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The Contribution of Economic Analysis in Developing Promising Research Agendas: A Maize Nitrogen x Phosphorus Trial in Zimbabwe

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Introduction

Maize accounts for 70% of Zimbabwe's cereal growing area. Its productivity, particularly in the communal areas, is limited by both soil and moisture constraints. Most soils in communal areas are coarse-textured sands derived from granite. They are inherently deficient in nitrogen and phosphorus (Grant 1981; Mashiringwani 1983), and have a poor water retention capacity. The majority of these areas are situated in marginal rainfall zones and do not have irrigation facilities, making the application of large quantities of fertiliser risky and uneconomical.

A maize fertiliser x plant population on-farm trial conducted by the Agronomy Institute at 19 sites showed that applying more than 50% of the recommended fertiliser—in most cases 350 kg Compound Z 8:14:7/ha and 400 kg ammonium nitrate/ha—was uneconomical (Whingwiri *et al.* 1987; Mataruka *et al.* 1987). However, maize response to nitrogen and phosphorus separately could not be assessed by using compound fertilizers. To establish economically optimum levels for both nitrogen and

phosphorus, researchers should use trials with straight fertilizers. This paper discusses results from two seasons of an on-farm trial being conducted by the Agronomy Institute to determine the effects of nitrogen x phosphorous on maize.

Trial description

The trial was conducted at eight sites in Zimbabwe natural regions II, III, and IV during 1986/87, a season characterised by poor rainfall, and 1987/88, during which there were relatively good rains. Four of the sites used in 1986/87 were written off due to drought. Total rainfall received from planting to harvest, along with the amount received one week before and two weeks after topdressing, are shown in Figures 1 and 2. The average soil pH, soil nitrogen after incubation, and P_2O_5 statuses of the sites are given in Table 1. In general, the soils exhibit relatively high phosphate levels.

The maize hybrid R201 was planted at a spacing of 30 cm by 90 cm. The experimental design was a randomised block with three replications. Nitrogen

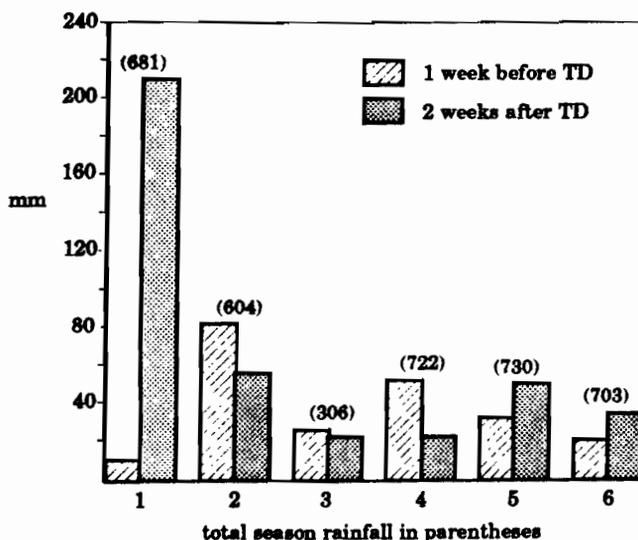


Figure 1. Precipitation at six sites used for on-farm fertiliser experiments with maize in Zimbabwe, 1987-88

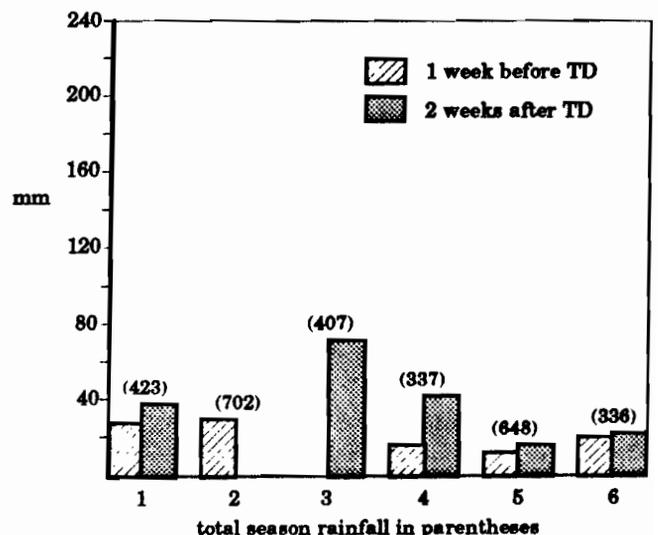


Figure 2. Precipitation at six sites used for on-farm fertiliser experiments with maize in Zimbabwe, 1986-87

