Improving Access and Utilization of Fertilizers by Smallholder Farmers in the Limpopo Province of South Africa

Report No. 3

ICRISAT
INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS
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ACRONYMS

ACIAR	Australian Centre for International Agricultural Research
CAN	Calcium Ammonium Nitrate
HSRC	Human Science Research Council
ICRISAT	International Crop Research Institute for the Semi-Arid Tropics
LAN	Lime Ammonium Nitrate
LIMPAST	Limpopo Agricultural Strategic Team (farmer-based organization)
LPDA	Limpopo Department of Agriculture
MAP	Mono Ammonium Phosphate
N	Nitrogen
NEPAD	New Partnership for Africa's Development
NPK	Nitrogen, Phosphorous, and Potassium
NTK	Northern Transvaal Kooperasie
PPP	Public–private partnerships
SPSS	Statistical Package for Social Scientists
SADC	Southern African Development Community

Introduction

1.1. Background

Africa is a rural continent and agriculture is by far its most important economic sector. More than 70% of Africa's population is directly engaged in agriculture. Traditionally, farmers have cleared land, grown a few crops, and then moved on to clear more land, leaving the land fallow to regain its fertility (Sanchez 2002). However, the 3% annual growth in population – among the world's highest – now forces farmers to grow crop after crop on the same land, "mining" or depleting mineral nutrients from the soil while giving nothing back, and to bring marginal land into production (Africa News Network 2007).

Today Africa faces a soil fertility crisis. African soils are losing an estimated $4 billion worth of soil nutrients annually. Three-fourths of the farmland in sub-Saharan Africa is plagued by severe nutrient depletion and 46% of the African continent suffers from desertification. African farmers desperately need mineral fertilizers to bring life back to the depleted soils and to feed the continent (African Fertilizer Summit 2006). Improving agriculture through improving soil fertility is an important priority for the New Partnership for Africa's Development (NEPAD), Africa's development framework. NEPAD promoters held a Fertilizer Summit in Abuja, Nigeria, that brought together heads of state and diverse stakeholders (African Renewal 2007), who subsequently adopted 12 action points that included taking concrete steps to improve farmers' access to fertilizers by developing agro-dealer networks in rural areas by 2007.

Agricultural production in sub-Saharan Africa is hampered by low use of inputs such as improved seeds and mineral fertilizers, low inherent soil fertility in much of the continent, and nutrient-depleted soils. Millions of smallholder farmers suffer from poverty and hunger not only because are they unable to obtain appropriate fertilizers and improved seed varieties, but also because they are unaware of the correct inputs required to achieve subsistence yields from increasingly depleted soils (Ruben and Lee 2000). Fertilizers are the key to alleviating these constraints but must be integrated with other inputs and proper soil management for their economic potential to be realized (Adesina 2001). Organic fertilizers such

as plant residues or livestock manure can also be used to supply plant nutrients. This can have long-term positive effects on soil fertility though the concentation of nutrients is low. Improvement in crop growth and yield greatly depends on the efforts towards improving soil fertility. Mineral fertilizers are the only practical way to restore plant nutrients back to the severly depleted soils. However, African farmers have little access to fertilizers and cannot always afford them (Sachs 2008). It is critical to address the issue of fertilizer accessibility and availability as well as ensuring fair prices for farm products.

In most parts of the Limpopo Province of South Africa, crop yields are poor and continue to decline. This can be explained by declining soil fertility which has been identified as a major production constraint to the small-scale farmers (Sanchez et al. 1997; Ramaru et al. 2000). The situation is aggravated by the monoculture of maize and sorghum which are the staple crops in relatively wetter and drier areas respectively. Farmers have identified soil erosion, poor soil type, lack of fertilizer and lack of manure as factors that greatly contribute to low soil fertility. In most instances, low productivity is attributed to inadequate soil moisture during the growing season (Ayisi 2005). However, it was established by Odhiambo (2005) that crop growth and yield is often poor even in areas with adequate amounts and proper distribution of rainfall or even under irrigated conditions. This reveals the fact that other factors, besides water, contribute to low crop productivity; these include soil fertility and crop management practices.

