets of recommendations for specific agroecological zones but sought to develop sets of options for farmers with varying socioeconomic characteristics, objectives, and management performance.

### **Researchable Problems and Trial Agendas**

On the plateau in Zambia, as well as in the high- and middlelevel of Swaziland, three technical or crop management problems were identified in maize production. These problems, on which the trial programs were eventually based, are listed in Table 3. In both countries, shortages of draft power (oxen) and labor were major causes of production problems. In Zambia's plateau area, labor shortages were associated with high land-to-labor ratios, whereas in Swaziland they were associated with labor opportunities outside farming.

The trial programs in Zambia and Swaziland reflect these countries' respective technical, socioeconomic, and institutional situations. For the plateau area of Zambia, researchers focused on improving the efficiency of weeding by adjusting management practices, on intercropping as a labor-saving device, and also on shorter duration maize hybrids more suited to the late plantings necessitated by the labor/ draft power constraint. Farmers' timing and method of fertilizer application was also thought to constrain yields, and research on this topic was included in the program.

**Table 3. Management problems in maize production and resulting research opportunities**

<b>Management problem</b>	<b>Contributing factor</b>	<b>Research opportunity</b>
Late and inadequate weeding (Z,S)	Labor shortages (Z,S)	Intercropping (Z)
		Alternative hand weeding strategies (Z)
		Herbicides (S)
		Alternative mechanical weeding strategies (S)
Late planting (Z,S)	Inadequate draft power (Z,S)	Cattle feeding (S)
		Early maturing maize (Z)
		Alternative crops for late planting (Z)
		Herbicides and other weeding strategies (S)
Low fertilizer levels and delayed application (Z,S)	Labor bottlenecks (Z,S)	Alternative basal application strategies (Z)
		Alternative topdress strategies (S)
		Planter modification (S)
		Higher seeding rates (S)
	Low plant populations because of poor planting techniques (S)	Relate nitrogen topdress levels to achieved plant stands (S)

Note: (Z) = Zambia, Plateau Zone; (S) = Swaziland.

In Swaziland, researchers examined the use of purchased herbicides and alternative mechanical weeding techniques as methods of reducing the labor demand for weeding and influencing the time of planting. Planting was often delayed so that weeding could be done in the December/January holidays, when returning wage earners and school children could work in the field. Delayed weeding also resulted in delayed topdressing application (Seubert 1988). Since low levels of fertilization were seen to be related to the low plant stands achieved by most farmers, trials also tested ways of improving the efficiency of current planting methods and machines and examined relationships between fertilizer timing, rate, and plant population.

### **Recommendations Based on OFR Trial Results, and Their Dissemination**

The following discussion focuses on the recommendations produced from OFR trials. The word "recommendation" refers to the final output from research. This output often needs to be translated into extension messages or demonstrations, which then become "extension recommendations."

#### **Maize Varieties and Hybrids**

In Eastern Province of Zambia, a series of trials was developed to identify suitable maize hybrids and varieties for late (December) planting and for early harvesting in food deficit areas. The trials eventually identified a range of maize varieties suitable for the plateau:

- MM-752 (hybrid; November planting; for sale).
- MM-604 (open-pollinated variety; December planting; for sale).
- MMV-600 (open-pollinated variety; substitute for local maize; for subsistence).
- MMV-400 (open-pollinated variety; for early harvest to overcome the hungry period before longer duration maize varieties are ready for consumption).

In Eastern Province, three major methods are employed to disseminate recommendations: T&V demonstrations, T&V monthly bulletins, and updates of crop recommendations. Results from locational testing of maize varieties fitted easily into all three formats. In a survey of T&V contact farmers and farmers selected to demonstrate new varieties, 85% were fully aware of the varieties and their distinctive features. All the seed demonstrator farmers indicated that they were

willing to grow the new varieties on a larger area in subsequent seasons. Only 33% of non-contact farmers, however, were aware of the new varieties and their characteristics.

In Swaziland, on-farm testing of commercially available hybrid maize varieties resulted in recommendations about varieties that varied according to management level, time of planting, and ecological region. Information on maize varieties is disseminated in Swaziland through extension leaflets put out by the Ministry of Agriculture and Cooperatives and the Seed Multiplication Unit. Most farmers select hybrids for their specific purposes on the basis of this information.

Generally speaking, the outputs from trials directed towards locational testing of varieties or practices are easily assimilated and used by field extension staff. On-farm research has introduced more specific targeting of varietal recommendations, which means that the choice of recommendations is greater than before. But the criteria for selecting among the recommendations are largely technical and extension staff feel comfortable with them. This contrasts sharply with other kinds of recommendations generated from OFR, which are discussed below.

#### Maize Plant Population and Fertilizer Levels

Trials in Zambia's Eastern Province sought to answer questions about appropriate plant populations for MMV-600 and local maize varieties without fertilizer and under low levels of fertilizer. In Swaziland, researchers sought to determine how recommendations for basal and topdress fertilizer applications should vary with plant populations ranging from 25,000 to 45,000 plants per hectare.

Both trials produced a set of "conditional" recommendations. For Eastern Province, the conditional variables were technical and quite straightforward (Table 4). The conditions determining recommendations were more complex in

**Table 4. Conditional variables determining appropriate plant populations for different maize varieties under different fertilizer levels, Eastern Province, Zambia**

Condition	Recommended plant population (plants/ha)
Local maize, no fertilizer	25,000
Local maize, 60 kg N/ha	35,000
MMV-600, no fertilizer	Not recommended
MMV-600, 60-120 kg N/ha	40,000

Swaziland, since the amount of topdressing applied depended on the basal rate and on expected grain yield (which in turn was related to plant population). The example for light-textured soils in Table 5 is a simplified version of tables provided in *Field Support Guide* No. 71 (Appendix B).

