On-Farm Research and Extension Linkages: Experience From Zambia’s Eastern Province, 1982/88

by Jim Waterworth

Network Report No. 20
December 1989
On-Farm Research and Extension Linkages: Experience In Zambia’s Eastern Province, 1982/88

CONTENTS:

PART I
Introduction 1

PART II
Preliminary Stage in Adaptive Research in the Eastern Province of Zambia 4

PART III
Roles of On-Farm Research in Meeting Extension Demands 12

PART IV
Links Between Research and Extension in Development of Production Recommendations 24

APPENDIX 1
Extension T&V Bulletin For September 1988 (No. 11) 31

APPENDIX 2

APPENDIX 3
Management Briefs 38

Network Report No. 20
December 1989

CIMMYT Regional Office
P.O. Box MP 154
Harare, Zimbabwe
On-Farm Research and Extension Linkages: Experience in Zambia’s Eastern Province, 1982/88

I INTRODUCTION

Objective Of The Report

After half a dozen years of field implementation, on-farm research programmes in southern Africa have developed research results which are now being passed onto extension for dissemination to farmers. Given the system, management and local specific nature of on-farm research, these results can be expected to differ in style and content from those previously available from on-station research.

Much attention has been paid to the development of relevant new technology for small farmers through on-farm research. However relatively little attention has been given to the transfer of on-farm research results from researchers to extension and farmers. It is commonly assumed that the process of on-farm research will, of itself, facilitate this transfer.

This network report traces the origins and rationale for the adaptive trials programme implemented in Eastern Province (Part II). Four different types of trials were conducted, based on diagnosed problems, extension demand for specific information and the requirement to test station developed technologies. The characteristics, evolution and output from these four types of trials are given in Part II.

Parts II and III provide the context for an appreciation of the types of information produced by the adaptive research effort. Part IV looks at how the information generated was passed from researchers to extension and to the farmer.

The lessons from this experience caution against relying on the on-farm research process of itself to solve research/extension linkages. They suggest that there is a need to pay more attention to:

1. Developing effective ways of transferring non-blanket, problem specific and system oriented information to extension.

2. Encouraging new approaches and perspectives to the effective dissemination of such information to farmers.

3. Committing the time of researchers to communicating the implications of research findings to input supply services and policy makers.

On-Farm Research in Zambia

Most agricultural research in Zambia, particularly crop research, is conducted by the Research Branch of the Department of Agriculture. This research was, before the early
1980's, undertaken on research stations, and the results applicable mainly to large scale commercial farmers who were facilitated in producing and maintaining high yields.\(^1\)

However, results were less applicable to subsistence and small-scale farmers who constitute some 85% of the rural households in Zambia and where yields are much lower. Research recommendations were not widely adopted by these small-scale farmers; this has been attributed\(^2\) to three main problems:

a) Insufficient on-farm research and ignorance of farmers’ conditions (e.g. that farmers wanted maize varieties which could store well and be easily pounded).

b) Single crop or separate discipline approach rather than a whole farm, systems, approach.

c) Neglect of economic and social factors (e.g. few small-holders planted hybrid maize at the technically optimal time because of resource limitations, and other activities taking priority).

Early in the 1980's, recognising these limitations, the Research Branch was reorganised into multidisciplinary Commodity and Specialist Research Teams (CRT’s and SRT’s) and provincial Adaptive Research Planning Teams (ARPT’s).

An ARPT is a provincially based team of researchers conducting 'on-farm research with a farming systems perspective'.\(^3\) Each provincial ARPT, when complete, is made up of an agronomist, an economist and a research extension liaison officer, with support from a rural sociologist with responsibility for several provinces.

The farming systems research procedures adopted by Zambia’s ARPT’s are substantially those developed by CIMMYT’s East African Economics Programme\(^4\) and consist of seven stages:

a) Zoning, or grouping of farmers with similar resource levels, cropping patterns and problems into broadly homogeneous categories each of which may require its own set of recommendations (‘recommendation domains’).

b) Collecting background information on natural and economic circumstances of ‘target’ farmers (i.e. farmers belonging to the group or system selected for priority attention).

c) Agro-economic ‘diagnostic’ survey, to find out the basic characteristics of the target system selected; in particular to identify the constraints in the system, understand farmers’ problems and assess the potential for development.\(^5\)

---

\(^{1}\) Ref. ‘Institutionalising Farming Systems Research in Zambia’ S.A. Kean and W.M. Chibasa, 1982 (Department of Agriculture).


d) Formal verification survey, to verify, quantify and prioritise the identified constraints.

e) On-farm trials (and preliminary on-station work), to test potential techniques and materials.

f) Extension demonstrations to disseminate information on recommendations (practices or inputs) derived from the trial programme, and

g) Monitoring the level of adoption by farmers of the new technology, and constraints to adoption, to enable appropriate recommendations to be made to concerned institutions.

It was recognised that some types of research will not fit this sequence, that often one or several steps can be by-passed and that some activity is required at all seven stages even in the early years of adaptive research work.

On-Farm Research in Eastern Province

Adaptive research in Zambia's Eastern Province began in mid-1982 as part of a 5-year development project (the Eastern Province Agricultural Development - EPAD - Project), whose main task was to introduce the "Training and Visit" system of extension. For this project up-dated smallholder crop recommendations were required for the whole province, with priority attention to be given to those crops with which the project appraisal study had indicated as of most potential for giving improved farm incomes, i.e. hybrid maize, groundnuts, sunflower and cotton. This urgent, province-wide assignment lent support to some deviation from the more localised 'target area' approach adopted by the ARPT's in other provinces where on-farm trials were located in compact geographical areas 'up to 20 km. radius' representative of selected farming systems, each manned by a trials assistant (TA).

II PRELIMINARY STAGE IN ADAPTIVE RESEARCH IN THE EASTERN PROVINCE OF ZAMBIA

A) Zoning And The Agro-Ecological Context

Zoning or the delineation of recommendation domains forms a necessary basis for prioritising farming systems for initial research and selecting target areas within them.

For Eastern Province, as for all Zambia, a detailed land-use map was available (Schultz, 1974) showing available land, woodland, hilly areas, etc and demarcating regions with a high homogeneity of type and size of farms ('farming regions'). Schultz designated the dominant or average type of farm in these regions as 'farming systems'. Major features of the classification were degree of commercialisation (related to size of holdings), systems with or without cattle, and dominant crops. Schultz also prepared crop maps, utilising the

---

1971 Agricultural Census data, and showing areas where 50% or more of farmers grew the named crop. By superimposing these crop maps on the land use map, Eastern Province's two main farming regions; the Luangwa Valley and the Eastern Plateau, were each sub-divided into three areas with differing cropping patterns. On the plateau there are both hand and ox-cultivation farming systems but these could not be separated geographically.

In the Eastern Province there are three distinct physiographical regions: the Plateau, a rolling, partially wooded upland area of elevations between 900 and 1500 m; the Escarpment Zone which consists of discontinuous dissected upper and middle slopes of the Luangwa Valley and the Luangwa Valley proper, a relatively hot, sparsely populated, tsetse infested area about 400 to 600 m in elevation.

The mean annual rainfall map of Zambia shows a range from about 800 mm near the Luangwa river to over 1000 mm around Chipata, the provincial capital.

By superimposing the farming systems map derived from Schultz on a population map (updated on a district basis with 1980 census figures) it was possible to estimate the number of farm families in each of the systems (over 83% were on the plateau where a major part of our work was therefore sited).

The 1982/83 'Overview' survey, discussed later, gathered up-to-date information on current frequency of crops grown and enabled some up-dating of the cropping/farming systems map derived from Schultz. For the plateau systems' a preliminary estimate of the proportion of ox-owners, ox-hirers and hoe-cultivators was also obtained. By 1984 some formal base-line statistics became available from formal survey work of the EPAD Projects' Research and Evaluation Unit and it was possible to delineate a belt of land, about 25 km wide, along the boundary between the valley/escarpment zone and the plateau, within which hoe cultivation systems were predominant (over 50% of farm families) in contrast to the major part of the plateau where over 50% of households used oxen (owned or hired).

During 1984 an agro-ecological map of the province was drafted. Important parameters were physiography (valley/plateau), length of growing season and soil type (Dalal-Clayton, 1982). Some boundaries were adjusted to fit differences in cropping systems within which the climatic features were then described (rather than rigidly mapping out climatic zones and sub-dividing these according to cropping systems). In this way a combined agro-ecological and farming systems map was produced. Length of growing season ranges from around 125 days in the southwest of the province to some 145 days in the north. The length of season was obtained by superimposing meteorological maps showing mean dates of commencement of planting rains (Das, 1979), and mean dates of the end of the rains (Anon, 1971). In 1984 a national Agro-Climatic Map, utilising 70% probability values for growing season lengths and occurrence of 10-day droughts among other parameters, also became available (Veltkamp et al.).