In response to the aforementioned constraints, a consortium of partners – the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT), SASOL Nitro, Progress Milling, and the Limpopo Agricultural Strategy Team (LIMPAST) teamed up to design a program aimed at providing small packs of fertilizers of various sizes to a select number of Progress Milling depots. It was deemed that the small packs would be convenient in two ways: first, it would be affordable to many who could not meet the full cost of the traditional 50 kg bags and, second, it would create convenient access to farmers as the fertilizer would be sent to a depot close to them.

This initiative builds on a two-year experiment and trials with farmers on improved soil and water management technologies and after 1 year of providing small packs, both of which were spearheaded by ICRISAT through

the Australian Centre for International Agricultural Research (ACIAR) project resources and supported by the Limpopo Department of Agriculture (LPDA), Sasol Nitro, and Pannar (Table 1). These trials concentrated on microdosing which is the precision application (through time and space) of small doses of fertilizer aimed at maximizing returns from small investments in fertilizers.

Table 1. Depots in the Limpopo Province, South Africa, that received small packs and had trials conducted with surrounding farmers in 2005/06

No.	Depot name	Village name	District/Municipality
1	Lenyeneye	Lenyenye	Tzaneen
2	Matupo	Ga-Kgapane	Tzaneen
3	Matatja	Tshebela	Polokwane
4	Chuene	Ga-Thaba	Polokwane
5	Maja	Samata	Polokwane
6	Rakgoatha	Rakgoatha	Polokwane
7	Perkesbult	Ga-Makgokong	Polokwane
8	Masenya	Ga-Rampuru	Aganang
9	Mphambo	Mphambo	Malamuleke
10	Mafefe	Gamampa	Lepelle-Nkumpi
11	Koedeskop	Malepisdrif	Lepelle-Nkumpi
12	Batau	Mashabela	Sekhukune
13	Sibasa	Sibasa	Thulamela

Source: ICRISAT survey data (2007)

Recent results from demonstration trials on the use of smaller quantities of fertilizers across southern Africa, Limpopo Province included, show that farmers are likely to have higher pay-offs to fertilizer applications even in drought conditions (Dimes and Carberry 2007). Stocking of small packs of fertilizers (with some fertilizer application information) in community depots where trials had been successfully carried out was therefore deliberately meant to provide an environment of availability and affordability to farmers who had been exposed to these technologies. This would provide them with the incentive to purchase and apply the fertilizers. The program has the aim of laying the foundation for a rapid uptake of fertilizer through increased participation of the private sector in partnership with the public sector.

1.2. Objectives

The purpose of this study was to assess the effect of improved fertilizer access by smallholder farmers in the Limpopo Province following increased availability of fertilizers. The specific objectives of this study are to:

1. Characterize the buyers and non-buyers of fertilizer among the smallholder farming community
2. Determine the factors that affect pack size preference
3. Assess the existing private-public partnerships (PPP) in fertilizer supply and draw lessons for future undertakings
4. Inform policy on strategies that can be pursued to increase fertilizer uptake and use in order to improve smallholder crop productivity.

The study aimed at answering the following research questions in relation to the Limpopo Province:

1. What are the current cropping patterns and soil fertility management practices of the smallholder farmers?
2. What are the key farm household characteristics driving the use of fertilizer?
3. What are the factors determining the preference of fertilizer pack size among farmers who use fertilizer?
4. To what extent has research efforts and extension support influenced current cropping systems and fertility management practices among smallholder farmers?
5. What is the role of private-public-farmer partnerships in promoting fertilizer use in the remote areas?