The reason for developing recommendations that are conditional on plant population is that, when plant populations are low, economic returns are not obtained with high levels of fertilizer. Likewise, although topdressing can compensate for nitrogen deficiencies, when a very low basal dose of nitrogen is applied, yields are likely to be low and a low level of topdressing would be appropriate. Of course, it is more important for extension officers to understand this reasoning and the relationship between yield potential (which is related to plant populations and basal fertilizer application rates) and topdress levels than it is for them to remember the table. For guidance, the *Field Support Guide* (Appendix-B) lists eight characteristics—relating to management as well as natural and historical circumstances—likely to determine yield potential.

Demonstrations, the standard tool for disseminating recommendations, are clearly less appropriate for conditional recommendations such as those described here. Extension leaflets, bulletins, and the like can get the information to extension officers. But how do the extension officers handle the types of conditional recommendations produced in Eastern Province and Swaziland?

The experience from Swaziland suggests that they do not do it very well. Researchers in Swaziland found that extension officers had difficulty in understanding the need to vary messages according to farmers' resource levels, commitment, or prior management of the crop. Doing so required a change in the extension workers' perspective that went against nearly all of their academic training and work experience, which emphasized teaching farmers "correct

**Table 5. Recommendation conditions for applying nitrogen topdress, Swaziland**

Basal N (kg/ha)	25,000 plants/ha, low yield potential	40,000 plants/ha, high yield potential
	Nitrogen topdress (kg / ha)	
< 15	20	na
15-20	0	50
20 +	0	40

Source: *Field Support Guide* No. 71.  
na = not applicable.

husbandry practices” (Seubert 1989). In Zambia, also, the concept of extending different messages, especially for resource-poor farmers (e.g., local maize, no fertilizer), was difficult for many extension workers to grasp (Kean and Singogo 1988).

### **Labor Shortages at Weeding**

In both the Eastern Province of Zambia and in Swaziland, labor shortages resulted in farmers delaying weeding beyond the optimum time. Numerous studies had shown that it is best to weed within the first three weeks after emergence, and recommendations to this effect have existed for decades. Researchers in Eastern Province and Swaziland conducted trials that attempted to answer the question, “How can we enable farmers who are short of labor to move towards the technically optimal time of weeding?” In each country, they came up with very different trials and recommendations.

In Eastern Province, the “correct husbandry” recommendation is to apply compound fertilizer as a basal dressing before planting, to apply topdress at 50 cm, and to weed when plants are at 20 cm and again at 50 cm. Farmers typically apply a basal fertilizer around two weeks after emergence (20 cm) and then topdress with urea when plants are around 70 cm (after the first weeding at 60 cm height). Farmers said that their main reason for not applying basal fertilizer before planting was that they were “too busy” at that time. Earlier trials had shown that farmers could expect equally good yields from applying nitrogen at six weeks after planting as from applying it before planting; subsequent OFR trials showed that:

- Weeding and topdressing maize at 20 cm height gave 20% higher yields compared with weeding and topdressing at 60 cm height.
- Across 58 demonstration sites, mixed applications of compound fertilizer and urea at 20 cm plant height gave 30% higher yields compared with applications of compound at 20 cm height and urea at 60 cm.
- Compared with the recommendation of applying basal fertilizer at planting and then weeding at 20 cm, a combined fertilization and weeding at 20 cm could save 6 person days/ha on the average farm in the peak period.

In addition, trial records showed that hand weeding along the row takes three times as long as weeding by ox cultivation, and that it could take up to two weeks to weed a typical maize field by hoe.

On the basis of these results, two separate weeding recommendations were developed for hoe and ox cultivators. For hoe cultivators, a combined weeding and fertilizer application should commence 10 days after emergence, followed two weeks later by a second hand weeding to remove missed, recovered, or later germinating weeds. For ox cultivators the recommendation was to apply the mixed basal and urea fertilizer around two weeks after emergence, covering with an ox cultivation-cum-weeding. In the next two weeks, hand weeding within the rows for weeds not controlled by the ox cultivation should be done.

In Swaziland, herbicide trials indicated little effect on yields but substantial labor savings. The attractiveness of herbicide then depended on the scarcity of family labor and the hiring or opportunity cost of weeding labor. For labor-scarce households, two main options were recommended:

- Use pre-emergence herbicide (relatively expensive) banded over the row at planting, followed by a light hand weeding at 30-35 days after emergence.
- Perform an ox-drawn cultivation when maize is knee high, followed by the application of 2,4-D herbicide (relatively cheap) as a post-emergence spray.

These recommendations can be modified according to particular circumstances. For example, if the household wants to intercrop pumpkins with maize or use the edible weeds in the field, the pre-emergence herbicide user can skip every fourth row or so, or use 2,4-D after the edible weeds have been harvested. The point is that the decision about which weed management option is appropriate should be made by the farmer, but with advice from the extension worker on the pros and cons of the alternatives.

Discussing alternatives with farmers does not fit very well with typical extension methodologies such as T&V and crop demonstrations, nor with extension officers' training and outlook. Throughout their training and working careers, Swaziland's extension workers are taught to solve problems with technical solutions. They are attuned to the "technical perspective" usually taken by researchers and teachers instead of the "management perspective" taken by farmers. In the case of maize, extension efforts focused on communicating to farmers the techniques needed to maximize economic returns.<sup>2</sup> Winter plowing, early planting of full-season hybrid maize, high plant populations, high basal and topdress fertilizer rates, high rates of lime for acid soils, cutworm and stalkborer control, weed-free fields with two hand weedings and one ox-drawn cultivation, were all part of the standard maize production package recommended to farmers. For various reasons, particularly cash and labor constraints, few farmers were able to take up all of these recommendations.

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2 The value of output net of purchased inputs other than labor, and excluding family labor.

Some extension workers tried to modify the complete technical package so that a few farmers could adopt parts of it. But many extension workers concentrated on the better farmers, who could follow their recommendations (preaching to the converted), or lost credibility with the majority of farmers by delivering impractical messages which could not be used (preaching to the deaf).