---

9 J.C. Das (1979), Commencement of Sowing Rains.
10 The Climate of Zambia, Climatic Data Publications No. 6: Meteorological Department, Lusaka.
B) Overview Survey: Collection Of Information On Farming Systems And Farmer’s Circumstances

The overview survey, conducted by the Farming Systems Agronomist in August 1982, was essentially a questionnaire administered to field extension workers to up-date and revise the zoning based on Schultz. A major parameter in the plateau systems which cannot be mapped is the degree of use of ox-cultivation and the intensity of use of purchased inputs, in particular, fertilisers. Questions on both these subjects were included in the survey.

Each administrative district in the province is divided into about four blocks and 22 of the 31 block supervisors were interviewed to gain a picture of their accumulated knowledge of farming systems in each district. Questions included those on the frequency of cash and subsistence crops grown, farming calendar, busiest periods, farming practices, etc and, in addition, since there was insufficient time for a diagnostic farmer survey prior to the first season’s trials, extension workers were each asked their own assessment of farmers’ constraints.

Leaving aside the institutional constraints concerning input supply, credit and marketing, improving efficiency of weeding, especially by hand cultivators, and maximising returns from limited funds available for fertiliser purchase appeared to be the most widespread problems.

Later, past surveys and papers identified by ARPT bibliography compilation were reviewed (Ilunga, Kangulu and Kean, 1983)12. These gave both a historical perspective to agricultural development in the province and, from the more recent papers, further insight into the current farming systems. They confirmed that late planting of maize (hybrid) by some farmers requires investigation, (including the search for quicker maturing varieties if it is found that early planting of the whole maize crop is not practicable - because of the noted labour ‘bottleneck’ early in the growing season).

Other data such as that in provincial annual reports of the Department of Agriculture on production of various crops, fertiliser sales by the Cooperative Union etc. was also monitored from year to year, and, concerning economic data, produce floor prices and fertiliser prices are analysed in terms of value to cost returns (to fertiliser) and estimated returns per manday by crop (ref. Jonsson, 197713, for manday data).

C) Informal (Exploratory) Diagnostic Surveys

Detailed descriptive data on farming systems was collected during zoning as part of the compilation of background information. Partly to verify such data, similar details are also collected during diagnostic interviews with farmers, for example concerning which crops are grown, areas of each, farming practices and farming calendar. The more precise such information is, (for example on exactly when and how fertiliser is applied to a crop), the more precise can be the matching of common farmer practices against known agronomically "optimum" practices and then identification of points of divergence from these and reasons for these divergences. As many as 50 farmers were interviewed in such surveys.

---

12 Z. Ilunga, C. Kangulu, S.A. Kean (1983), 'Bibliography of Rural Studies Undertaken in Zambia, ARPT, Department of Agriculture: Notable among studies reviewed were: –

* Priestly M.J.S.W and Greening P. (1956); Ngoni Land Utilisation Survey, 1954 -55, Department of Agriculture, Lusaka.


Plateau Farming Systems

The April 1983 and November 1984 surveys re-affirmed findings of the 1982 overview survey, i.e. that, leaving aside the institutional constraints concerning input supply and marketing, shortage of labour, especially early in the growing seasons, was the major constraint. This indicated the need for research on improving the efficiency of weeding, on intercropping as a labour-saving device, and also on quicker maturing maize hybrids more tolerant to the late plantings necessitated by this constraint.

Another area where farmers' practices were sub-optimal and further investigation indicated was in relation to timing (and method) of fertiliser application to maize. Cattle-ox owners had a problem of heavy losses from East Coast Fever. There was also the problem of inadequate equipment (farmers often managing with no ridger and facing a general shortage of spare parts).

Later (1985, 1986) survey findings showed the need for an increased research emphasis on 'late season' January-planted crops which compete little for labour with the major early-season crops (local and hybrid maize and groundnuts). Farmers interviewed favoured beans and sunflower as late season crops over soyabeans. Sunflower management was often poor, however (late planting, no thinning).

In the report of this survey of late season crops, it was suggested that in future surveys, in addition to probing identified constraints and possible solutions, an attempt could be made to compare and contrast the 'most successful' farmers with 'least successful' farmers within the same farming system. In the 1987 Luangwa Valley Survey, discussed earlier, local concepts of what makes 'resource-poor' and 'resource-rich' households were examined.

Valley Farming Systems

The 1983 Informal Survey of the northern Luangwa (Chama) farming systems was again partly descriptive (using a questionnaire) covering data on enterprise patterns and husbandry practices and partly diagnostic (through in-depth discussion) seeking constraints in the systems - particularly those for which there may be agronomic solutions. Such constraints included a seasonal shortage of preferred staple foods (December to March); weed control problems, bird damage (to sorghum) and an early-season labour bottleneck combined with a lack of draught power (no tractor-hire now and no oxen because of trypanosomiasis).

The survey of cropping systems in the southern part of the Luangwa Valley (1987) found that 'resource-poor' households were in a majority and have little staple food remaining in store for 3 - 6 months of the year. It was concluded that the adaptive research programme in the valley should concentrate on this category of farmer and focus on, among other topics, very early maturing maize varieties (such as MMV 400) and on those cash crops such as sunflower which are least attractive to wild animals, damage from which was another persistent problem. (Animal attack may limit the total area of farmland which a farmer can 'protect'). It was concluded that emphasis should be placed on appropriate agronomy for low-input (principally low fertiliser) conditions and on crops adapted to these conditions, such as rice and sorghum, rather than a high input hybrid maize. It was also observed that 'a special effort was needed to reach the poorer farmers with seeds of new varieties of the subsistence crops of non-hybrid maize and sorghum, possibly though having smaller, cheaper, packs and a special distribution system in isolated areas'.

D) Formal, Verification Survey

Under the EPAD project a unit separate from the ARPT was established to undertake a baseline survey and to monitor, and later evaluate, project impact. Baseline survey data was collected in 1982/83 throughout the province and subsequent annual surveys were undertaken up to 1988, of small farmers agronomic practices and of the degree of impact on them of the newly introduced Training and Visit System. For the baseline small farm surveys representative villages in each
district were selected and a random sample taken of 25 to 30 households in each, to which were administered a comprehensive questionnaire supported by crop area measurements to determine cultivated area by crop, proportion of farmers growing principal crops, and other information. Identification of the dominant farming systems in the selected villages enabled tabulation by agro-ecological zones/farming system of crop frequency and area per grower for each system (see Table 1).
<table>
<thead>
<tr>
<th>Agro-Ecological Zone</th>
<th>Feature</th>
<th>Mean Growing Season</th>
<th>Mean Annual Rainfall</th>
<th>Mean Temp Dec - Feb (Mean Max Min)</th>
<th>Arable Soils (Pre dominant)</th>
<th>Dominant Farming Systems</th>
<th>No. of Farm Families, 1967 (estimate)</th>
<th>Dominant Crops (in order of frequency)</th>
<th>% of Hectares growing</th>
<th>Hectares per farmer growing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EASTERN</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PLATEAU</td>
<td>125 days</td>
<td>900 to 1250</td>
<td>27 - 30</td>
<td>Clay/soils (except SW to sandy)</td>
<td>EPS HOE (short season)</td>
<td>13 000</td>
<td>Local Maize</td>
<td>96</td>
<td>1.32</td>
<td></td>
</tr>
<tr>
<td>WEST</td>
<td>135 days</td>
<td>950 to 26 - 29</td>
<td></td>
<td>Sandy (Sandveld)</td>
<td>EPS (Hoe dominated)</td>
<td>5 000</td>
<td>Finger Millet</td>
<td>100</td>
<td>0.88</td>
<td></td>
</tr>
<tr>
<td>(National)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zone 12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PLATEAU</td>
<td>16 days</td>
<td>1000 mm</td>
<td>18 - 19</td>
<td>Mwase (Ox-dominant)</td>
<td>EPS HOE (short season)</td>
<td>2 250</td>
<td>Hybrid Maize</td>
<td>76</td>
<td>3.06</td>
<td></td>
</tr>
<tr>
<td>SOUTH</td>
<td>140 days</td>
<td>31 - 32</td>
<td></td>
<td></td>
<td>EPS HOE</td>
<td>18 250</td>
<td>Groundnuts</td>
<td>49</td>
<td>0.32</td>
<td></td>
</tr>
<tr>
<td>(National)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zone 20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LUANGWA</td>
<td>145 days</td>
<td>315 - 315</td>
<td>20 - 21</td>
<td>Sedimentary (Short drought periods)</td>
<td>Variable</td>
<td>8 000</td>
<td>Finger Millet</td>
<td>67</td>
<td>0.20</td>
<td></td>
</tr>
<tr>
<td>CHAMA</td>
<td>140 days</td>
<td>750 to 31 - 32</td>
<td></td>
<td></td>
<td>Variable (HOE)</td>
<td>7 000</td>
<td>Groundnuts</td>
<td>37</td>
<td>0.19</td>
<td></td>
</tr>
<tr>
<td>(Zones 2CV 2NE,NEW)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CENTRAL</td>
<td>125 days</td>
<td>315 - 315</td>
<td>20 - 21</td>
<td>Sedimentary (Short drought periods)</td>
<td>Variable (HOE)</td>
<td>4 330</td>
<td>Groundnuts</td>
<td>96</td>
<td>0.34</td>
<td></td>
</tr>
<tr>
<td>2-CEE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-CEW</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SOWTH</td>
<td>125 days</td>
<td>750 to 31 - 32</td>
<td>20 - 21</td>
<td>Sedimentary (Short drought periods)</td>
<td>Variable (HOE)</td>
<td>1987 Informal Survey</td>
<td>Groundnuts</td>
<td>96</td>
<td>0.34</td>
<td></td>
</tr>
<tr>
<td>(Zones 25V 2-SE 6- E)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
III ROLES OF ON-FARM RESEARCH IN MEETING EXTENSION DEMANDS