1.3. Methodology

Qualitative data such as soil fertility status management and cropping practices in the Limpopo Province and quantitative data such as poverty levels and demographic data were obtained from desk reviews of existing information (secondary data) from various sources and from primary data obtained through field work designed and implemented by the research team. Two surveys were carried out to obtain the primary data

subsequently used to address the research questions. The preliminary survey was held in 2005/06 and a total of 75 farmers were interviewed in this first round from the villages listed in Table 1. The interview was targeted at farmers who had bought fertilizer for the 2005/06 farming season. In the same year a reconnaissance survey covering Progress Milling depots that had sold small packs of fertilizer was conducted to assess the state of the depots. The 13 depots were selected randomly out of the 100 depots spread throughout the Province. Agricultural extension officers who were within the vicinity of the depots were interviewed as part of the reconnaissance survey.

A larger and more in-depth farmer survey was carried out in the 2006/07 season targeting 180 randomly selected farmers consisting of 120 buyers and 60 non-buyers of fertilizer (Table 2).

Table 2. Sample of buyers and non-buyers of fertilizer in the Limpopo Province, South Africa

District	Depot	Buyers	Non-buyers	Total
Vhembe	Siloam	14	0	14
	Makado	4	0	4
	Sibasa	9	0	9
Mopani	Lenyenye	0	14	14
Capricorn	Ramagoale	24	4	28
	Masenya	10	19	29
	Bergvlei	22	6	28
	Cheune	17	2	19
	Sebati	21	1	22
	Matatja	5	7	12
Total		126	54	179

Source: ICRISAT survey data (2007)

1.4. Location of this study

The survey was conducted in the Limpopo Province, South Africa, in June 2006 and July 2007, covering three districts as indicated in Figure 1.

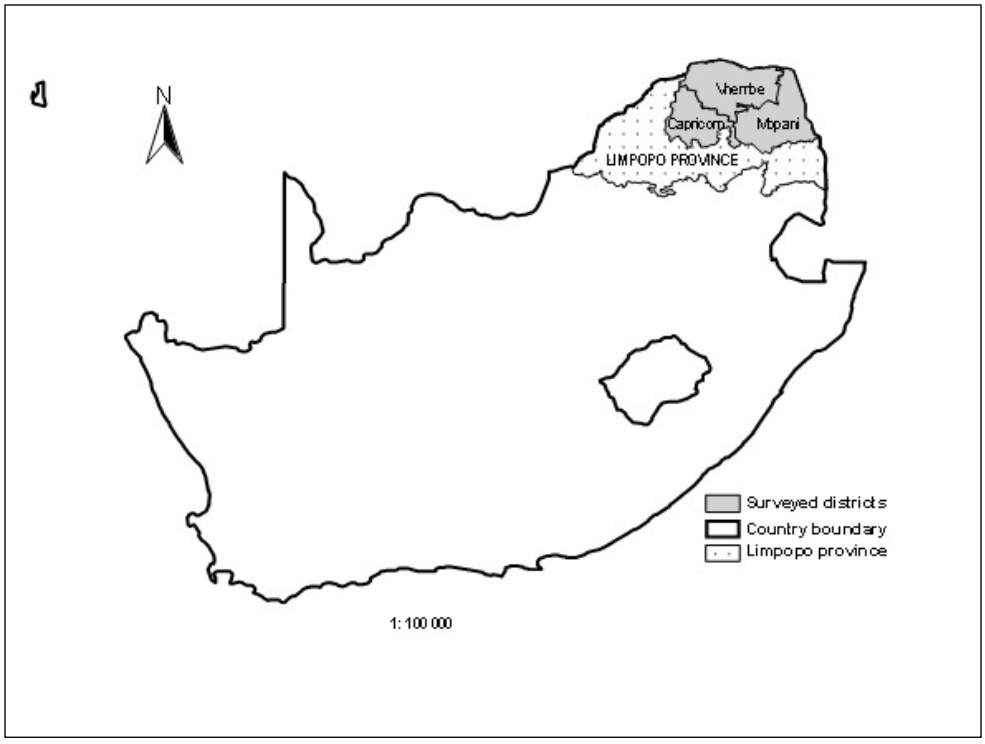

Figure 1. Surveyed districts in the Limpopo Province.