When the T&V extension method was introduced to Swaziland, it formalized and *routinized* an already unworkable extension approach which had a strong technical bias. Instead of being used as a management and training approach to improve extension workers' technical and organizational skills, T&V was used as a rigid communication structure. Standard messages that had been used for years were bundled up and delivered in an exact order and timing, regardless of the needs of client farmers. The timing of the messages was so rigid it did not allow for the modifications made by farmers, such as adjusting the planting date for maize because of rainfall patterns or labor constraints. Thus, extension workers sometimes found themselves telling farmers who had not yet planted maize that it was time to topdress with nitrogen. This rigid message delivery left little scope for changing recommendations to fit farmers' resources, for considering different farmer management strategies, or modifying messages depending on the conditions in that season. As a result, most T&V messages didn't fit the situations for most farmers most of the time and, after three seasons, many features of the T&V extension system were abandoned.

In Zambia, extension workers experienced difficulty in using demonstrations to extend the combined fertilizer and weeding recommendations designed to save labor and encourage earlier weeding and topdressing. A study of the effect of the demonstrations in Eastern Province (Eastern Province ARPT 1988) showed that they did not appear to have influenced the mode and timing of fertilizer use among the respondents. Major difficulties with the use of demonstrations to extend this recommendation included:

- Lack of clarity about what practice was being extended (fertilization or weeding).
- Inability to demonstrate a major aspect of the recommendation (its advantage for saving labor to enable more timely weeding and topdressing).

These experiences in disseminating OFR recommendations in Zambia's Eastern Province and Swaziland suggest that the introduction of OFR, even in conjunction with the T&V extension approach, will not in itself improve links between research and extension. Four issues seem to be relevant. They are discussed in turn in the next section.

## Research-Extension Linkage Issues

### Relating Extension Methods to Message Content

*FSR, in recognizing the diversity of farmers, has been instrumental in developing non-blanketed, targeted, and conditional recommendations. Unfortunately, however, conventional extension programs—and even the Training and Visit approach—are not yet usually geared to accepting and delivering such recommendations.*

Baker and Norman (1987)

Crop demonstrations are seen by some to be the most appropriate method of introducing proven recommendations to farmers (Russell 1981). However, demonstrations are not the only extension tool available and, as we have seen, may be particularly unsuitable for imparting information about technically suboptimal practices aimed at increasing the efficiency of resource use or selecting options that depend on a variety of technical, economic, and management conditions.

It has been suggested that conditional recommendations will become more important as we move beyond the Green Revolution era and its emphasis on seed-fertilizer technologies, and as research focuses on more difficult crop management issues (Byerlee 1987) and on marginal rainfed areas (Chambers 1988). For Africa it has been suggested that research needs to shift from varietal improvement to agronomic issues (Lele 1989). Also, as the research orientation moves from developing technical packages to solving farmers' problems, more complex, conditional, suboptimal recommendations are likely to be produced (Baker and Norman 1987). The challenge to extension is thus to place less emphasis on merely communicating recommendations and more emphasis on enabling farmers to develop the improved technical and managerial skills to understand and adopt more complex recommendations (Byerlee 1988).

The extension of conditional and technically suboptimal “enabling” recommendations<sup>3</sup> requires dialogue with farmers (in groups or individually) about the choice of options or the reasoning behind the management compromises. This extension approach suggests a collaborative rather than a teacher-pupil relationship between farmers and extension agents. Much is said about developing a two-way flow of information between farmers and extension workers. However, extension training and perceived roles ensure a one-way

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3 “Enabling” recommendations allow farmers to alleviate constraints, such as labor shortages, and gradually move toward ideal management practices. For example, more labor-efficient weeding techniques are enabling strategies, in that they contrast with purely technical “early weeding” recommendations that are still the norm.

flow from those who know to those who supposedly do not. Unless methods of delivering extension messages change, it is unlikely that the conditional and more complex *enabling* types of output from OFR will be extended much beyond those few farmers who collaborate directly with on-farm researchers (see Baker, 1988, for an example from Botswana).

### **Problem-oriented Research versus Extension of Technical Packages**

Most extension advice is still based on standard technical crop production packages. Extension officer training at all levels has emphasized "correct crop husbandry methods." Extension methods have been geared to demonstrating and teaching these technical husbandry standards. In-service training focuses on upgrading and updating technical knowledge. It becomes difficult therefore to *accept* deviations from the norm. In Zambia (Sutherland 1988) and Botswana (Baker 1988), subject matter specialists as well as field extension workers could not easily see how resource and socioeconomic factors related to technical aspects of production. Training in a management perspective was advocated to enable extension workers to solve problems more effectively and to vary their advice, taking account of particular sets of circumstances.

Researchers in Swaziland also recognized that extension workers needed to gain experience in considering farmers' resources, viewpoints, and strategies to improve their extension approach and the relevance of the advice they gave. The extension worker training sessions conducted by researchers, starting in 1988, included farmer participation. Extension workers, guided by farming systems researchers, used actual case studies of farmers to perform their own resource and constraints analysis.

In Zimbabwe, extension workers have been very receptive to training in field diagnosis techniques emphasizing a problem-oriented approach. Though new, the idea of starting with an understanding of what farmers are doing, and why, and developing messages around identified problems and opportunities, has been well received. Informal field diagnosis is now the standard technique used to develop the content of an extension officer's program of work (Hakutangwi, pers. comm.).

Through OFR, researchers have embraced a problem-oriented approach to developing their research agendas. Substantial resources have been spent on demonstrating the benefits of this approach and training researchers in how to use it. Little attempt has been made to reorient extension services in the same way. Logic, as well as the limited experience that exists, suggests that extension staff would be more receptive than researchers to adopting a problem-oriented approach to developing extension messages. Extension staff are more used to working with farmers and are aware of the differences among them.

## **Research and Extension Communication**

In both Swaziland and Eastern Province, Zambia, OFR teams have found it necessary to devise mechanisms for improving communication between research and extension. In both cases these efforts have focused on communicating information from research to extension. The importance of improving the flow of information from extension to research was recognized but neither project was very successful in establishing useful mechanisms for transferring information back from extension to research.

In Eastern Province, formal liaison structures, information formats, and extension training, in that order of emphasis, have been used to enhance research-extension communication. In Swaziland only the last two methods of transferring information have been given attention, and they have been given different treatment and emphasis.