In responding to extension requirements to develop technical content for messages, Eastern Province ARPT conducted 4 main types of trials.

a) Trials which were essentially location testing of technologies developed by commodity research teams

b) Trials aimed at identifying production components with the best potential for increasing current levels of production in the short-term

c) Trials designed to test solutions to specific production constraints

d) Trials aimed at improving productivity through exploiting system interactions.

Each of these types of trials have different characteristics and produce different types of results. In the following section examples of each trial type are given. This is followed by a discussion of how trial results were extended to farmers and the relation between trial type and success of the dissemination tools used.

A) 'Supply-Driven' Work Derived From On-Station Commodity Research

Prior to planning the first season’s trial programme (i.e. 1982/83 season) a review was made of relevant past research results in Zambia and discussions held with Commodity Research Team (CRT) members, in order to arrive at a compilation of what was 'on offer' in terms of new varieties or technologies. Similar reviews were done annually, including review of ARPT work in other provinces, by participation in the annual national research committee meetings.

Starting in 1983 a Provincial ARPT committee chaired by the Provincial Agricultural Officer reviews ARPT trial results and programme of surveys and trials proposed for the next season.

Some adaptive research is supply-driven in the sense that it is, for example, derived from the need to test on-farm new varieties bred or selected by Commodity Research Teams (CRT’s); not all such work can be related to system constraints.

One example of such supply-driven on-farm research, which also has several system implications, is the development of maize hybrids and varieties for smallholder conditions through research conducted in Eastern Province over some six cycles, or seasons, from 1982/83 to 1987/88:

Development of Maize - Hybrids and Varieties for Smallholder Conditions

Cycle 1 & 2: 1982-84 Seasons

a) Objectives
Because of priority given by farmers to food crops such as local maize, and a labour constraint in the early part of the growing season, most hybrid maize is planted in December after the optimum period for the hybrid SR52 currently available. The trials sought to identify quicker maturing hybrids (MM502) or varieties (population 10) better suited than SR52 to December planting.
b) Results

MM752 (purified SR52) and imported Zimbabwean R215 significantly outyielded all other material. Farmers favoured MM752 and R215 equally believing that the latter was able to give a good yield when planted late.

c) Conclusion

Further Zambian hybrids available should be tested and examined in (CRT) trials for planting date response. Farmers' assessment of Population 10 was that it appears suitable for local storage and processing; it was concluded, however, that 'improved' varieties higher yielding than Pop 10 should be sought.

Cycle 3 & 4: 1984-86 Seasons

a) Objective

Separate hybrid and variety trials were planned, the former to continue to screen out the highest yielding Zambian hybrids for December planting. The variety trial sought both a very early maturing variety to relieve the food constraint or 'hungry period' in February to March and generally higher yielding material than locals which, if adopted, would require less land (60% of holdings are currently planted to local maize) and labour to meet farmers' subsistence needs. The released labour could be diverted to growing a larger cash crop area.

b) Results and Conclusions

Hybrid Trial

Four new Zambian hybrids were tested as alternatives to R215. MM601, 604, 605, and 606 were equally high yielding and suitable for December plantings, but farmers preferred the later maturing and familiar large-cobbed MM752. The still earlier MMS04 gave lower yields than R215 and cannot be recommended.

Variety Trial

The very early maturing MMV400 was liked by farmers for an early harvest and was not significantly lower yielding than later maturing local material.

Of the new later maturing varieties (still earlier than locals), MMV600 was preferred over ACROSS7844 (and even above MM752 hybrid, which gives a 50% higher yield) because of its flinty grain type expected to store well and pound without shattering. It was recommended that MMV600 and MMV400 both be demonstrated to farmers, particularly in the dryer southwest where the rains cease earlier and in another area where survey had shown that local maize is planted late by some farmers (waiting for ox-hire).

Cycle 6 & 7: 1986-88 Seasons

a) Background

The hybrid trial was discontinued as seed of MM604 and MM603 was widely available. Recognising that late season (i.e. January planted) crops compete least for labour with the major food and cash crops (of local maize, hybrid maize and groundnuts) it was reasoned that these crops may provide the easiest means for farmer to raise cash to buy fertiliser for their local maize. The 1986/87 trial programme therefore included an examination of a range of alternative late season crops. It also tested (on-station) relay-cropping beans and other late season crops through MMV400 maize harvested green (in February).

---

14 Note: detailed individual trial results are given in the mimeographed departmental ARPT Eastern Province Annual Reports
The search continued for higher yielding later-maturing 'open-pollinated' (non hybrid) maize varieties of acceptable grain type; this trial included two named local varieties, Mnkangala and Kapesi as well as site locals.

b) Results and Conclusion

In 1986/87 streak virus disease was severe at some sites, affecting local materials more than ZUCA and MMV600. Attributed to this was the +40% higher yield of ZUCA compared with site locals and Mnkangala and Kapesi. In the following season when streak was not a factor there was no significant yield difference between ZUCA and the locals. Farmers preference placed ZUCA (and MMV600) above local material as first choice for planting next season.

It is recommended that storage trials should be initiated to compare storability of ZUCA, MMV600 and local varieties. Seed of Mnkangala has been made available to the plant breeders as there may be potential for improving its streak resistance and improving its yield while retaining grain quality.

All late season crops planted in January in relay through February-harvested MMV400 failed (yields of sunflower, soyabeans and beans were respectively 13%, 20% and 6% of sole crop yields.)

General Conclusion of the Trial Series

As noted by Kean and Singogo (1988)\textsuperscript{15}, the evolution of this trial demonstrates the dependence of the ARPT on the maize research team (CRT) for material to test in on-farm trials. Initially only imported hybrid material could be tested. Subsequently, new Zambian hybrids became available. However, progress has been slower in breeding of 'open-pollinated' varieties suitable for on-farm testing. The trial also shows how survey data helped the team to more fully appreciate the problems farmers were facing and to develop a wider range of possible solutions (i.e. to the early season labour problem, e.g. by expanding late season cropping to raise cash to buy fertiliser for subsistence maize production from a smaller hectarage).

Development of Revised Recommendations for Sunflower Production

A second example of supply-driven research is that arising from past on-station agronomic work on sunflower leading to date of planting, thinning and fertiliser recommendations that had not been adopted by farmers. Fertiliser response trials showed no economic response in either CCA75 composite or local materials. At the end of the period 1987/88 a new hybrid CH301 became available. This gave an 80% yield advantage with fertiliser (20N; 40P\textsubscript{2}O\textsubscript{5}), which was economic. Overplanting (by 50%) and thinning to 35-40 thousand plants/ha as recommended was compared with planting and thinning to obtain 25 thousand plants per ha. There was no significant difference in yield between the two treatments, but at the higher plant populations harvesting took 7 man-days per hectare longer.

Results and Conclusions

The evolution of this trial shows how a matching of extension recommendations with surveyed farmer practice led to re-examination of the promotion of fertiliser on sunflower with trial results

supporting the farmers' practice (no fertiliser) until new, hybrid, material became available (CH301, 1986) which gave a dramatic fertiliser response.

Consideration of the increased labour required (rather than of any difference in yield) led, after study of the results of trials set up to examine thinning, to a lower population recommendation for this 'crop' (25 000 plants per hectare compared with the earlier recommended 35 to 44 000).

Re-testing of planting dates on-farm, in 1983/84, led to immediate confirmation of earlier on-station findings of the halving of yields following late (i.e. February) planting. This trial was not continued, but on-farm extension demonstrations on this topic were mounted, starting in 1984/85 season. This demonstration included thinned and non-thinned plots.