2. An overview of South Africa's smallholder agriculture

2.1. Some key features

South African agriculture is characterized by the unequal distribution of essential resources that include land, economic assets, support services, market access, infrastructure and income (South Africa info 2005). This is even more critical in the former black homelands where agriculture is poorly developed and oriented mainly towards household consumption. Dryland cropping does no more than supplement household income and rarely, if ever, constitutes people's principal source of livelihood. Approximately 40% of South Africa's population can be classified as living in poverty (Terreblanche 2002; FAO 2004) whereas 25% of the population can be categorized as ultra-poor. Smallholder agriculture, which provides a shaky

living to millions of poor rural households, presents a greater challenge to policy makers in the country. Consequently, smallholder agriculture is characterized by a high degree of uncertainty, low profitability, and lack of ability to meet ever-changing necessities of final markets (ICRISAT 2004). Smallholder farming is saddled with constraints in limited purchasing power, inadequate infrastructure, and limited access to support services that include effective extension, high input prices and poorly functioning output markets (FAO 2005). This tends to counterbalance the effort of many organizations aimed at increasing the productivity of subsistence smallholder agriculture. While South Africa as a country is self-sufficient in food production, 43% of households are classified as vulnerable to food insecurity (Department of Agriculture 2004). Alleviating food insecurity will therefore require more effort directed towards subsistence agriculture and developing smallholder agriculture.

Limpopo Province is mostly semi-arid and is prone to drought and floods. It is the second poorest province next to the Eastern Cape with 72% of the population in the province living below the poverty datum line (Swabe 2004). According to the Human Science Research Council (HSRC) data of 2004, the Limpopo Province is overwhelmingly rural. Smallholder farms make up approximately 30% of the provincial surface area and poverty levels are high with 40% of the population being food insecure (Swabe 2004). Farming under the smallholder system is characterized by low levels of production technology and the size of a farm holding is approximately 1.5 hectares per farmer with production primarily for subsistence and little marketable surplus. A significant feature in the smallholder farming in the province is the absence of youth involvement. This is due in part to more lucrative employment elsewhere such as the mining industry (McCarthy 1998).

2.2. Soil fertility status and fertilizer use in the Limpopo Province

Much of the arable land in the Limpopo Province of South Africa is inherently infertile and subject to unreliable rainfall. The province has diverse soils which vary in productivity (Oettle et al. 1998). The soils are also vulnerable to various forms of degradation (physical, chemical and

biological) and hence appropriate management strategies are critical if productivity of soil is to be improved or sustained (Odhiambo 2005). Communal fields are mostly sandy, ranging from sandy loamy to loamy sand. The soils lack a wide range of nutrients, particularly nitrogen and phosphorous, and are depleted by continuous maize cropping. There is little likelihood of increasing production unless nutrient levels improve (Skeen 1999). Fertilizer application can have a significant impact on raising smallholder agricultural productivity, especially in view of declining soil fertility levels which have become typical of subsistence agriculture throughout Africa (Machethe et al. 2004). In cultivated areas depletion of nutrients is caused by the imbalance between the output of nutrients (mainly through crop harvest and erosion in form of organic and inorganic fertilizers), resulting in a negative nutrient balance of the soil and its consequent gradual loss of soil productivity. The areas used for small-scale farming have moderate-to-high nutrient mining due to low levels of inputs used for crop production (Ayisi 2005).

2.3. Dryland crop production and the use of chemical fertilizers

Maize is a cereal crop, widely grown by resource-poor farmers in Africa (Govereh et al. 2003). Maize is both South Africa's staple food and most extensively grown field crop; in fact, South Africa produces 65% of the Southern African Development Community's (SADC's) (15 country regional grouping) maize. Maize is also the dominant dryland crop for smallholder farmers. About 84% of households attempt to grow the staple food crop, despite the fact that they are unlikely to get a good harvest (Gouse et al. 2003). However, literature shows that when the harvest is good, the value of the product exceeds that of sorghum (Rohrbach 1991). Maize outyields sorghum and millet in many, if not most, years in drought-prone regions and it offers higher yields in many areas with acidic soils. Maize is often grown in areas of marginal rainfall or soil depth, together with some sorghum and cotton.

