# Financial imperatives for fertiliser decisions by smallholders in Myanmar

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# Financial imperatives for fertiliser decisions by smallholders in Myanmar

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## Abstract

Decision Support Tools (DSTs) to improve farm-level decisions are available widely but generally underutilised by farmers. Problems with DSTs, from user perspectives, include a lack of awareness by DST developers about end-user objectives or needs, and the typical constraints and circumstances for on-farm decision making; end users lacking compatibility with, or confidence using, computers or hand-held devices; perceived complexity of the DST or perceptions that it is a 'black box'; and lack of relevance to local conditions. In this paper we address issues of end-user objectives or needs and relevance to local conditions for smallholders in the Central Dry Zone of Myanmar. The focus is development of a DST for fertiliser management by smallholders growing cereals (rice and maize).

Substantial research within an ACIAR-funded project in Myanmar has provided information about the local farming systems and circumstances for smallholders, and their objectives, actual fertiliser decisions and perceptions about the context for their decisions. Many smallholders are conscious of factors affecting profits and the risks in their agricultural production systems. Many borrow capital to buy fertilisers and other crop inputs. Drawing on these imperatives, we set out a framework for their fertiliser decisions based on information from the project about production function responses of crop yields to added Nitrogen fertiliser. The paper includes contextual information about the farming systems and farm family issues in the Central Dry Zone of Myanmar, a review of DSTs and presentation of a simple economic framework for fertiliser decisions when finance for the input is borrowed. The loan implications are that the return has to repay the loan (including interest) and provide an extra margin to reward entrepreneurship and account for risk aversion or caution by the decision maker. Final comments relate to how existing DSTs could incorporate this type of framework, and whether it is decision support or discussion support that is more relevant in assisting smallholder fertiliser decisions.

Key words: Decision support, fertiliser management, cereal crops, Myanmar

## Introduction

This paper is focussed on farm-level decision making for fertiliser use by smallholders growing cereal crops in the Central Dry Zone of Myanmar. The context is an agricultural development project titled '*Management of nutrients for improved profitability and sustainability of crop production in Central Myanmar*' (ACIAR, 2016). The premise for this project was that cereal growers use inadequate Nitrogen (N) fertiliser and improvements could 'increase incomes and strengthen local food security of small-scale farmers and their families in central Myanmar by improved fertiliser use and associated crop management practices'. Evidence shows that (with some variation) many smallholders seem to have a good understanding of fertiliser needs and are applying appropriate amounts in appropriate ways.

Associated with the project there is interest in developing a DST to improve fertiliser decisions. This has prompted reviews of DSTs (Thar *et al.* (2018), Thar *et al.* (2020a)). Many DSTs appear to have been developed following agricultural research and development projects and have drawn together important scientific information into a platform or framework to help inform and improve agricultural decisions on management and resource use. There is substantial evidence that such DSTs are not used by farmers. Many of these tools have not been developed in consultation with farmers, and without an understanding of typical farmer contexts or decision imperatives - they are not relevant for farmers to adoption and use.

Other research has investigated the farming systems and context for smallholders growing cereal in Central Myanmar (Ramilan *et al.* (2017), Thar *et al*. (2020b)). This has found that financial imperatives and risks in making fertiliser decisions are important for many smallholders. Many smallholders borrow capital to buy fertilisers and other agricultural inputs, and the financial implications are not recognised by traditional developers and purveyors of DSTs.

In this paper we present contextual information and develop a framework for fertiliser decisions by smallholder cereal growers in Myanmar. We focus on the economic and risk-adjusted aspects of the decision, as expressed by these smallholders in discussions with them. The resulting process or framework provides a novel view of how a DST might be configured, which is different to the usual approaches taken. A related question is whether a new DST is needed, or whether an alternative discussion-support framework is more relevant. The paper presents evidence of agricultural production systems used by smallholders, and their expressed objectives and priorities; briefly reviews the status and effectiveness of existing DSTs, and provides comments by smallholders about these applications; and sets out a framework for incorporating financial, risk and return on investment requirements into any new DST or discussion-support process. Discussion of the implications and concluding comments sections follow.