B) Adaptive Research Directed At Maximising Exploitation Of Production Opportunities In Existing Systems

A distinction can be drawn between adaptive research directed at finding the best ways of exploiting opportunities in an existing system, as opposed to work directed at overcoming specified constraints in the system.

Exploratory research may need to assess the relative importance of several factors affecting yield between some of which there may be important interactions. To examine interactions, trials with as many as four factors each at two levels or 16 treatment combinations, have been found to be particularly useful by the Eastern Province ARPT.

Over the six years, 1982 to 1988, some 39 ARPT trials or studies were mounted in Zambia’s Eastern Province, covering 20 crops/topics. A wide range of trials was necessitated partly by the requirement to produce revised production guidelines for extension, particularly for the major cash crop of hybrid maize. The earlier emphasis of Commodity Research Teams on plant breeding and on-station rather than on-farm work also led to the need for adaptive research to 'gap-fill' knowledge of crop husbandry suited to smallholder conditions.

The trial series described below examined the response of maize to various factors, and interactions between them.

Factors of Maize Yield and Interactions

Consideration of past research within and outside Zambia led to an expectation of varying degrees of interaction between the various factors of yield (e.g. genetic - or variety - with date of planting; fertiliser level with plant population, etc.). Multi-factorial trials were considered essential if important interactions do occur, and they also serve to rank yield factors in order of importance; thus Allan (1974)\(^1\) found that early planting and variety (local compared with hybrid) had greater effects on yield than either high plant population or intensive weed control. However, except for Vernon and Parker’s\(^2\) work on weed control and early work on the interactions between plant population and fertiliser level, little work on interactions had been carried out in Zambia. Factorial trials with say 4 or more factors were considered important ‘tools’ in the exploratory stages of farming systems work. Although with the 16 treatment combinations of a \(2^4\) factorial, they are not suited to placement on-farm, where only 2 or at most 3 factors can conveniently be examined together.

---


The 'Maize Management' 2^4 factorial trial discussed below was conducted at the Msekera Regional Research Station; it examined the four factors of planting date, fertiliser level, variety and intensity of weed control. Parallel with this trial various single factor trials were mounted, usually on-station at first and then on-farm (e.g. maize variety trial, discussed earlier, and weed control and fertiliser trials). The interactions between plant population, fertiliser level and variety were also examined, in a separate 'Field Factor' trial at Msekera. The discussion below shows the contribution of these trials to an increased knowledge of maize agronomy in Zambia (and in Eastern Province in particular), and, where appropriate, the derived recommendations for farmers.

Results and Recommendations: Maize Management Trial 1982/83 to 1985/86

In this trial a local maize variety, Mulenga, was compared with SR52 hybrid in the first two seasons, and then with MMV600 composite. Fertiliser was at nil and 200 kg/ha basal plus 200 kg/ha urea levels (except 1982/83, nil and 200X); planting dates were late November, with the planting rains, and late December and weeding regimes were once, late, versus twice (the first early).

Except for the first season, when the lower level of fertiliser was used, fertiliser use was the major factor of yield improvement, followed by early planting (1st in 1982/83). The benefits of changing to an improved variety (or to hybrid) were usually much smaller while early and a second weeding was observed to have a significant effect only when coinciding with a dry period i.e. when the single late weeding (one month after emergence) followed a short drought permitting weed competition for soil moisture, (ARPT EP Annual Reports especially 1984/85, 1985/86). Mean responses to main treatment in this trial are tabulated below:

<table>
<thead>
<tr>
<th>Main treatment: Mean Responses, kg/ha and significance:</th>
</tr>
</thead>
<tbody>
<tr>
<td>--------</td>
</tr>
<tr>
<td>Fertiliser use</td>
</tr>
<tr>
<td>Early planting</td>
</tr>
<tr>
<td>Improved variety</td>
</tr>
<tr>
<td>(SR52)</td>
</tr>
<tr>
<td>Weeding early</td>
</tr>
<tr>
<td>CV %</td>
</tr>
<tr>
<td>poor germination of local</td>
</tr>
</tbody>
</table>

Among conclusions drawn were that MMV600 variety although quicker maturing than local should also be planted early for highest yields, and recommendations released in May 1985 emphasised the need to plant it in mid-December. It was observed that early plantings can give twice the fertiliser response of late plantings in terms of kg/ha and 'value to cost ratio'. In 'Guidelines on Fertiliser Use in Eastern Province Farming Systems' (1986) advice was given on the use of less fertiliser on late planted crops because of this lower economic response. Trial data also showed that early weeding was particularly important when no fertiliser was available for the local maize crop as well as when dry weather prevailed at the recommended time for this weeding (10 - 14 days after crop emergence).
C) Adaptive Research Directed At Specific System Constraints

Initial overview survey data has shown that farmers had maize weeding problems and, for hybrid, problems of timely planting, both related to the early season labour constraint. Funds clearly limited fertiliser use indicating a need to determine ways of maximising returns from relatively low levels of input. Existing recommendations on fertiliser use were to apply 'basal' fertiliser before planting, 'top dress' at crop knee height (50 cm), whereas farmers almost invariably applied basal after crop emergence and top dress sometimes later than knee height.

Here is described the development both of fertiliser usage and of weed-control recommendations for maize.

Fertiliser trials examined mainly the timing of the 'top dressing' fertiliser which many farmers applied later than recommended. (Ref. 1982 Overview and subsequent surveys). In the 1983/84 season, however, the application of 'basal' fertiliser at time of planting was tested (as then recommended but not adopted by farmers). Central Province's ARPT, in 1984/85, also examined timing of basal fertiliser application, finding in one trial that by delaying basal application from planting time to when plants were at 20 cm height yields were increased (from 4255 kg/ha dry grain to 6065 kg, LSD 5% 1915 kg, CV 27%).

Interactions between time of weeding and time of fertiliser application have not been studied but Central Province ARPT found, in 1983/84, that a significant increase in yield (+20%) resulted from weeding and applying top dressing at 20 cm plant height (say 12 days after emergence) compared with weeding and top dress application at 60 cm (a common practice), (weeding and fertiliser effects not separated in this trial). Special Research Team (SRT) weed control trials at Msekera (and other sites in Zambia) in 1979/80 and 1980/81, showed that there was a 'critical period' between 10 and 20 days after crop emergence (DAE) when weed competition was most damaging to subsequent yield.

Fertiliser Usage

In 1983/84 season trial farmers were questioned on why they did not apply basal fertiliser at planting time and it appeared they were 'too busy' at that time. In an on-farm trial that season two (of 6) sites gave a much reduced emergence from this practice (i.e. basal fertiliser placed below the seed, covered), which was attributed to 'salt' damage. (Emergence was down to 15% and 21% compared with 70% and 65% when basal fertiliser was applied after emergence). Revised smallholder recommendations (from late 1983) advocated basal application approximately 10 days after crop emergence.

As noted above, Eastern Province ARPT fertiliser trials focussed on the timing of the nitrogenous 'top-dressing' fertiliser. Much earlier trials in Zambia, on both sandy and heavier soils showed that equally good yields could be expected following nitrogen application before planting or up to 6 weeks after planting. Splitting the application (half at planting, half at 4 or 6 weeks) also had no effect on yield. However, later CRT trials at Msekera (1976/77 to 1979/80) showed, in two seasons, a significantly reduced yield from applying all the nitrogen at planting time compared with $\frac{1}{3}$ at planting, and $\frac{2}{3}$ 20 days after crop emergence.

Weed Control

Weed control trials by the Eastern Province ARPT focussed on time/frequency of weeding for both hand cultivated and ox-cultivated maize. In arriving at the final recommendations consideration was given to the fact that, from trial records, hand weeding along the maize row takes

approximately three times as long (in mandays) as ox-weeding in ox-team days, and that it could take up to two weeks for a single hoe-weeding to pass through a typical maize field. ARPT work confirmed SRT findings on the importance of early completion of the first weeding. This was found to be particularly important when dry periods intervened, or when little fertiliser was available. It was recognised, too, that post-emergence application of basal fertiliser should not be later than two weeks after crop emergence.

Taking these facts into consideration it was concluded (1986/87) that the most efficient conventional weeding regime for an ox-cultivator would be to ox-weed at around two weeks after emergence, at the same time covering the mixed basal and top dressing fertiliser applied immediately before. Hand weeding along the maize rows (of weeds not controlled by the ox-drawn ridger) should follow this ox-weeding, and completed within the succeeding two weeks or so.

For hoe-cultivators the first weeding should commence around 10 days after crop emergence (combined with fertiliser application), followed about 2 weeks later by a second weeding to remove missed or recovered or later germinating weeds.

It was advised that weeding early and twice is particularly necessary for local maize receiving low levels of fertiliser; heavily fertilised hybrid maize is less dependent on the limited nutrients available in the soil. It was emphasised that substantial (-25%) yield losses can be expected from delayed first weeding'.