The smallholder area of the Limpopo Province is subject to frequent droughts and poor soil fertility – two problems that commonly keep smallholder farmers in a cycle of poverty. One thing is certain: yields will not increase unless farmers apply fertilizer to replace lost nutrients. However,

fertilizer use remains very low because of costs, availability, high risk due to uncertain rainfall, and inappropriate fertilizer use recommendations. Ayisi (2005) noted that very limited research has been carried out to address soil fertility problems in the province and research results are fragmented and have not been collated or made easily accessible. The recommendations (200 kg/ha starter fertilizer and 100 kg/ha topdress) are unrealistic and irrelevant to smallholder farmers because they are based on achieving optimum production on resource-rich farms (Dimes and Carberry 2007).

Fertilizer presents a substantial share of production costs; low profitability tends to weigh heavily in a farmer's decision about whether or not to use them. The contribution of fertilizer costs to smallholder maize production varies according to the farming system and country economics. In Nigeria, an average of 12% was reported by Ogundari et al. (2006). In Kenya, surveys by Tegemeo Institute showed 23% (Nyoro et al. 2004) and fertilizer costs in Malawi constituted up to 50% of total production costs of dryland maize under the smallholder farming system (Takane 2007). When cost and risk act in tandem, as they do in most rainfed environments, the impact on fertilizer demand can be significant. Blanket fertilizer recommendations – even if suitable for a minority of circumstances (ie, biophysical and socioeconomic) – will inevitably be inappropriate to others. Moreover, the rates are not distinguished by area or soil type or status and tend to ignore micronutrient issues (Roberts et al. 2001). As a result, many farmers do not follow them; if they do, it can lead to inefficient or unprofitable use of fertilizers. However, crop yields can often be enhanced at low cost by a quite modest application of nutrients as in microdosing. In summary, fertilizers can and have been shown to be beneficial even in dry areas where soils have inherently low fertility.

2.4. Constraints, challenges and opportunities for supplying and utilization of fertilizer by smallholder farmers

The fertilizer equation for a smallholder farmer can be summarized as having the following key components: availability, accessibility (affordability), and utilization. Each one of these has, in practice, several smaller components that are key to driving the fertilizer industry. Concerns with the slow expansion of the commercial input supply given declining soil fertility and increasing food insecurity have renewed interest in government-run

programs (Kelly et al. 2003). Government input distribution programs face a number of problems, including political interference, ineffectiveness of means-targeting, sizable leakages, procurement and distribution delays, and inadequate farmer training that reduce the effectiveness of the package. For example, during the 1998/99 and 1999/2000 cropping seasons, Malawi implemented an extensive seed and fertilizer distribution (Starter Pack Program) program for all smallholders to plant 0.1 ha of maize/legume intercrops. The program faced some challenges in addressing the problems of poverty and lack of purchasing power underpinning the food security problems and missed opportunities to build private sector systems for supplying farm inputs (Kelly et al. 2003). However, the "Abuja Declaration on Fertilizers for an African Green Revolution" adopted by head of states and governments from across Africa called for an increase in fertilizer use from the current 8 kg/ha to at least 50 kg by 2015 (African Fertilizer Summit 2006).

The prime problem in making fertilizer available to smallholder farmers is lack of finance (Donovan et al. 2002). Smallholder farmers buy fertilizer in small quantities as and when rain comes and with different stages of crop growth because of limited cash resources. Consequently, the demand from communal farmers is very low and uncertain especially after drought (Morris et al. 2007). Fertilizer is characterized by a marked seasonality of demand and bulkiness, which leads to the relatively slow turnover and considerable storage requirements that, in turn, result in high financial charges (Crawford et al. 2006). Fertilizer requires high sales margins to give returns that are competitive with those from other products (Kelly 2006). In addition, there are logistical difficulties of making fertilizer available to farmers and high transaction costs of establishing distribution networks because of the long channels of distribution, poor infrastructure, and lack of competition in rural transportation (FAO 2004).