Table 1. Soil nutrient status for two seasons at eight sites used for on-farm fertiliser experiments with maize in Zimbabwe

Site	1986/87			1987/88		
	Resin P ₂ O ₅ (ppm)	N after Incubation (ppm)	pH (CaCl ₂)	Resin P ₂ O ₅ (ppm)	N after Incubation (ppm)	pH (CaCl ₂)
Ntabazinduna*	40	41	6.1	19	44	5.6
Esigodini*	05	06	4.8	33	53	5.1
Mutoko	15	06	5.5	27	12	6.0
Chiwundura	12	20	4.7	21	21	6.7
Zvimba*	21	11	6.5	05	20	4.5
Zaka	30	41	5.7	30	41	5.7
Marange North	36	40	5.0	33	02	4.5
Rushinga*	-	-	-	09	08	6.9

*Sites written off due to drought in 1986/87

treatments consisted of basal applications and a top dressing, (Table 2) both of ammonium nitrate. A blanket application of 60 kg K₂O per hectare was applied as muriate of potash to all the plots at planting.

Results and discussion

In 1986/87 (a dry season), only four sites could be analysed, whereas all eight sites were analysed in 1987/88. In the latter season, the distribution of rain was favourable except at two sites.

The statistical analysis revealed differential responses for the different sites. Where rainfall was high and well distributed, particularly during the period around the nitrogen topdressing, there was a response to the topdressing. Where the distribution was poor (Fig. 1 and 2), there was little response. The sites were then grouped into two categories, depending on the rainfall received around topdressing. Six sites fell into the high rainfall groups and six into the low rainfall group. The high rainfall sites represent the levels and

Table 2. Fertiliser treatments (kg/ha) in on-farm experiments with maize in Zimbabwe, 1986-88

P ₂ O ₅ *	Basal	Nitrogen Top	Total
0	0	0	0
20	30	0	30
40	30	30	60
60	30	60	90
	30	90	120

* as single superphosphate at planting

distribution of rainfall normal for natural regions II and III. The low rainfall sites represent what farmers in region IV might expect in most years.

In both the high and low rainfall environments, there was a positive response to 30 kg N/ha applied as a basal-dressing. Further increase in applied nitrogen up to 90 kg N/ha (topdressing up to 60 kg N/ha) significantly increased grain yield in the high rainfall group. No advantage for treatments beyond the basal application was achieved in the drier areas (Fig. 3). From Figures 1 and 2, it would appear that responses to topdressing were influenced by the total rainfall received from planting to harvest, as well as the rainfall distribution just before and after topdressing.

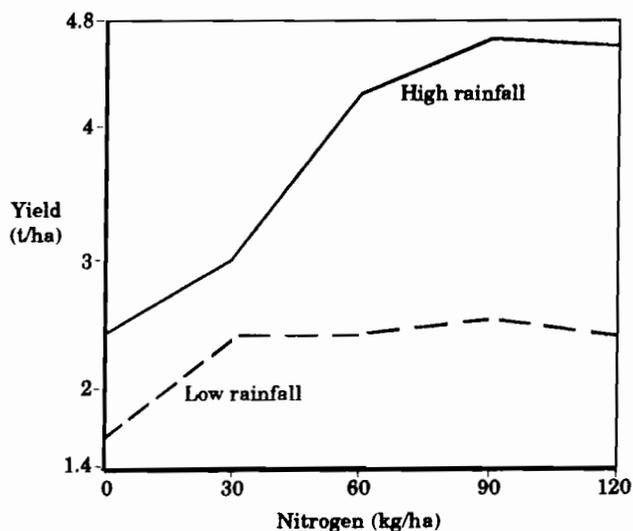


Figure 3. Yield response to nitrogen for maize under two types of rainfall environment in on-farm experiments in Zimbabwe, 1986-88

The response to phosphorus was low in both environments (Fig. 4). Under the present communal area production levels, a response to P_2O_5 levels above 18 ppm should not be expected. There was a significant increase in grain yield between zero and 60 kg P_2O_5 per hectare under high rainfall, but this was not economic. The poor response to phosphorus was probably due to the generally high inherent phosphate levels in the soils at the experiment sites.