**Research-extension liaison structure (Eastern Province)**—The idea of having Research Extension Liaison Officers (RELOs) within the ARPTs was first proposed in 1982. At that time the RELOs were intended to:

- Assess the extent to which technologies developed in OFR have been adopted by farmers in the area.
- Organize short training courses for extension staff within a recommendation domain to explain the implications of new recommendations arising from OFR.
- Participate in ARPT surveys, on-farm trials, farmer tests, and other related team activities.
- Organize activities to ensure maximum discussion of trials by farmers and extension workers, especially through the T&V system.
- Make the necessary arrangements to ensure that extension literature concerning the new recommendations is available.

In Eastern Province a RELO has only been in position in one out of the six years, and the functions of the RELO have been carried out by the ARPT Agronomist and the project Farm Management Specialist.

Although RELOs are based in the extension branch, they are administratively and technically responsible to the Provincial ARPT coordinator. Over the last six years the actual roles of the RELOs have changed and have differed between

provinces. Extra activities have included producing regular (monthly) bulletins, updating all recommendations for the province, and organizing extension demonstrations. Some of the intended roles of the RELOs have hardly been touched, such as producing extension training materials and monitoring adoption and feedback.

The RELO positions can play an important linkage role. However, it is necessary to understand where communication is breaking down and then to define RELOs' terms of reference accordingly. If extension staff are having difficulty understanding or accepting research findings, a key RELO role should be providing a better flow of information to extension staff about these findings. If recommendations are not passed on because farmers are not interested in them, RELOs should emphasize the development of feedback information on adoption.

**Information formats**—Too little emphasis has been placed on providing assistance and training to enable researchers to package their findings in ways that are useful to extension and others. Ewell (1989) suggests that lack of good information about research findings has particularly limited the transfer of technologies other than improved varieties. In both Swaziland and Eastern Province, most of the effort to improve research-extension communication has gone into devising information formats suited to the types of output being produced by the OFR teams.

The monthly T&V bulletin put out by Eastern Province started by being technically oriented and crop specific. More recently researchers recognized the need to include more economic information, related to a management context, in the bulletin (Appendix A). This information conveys the rationale behind conditional recommendations to assist extension staff in applying them in different circumstances.

In Swaziland, a similar need was recognized and researchers developed *Field Support Guides*, which differ from previous extension support materials in several ways:

- They focus on a particular topic, often a constraint or part of the production system, rather than on all of the recommended practices for a crop.
- They give the extension worker background on the topic (including social, economic, and biological aspects) to help him or her understand why recommendations are made.
- They also provide guidance on when to apply a recommendation or how to modify it to suit a farmer's situation or resources.

The format of the *Field Support Guides* also differs significantly from previous materials. The guides are illustrated, short, and easy to read, use simple language, and explain new technical terms fully. They are small enough to be carried easily in the field (see *Field Support Guide* No. 71, Appendix B).

### **Compatibility of OFR with T&V**

One would expect a natural symbiosis between OFR and T&V (Roberts 1989, Gentil 1989). Both emphasize a bottom-up approach that begins with the farmer and his or her problems. Both emphasize a concentration on key "impact points" in the farming systems. Both claim to improve research-extension contact. However, proponents of each system see it as solving most of the research-extension linkage problems alone. Therefore, OFR and T&V have not been introduced into southern Africa as integrated research-extension systems. They have been promoted either as extension systems or research systems. In practice T&V has emphasized the delivery, not the content, of messages (Drinkwater 1987, Chipika 1987). On-farm research has emphasized diagnosis and testing and has neglected the transfer of research findings to extension systems (Moris 1989). Each system has required relatively high levels of resources which, until now, have been provided by donors. Each system has placed high demands on the time of field staff and specialists, who are able to do either OFR or T&V work, but not both.

In practice there would seem to be tremendous potential for integrating the two systems. Extension staff already in the field should be able to take on much of the diagnosis done by on-farm researchers. Contact farmers and OFR collaborators (if representative) could be one and the same. The regular meeting structures of T&V could be used to ensure compatibility in planning and implementing research and extension programs. Extension training sessions conducted by on-farm researchers (as in Swaziland) could provide a valuable forum for feedback on adoption, as well as the transfer of research findings to extension.

But both systems need to adapt somewhat. Extension messages may have to become more oriented to particular problems and issues and less rigid and regular. Contact farmers have to become more representative of problems or issues under investigation. Researchers need to adjust their trial programs around extension programs. Extension may have to accept fewer demonstrations and more on-farm trials. Above all, directors of research and extension would need to accept that their staff are working in an integrated program and support this integration.

## Remedies and Conclusions

The major contribution from this study is that it cannot be assumed that OFR programs will necessarily produce a smooth flow of information from research to extension, not even if OFR is implemented jointly with T&V. One reason for this is that practical implementation often differs markedly from the procedures that are specified in the literature on OFR and T&V. This is particularly so with T&V in southern Africa, where T&V programs have had little impact on message content, targeting, or feedback linkages.

A second reason is that in some cases procedural theory fails to emphasize key aspects of communication between research and extension. On-farm research methodology is weak on the incorporation of OFR findings into the extension system (Moris 1989). A third reason is the nature of the findings produced by a bottom-up approach to technology development. Some, though not all, of these difficulties seem to require changes in methods of dissemination, but little attention has been paid to the relationship between types of information and methods of dissemination.

### Managing the Research-Extension Interface

It is evident that several shortcomings limit the transfer of agricultural information by research and extension. On-farm research, problem-oriented research, and the "farmer first" approach all have the objective of developing new types of technology and information for resource-poor farmers. Chambers (1988) talks about producing a "basket of choices" instead of a "fixed menu." Byerlee (1987) points to the increasing need for recommendations conditional on discrete or continuous variables. But these approaches create "translation problems" because extension is unprepared to receive these new types of information. More attention needs to be paid to training extension workers in the problem-oriented, farmer first approach. CIMMYT's involvement with training extension workers in Zimbabwe to use rapid rural appraisal techniques to develop extension work programs and messages around farmers' problems is one example of such training (Low 1988).