2.5. The role of private-public partnerships in smallholder agriculture

Historically, public sector agencies have been the key change agents for smallholder agriculture. However, there is an increasing trend towards private sector and public–private–NGO partnerships for research and extension, input supply and output marketing because of the failure of

public sector driven approaches (Rusike and Dimes 2004). Public–private partnerships (PPP) are broadly described as any joint effort between public and private entities in which each contributes to planning, commits resources, shares risks and benefits, and conducts activities to accomplish a mutual objective. The major reason for the effectiveness of the partnerships is the synergetic effect of the complementation of partner institutions including accumulated knowledge and untapped institutional resources. By exploiting the potential for research synergies, complementarities, scale economies and knowledge-sharing among participants, partnerships can conduct research and development in greater quantities, with greater chances of success or at lower costs than public or private actors might otherwise expect when acting alone. Most importantly, PPPs are valuable because they can bring private sector resources and expertise to bear on public research priorities in developing countries. Often, limited emphasis is placed on how the partners will interact effectively or how relationships might be improved. Hence, PPPs often suffer from lack of trust and commitment, with the result that they fail to meet their potential (Spielman and von Grebmer 2004). The current model of PPPs is flawed because they do not firmly integrate the farmers – the end beneficiaries of the partnership.

3. Analysis and discussion

3.1. Farm household characteristics in relation to use and non-use of fertilizer

This section of the paper examines the characteristics of the sampled households and how they affect whether or not the household used fertilizer or not. Other factors affecting fertilizer use such as the price of fertilizer, type of fertilizer, pack size, source of fertilizer, access to extension support and training will be explored in this section.

In the preliminary survey held in 2006, the interviewed farmers were typical subsistence farmers; 70% of them had been farming for 5–20 years, making farming their way of life. A summary of the household characteristics which help to describe the sample is shown in Table 3. Many of the households (70%) are female headed with a notable absence of males. This can be confirmed by the South Africa census data of 2000 where it was reported

that women constitute 80% of smallholder farmers in Limpopo Province (Statistics South Africa 2000). Most of the farmers interviewed were above 55 years of age and were mostly pensioners. The households in Limpopo are fairly large, averaging 6.6 persons per household irrespective of whether one is a buyer or non-buyer of fertilizer. The household size has, however, no immediate relationship with farming because almost all households make use of hired labor.

The level of illiteracy is high in Mopani with 57% of the households being headed by those who have never been to school. Where literacy levels are fairly high, those who had the opportunity to get an education only spend a few years in school. In general, the buyers are more educated than the non-buyers. Survey data show that less than 20% of the buyers are illiterate compared to 35% for non-buyers of fertilizer (Table 3). The households have been farming for more than 15 years in their respective fields. The low levels of literacy coupled by the advanced age of farmers, leaves little room for embracing new innovations.

Ownership of a motor vehicle can be regarded as a status symbol because it is only the wealthy households who have access to such assets. The most popular assets are either a TV or radio, assets owned by almost all households. The two assets do not have any direct relationship with farming but can be an important source of agricultural information. Land size holding was 1.63 ha for the buyers and slightly lower for the non-buyers (1.38 ha). The biggest plots were located in Vhembe (2.7 ha), followed by Mopani (1.7 ha), and Capricorn had the smallest plots of 1.37 ha and 1.23 ha for buyers and non-buyers respectively (Table 3). The differences in size of land are location specific depending on local customs and practices.