No significant interactions between treatments were detected.

Economic analysis

Economic analyses for the high and low rainfall environments are presented for nitrogen only (Fig. 5 and 6), since P gave no technical or economic response in either situation and there was no significant interaction between N and P. For each rainfall environment, two analyses were conducted: one based on the basal application of ammonium nitrate, as occurred in the trials, and the other based on the basal application of Compound D, which reflects farmers' practices and the current recommendations.

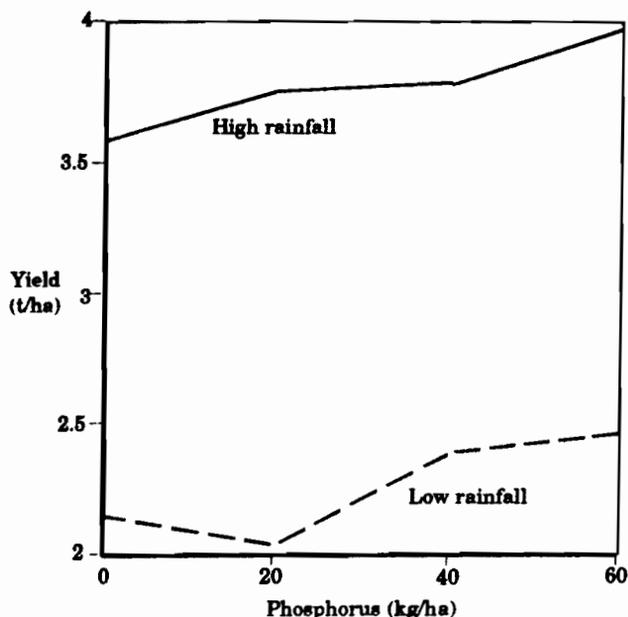


Figure 4. Yield response to phosphorus for maize under two types of rainfall environment in on-farm experiments in Zimbabwe, 1986-88

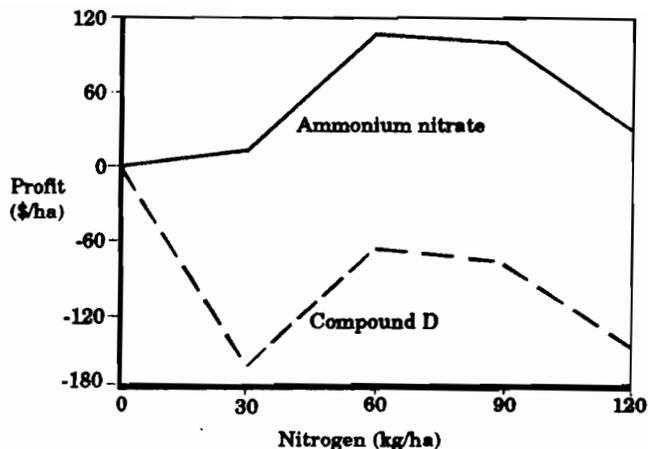


Figure 5. Change in profit, based on a 60% rate of return, from two nitrogen fertiliser treatments on maize in on-farm experiments in high rainfall environments of Zimbabwe, 1986-88

The data used to calculate these budgets are given below:

- Field price of maize = Z\$157.26
- Field price of nitrogen (ammonium nitrate) = Z\$1.26/kg
- Field price of nitrogen (Compound D) = Z\$4.82/kg
- Opportunity cost of labour = Z\$2.00/day
- Minimum acceptable rate of return = 60%

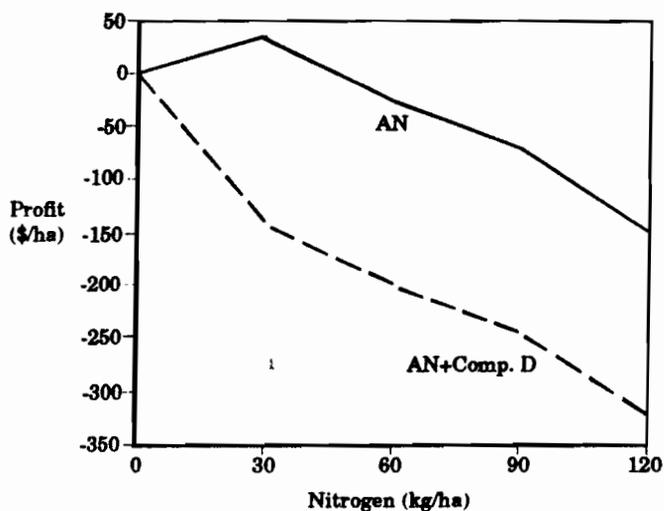


Figure 6. Economics of N in the low rainfall situation

High rainfall conditions

Figure 5 shows the profitability of using nitrogen on maize under high rainfall conditions, assuming a 60% minimum rate of return on investment.