## Context for smallholder fertiliser decisions in Central Myanmar

This research was conducted in the Central Dry Zone of Myanmar – see Figure 1. Field trial sites are at Tatkon, Lay Thar, Yezin and Taungoo villages in the Townships of Tatkon, Zeyarthiri and Taungoo.


Figure 1: Project locations in Central Myanmar

### *Smallholder perceptions of their farming situations*

Focus Group Workshops (FGWs) were held at the start of the project (Farquharson *et al*. (2017)). Eighteen workshops were conducted with 156 farmers attending (136 male and 20 females). These workshops investigated the farmers in the project area and their economic, social and farming system characteristics.

*Land types, cropping patterns and livestock*

Land types (as described by the smallholder farmers) were both lowland and upland, with some rainfed and some irrigated. Their descriptions of crop seasons included monsoon (rainy) and dry (winter or summer).

With respect to cropping patterns we originally thought the main crop sequences would be either rice-rice or maize–legume for monsoon-dry seasons. Although rice and maize are regularly grown in these villages, the workshop information showed that there is a diversity of crops being grown. These include legumes (lablab, black gram, groundnut, green gram, and chickpea), vegetables (onion, chilli, tomato, potato, cabbage, sweet corn, eggplant, and radish), fruit (banana, watermelon) and other (sesame, sugar cane). A typical cropping calendar for Zeyarthiri Township in 2017 is in Figure 2.

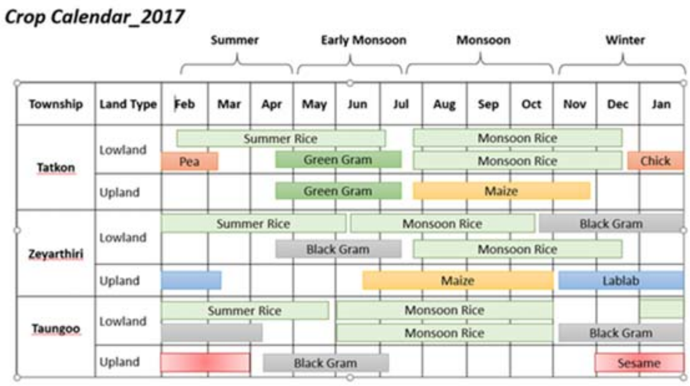


Figure 2. Cropping calendar, Zeyarthiri Township

Many of these smallholder farmers are diversifying out of traditional subsistence crops. Rice is still the major crop in Myanmar. Some smallholders are diversifying into higher-value crops and selling fruit and vegetables direct to local buyers or transporting to the Chinese border for direct sale.

*Crop varieties*

The cereal crop varieties were classified according to whether they were open pollinated, hybrid and/or high-yielding varieties (HYVs). For monsoon rice all the varieties except Palal Thwal (hybrid) and Paw San Bay Gyar (traditional fragrant) were HYVs. The maize varieties were classified as hybrids but not HYVs.

*Issues and sources of information*

Important issues raised by the farmers were market instability and price decline, their need for profits to maintain farm-family livelihoods, farm heritage, weather, quality seed, new technologies for higher yield, capital, water, fertiliser prices, mechanisation, and HYVs.

The issues identified by the farmers centred on the economics of agricultural production and the major factors generating instability in crop profits – price fluctuation (markets), weather fluctuation (crop yields) and the need for improved technology to increase crop returns. Myanmar smallholder farmers have changed from subsistence to a semi-subsistence or semi-commercial focus, so the crop economics (costs and productivity of inputs and the value of outputs) are important.

*Smallholder objectives, motivations and priorities*

The main objectives of the smallholders were profit, sustain livelihoods, family consumption and farming heritage.

*Off-farm work, labour supply and challenges*
Farmers in the workshops made many references to off-farm work. Major types of off-farm or non-farm work were farm labourer, casual work, construction, various types of work in Singapore, Thailand and Malaysia, carpenter, mining, driving and phone cabling. The young women worked on farms, in sewing/garment industry and as domestic staff. A major purpose of this work is to remit cash back to the farm family.