Even though by national standards, smallholder farmers occupy the bottom seat of the poverty strata, these farmers own some assets. Cattle ownership is very low, 19.8% among buyers of fertilizer and 25.9% for the non-buyers. Ownership of farm implements is extremely low with only 5% of the farmers owning such assets. This can be explained by the fact that these farmers do not use animal draft power for land preparation because plowing is largely done using privately hired tractors. Farming operations in Limpopo Province are therefore highly dependent on the liquidity position

of the household because farmers have to pay for land preparation. Farmers, who may not have enough cash at the time of plowing, may not be able to plant that season. The use of cash resources for plowing has a negative ripple effect on the acquisition of other purchased inputs such as seed, fertilizer, chemicals, and labor.

Table 3. Household characteristics

Descriptive variable	Capricorn		Vhembe	Mopani	All	
	Buyer	Non-buyer	Buyer	Non- buyer	Buyer	Non-buyer
Sample size (n)	100	39	25	14	125	53
Gender (% female)	81	87.2	32	92.9	71.2	87
Average age	60.1	56.4	57.6	60.1	59.6	57.2
Illiterate (% with no schooling)	21	25.6	12	57.1	19.8	35.2
Average years in school (yrs)	7.2	6.7	8.59	3.67	7.47	6.17
Farming experience (yrs)	16.6	16.4	21.5	16.6	17.5	16.2
Household size	6.5	6.8	7.2	6	6.6	6.6
Land ownership (ha)	1.37	1.23	2.68	1.7	1.63	1.38
Proportion (%) of farmers with						
Access to extension	67	53.8	80	92.9	68.3	37
Cattle	20	30.7	20	14.3	19.8	25.9
Motor vehicle	8	20.5	44	7.00	15.1	16.7
TV/ radio	88	87.1	100	64.3	90.5	79.6
Farm implements	3	76.9	12.00	0	4.8	5.6

Source: ICRISAT survey data (2007)

3.2. Differentiation of buyers from non-buyers

Inherent household characteristics such as age, farming experience, and household size are not significantly different between the two groups of farmers (Table 4). Findings from the preliminary survey also confirm that the more experienced farmers (in terms of years of farming) were not necessarily experienced in fertilizer use because 20% of the sample farmers only started using fertilizer in the 2005/06 season, thereby constituting first-time users. Resource endowments such as cattle ownership and subsequent use of cattle manure on maize cannot be used to explain differences between buyers and non-buyers. Cattle ownership is actually high among non-buyers but the subsequent quantities of cattle manure used on maize are lower among non-buyers.

Table 4. Distinguishing characteristics of buyers and non-buyers

Descriptive variable	Buyers	Non-buyers	t-value
Age (years)	59.36	58.45	0.604
Farming experience (years)	17.59	16.39	0.500
Schooling (years)	6.08	4.0	3.292**
Household size	6.74	6.31	0.803
Land size holding (ha)	1.63	1.37	1.178*
2005/06 cereal production (kg)	2303.48	1074.78	3.197**
2006/07 cereal production (kg)	619.48	291.24	1.867*
Number of extension meetings	4.34	2.04	3.231**
Number of cattle owned	6.9	7.3	–0.173
Quantity cattle manure applied to maize (kg)	800.52	690.37	0.977
Average annual income (Rands)	26327.74	15 317.51	1.848*

*** 5% level of significance* * *10% level of significance*

Source: ICRISAT survey data (2007)

The land size holding and annual income earned is significantly different at 10% level between buyers and non-buyers. The income of buyers of fertilizer will be expected to be higher because they get additional income from crop sales. However, the most common source of income for smallholder farmers in Limpopo Province is the government pension grant, disability grant, and child grant for children below 14 years, averaging R1000 per month receivable by any qualifying persons in a given household. The sizes of the fields are already determined by the land tenure system and differences can only be attributed to the ability to acquire more land if it is possible. The land size holding between buyers and non-buyers is not significantly different. Education is an important factor in distinguishing buyers from non-buyers and the difference in the number of years spent in school is significantly higher among buyers. It is hypothesized that education enlightens farmers and they are subsequently better able to appreciate new technologies as they come along. Moreover, it is these educated farmers who are always targeted by extension officers for trials and training. The compounded effect will result in educated people appreciating and hence using fertilizer compared to those who are not as highly educated.