In this situation, given a basal application of 30 kg of nitrogen (ammonium nitrate) and additional nitrogen as a single application topdress, it is economical to apply up to 60 kg/ha of nitrogen (or 174 kg/ha ammonium nitrate). This contrasts with current recommendations, which hold that farmers should apply 300 kg/ha compound D and 200 kg/ha ammonium nitrate (i.e. the equivalent of 93 kg/ha nitrogen¹). The economical level as indicated by these data is around 65% of the current recommendations, but this holds only if ammonium nitrate is used for both the initial application and the topdressing.

Figure 5 shows that applying Compound D prior to emergence is not economical. The initial loss resulting from Compound D outweighs even the benefits from the nitrogen subsequently applied as topdressing.

Low rainfall conditions

Though the same minimum acceptable rate of return is used here, the risky nature of crop production in low rainfall areas means that the required rate of return may be higher than the 60% used for analysis of the data from the high rainfall sites.

Under low rainfall conditions, if the source of nitrogen is ammonium nitrate, it is economical to use 30 kg nitrogen as a basal application. Additional applications of nitrogen result in losses, as shown in Figure 6. The economical level of nitrogen (30 kg/ha) is equivalent to 87 kg/ha ammonium nitrate. Current recommendations endorse the use of 200 kg/ha compound D and 100 kg/ha ammonium nitrate, (the equivalent of 51 kg nitrogen¹). The economical level, as indicated in Figure 6, is about 60% of the current recommendation. Figure 6 also shows that using Compound D as the basal N source is considerably less attractive than using ammonium nitrate or not using fertilizer at all, assuming farmers require a 60% return on their cash outlay.

Discussion

Under high rainfall conditions, there was an agronomic response with up to 90 kg N/ha. However, it was economical only up to 60 kg N/ha, while under low rainfall conditions 30 kg N/ha was both the agronomic and economical optimum. In soils with marginal-to-adequate phosphorus levels, it may also be uneconomical to apply phosphate fertilizer. Thus, if profitability is the farmer's only concern, it is not economical to apply Compound D. This however may have serious consequences for soil fertility in the long run, and a long term study on phosphorus requirements may be necessary to identify any danger of soil depletion.

Although these analyses cannot be used for making recommendations to farmers, they may serve to indicate a course for further experimentation. Since there was no interaction between nitrogen and phosphorus, it seems justifiable to look at the efficiency of use of these two elements independently.

A low response to P in researcher managed experiments means that there will likely be an even lower response to P under normal farming conditions, since most farmers apply their compound basal dressings after emergence, whereas most researchers use pre-emergence applications in their trials. Recommendations for basal compound fertilizer prior to or at planting are based on the assumption of a positive response to P from these early applications. If there is no such response or if farmers do not follow these recommendations because of labour constraints, then the recommendations regarding application methods for P and initial N should be reconsidered.

Sustainability considerations may dictate applying P, but this could be done more cheaply and conveniently at a time other than around planting, which is a labour-intensive period for smallholder farmers.

Given the increasing scarcity and expense of fertilizers, there is a need to investigate ways of improving the efficiency of their use. These

preliminary results indicate the potential to substantially improve the economic efficiency of N application in maize on communal farms by:

- reducing recommended application levels
- changing initial N application from compound fertilizers to ammonium nitrate

In addition, researchers need to take into account the rainfall characteristics of the different natural regions when designing nitrogen fertilizer trials. In high rainfall areas, work needs to be done on the levels and timing of topdressing as well as on the form of basal N applications. In contrast, the emphasis in the low rainfall areas should be on optimum timing, form, and levels of initial nitrogen applications. In both areas the questions of form, timing, and levels of P applications for maintaining soil fertility require investigation.

Acknowledgement

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