The daily wage rate for casual workers or farm labourers was 4,000 – 5,000 Myanmar kyats (MMK) (AU$4-5/d). The amounts sent back from working overseas ranged from 100,000 MMK per month (Malaysia) to 200,000 – 300,000 MMK per month (Thailand and Singapore) (AU$96, $192 and $290/month).

*Climate change*
Farmers in Sein Sar Pin village said that during the past 10 years they have seen more of irregular weather patterns such as sudden heavy rainfall during harvesting time and drought during cultivation time, which leads to crop failures and losses. Also, there are pest outbreaks after rain. In Lay Thar and Moe Te Kwin villages farmers reported that the yield of crops has declined over the last 10 years. They cannot predict the weather for crop cultivation nowadays. There have been extreme heat conditions. One farmer talked about El Nino having impact on the weather patterns with extreme heat and extreme cold conditions. Several comments were to the effect that there was extreme heat and drought conditions causing yields to fall.

As well, there were shorter monsoon seasons (monsoon starts late and finishes early), with associated pest and disease outbreaks. Increased weather uncertainty has meant farmers do not apply many inputs into crops since they buy most of the inputs on credit and cannot afford to take the risk of losing their investment in inputs.

*Knowledge of fertiliser concepts*
The smallholders used Urea and Compound (NPK) fertilisers as basal and in-crop fertiliser applications. They were generally aware that using fertiliser can increase the yield of the crop. They use fertiliser brands from Armo and Awba companies, and fertiliser imported from China and other countries.

Some farmers said that they rely more on using pesticides for yields than on fertilisers. Some said that they rarely use fertiliser because there is no dam water, because of climate change, because of market instability and no crop price guarantee. They buy fertilisers from village or township shops. When deciding how much fertiliser to use, some look at plant condition (their experience), some have attended training, and in other cases fertiliser company agents tell them how much to use. They mostly buy on credit – there are no contracts and the loans are on trust.

## Fertiliser usage

From a survey of 600 smallholders in the project area, applications of Urea and Compound fertilisers are shown in Figure 3. Smallholders also split the fertiliser applications as shown in Figure 4.

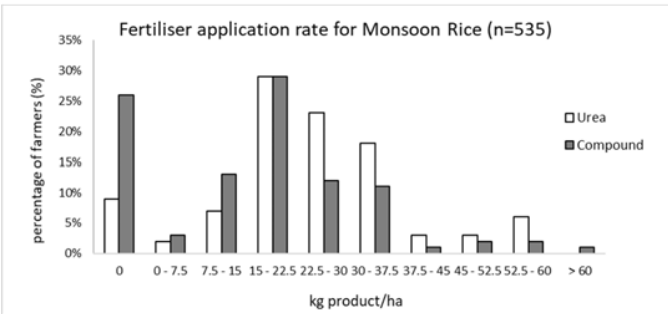


Figure 3. Distribution of fertiliser application rates

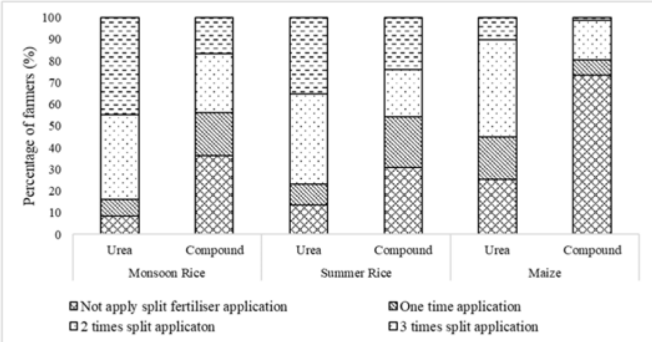


Figure 4. Split applications of fertiliser by type of crop and fertiliser

Further information is shown in Figure 5 about the timing and rates of fertiliser application for monsoon and summer rice.