At the same time, extension agents need to be trained in appropriate methods for extending "baskets of choices." Some of the options suggested by Sutherland (1988) include field meetings at strategically selected local farms, group discussions focused on common problems, individual informal visits to innovative farmers, and more focused T&V messages on priority crops and problems.

A second way of smoothing the research-extension interface is by training research scientists in how to transfer knowledge to other actors in the agricultural information system. The format of the Swaziland *Field Support Guides* is an example of innovation in this direction.

### **Improving the Effectiveness of Linkage Mechanisms**

As linkage mechanisms, OFR and T&V have been less effective than expected. Clearly there is room for improvement in the way some of the linkage structures built into these approaches operate in practice. Examples are the monthly T&V meetings or field contact between on-farm researchers and extension agents. Additional linkage mechanisms have been introduced in Zambia and Swaziland, such as the appointment of RELOs or the use of on-farm researchers to train field extension staff in the use of OFR findings.

However, the real requirement is fuller integration of OFR and extension. Joint planning and implementation of field programs involving both research and extension staff in diagnosis, on-farm testing, evaluation, demonstrations, and message development should be the ultimate goal. Lessons on how this goal might be achieved exist in the region. Zimbabwe's Committee for On-Farm Research (COFRE) has developed a workable (and working) structure for joint planning of OFR and extension programs at the national level (Fenner and Shumba 1989). Lesotho's experience with implementing a collaborative research and extension program (Low and Mokheseng 1989) and Botswana's use of farmer groups to bring researchers and extensionists together (Norman et al. 1988) provide pointers to what can be achieved at the field level.

The experiences reviewed in this study support a growing body of evidence which suggests that the generation of technical solutions to the production problems of target groups of resource-poor farmers is only the first step. Successful extension of these solutions beyond a few research collaborators remains the next, possibly larger, challenge.

## Appendix A

### T&V Monthly Bulletin, Zambia

The extracts from a T&V monthly bulletin from Eastern Province, Zambia (below) provide an example of an improved information format developed by researchers to better communicate their findings to extension. Earlier bulletins focused on technical information and provided “recipes” on how to grow each crop. Bulletins now place the recommendations in a farming systems, management, and economic context. It is an attempt to provide a guide for extension in selecting appropriate messages for groups of farmers and contrasts with the former technical “correct husbandry” type of crop production recommendations.

#### Extension T&V Bulletin for September, 1988 (No. 2)

1. Farm planning: decide on crops, crop areas, and plan seed and fertilizer purchases: note seed required per lima\* (and pack sizes available and price).
2. Ox-cultivators: Purchase ridger if only have a plow for more efficient ridging and weeding. Buy new spares, repair implements.
3. Soil conservation: Peak pegging period for contour ridges.
4. Animal husbandry: As described in previous bulletins, construction of calf pens, improved *kraals*, information on vaccination against E-CF.
5. Horticulture: gardening, September.

#### 1. Farm Planning

- i) This is the time of year when farmers should calculate their cash crop profits in the past season to plan for next season, knowing how much they can spend on fertilizer and seed.
- ii) Decisions have to be made on which crops to grow and what area to grow of each (and then calculate the seed and fertilizer needed and how much this will cost).
- iii) It is useful to plan the “early season” or October-December planted crops first, as the total area of these crops is (usually) limited by the amounts of labor available (or labor plus oxen). (Land is usually not short.) Typically a hoe cultivator would be able to cultivate some 1 1/3 ha or over 5 limas of early season crops and, with one pair of oxen, some 3 ha or 12 limas. A larger part of the area would be local maize for family use, hoe cultivators typically having 4 limas and ox cultivators around 7 limas, on average. Farmers growing groundnuts usually have 1 or 2 limas only of this crop.

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\* 1 lima = 1/4 ha.

- iv) Some crops, such as cotton, can be considered only by farmers with suitable soil (not very sandy).

To grow hybrid maize, the cost of seed and fertilizer is high. (Fresh seed should always be bought, for saved hybrid seed gives poor yields.) Thus, for 2 limas of hybrid maize a farmer will need:

	K
10 kg MM-752 (for Nov. planting)	= 128-50
or	
10 kg MM-604 (for Dec. planting)	= 72-100
and	
2 bags X (or D, if no X)	= 190
(196)	
and	
2 bags urea	= 142
<b>Total: (MM-752)</b>	<b>= 461-50</b>
<b>(MM-604)</b>	<b>= 405-00</b>

- v) Some calculations have been done for a range of crops to compare the profits per day of work or "man-day" that can be expected under good smallholder management (after deducting the cost of seed—and fertilizer, if recommended).
- vi) Crops such as groundnuts, which need a lot of labor, especially for shelling, give a relatively low "return" to each day needed (to grow 1 ha). Also, the cost of groundnut seed is high if it has to be bought (K 489 for 40 kg to plant 2 limas; if own seed is priced at producer price, 40 kg is K 168). The table\*\* shows a "return" of K 11 for each day for producing shelled Chalimbana, but K 16 if it is sold unshelled because the labor of shelling is saved but the price for the contained nuts (in 4 bags of 30 kg) remains the same.
- However, for hybrid maize a return per man-day of work is more than three times this, or over K 35! So if farmers can buy the fertilizer and seed they should plant hybrid maize as their first choice of early season cash crop (hoe cultivators growing test crop often have 3-4 limas, but it is better to plant with less than test at first to ensure good management—early planting, early weeding, etc.).
- vii) The return from cotton (where there is the benefit of seed and chemicals on credit and some fertilizer) is rather less than from hybrid maize (K 18 per man-day, or K 23 if fertilizer is used).
- viii) Farmers growing *dambo* rice need 15 kg of seed for 1 lima if drilled (30 kg if broadcast). The cost of 15 kg of Angola Crystal Seed is K 138-50. The area grown should not be too large as early weeding is essential for high yields—only grow an area that can all be weeded in one week. (See Lima memos on Rice and on Weeding.)