Earlier work by the SRT, and ARPT trials in Eastern and Central Provinces, led to the conclusion that in Eastern Province, herbicides (pre-emergent) can only be recommended for hybrid maize and then only under certain conditions; because of cost its use is only economic when the alternative is not to weed at all; i.e. when sufficient labour and ox-power is simply not available. Also the herbicide recommended (Primagram) requires moist soil to be effective and does not control some weeds such as Rotboellia exaltata and Commelina spp.

The evolution of this trial work on weed control and fertiliser usage demonstrates the importance of (i) reviewing past and concurrent research results (in this case, on split/non-split nitrogen application and on the critical periods for weed competition); (ii) matching farmer practice against current recommendations (for example in terms of farmers’ timing of basal and top-dress fertiliser applications vis-a-vis recommended timing), and, (iii), of considering economic factors such as the smallholders’ labour resources in drawing recommendations.

D) Adaptive Research With A Systems Approach To Improving Smallholder Incomes

The terms of reference of the ARPT within the EPAD project required a review of existing packages of crop recommendations for the extension service (and, by implication, a review of the research on which they were based). Priority attention was to be given to those (cash) crops with which the project was most concerned, i.e. hybrid maize, groundnuts, sunflower and cotton. In reviewing past research certain gaps were identified in basic agronomic knowledge, particularly area-specific information such as local fertiliser responses of a number of crops, which the ARPT felt obliged to study in order to fulfil these terms of reference.

Some of this work, designed to test specific points of crop agronomy was conducted on-station, not on-farm, and was not directed at specified system constraints. Additionally, some ARPT work, both initially and up to the present, is ‘supply-driven’, in particular the on-farm testing of new crop varieties being developed by the breeders (of sorghum, finger millet, rice and, recently, groundnuts). However, through the seasons, there has been an increasing emphasis on a whole-farm or systems approach.

Trial Cycles 1 and 2: 1982/83 and 1983/84
Trials with a systems or holistic farm management orientation included, in these seasons, a
maize-groundnut intercropping trial (intercropping being a labour-saving device) and the maize hybrid on-farm trials seeking hybrids suited to later planting as an answer to the labour constraint necessitating late planting. Another trial with farming systems implications begun then was that examining nitrogen fertiliser saving and weed control labour-saving that may result from growing maize through a ‘live mulch’ of pasture legume. There was also a crop rotation trial started in 1983/84, set up to assess residual benefits (equated with fixed nitrogen) from various legume crops in rotation with maize.

**Trial Cycles 3 and 4: 1984/85 and 1985/86**
ARPT economic study in 1984/85 focussed on the labour constraint in the Eastern Plateau farming systems, especially with regard to weeding, seeking data to guide the difficult decision as to ‘when to stop planting (maize) and start weeding’. Maize weeding trial work itself continued on-station in 1984/85 and moved on-farm in 1985/86.

The extent of dominance of local maize in the plateau systems was noted from formal survey data which became available by 1984, i.e. a mean 1.5 hectares of 2.5 hectares mean farm size devoted to this crop. (Mean farm size for ox-cultivators 3.2 ha, hoe-cultivators, 1.7 ha).

Higher yield potential varieties and the use of fertiliser were seen as the major ways of improving on subsistence maize yields. It was estimated that, for many farmers, local maize yields could quite feasibly be doubled and ‘subsistence hectarage’ halved principally by use of fertiliser obtained from growing late season cash crops (sunflower, Carioca beans). At the same time (early 1986) the idea was put forward to the agency (Cooperative Union) concerned with fertiliser sale and sunflower produce purchase of a barter system in which bags of produce would be exchanged for bags of fertiliser for the next season. (Coincidentally fertiliser and sunflower bags were then nearly the same price). It was envisaged that, with full implementation, such a system could obviate the need for seasonal credit devoted to fertiliser purchase.

**Trial Cycles 5 and 6: 1986/87 and 1987/88**
There was a return to intercropping work in 1986/87 with a cotton/groundnuts intercropping trial, (the earlier maize/groundnut combination had not proved efficient), and a relay-cropping trial testing late-season crops relay planted through the very early maturing MMV 400 maize variety then available.

Increased attention was paid to late-season crops, not only continuing the examination of points of agronomy of individual crops (soyabean fertiliser and seed rate, bean varieties and fertiliser response) but also in a major new on-farm trial comparing ‘alternative’ late season crops (combined with relay cropping in 1986/87, in a separate trial in 1987/88).

An informal survey of late season cropping was also undertaken (1986/87), which sought, in part, to test the reaction of farmers to the concept of ‘growing more late season crops to raise cash for fertiliser purchase to use on local maize, enabling a reduction of subsistence hectarage.’ Also in 1986/87 observation trial work began on soil conservation as part of an increased emphasis on a systems approach and on the longer term problem of sustained productivity through maintenance of soil fertility (‘improved fallows’ work) and control of soil erosion.

By 1987/88 ‘following solution of several agronomic questions relating to cash crops’ more attention was devoted to food/relish crops important nutritionally (but not as cash-earners) with new trials on varieties of cowpeas and sweet potatoes as well as continued work on local maize and beans.

IV) **LINKS BETWEEN RESEARCH AND EXTENSION IN DEVELOPMENT OF PRODUCTION RECOMMENDATIONS**

A close link was forged between adaptive research and extension in the Eastern Province. The local, provincial, mechanism for reviewing adaptive research results, considering draft
recommendations and approving (or multiplying) the subsequent seasons research programmes is the provincial ARPT Committee. This is chaired by the Provincial Agricultural Officer and members include Provincial Subject Matter Specialists (SMS's) and District Agricultural Officers (DAO's). There is no direct farmer representation which could be a shortcoming although farmers' views are expected to be represented by the DAO's as well as being routinely fed back to the provincial office through the regular training and visit extension programme meetings.

Monthly T & V Bulletin

Under the T & V system in Eastern Province, a monthly bulletin of extension advice is prepared, with ARPT participation, and this is discussed in the monthly meetings between provincial SMS's and district level staff and, in turn, in meetings within districts at village extension worker level. Village extension workers each have some 100 'contact' farmers whom they meet twice monthly in regular scheduled sessions at different villages each attended by some 12 of these contact farmers. After these meetings farmers' response to the previous month's bulletin information is supposed to be reported back to district and then provincial level.

Initially information in the bulletin was crop-agronomy oriented, but more recently efforts have been made to give farm-management advice, as the appended extract from the September 1988 bulletin shows (Appendix 1). We have also tried to target the monthly bulletin on to priority crops and topics or 'messages' appropriate to the month. Appendix 2 shows 'prime' extension messages tabulated against farming systems, indicating also possible topics for demonstrations, and those requiring further research.

It is relevant to note here that a recent questionnaire study (March/April 1988) of bulletin impact, administered to village extension workers, showed that in the meetings at which it is discussed, farmers were preoccupied with problems relating to input supply, especially of fertiliser, with only 17% of 'most important questions raised by most farmers' being concerned with technical problems.

Revision of Crop Recommendations (Eastern Province Farming Systems)

After analysis of the 1982/83 ARPT trial results and review of earlier (Commodity Research Team, CRT) research work, some proposed changes in the current crop recommendations for smallholders were proposed. At the same time the head of research (Assistant Director of Agriculture, Research) decentralised to provinces (to the Provincial ARPT Committees), the responsibility for formulating such recommendations, 'adapted for farmers in their (local) recommendation domains'. A complete review was undertaken in 1985 involving much informal dialogue with CRT staff as well as formal meetings chaired by the national Research Extension Liaison Officer. Revised crop husbandry guidelines were issued to all extension workers, with separate series covering hoe-cultivators, ox-cultivators and Luangwa valley (hoe cultivator) farming systems. (Complete coverage of the province was demanded by the extension service, under the 'Eastern Province Agricultural Development Project). Similar guidelines were prepared for non-hybrid maize, cotton, groundnuts, soyabeans, beans, rice, sorghum and finger millet. Guidelines were also prepared on topics such as 'Weed Control', 'Fertiliser Use' and 'Soil Conservation Measures for Plateau Farming Systems.'

When drawing up new recommendations or guidelines, current farmer practice (as learnt from surveys) is matched against current recommendations in addition to a review of past and recent research results. Thus it was noticed that ox-cultivators had generally 'standardised' on a 75 cm

row to row (ridge) spacing in contrast to the post-metrication recommended 100 cm row spacing for all smallholders. Also, in the light of farmers’ practice never to apply basal fertiliser at planting time, past time-of-application research was reviewed and some new work undertaken.

In order to provide greater emphasis some ‘negative’ recommendations were made. Examples include:-

- Cotton: ‘one month’s delay in planting can reduce yields to a half;
- Hybrid maize: ‘do not save seed, or the resulting yield will be 30 - 40% lower than from using new seed,’
- Sunflower: ‘do not plant late; yields can be halved by late (February) planting.’