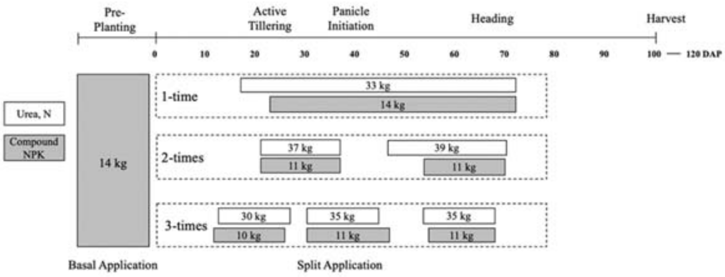


Figure 5. Monsoon rice fertiliser timing and rates

## *Rice and maize trial yields responding to N fertiliser*

On-farm and research station trials were conducted as part of the project, with six levels of N fertiliser tested to generate yield response (production) functions to added fertiliser. Thornley and France (2007) noted that diminishing returns responses are often observed in biological responses. A crop simulation model, the Water and Nutrients Management Model (WNMM) (Li et al., 2007) was calibrated and validated to predict cereal responses to the added N fertiliser. Crop yields are shown in Figure 6 with a Mitscherlich-Baule function fitted. Crop simulation responses are shown in Figure 7. Relationships between yields on farms and in experiments were established by Davidson and Martin (1965); the results of crop simulations are likely to overstate the yields achievable on farms.

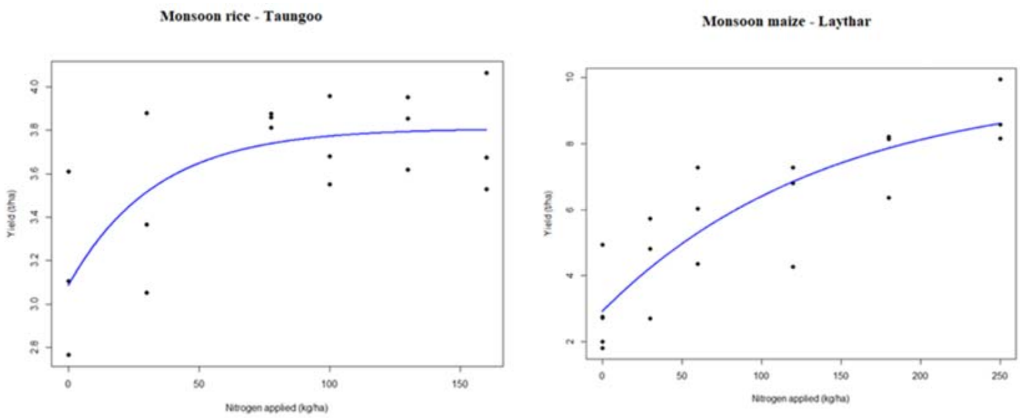


Figure 6. Monsoon rice and maize trial results and fitted Mitscherlich-Baule functions

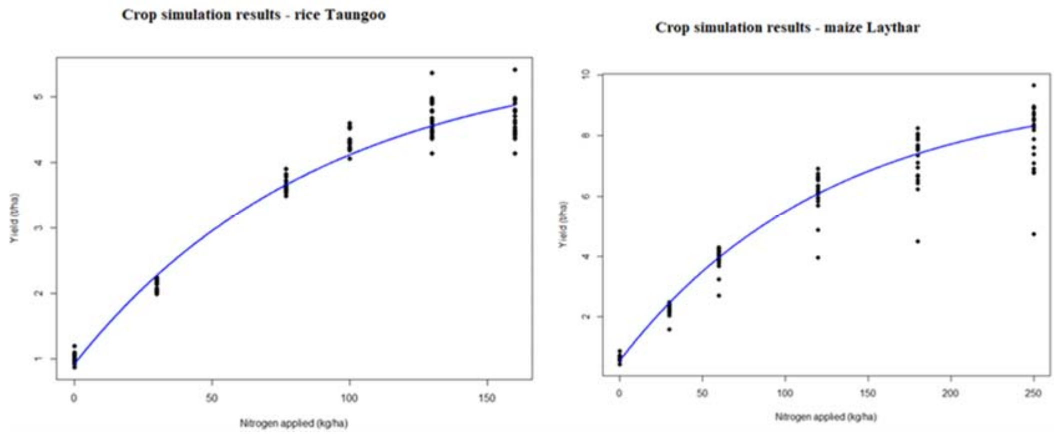


Figure 7. Monsoon rice and maize simulated results and fitted Mitscherlich-Baule functions

### *Summary*

Despite initial assumptions that smallholder cereal growers in the Central Dry Zone of Myanmar are relatively unsophisticated in their fertiliser management decisions, the information presented here shows that many of the farmers understand fertiliser management decisions and apply substantial amounts to their crops as both basal and split applications within the crop growth period. The main objectives of these smallholders included profit, sustaining livelihoods, family consumption and farming heritage. They were concerned about several issues including market instability and price decline, and irregular weather patterns associated with climate change.