\*\* Not reproduced in this paper.

- ix) Other crops, such as hybrid maize, also need weeding in time, and it is not wise to plant too large an area which cannot be weeded properly (and then waste fertilizer feeding weeds).
- x) Local maize needs fertilizer, too, though less than hybrid maize; it is unprofitable for farmers to use most of their valuable "early season" labor on a very large area of unfertilized local maize and then have no time to grow a cash crop, too.

How can farmers raise the cash to buy this fertilizer? Most farmers have some time to spare in January and February after they have weeded their maize. Then is the time to grow "late-season" cash crops like sunflower and beans. Soybeans clash more with maize weeding because for the highest yields soybeans are best planted in December, whereas sunflower gives good yields planted up to mid-January and Carioca beans are planted after mid-January. (Note: If soybeans are grown, they should only cover an area that can be harvested within one week or losses from shattering may occur).

- xi) At the premium price now offered (1988-89) for hybrid sunflower (K 162-30 per 40-kg bag, unclamped, local K 129-90), it will pay farmers to buy seed of CH-301 hybrid and to use fertilizer on it (3/4 bag X for 1 Lima), because this hybrid gives a good profit from fertilizer use (and return per man-day, nearly as high as for hybrid maize). Fertilizer is not profitable on local sunflower.
- xii) Fertilizer is also recommended for Carioca beans (not local varieties which do not "respond" well to it). (But Endosulfan seed dressing against stem maggot is essential as well—see Lima memo.) Appendix 5 shows how much profit can be expect for various crops for seeding 1 Kwacha on fertilizer.\*\* Hybrid maize, cotton, hybrid sunflower, and Carioca beans all give between K 4-50 and K 5 worth of extra yield from each Kwacha spent on the fertilizer (used as recommended—see "Guidelines on Fertilizer Use").\*\*
- xiii) By growing more late-season cash crops such as sunflower or Carioca beans (which can be sold locally) or soybeans, farmers can take steps up a "Lima Ladder" (see figure) to become more prosperous. (Mt. Makulu National Research Station has suggested the name "Lima Ladder" for a practical series of steps a smallholder can take to improve his or her position—say, from a near-subsistence cultivator barely growing enough maize for the family, to a hybrid maize grower with a good cash income—without waiting for credit, which may never come.)

Briefly:

- GRC V MORE LATE-SEASON CROPS SUCH AS SOYBEANS, SUNFLOWER, OR BEANS...
- TO RAISE CASH TO BUY FERTILIZER FOR LOCAL MAIZE.
- THEN GROW LESS AREA OF LOCAL MAIZE—BUT WITH FERTILIZER—SO THE YIELD IS EVEN MORE THAN BEFORE...
- TO THEN HAVE MORE TIME (PREVIOUSLY GIVEN TO A LARGE AREA OF LOCAL MAIZE) TO GROW MORE GROUNDNUTS, TO SELL, OR GROW HYBRID MAIZE.

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\*\* Not reproduced in this paper.

**A Lima Ladder  
for  
Eastern Province  
hoe cultivators**

**Oxen purchase**

:  
:  
:  
:  
:  
:

\_\_\_\_\_ : **Season 4**

: Farmer hires oxen,  
: grows 4 limas  
: hybrid maize

:  
:  
:

\_\_\_\_\_ : **Season 3**

: Farmer halves local maize area,  
: adds 2 limas hybrid maize  
: (fertilizer or cash from surplus  
: maize sold, and sunflower  
: or soybean crop)

:

\_\_\_\_\_ : **Season 2**

: Farmer buys 4 bags of fertilizer for his/her  
: local maize from cash from 4 bags of  
: sunflower or 2 bags of soybeans

:  
:  
:

\_\_\_\_\_ : **Season 1**

: Farmer grows 1 lima of soybeans or 1-2 limas of  
: sunflower (the farmer is more likely to have labour for this work  
: in late December/early January than for trying to grow  
: more groundnuts to sell, since groundnuts will require labour when  
: farmer is busy planting and weeding local maize).

:

\_\_\_\_\_ : **Last season**

: Subsistence farmer with no cash crop  
: and no fertilizer for his/her local maize

# Appendix B

## Field Support Guide, Swaziland

The *Field Support Guide* reproduced below is one example from this series, which is produced by the OFR team in Swaziland. These guides are another attempt to overcome the problem of communicating conditional and technically suboptimal types of output generated by OFR. The guides contrast with the "correct husbandry" recipes that have characterized previous technical bulletins developed from trial programs on research stations.

### Nitrogen Topdressing of Maize



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USAID/Swaziland Cropping Systems Research and Extension  
Training Project

Field Support Guide - FSG 71

#### NITROGEN TOPDRESSING OF MAIZE

By Chris Seubert

##### A. INTRODUCTION

###### 1. Need for improved yields

The rapid human population growth in Swaziland and the maize production deficit are both well known facts. There is a critical need to improve maize yields so that the country can become self-sufficient and no longer have to import grain to feed the population. One important aspect of increasing maize production is to improve the management of major production factors.

###### 2. Nitrogen plays a critical role

Plant nutrition is one of the easiest management factors to improve. Properly fertilised maize plants produce more grain. The most commonly deficient element in the soil is nitrogen, and providing supplemental chemical nitrogen is very important for good maize production. Small scale and semi-commercial farmers growing maize on Swazi Nation Land often delay their applications of nitrogen, or put on amounts that are too small to produce top yields. This publication advises extension workers on the amounts, type and timing of nitrogen topdress applications for farmers growing maize.

##### B. NITROGEN IN THE PLANT

###### 1. Three major nutrient elements

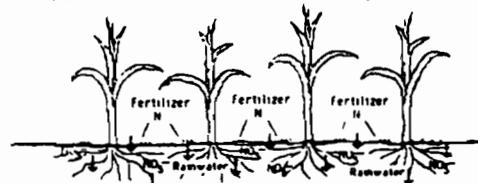
The three nutrient elements needed in the largest amounts by maize are nitrogen, phosphorus and potassium. Of these three, nitrogen is needed in the largest amount. The chemical form of nitrogen used by the plant, nitrate ( $\text{NO}_3^-$ ), is easily leached out of the soil. For this reason it is usually in short supply in the soil and must be added. Nitrogen is a very important element in the maize plant. It is an essential element in the amino acids, which form the building blocks for protein. The plant cells, leaves, ears, grains, and stalks all need nitrogen.