Extension Demonstrations and Feedback on Adoption Demonstrations

It is generally agreed that proven recommendations are most appropriately introduced to farmers by demonstrations on their own fields.20

‘Demonstrations encourage adoption by providing physical evidence on farmers’ fields of the advantages (mainly of improved yields) of adopting a new variety or crop management practice. In addition, demonstrations make the adoption of new varieties easier by giving some farmers access to seed.21

Since 1984/85 season (up to 1987/88) the following demonstrations of ‘improved technology’ based on preceding adaptive research, have been mounted:

a) MMV 400 and MMV 600 maize variety demonstrations, the former for early (Feb.) harvest, the latter for any late (December) plantings.

b) Demonstration of (lower) yield resulting from late application of Urea top dressing to hybrid maize compared with application mixed with basal two weeks after germination.

c) Sunflower planting date demonstration to demonstrate the (greatly increased) yields associated with planting at the recommended time compared with late (Feb.) planting.

These demonstrations planned under the auspices of the Provincial ARPT committee were implemented by the extension service through village extension staff who are provided guidelines and inputs for 3 to 4 demos annually, under the supervision of the Crop Husbandry Officer of each district.

In 1988 a survey was conducted (De La Paz and Waterworth, 1988)21 to assess how effective these demonstrators had been and to find ways of improving their usefulness in inducing farmers to adopt new extension recommendations. It was concluded that demonstrations of new crop varieties were a very effective means of making these varieties known as well as adopted by those who had access to seed (which was mainly demonstration hosts themselves as seed was not available through the normal, Cooperative Union, sales channels). 12 out of 16 ‘contact’ non-demonstrator farmer respondents were ‘aware of the new maize varieties by name or by their qualities’ but fewer non-contact farmers (4 out of 12 respondents).

---

Most variety demonstrators (9 out of 13) saved seed for replanting for at least one season.

On sunflower planting date only one farmer who conducted the demonstration was interviewed; however, 10 (out of 19) T & V contact respondents gave 'preferred planting dates' within the recommended period (late Dec. - early January), in contrast to none (of eight) non-contact farmers questioned on this point.

The fertiliser demonstrations were more complex and errors in implementation were found at some sites. There were three, or four, treatments and this number, combined with the implementation errors and some farmers' prejudice against both early top dress application and mixing except where there is insufficient fertiliser, may all have contributed to the nil adoption rate on farmers' hybrid maize. However, nearly half (11/25) contact/demo farmers did apply mixed basal and top to their local maize (but not very early). This is in contrast to only 1 (of 8) non-contact farmers applying mixed basal + top to local maize (but two of these 8 had 'insufficient money to buy basal and top'). Farmers' comments confirmed again a strong preference for 'X' basal for hybrid as well as local maize in contrast to a high usage of 'D' basal. (NAMBOARD appears to have been unresponsive within recent years both to farmers' demands or to the Department's recommendation (since 1979) that X not D basal should be used for post-emergence applications).

It was concluded that for more complex recommendations an information campaign should accompany demonstrations and that as a partial remedy to information not passing on from contact to non-contact farmers, much larger numbers of demos should be considered, at least of the simpler 'seed only' type, with non-contact farmers included as hosts.

Development of New Extension Approaches
Researchers found it necessary to adjust standard extension methods and materials in a number of ways. The simplest adjustment related to changing existing recommendations based on local specific information. Location testing type trials (on maize varieties) provided information for this simple 'content update'. Standard demonstrations were found to be an effective dissemination tool and it was recommended that those be conducted in much larger numbers with non-contact farmers included as hosts.

Trials aimed at identifying components with greatest production increasing technology fed into constraints relieving and systems based trials. Results of constraints relieving trials, such as those on mixed basal and topdressing with early first weeding, proved difficult to extend through standard demonstrations. One conclusion was that for more complex recommendations an information campaign focusing on the specific constraint should accompany the demonstrations.

System related results where benefits are mainly of an indirect nature are clearly not suited to extension through demonstration. The Eastern Province team have expanded standard extension bulletins to include more management type information to accompany standard technical information.

It seems clear that as on-farm research teams move away from location testing to trials aimed at specific constraints or exploitation of system interactions, new demands will be placed on extension to develop innovative ways of effectively disseminating these new types of research findings. Extension will need to move from a purely technical to a more management perspective.

V SUPPLY CONSTRAINTS

Even when a close working relationship is forged between on-farm research and extension, severe constraints to adoption of recommendations remain. These include, in particular, the issue of supply constraints.
Management Briefs

As new recommendations have been developed various 'management briefs' have been prepared, to encourage complementary input supply, Appendix 3 contains copies of several of these briefs, including:

a) A suggested barter system for sunflower/fertiliser,
b) Provision of credit for ox equipment especially the multipurpose toolbar,
c) On why fertiliser should be included in the standard credit package for cotton growers, and
d) Brief on failure to supply adequate quantities of 'X' fertiliser to Eastern Province.

However, achievements of the ARPT have been minimal in influencing the 're-gearing' of either input supply or credit decision-making mechanisms to encourage and support farmer adoption of the 'new technologies'. Thus the proposed barter system, to encourage sunflower production to raise cash for fertiliser for local maize, has never been implemented, even on a pilot scale. The agency responsible for produce purchase (the Cooperative Union) is also responsible for fertiliser sales and it should be possible to use the same vehicles for fertiliser distribution and produce collection.

Concerning improved ox-equipment we have not yet (Oct. 1988) convinced the main engineering company concerned (Northlands Engineering Ltd) to manufacture the improved tool bar and plough/ridger bodies which have been tested and developed over several years at the Msekochika project near Chipata. Nor has the Cooperative Union introduced the Malawi Agrimal toolbar into their medium term ox-cultivation credit package.

LINTCO, the organisation responsible for cotton development and marketing have not been able to finance the inclusion of fertiliser in their standard credit input package, although LINTCO Eastern Province management have been convinced of the economics of its use, and, in cooperation with the ARPT, have mounted their own on-farm fertiliser demonstrations, in 1987/88 and 1988/89.

Despite representations and specific recommendation to use 'X' not 'D' basal compound fertiliser since 1983 (in fact since 1979 'X' was recommended for post emergence applications), 'D' has predominated in the fertilisers supplied to the province from 1984 right up to 1988.

It was therefore, concluded, with CIMMYT (1985)\footnote{CIMMYT, (1985) 'Report on a Networkshop on Issues in On-Farm Experimentation, Lilongwe, May 1987; CIMMYT, Nairobi}, that 'a local (and national?) mechanism for reviewing on-farm research results, making recommendations and initiating and co-ordinating complementary input and credit supplies is vital' and 'there is a danger of farmers' enthusiasm for adoption being lost due to poor linkages of research with extension and input supply'.

\footnote{CIMMYT, (1985) 'Report on a Networkshop on Issues in On-Farm Experimentation, Lilongwe, May 1987; CIMMYT, Nairobi}
1. **Main Messages For September**

1. **FARM PLANNING - DECIDE ON CROPS, CROP AREAS AND PLAN SEED AND FERTILISER PURCHASES:**
   NOTE SEED REQUIRED PER Lima (AND PACK SIZES AVAILABLE AND PRICE).
   (SEE LISTS, APPENDIX 3).

2. **OX-CULTIVATORS - PURCHASE RIDGER IF ONLY HAVE A PLOUGH 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 BULLETIN(S), CONSTRUCTION OF CALF PENS, IMPROVED KRAALS, INFORMATION ON VACCINATION AGAINST E-CF.**

5. **HORTICULTURE - DIMBA 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 fertiliser 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 fertiliser needed and how much this will cost.

   iii) It is useful to plan the "early season" or Oct - Dec planted crops first as the total area of these is (usually) limited by the amounts of labour available (or labour plus oxen). (Land is usually not short). Typically a hoe cultivator would be able to cultivate some 1 1/3 hectares or over 5 Limas of early season crops and, with one pair of oxen, some 3 hectares 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 on the average. Farmers growing groundnuts usually have 1 or 2 Limas only of this crop (Lima = 1/4 hectare).

   iv) Some crops like cotton can be considered only by farmers with suitable soil (not very sandy).