## Review of Decision Support Tools

Agricultural DSTs are many and available widely. They can have a range of potential uses and advantages for users such as providing solutions for crop preparation and planning, sowing and harvesting, as well as providing recommendation for different management practices (e.g. seed rates, irrigation, pest and disease remedies, and fertiliser application) according to seasonal climate variability (e.g. rainfall and temperature) (Churi *et al.* (2013)). Despite these efforts, there is limited evidence of the acceptance and successful uptake of these tools by farmers (McCown (2002a); Kerr (2004); Alvarez and Nuttall (2006), Schtienberg (2013)).

Lack of user participation in the development of DSTs is argued to be the main cause for low uptake by farmers: the tools are not relevant for growers as they have been developed based on what developers and scientists considered necessary for decision support and not on practical farmer needs (McCown (2002b); Walker (2002); Lynch and Gregor (2004); Muchow (2011); Prost *et al.* (2012)). Further work has been conducted to improve DSTs by using participatory approaches in their construction and considering user-centred aspects for successful delivery of DST to farmers (Parker and Sinclair (2001); Carberry *at al.* (2004); Jakku and Thorburn (2010); Thorburn *et al.* (2011); Van Meensel *et al.* (2012); Valls Donderis *et al.* (2014); Lacoste and Powles (2016); Antle et al. (2017); Smith *et al.* (2017)). Yield Prophet (Hunt *et al.* (2006), Hochman *et al.* (2009)) is an example of farmer participation in using a systems approach for decision making as it integrates the FARMSCAPE (Farmers', Advisers', Researchers', Monitoring, Simulation, Communication And Performance Evaluation) program (Hochman *et al. (2000)*; Carberry *et al.* (2002)).

High initial costs can limit adoption of DSTs by farmers by constraining the availability of finance for investment (Pannell *et al*. (2006)), although some DSTs are free (e.g. DSSAT, IRRI-RCM). When users must invest time and effort, and sometimes cash for registrations, licenses or soil analysis, and to collect information for DSTs, it is important that they benefit. A study by Rose *et al.* (2016) suggested that tools are likely to be trialled and tested by farmers if they are free or if a grant supports purchase. Other factors affecting the adoption of DSTs include: human capital (skills, education, age, farmers personalities, objectives) (Cox (1996); Carayannis and Sagi (2000);

Asfaw and Admassie (2004); Alvarez and Nuttall (2006); Lindblom *et al*. (2014); Lundström and Lindblom (2018)), and simplicity and accuracy (Jørgensen *et al.* (2005); Nguyen *et al.* (2019); Rose *et al*. (2016)).

Moreover, current models are limited in representing real situations of yield-limiting factors and deal with only one aspect of crop production while crop management decisions are multidimensional under changed bio-physical and socio-economic conditions (MacCarthy *et al.* (2017)). An automated data collection process using sensors or other mobile devices from web-based sources for climate forest or economic data including market prices can be an area for improvement (Capalbo *et al.* (2017)).

Taking an explicit economic focus for decision support, Stott *et al.* (2018) developed a Dairy Nitrogen fertiliser Advisor which included marginal economic analysis to inform dairy farmers and advisors about how a range of N applications for particular cases might add to profits. The tool contained response functions derived from a meta-analysis of experiments in pasture yield response trials.