###### 2. Critical times in the plant's life cycle

Nitrogen is needed throughout the growth and development cycle of the maize plant, but there are times when larger quantities must be available. The period from when maize becomes knee high to shortly after tasseling (from about 40 to 80 days) is a time when the plant does most of its growing. The factory for producing grain - the stalks and leaves - are developed at this time. Adequate amounts of nitrogen, provided at the start of this growth period, improve the ability of the plant to produce grain.

###### 3. Nitrogen forms and mobility

The two most common forms of chemical nitrogen in the soil are nitrate ( $\text{NO}_3^-$ ) and ammonium ( $\text{NH}_4^+$ ). The fertilisers commonly used in Swaziland for nitrogen topdressing contain one or both of these forms of nitrogen. In most well drained soils the ammonium form of chemical nitrogen is rapidly changed to the nitrate form and absorbed into the plants' roots. Nitrogen is a very mobile element both in the plant and in the soil. That means that nitrogen rapidly moves from one part of the plant, such as the lower leaves, to another part of the plant, like the upper leaves. Nitrogen also moves very rapidly in the soil. Rain can leach most of the nitrogen down past the root zone of the plants within weeks or months depending on the rainfall and other factors. For this reason it is usually best to apply about 1/3 or 1/2 of the nitrogen at planting time, and the rest as a topdress about 30 to 40 days later.



Nitrogen rapidly leaches down through the soil

#### 4 Signs of deficiency

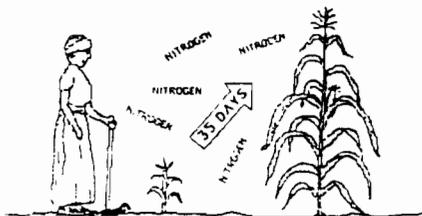
The most common signs of nitrogen deficiency seen in Swaziland, early in the growing season, are plants that are light green in colour, instead of dark green. As the plant approaches tasseling, nitrogen deficiency can be seen as a yellowing and dying of the lower leaves of the plant.

#### C. WHEN TO APPLY TOPDRESS

##### 1 The timing of nitrogen application

The time that nitrogen is applied is very important. The number of grains on the ear, and other components of yield potential, are being determined in the period following 30 days after planting. Also, because the maize plant does most of its growing in the time period from knee high to tasseling, it is very important that it have an adequate supply of nitrogen at that time.

The 2.3.2 (22) and 2.3.2 (38) basal fertilisers used in Swaziland contain nitrogen. If high amounts of basal fertiliser are applied, the amount of nitrogen is usually adequate until the plant is knee high (about 40 days after planting) and short delays in topdress application are not so critical. When low amounts of basal fertiliser are used the maize plant usually runs out of nitrogen before it is knee high. In such cases it is especially important that the topdress be applied without delay when the plants are knee high.

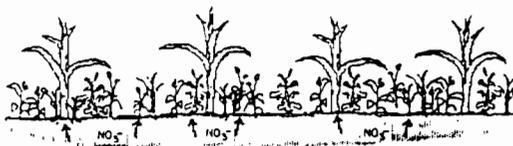


Nitrogen is the nutrient in shortest supply

- 3 -

#### 2 The timing of weed removal

If weeds are present when nitrogen is applied the maize plants will have to compete with the weeds to obtain the nitrogen from the soil. Weeding should be done before or immediately after nitrogen is applied. It is important that farmers control weeds early in the season. The delay of hand weeding is the most common cause for delays in the application of the nitrogen topdress.



Weeds compete for nitrogen, other nutrients, and water

#### D. RECOMMENDED NITROGEN SOURCES

##### 1. LAN, AN, and ammonium sulphate

The recommended fertilisers for nitrogen topdress are LAN (lime ammonium nitrate) and AN (ammonium nitrate). LAN is slightly better to use because it contains a small amount of lime which neutralizes the slightly acidic effect of fertiliser; but AN is alright to use if LAN is not available. Because they are about the same in nitrogen content, the same rates of application can be used for both.

Ammonium sulfate is sometimes used by farmers. It is also a good nitrogen source. It has a moderately acidic effect on most soils of the Middleveld, Highveld and Lubamba regions. If ammonium sulfate is often applied to these acid soils, the farmer should have the soil tested regularly to make sure that the soil pH is not too low. Liming may become necessary.

- 4 -

LAN, AN and ammonium sulfate can be applied and allowed to remain on the surface or incorporated (buried) into the soil. Incorporating fertilisers to a shallow depth is slightly better because it puts the fertiliser closer to the plant roots. Covering these fertilisers is helpful - but it is not critical if the farmer cannot do this. If these fertilisers are not incorporated, the rains will eventually move them into the root zones.

##### 2. Urea

Urea is recommended for use as a topdress, provided it is covered the same day that it is applied. It may be covered either by hand hoeing or by use of a cultivator. If it is not covered the same day, some of the nitrogen in the urea may volatilise (turn into the gas form of nitrogen and be lost in the air). If the farmer is prepared to cover urea the same day, it is a good nitrogen source.

#### E. NITROGEN MANAGEMENT FACTORS

The amount of nitrogen required by a maize crop depends on many factors, including the timing of the application, the type of fertiliser used, its placement, the plant population, date of planting, maize variety, rainfall, leaching conditions of the soil, and the amount of nitrogen applied in the basal application. It is not possible to recommend the best rate and timing of nitrogen application without considering all of these factors. However, some simple guidelines are presented here. Studies on fertilisers take many years to complete and many management and climate factors are involved in determining the correct rates. For this reason it is recognized that these recommendations may change as new information comes from research, as climate changes, as new varieties appear, and as farmers change their management practices.