   To grow hybrid maize the cost of seed and fertiliser is high. (fresh seed should always be bought, saved hybrid seed gives poor yields)

   Thus for 2 Limas hybrid maize needed is:

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 kg MM752</td>
<td>128-50</td>
</tr>
<tr>
<td>or 10 kg MM604</td>
<td>72-00</td>
</tr>
<tr>
<td>and 2 bags X</td>
<td>190(196)</td>
</tr>
<tr>
<td>and 2 bags Urea</td>
<td>142-00</td>
</tr>
<tr>
<td>Total (MM752)</td>
<td>461-50</td>
</tr>
<tr>
<td>&quot; (MM604)</td>
<td>405-00</td>
</tr>
</tbody>
</table>

   v) Some calculations have been done for a range of crops to compare the profits per day of work or "manday" that can be expected under good smallholder management (after deducting the cost of seed, and fertiliser if recommended).
vi) Crops like groundnuts needing a lot of labour, especially for shelling, give a relatively low 'return' to each day needed (to grow one hectare). Also the cost of groundnut seed is high if it has to be bought (K489 for 40 kg for 2 Limas). (if own seed, priced at producer price 40kg is K168). The table shows a "return" of K11 for each day for producing shelled Chalimbana but K16 if it is sold unshelled because the labour of shelling is saved but the price for the contained nuts (in 4 bags of 30 kg) remains the same.

However, for hybrid maize the return per manday of work is more than 3 times more or over K35! So if farmers can buy the fertiliser and seed they should plant hybrid maize as their first choice of early season cash crop (hoe cultivators growing test crop often have 3 to 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 fertiliser) is rather less than from hybrid maize (K18 per manday or K23 if fertiliser is used).

viii) Farmers growing dambo rice need 15 kg of seed for 1 Lima if drilled (30 kg if broadcast). 15 kg Angola Crystal Seed is K138-50. 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).

ix) Other crops like 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 fertiliser feeding weeds).

x) Local maize needs fertiliser too though less than hybrid; it is unprofitable for a farmer to use most of his valuable 'early season' labour on a very large area of un-fertilized local maize, and then have no time to grow a cash crop.

How can farmers raise the cash to buy this fertiliser? 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. Soyabeans clashes more with maize weeding because for highest yields it is best planted in December (See Appendix 2), while sunflower gives good yields planted up to mid-January and Carioca beans are planted after mid-January. (Note: If soyabeans 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 (K162-30 per 40 kg bag, unclamped, local, K129-90) it will pay farmers to buy seed of "CH 301" hybrid and to use fertiliser on it (3/4 bag x for 1 Lima), because this hybrid gives a good profit from fertiliser use (and return per manday, nearly as high as for hybrid maize). Fertiliser is not profitable on local sunflower.

xii) Fertiliser 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 3 shows how much profit can be expected for various crops from spending one Kwacha on fertiliser. Hybrid maize, cotton, hybrid sunflower and Carioca beans all give between K4-50 and K5's worth of extra yield from each Kwacha spent on the fertiliser used as recommended (See 'Guidelines on Fertiliser Use').

xiii) By growing more late season cash crops like sunflower or Carioca beans (which can be sold locally) or soyabeans, farmers can take steps up a "Lima Ladder" to becoming more prosperous.
Mt Makulu National Research Station has suggested the name Lima LADDER for a practical series of steps a small holder can take to improve his position say from a near 'subsistence' cultivator barely growing enough maize for his family to a hybrid maize grower with a good cash income (and without waiting for credit which may never come).

- Briefly, GROW MORE LATE SEASON CROPS LIKE SOYABEAN OR SUNFLOWER OR BEANS.....

- TO RAISE CASH TO BUY FERTILISER FOR LOCAL MAIZE ..... 

- THEN GROW LESS AREA OF LOCAL MAIZE (BUT WITH FERTILISER) SO THE YIELD IS EVEN MORE THAN BEFORE ..... 

- TO THEN HAVE MORE TIME (PREVIOUSLY GIVEN TO A LARGE LOCAL MAIZE AREA) TO GROW MORE GROUNDNUTS, TO SELL, OR GROW HYBRID MAIZE.
A Lima LADDER FOR EASTERN PROVINCE HOE CULTIVATORS

SEASON 4
FARMER HIRES OXEN; GROWS 4 Limas HYBRID MAIZE

SEASON 3
FARMER HALVES LOCAL MAIZE AREA, ADDS 2 Limas HYBRID MAIZE (FERTILISER OR CASH FROM SURPLUS MAIZE SOLD, OR SUNFLOWER OR SOYABEAN CROP)

SEASON 2
FARMER SELLS 4 BAGS OF SUNFLOWER FOR 4 BAGS OF FERTILISER FOR HIS LOCAL MAIZE OR BUYS FERTILISER FROM CASH FROM 2 BAGS OF SOYABEANS

SEASON 1
FARMER GROWS 1 Lima OF SOYABEANS OR 1 - 2 Limas OF SUNFLOWER (HE IS MORE LIKELY TO HAVE LABOUR FOR THIS IN LATE DECEMBER/EARLY JANUARY THAN TRYING TO GROW MORE GROUNDNUTS TO SELL, WHICH NEED LABOUR WHEN HE IS BUSY PLANTING AND WEEDING LOCAL MAIZE).

LAST SEASON
SUBSISTENCE FARMER WITH NO CASH CROP AND NO FERTILISER FOR HIS LOCAL MAIZE
APPENDIX 2
EXTENSION MESSAGES TABULATED BY FARMING SYSTEM: EXTRACT FROM APPENDIX V OF ARPT EP ANNUAL REPORT 1985/86.
SEE ALSO APPENDIX VI 'SUPPORTING MEMO. ON IDENTIFIED PRIME EXTENSION MESSAGES/DEMONSTRATION SUBJECTS:
(see Table, para. 4.4.04 for Features of the Agro-Ecological Zones)

<table>
<thead>
<tr>
<th>Farming System</th>
<th>Further Research Required</th>
<th>Topic for Extension (peak month*)</th>
<th>Topic for Demonstration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>X</td>
<td>X(Dec)</td>
<td>X X X X X X</td>
</tr>
<tr>
<td>1(a) LM. Grow more late season crops to raise cash for fert. for LM (+ crop memos).</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1(b) Sorghum. Try new sorghums as late season crop.</td>
<td>X</td>
<td>X(Dec)</td>
<td>X X X</td>
</tr>
<tr>
<td>2. LM. Try MMV400 followed by late season crops in relay.</td>
<td>X</td>
<td>X(Nov)</td>
<td>X X X</td>
</tr>
<tr>
<td>3. LM. Use MMV600 for late planting short season (Mwase/EPW)</td>
<td>X</td>
<td>X(Nov)</td>
<td>X X X</td>
</tr>
<tr>
<td>4. Sunflower - plant early</td>
<td>X</td>
<td>X(Dec)</td>
<td>X X X</td>
</tr>
<tr>
<td>5. HM. Use MM604/601 for Dec. plantings (all plantings, EPW)</td>
<td>X</td>
<td>X(Nov)</td>
<td>X X X</td>
</tr>
<tr>
<td>6. HM. Apply top early (mixed) and cover</td>
<td>X</td>
<td>X(Dec)</td>
<td>X X X</td>
</tr>
<tr>
<td>7. HM. Try herbicides (Primagram)</td>
<td>X</td>
<td>X(Nov)</td>
<td>X</td>
</tr>
<tr>
<td>8. Finger Millet. Change to Steadfast for early plantings.</td>
<td>X</td>
<td>X(Dec)</td>
<td>X</td>
</tr>
<tr>
<td>10. (Colton. Heavy soils, plant (early use fert.</td>
<td>X</td>
<td>X(Nov)</td>
<td>X</td>
</tr>
<tr>
<td>11. (Colton. Try Intercrop Cotton/ Groundnut</td>
<td>X</td>
<td>X(Nov)</td>
<td>X</td>
</tr>
<tr>
<td>12. Beans. Change to Carioca + Fertiliser</td>
<td>X</td>
<td>X(Jan)</td>
<td>X</td>
</tr>
<tr>
<td>13. Cattle. Improve kraaling; improve calf care where mortality is high.</td>
<td>X</td>
<td>X(AP)</td>
<td>X</td>
</tr>
<tr>
<td>14. Cattle. Vaccinate against ECF</td>
<td>X</td>
<td>X(VET)</td>
<td>X</td>
</tr>
<tr>
<td>15. General. Use ridgers instead of only ploughs.</td>
<td>X</td>
<td>X(Dry)</td>
<td>X</td>
</tr>
<tr>
<td>17. General. Use marker ridges and tie ridging for soil conservation.</td>
<td>X</td>
<td>X(Dry)</td>
<td>X</td>
</tr>
</tbody>
</table>

*Messages per month: Jan 1; Dec. 5; Nov. 6 Oct. 2; Dry Season 4.  
Number of extension messages 4 11 6 8 4 6 6 5 6 6 6 6(6)  
Number of potential extension demos 3 5 5 5 3 5 3 4 3 3(4)(Av)

1985/86.
APPENDIX 3

MANAGEMENT BRIEFS

A A suggested 'Barter' System For sunflower/Fertiliser

Objectives

The proposal for establishing a barter system, for sunflower initially, has the following objectives:-

1) To stimulate production of sunflower for oil extraction at Katete etc.