Despite the apparent lack of potential success for DSTs, future prospects can consider two important points: 'computing is prevalent in everyday life and that simulation provides a cost effective and attractive means to quantitatively explain biological phenomena and predict outcomes under different environmental stimuli' (Newman *et al.* (2000)). Most evaluations of DSTs are for their use in developed countries (McCown 2002). In the case of developing countries with smallholder farmers, the limited experience of use of DSTs suggests that there is some potential. Working with farmers in India, Meinke *et al*. (2003) and Gadgil *et al.* (2002) used crop models to demonstrate possible management responses to climate forecasts. Both these studies concluded crop models were an effective way to achieve benefits based on information about weather and climate. A participatory workshop conducted in Sri Lanka for the construction of a DST also showed promising results for adoption with interest from farmers and policy makers (Cain *et al*. (2003)). This study explored the need for multidisciplinary approaches. Carberry *et al.* (2004) conducted a workshop with farmers in Zimbabwe using APSIM crop simulations as the basis for discussion. The famers found that the simulation results were relevant and credible. This study concluded that the model used within an action research framework lead to learning and increased the overall interest of farmers. It did this by facilitating a high level of farmer-researcher interaction.

Sam Coggins (ACIAR, personal communication) quoted Myanmar farmers discussing the IRRI Rice Crop Manager saying they want advice '*adapted to financial constraints'*, because '*unaffordable fertilizer prescriptions are useless*', and '*farmers optimise for risk reduction and profit (not yield*)'. Coggins also quoted a DST practitioner from Kenya: '*There are all these conferences, round tables blah blah blah. Experts assume farmers' needs, design solutions for them and the solutions fail*'.

## Framework for fertiliser decisions and decision support

### *Farmer involvement in developing decision support*

In much of the literature reviewed above, the DSTs were developed without input from, or proper consideration of the needs and objectives of, farmers. As well as being good practice if the aim of a DST is to be used by and useful to end-users, the interactive processes of developing the DSTs can provide valuable guidance about approaches to help farmers make decisions or facilitate discussions about such decisions.

### *Farmer objectives, knowledge and practices*

Smallholder farmers in Central Myanmar are semi-subsistence, selling at least part of their farm produce in markets for cash to meet family needs. From the FGW discussions, smallholders in central Myanmar are interested in profits, sustaining livelihoods, family consumption and farming heritage. Some quotes were: '*we don't know the cost of production because we haven't really noted it down*', '*we would rather do nothing if the cost of production and the income we get are the same*', and '*we would like to get 3 kyats if we invest 1 kyat*' (Farquharson *et al.* (2017).

Issues of concern for these farmers included market instability, price decline, need for profits, maintain family livelihoods, farm heritage, weather, quality seed, new technologies for higher yield, capital, water, fertiliser prices, mechanisation, high yielding varieties, market prices. There were many references to off-farm work.

Most of the DSTs reviewed above do not consider the economic objectives of farmers in their decision making.

## *A production economics framework*

The ACIAR (2016) project included six N fertiliser rates for both rice and maize crops to predict the pattern of yield responses at the field level. Trials were conducted on both farmer fields and on research stations. A production function analysis is possible from these results. But the well-known 'tyranny of site and season' means that measured responses were variable. This can be seen in Figure 6.

The WNMM simulator was also used to predict the cereal yield responses based on the field trial results. These results (see Figure 7) indicate that N is a risk-increasing input since the spread of predicted yields is greater at higher levels of fertiliser application. The simulated yields reasonably match the field trial responses in terms of maximum yields and response rates to N fertiliser. Crop simulations do not include the effects of weeds, pests and diseases on crop yields.

## *Some old truths revisited*

With respect to the economics of fertiliser recommendations, it is worthwhile remembering that, '*Precision is pretence and great accuracy is absurdity*' (Anderson (1975)) and be aware of flat economic responses (Pannell (2006)) over a range near the economic optimum.

In considering DSTs, the farmer makes the decision, not the scientific researchers. For individual farmers it is their own goals, situations and expectations of outcomes that are important. The farmer decision maker's subjective opinions of yield responses and prices are important. Anderson *et al.* (1977) distinguished between 'objective' and 'subjective' probabilities. Subjective opinions and probabilities, 'a personal concept of probability … incorporating the degree of belief or strength of conviction an individual has about a proposition' (Anderson *et al*. (1977), p.18), are the appropriate basis for farm decisions. But the subjective probabilities held by the farmer must be (1) consistent with the axioms and calculus of probabilities, and (2) consistent with the degree of belief really held.