##### 1. Farmer management level.

Nitrogen is usually applied to maize with some regard for the intended or expected yield. Larger amounts of nitrogen should be applied if the farmer is trying for a 4000 kg/ha yield than if he is going for a 2000 kg/ha yield. While all farmers would like to have

- 5 -

high yields, only those with high populations and high basal fertilizer application rates are likely to achieve high yields. It is important to determine if the farmer is in a low or high management group before making a nitrogen recommendation.

##### 2. Amount of N applied as basal

The total amount of nitrogen applied to the maize crop is the sum of the basal nitrogen and the topdress nitrogen. If low rates of 2.3.2 (22) or 2.3.2 (38) are used at planting, then the shortfall in nitrogen application can be made up with a higher topdress amount. Remember though, if a very low basal rate is used, the farmer will probably fall into a low management group and have a lower yield potential (meaning less topdress is needed).

##### 3. Soil texture

Lighter textured soils, sands and sandy loams, need a slightly higher amount of nitrogen topdress to make up for greater leaching losses that occur in these soils. Because these soils are more susceptible to leaching, farmers should carefully observe the colour of the plants. Topdress should be applied immediately if the plants show signs of a pale green colour.

##### 4. Nitrogen source used

AN and LAN are very close in their nitrogen content, so the same rate of application is recommended for both AN and LAN. Farmers who do not cover the urea the same day that it is applied should use a rate of urea application that is about 25% higher to make up for volatilisation losses.

#### F. AMOUNT OF NITROGEN TO APPLY

The types of topdress fertiliser used, farmer management levels, soils textures, and basal fertiliser rates need to be taken into account in order to provide a nitrogen topdress recommendation. The following tables summarize these factors and present recommended rates of application; the first table is for light soils, and table 2 is for heavy soils.

- 6 -

**Table 1 Nitrogen Topdress Rate Recommendations for light soils.** Light soil textures include the sands, sandy loams, and loamy sands

Basal fertiliser rate	Yield potential groups in tons/hectare			
	1.0-2.0 Low yield potential	2.0-3.5 Medium yield potential	3.5-5.0 High yield potential	5.0-6.5 Very high yield potential
<b>Nitrogen topdress in kg/hectare</b>				
2.3.2.(22)				
100	25	-	-	-
200	15	35	-	-
300	-	30	55	00
400	-	25	50	75
500	-	-	40	65
2.3.2.(30)				
50	25	-	-	-
100	20	40	-	-
150	-	35	60	85
200	-	30	55	80
250	-	-	50	75
300	-	-	45	70
<b>Recommended total N to apply (basal + topdress)</b>				
	30	50	75	100

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**Table 2. Nitrogen Topdress Rate Recommendations for heavy soils.** Heavy soil textures include clays, clay loams, loams, and sandy clays.

Basal fertiliser rate	Yield potential groups in tons/hectare			
	1.0-2.0 Low yield potential	2.0-3.5 Medium yield potential	3.5-5.0 High yield potential	5.0-6.5 Very high yield potential
<b>Nitrogen topdress in kg/hectare</b>				
2.3.2.(22)				
100	20	-	-	-
200	10	30	-	-
300	-	25	45	70
400	-	20	40	65
500	-	-	35	60
2.3.2.(30)				
50	20	-	-	-
100	15	35	-	-
150	-	30	50	75
200	-	25	45	70
250	-	-	40	65
300	-	-	30	60
<b>Recommended total N to apply (basal + topdress)</b>				
	25	45	65	90

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As mentioned previously, the yield potential group should not be determined by the yield the farmer would like to achieve. The best way to determine yield potential is by a combination of the farmer's past yields, the current season's management practices, and the weather. While a precise measurement of expected yield is rather complex, a few simple guidelines are presented here:

**Characteristics of Yield Potential Categories**

High Yield Potential

- 1 Early Planting
- \*2 Plant pop. above 40,000
- \*3 Early and good weed control
- 4 High rate of basal fertiliser
- \*5 High yields - previous years
- 6 Dark green colour plants
- 7 Good rains
- 8 Well drained, deep, fertile soils

Low Yield Potential

1. Late planting
2. Plant pop. below 20,000
- 3 Late weeding
4. Low rate of basal fert
- 5 Low yields - previous years
6. Light green colour plants
7. Poor or late rains
- 8 Shallow or infertile soils

\*If a farmer's maize crop has most of the characteristics listed in the High Yield Potential category (2,3 and 5 are especially important) then topdress should be applied using the rates listed in the High Yield Potential category. If, however, the farmer has a maize crop with most of the characteristics listed under Low Yield Potential, then the topdress rates for the High Yield Potential group would not be recommended.

As one would expect, farmers with characteristics in between High and Low Yield Potential lists, should follow the rates suggested in the Medium Yield Potential list. The Very High Yield Potential farmers are usually semi-commercial or commercial farmers

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**6. HOW TO APPLY TOPDRESS FERTILISER**

**1. Plant-by-plant method**

In the past, most farmers have applied topdress by placing small amounts of nitrogen fertiliser, usually about a teaspoonful, next to each plant. This method works alright but is slow and the required bending over is hard work. There is also the slight disadvantage in that the nitrogen is concentrated in one spot rather than being spread out to more of the plant roots that are extending out from the row beneath the soil surface.

**2. Banded over the row**

The nitrogen topdress can be applied in a narrow band 30-40 cm wide over the maize row when the plants are about knee high. The nitrogen is just as available to the maize plant as it is with the plant-by-plant method. This method is considerably faster than the plant-by-plant method, but getting the proper rate of nitrogen is a bit more difficult. A separate publication on using a cold drink can for calibrating fertiliser rate applications is available.

**H. SUMMARY**

- 1 Nitrogen is the nutrient in shortest supply in the maize plant because it is needed in large quantities by the plant and is easily leached from the soil.
- 2 It is very important to time the nitrogen topdress application so that it is applied when the maize plant is knee high - about 35 days after planting.
- 3 Weeds compete for nitrogen, other fertilizer nutrients, and water.

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