2) To obviate the need for small 'Lima'-sized units of credit for smaller/poorer smallholders who are in need of fertiliser for their local maize. Credit on this scale may be difficult to administer. Only about \( \frac{1}{3} \) of local maize is fertilised at present.

Some background information

1) About 50% of farmers are growing sunflower (1982/83 survey), usually in small plots of about 0.5 ha.

2) This crop is suitable for growing in all districts in the province.

3) For many smallholders sunflower is the only ECU purchased cash crop.

4) 0.5 ha gives about 4 - 5 bags of sunflower seed.

The Proposal

1) ECU buys sunflower from smallholders who produce only 3 - 5 bags each of this crop on the average. Produce receipt notes are issued for this, later redeemed for cash or cheques.

2) It is suggested that a barter system could be set up with very little extra administrative cost\(^2\) in which produce delivery notes are honoured by the ECU fertiliser sales outlets in payment for fertiliser and seeds (e.g. of the new sunflower variety CCA 81), supplemented, if necessary by a cash payment.

For example 5 bags of sunflower are worth the same as 4 bags of fertiliser plus 4 kg CCA 81 seed. The average smallholder has over 1 ha of local maize; 1 ha requires 2 bags X and 2 bags Urea.

3) It is suggested that this system could, if desired, be set up on a pilot basis first e.g. in Katete district, near to the oil mill, and later extended to other districts.

It could also be extended to other produce e.g. groundnuts, for which ECU wishes to stimulate production by smallholders.

It may be less important to extend it to (hybrid) maize where most seasonal credit currently goes, and where farmers are growing, on the average, between 2 and 2.5 ha each (i.e. those growing, which is about 30% of smallholders (1984/85 survey)).

In Katete district it is estimated that there are approximately 8 000 households growing sunflower i.e. 57% of 14 500 (1982/83 survey).

\(^{2}\) The extra administrative work is that concerned with 'balancing' the various accounts – sunflower purchases, fertiliser and seed sales.
4) In order to be effective in meeting these objectives wide publicity is needed within the selected district and fertiliser made available at the same place and time as the sunflower crop is purchased. It is unlikely that seed can be available at this time - perhaps a 'credit note' for seed could be given, although this would involve some additional administrative work.

B) Provision Of Credit For Ox Equipment

Data from EPAD Research and Evaluation Unit's small farm survey of 1982/83 together with that of 1984/85 indicates that a majority of ox-owners in Chadiza district, half those in Petauke and a lower proportion in Chipata (37%) and Katete (27%), do not own ridgers.

Setting this information against estimated numbers of ox-owners in these districts gives the following result:

<table>
<thead>
<tr>
<th>District</th>
<th>% of ox-owning households</th>
<th>No. of ox-owners</th>
<th>No. with ridgers</th>
<th>No. with Ploughs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lundazi</td>
<td>10</td>
<td>2 000</td>
<td>2 000</td>
<td>540</td>
</tr>
<tr>
<td>Chipata</td>
<td>10</td>
<td>2 800</td>
<td>1 765</td>
<td>2 490</td>
</tr>
<tr>
<td>N &amp; S</td>
<td>50</td>
<td>8 000</td>
<td>5 880</td>
<td>4 920</td>
</tr>
<tr>
<td>Katete</td>
<td>50</td>
<td>4 400</td>
<td>2 440</td>
<td>4 250</td>
</tr>
<tr>
<td>Petauke</td>
<td>15</td>
<td>4 500</td>
<td>655</td>
<td>3 555</td>
</tr>
<tr>
<td>Nyimba</td>
<td>15</td>
<td>4 400</td>
<td>2 440</td>
<td>4 250</td>
</tr>
<tr>
<td>Chadiza</td>
<td>50</td>
<td>4 500</td>
<td>655</td>
<td>3 555</td>
</tr>
</tbody>
</table>

Thus an estimated 8 960 or 41% of ox-owners are without ridgers (and 5 945 or 27% are without ploughs).

It is calculated that weeding with a plough takes twice as long (2 passes per furrow) as with a ridger, and that making ridges with a plough also takes at least twice as long as with a ridger.

It is argued that the 40% of ox-owners without ridgers could considerably expand their crop hectares and/or increase their maize yields through better weed control if they were able to adopt the use of ridgers. (Ploughing and ridging as land preparation also gives better weed control than ridging only and ox-owners in Lundazi without ploughs (73%) and those in Katete (39%) would be well advised to acquire this implement.

There is a clear case here for ECU to extend their seasonal credit programme to ox-ridgers and ploughs, as well as for firmly adopting a policy of not giving such credit year after year to the same farmers. (Such credit at present is for hybrid maize seed and fertiliser only).

For farmers adopting ox-cultivation for the first time, for example through ECU’s medium term credit programme, consideration should be given to introduction of the Malawian Agrimal toolbar, on which plough and ridger bodies can be interchanged easily in the field. Cost in US dollars for this equipment brought in by the EPAD project (Farming Systems) was:

24 See ARPT Annual Report 1986/87 for a note on a serious design/material defect in the Zambian Northlands ridger which is however to be corrected in future supplies. Failing this correction ECU should bring in ridgers from Zimbabwe and/or Malawi.

25 ECU's medium term credit also includes ox-carts; an estimated 55% of ox-owners do not have ox carts.
C) Brief On Why Fertiliser Should Be Included in The Standard Credit Package

D. Brief on Supply Adequate Quantities of X Fertiliser To Eastern province (Oct. 1986)

1. Research over several years has shown that, on the plateau, 4 bags of 'X' compound fertiliser per hectare will give a farmer an extra 500 kg or 50% more yield than unfertilised cotton.

Trials are continuing this season at Masumba, but the results so far indicate that an extra 400 kg or 33% more yield than that from unfertilised cotton can be expected on the richer valley soils.

2. This means that, by merely providing fertiliser in their package LINTCO could have increased production in the province (in 1984/85 season) as follows:

- 3,980 hectares on the plateau produced 2,402,035 kg cotton. With fertiliser the same hectarage could have produced an additional 1,201,020 kg.
- 1,760 hectares in the valley produced 1,245,175 kg cotton. With fertiliser the same hectarage could have produced an additional 415,025 kg.

Total production with fertiliser would then have been 5,263,255 kg instead of 3,647,210 kg.

3. It should be relatively easy for LINTCO to provide fertiliser for cotton and so dramatically increase cotton production. To produce more by an increased hectarage is much more difficult because this crop competes severely for labour with local maize, hybrid maize and groundnuts.

4. For the individual farmer the extra yield of, for example, +500 kg above a yield with reasonable management of 1,000 kg/ha is worth K495 (Grade A). This is against an outlay of K192 (assuming fertiliser will cost K48 and cotton price is 99N).

Fertiliser is only recommended, however, on November planted cotton which will be sprayed.

D. Brief on Supply Adequate Quantities of X Fertiliser To Eastern province (Oct. 1986)

1. Small farmers in the province are advised to use X fertiliser for maize. The 'Lima' recommendations are to use X fertiliser when applying basal to maize after the crop emerges. The extension service of the Department of Agriculture has been active in promoting this usage. Indeed GRZ has, under the EPAD project, reorganised the extension service in the Province to ensure the maximum effectiveness of such recommendations for small farmers. The imbalance of this particular recommendation and practice is underlined by the fact that the Eastern Province is now one of the leading producers of marketed maize in Zambia. We now produce more than two million bags of marketed maize in a year.
2. In the past, great quantities of 'D' compound have been sent to Eastern Province. Farmers are only too well aware that 'D' compound is very low in the nitrogen which their maize requires (10% only compared to X's 20%). 'D' compound is indeed to a large extent ineffective on maize. Small peasant farmers can hardly be expected to make their own equivalent of 'X' by trying to mix appropriate quantities of 'D' and Urea.

3. It was very disappointing to find therefore, that in 1985/86 season some 14 545 tonnes of 'D' were sent to Eastern Province by NAMBOARD compared with only some 1 800 tonnes of 'X'.

4. This matter was raised again at a workshop in June this year at Petanke which brought together Zambian and consultant staff of the three major IBRD Agricultural Development Projects (Southern, North-Western and Eastern Provinces). At their workshop it was stated that NAMBOARD would give immediate attention to the problem so as to ensure that the type of fertiliser provided is appropriate to the needs of each province (that is 'X' in Eastern Province).

5. Again this season 'D' fertiliser is very much in evidence in the Province. Some 'X' has now arrived but that is no assurance that the 16 000 tonnes or so of X basal required for our maize crop will be forthcoming. With the right (i.e. 'X') basal at the right time a further 250 000 bags of marketed maize could be produced in this Province.

6. 'D' compound is imported using scarce foreign exchange. If basal has to be imported until such time as our own local production is adequate, then why not import 'X', the type that Zambia's smallholders need, instead of the type 'D'. There is considerable evidence to show that world supplies of fertiliser (especially of nitrogen) are plentiful.