The relationships between yields on farms and in experiments (Davidson & Martin, 1965) must be remembered when interpreting field trial or crop simulation results with farmers. Experimental trials conducted on research stations may show unrealistic yield responses to crop inputs.

CIMMYT (1988), provided premises for smallholder decision making:

1. Farmers are concerned with the benefits and costs of particular technologies;
2. They usually adopt innovations in a stepwise fashion; and
3. They will consider the risks involved in adopting new technologies.

## *Farmer decisions accounting for production responses and risk*

Important aspects of fertiliser decisions for smallholders in Myanmar are that they often borrow capital to purchase fertiliser, and that their production environments are very risky due to weather variability, water supply uncertainty, the effects of climate change and product price variability (they have no market power).

The bio-physical evidence from the field trials about yield responses to fertiliser, and from crop simulations, is that crop yield responses to incremental N inputs increase at a decreasing rate (diminishing returns). Given the CIMMYT premises above (especially adoption and testing in a stepwise fashion), the decisions can be characterised as in Figure 8.

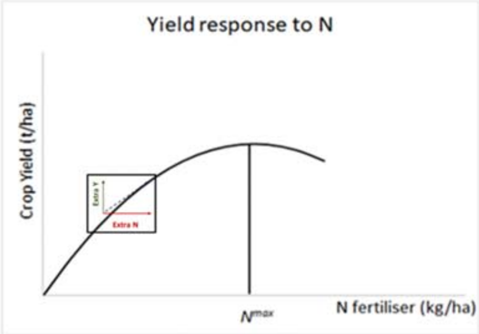


Figure 8. A small decision on the production function

A partial budget can be developed for the (small) decision by considering only the extra costs and additional revenue. Marginal Costs (MC) and Marginal Revenues (MR) can be evaluated using farmer's prices or price expectations and their expectations or beliefs about yield responses. This information allows a marginal analysis for a relevant part of the production function. The decision rule is to apply fertiliser if MR > MC by enough to allow for the risk of not getting the expected yield.

### *The Marginal Rate of Return*

The marginal rate of return (MRR) on extra capital invested is calculated as the change in Net Benefit (NB) (NB = MR – MC) divided by the extra (investment) MC. The percentage MRR is NB/MC x 100. Investment in fertiliser can be considered as working capital. The MRR here is return before interest.

An example is to borrow $1 and invest in Urea to use on a crop that has a growing life less than a year, with a consequent yield increase. If the farmer receives a (net) extra return of $1.50 then he or she can:

- use $1 to pay back the loan principal;
- the $0.50 that remains can cover interest for the period of the loan, provide a profit or return to entrepreneurship, and cover the risk of adverse outcomes;
- providing a 50% return before interest on the $1 investment.

### *Target (hurdle) rate of return*

How much extra might smallholders require from an annual crop beyond repaying the principal, i.e. how much MRR before interest and net profit? First approximations suggested by CIMMYT (1988) were (1) twice the interest cost of capital to cover interest and for profit and to allow for risk, or (2) a 50 – 100% return before interest on investment. On the first basis, if capital costs 20% interest p.a., the hurdle rate for the MRR before interest would be 40%. The second rule suggested by CIMMYT is a 100% return on investment (the '2 for 1' rule). If $1 is borrowed, a (net) return of $2 is required. From this the $1 principal is repaid, and the remaining $1 return before interest covers the interest and gives an extra return for entrepreneurship and risk aversion. With risk aversion, a higher target rate will require more certainty of a higher yield increase or imply use of less fertiliser.

### *What is the investment criterion used by smallholders in the Myanmar study?*

How much would smallholders expect as a return before interest on investment in fertiliser (for a crop with a life of a year or less) to prompt adoption? It is for them to decide! One smallholder quoted: "*we would like to get 3 kyats if we invest 1 kyat*", this implies a 200% MRR. This target MRR information is specific to farmers and they would need to specify it themselves.

### *Implications for decision support*

There are several important implications for agricultural DSTs from the foregoing.

A DST developed with a 'top-down' perspective, i.e. without considering or consulting with the end-users (farmers), is unlikely to useful for farm-level decision making. This is not new, several authors have recognised this point, including McCown (2002b), McCown (2002a), Carberry *et al.* (2002), and Hochman *et al.* (2000).

Any program or tool that provides a precise, prescriptive N fertiliser decision recommendation (rate) is unrealistic, given the inherent variability or uncertainty of underlying bio-physical (based on climate variability) and economic variability (Anderson (1975), Pannell (2006)). Any DST that provides a single 'economic optimum' rate is likely to be wrong for these reasons.

Programs and tools need to allow farmers to use their own expectations about, and estimates of, yields, prices, costs and interest rates.

Given that the context for smallholder fertiliser decisions is likely to be that they borrow capital to buy the fertiliser, the farmer making a decision is likely to encompass aspects of repaying the loan principal and paying the interest on it, and requiring an extra margin of profit for risk and entrepreneurship. This process can be accommodated by a partial budget framework to calculate an MRR before interest and comparing with target or hurdle rates before and after interest. The simple yet powerful partial budget required is easily constructed, but it has not been used by existing DSTs. This method is consistent with the recommendation that farmers use their own estimates, information and preferences.

### *Decision support or discussion support*

Stott *et al.* (2018) characterised their DST as being designed to enable farmer users and their advisers to test their intuition and judgements when making their N decisions. Rather than prescribing a fertiliser decision or recipe for farmers who are already making such decisions, informed as best they can be one way or the other, the DST can provide more information about a decision or the implications of varying the decision.

Another possibility for discussing fertiliser decisions or testing intuition is if a farmer has decided to apply an amount of fertiliser, he or she could use the tool to test the reasoning based on the information provided in the tool. This could include plant responses developed from crop simulators to check against subjective yield change estimates.

Another use for a tool with more explicit economic parameters (prices) could be to see what happens if there is an expected change in relative prices (prices of inputs and/or outputs) on the fertiliser decision. This information from a tool could allow individual farmer contemplation of the decision and a range of possible outcomes or promote discussion about this critical decision among a peer group of farmers (Bill Malcolm, personal communication).

## Conclusion

In this paper we have considered cereal crop fertiliser decisions by smallholder farmers in Central Myanmar. Given the circumstances and constraints under which they operate, we found that their fertiliser (Urea and Compound) decisions seem reasonable in terms of general quantity applied and timing to gain the most yield impact during the crop growth period, as well as when extra costs and extra revenues are taken into account.

The next question has been about possible improvements to these decisions through the development of a DST. To provide extra information, a literature review of agricultural DSTs indicates that many have been developed but end-users have not been enthusiastic to use them. Several commentators have remarked on the problem of the 'poor fit' of DSTs and farmers, being in part a result of researchers developing such decision tools when the farmers (end-users) have not been intricately engaged with and consulted in the development and planning process.

Discussions with smallholders in the project area in Central Myanmar support the conclusion that their shift from subsistence to semi-subsistence or semi-commercial agriculture has meant that their fertiliser decisions are much concerned with the extra profits and the extra risks that might be associated with these decisions. In addition, and relatedly, financing the extra input is always problematical; the finance for purchased inputs must often be borrowed with the need to repay the loan.

This information from the farmers in Central Myanmar led to a focus in this paper on the fertiliser decisions accounting for economic incentives and risk perceptions. A framework is presented where traditional agricultural production economics is used together with established thinking about making risky decisions.

This approach to thinking about smallholder fertiliser decisions has implications for developing DSTs as most existing tools do not consider the economic, finance or risk dimensions. In addition, agricultural economic thinking about the absurdity of being prescriptive about precise fertiliser rates, of being ignorant of the reality and implications of flat economic responses, and of risk aversion by decision makers, has substantial implications for DSTs developed to be relevant to farmers when making specific recommendations.

We conclude that assembling bio-physical and socio-economic information and using it for purposes of discussion support rather than recommendations for specific decisions is the way ahead.

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