Buyers attended significantly more extension meetings than non-buyers of fertilizer because these farmers adopted a more serious attitude to farm production and therefore seek out information from extension officers. Fertilizer use increases the yield of cereals and this can be confirmed by the yield differentials between buyers and non-buyers. On-farm trials

conducted in Limpopo by Sasol Nitro showed that farmers who applied 1 bag of LAN/ha could get an increase in maize grain yield ranging from 35–50% (Kgonyane and Dimes 2007). Under good rainfall conditions, as was the case in 2005/06, the grain yield was significantly different at the 5% level between buyers and non-buyers. However, in 2006/07, which was a bad season, the yield difference was only significant at 10% level. It can be safely confirmed that farmers who use fertilizer get better yields compared to those who do not use fertilizer. However, this study did not go into detail to compute the benefit/cost ratios, partly because such data was not the original intention of this study. To further ascertain the difference between buyers and non-buyers, a comparison was made with regard to the quantity of cattle manure used on maize (Table 4). Buyers apply more cattle manure compared to non-buyers, even if they own fewer cattle. This could imply that those farmers who buy fertilizer know about soil fertility and are aware of the importance of maintaining soil fertility using both organic and inorganic fertilizer.

3.3. Cropping patterns and fertilizer use by the buyers

The analysis concerning fertilizer buyers only applies to farmers in Vhembe and Capricorn because in Mopani all the interviewed farmers were non-buyers. The most commonly grown crop in the Limpopo Province is maize, which is grown by 88% of the farmers (Figure 2). Chemical fertilizers are applied solely to maize except for the irrigation schemes where they specialize in horticultural crops. The narrow range of crops grown implies that there are fewer blends of fertilizers to be promoted in the area. In terms of fertilizer promotion, it is easier to stock fertilizer of the same type in bulk.

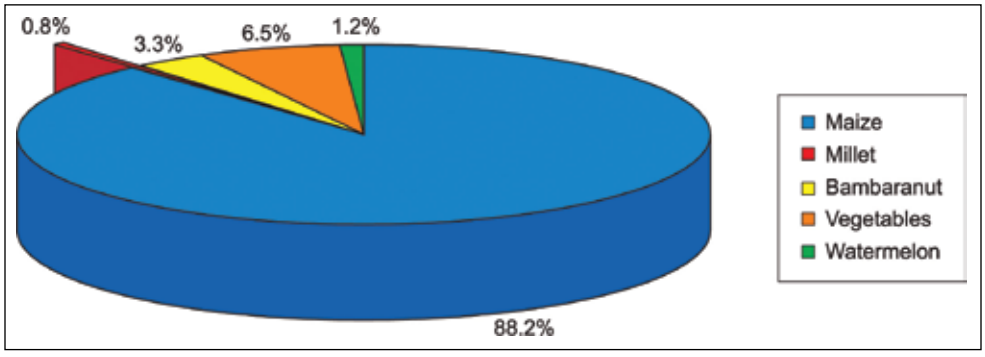

Figure 2. Proportion of farmers growing specified crops in Limpopo Province.

The focus of this analysis will be on fertilizer application on the maize crop for the 2006/07 season – the drier season. The type of fertilizer applied by the farmers varied from place to place depending on the available fertilizer and area recommendations based on soil analysis and advice from the local extension officers (Figure 3). There were more farmers in Capricorn who used basal fertilizer compared to farmers in Vhembe. Despite the popularity of basal fertilizer, farmers in Capricorn applied basal fertilizer in less quantity per household when compared to their counterparts in Vhembe (Table 5). The average amount of basal fertilizer applied in Vhembe was 165.3 kg and in Capricorn it was 119.1 kg. The figures for topdressing were high in Vhembe with an average of 208 kg whereas in Capricorn it was 61.8 kg. Generally, in Capricorn, the fertilizer applied to maize per household is lower when compared to Vhembe for both basal and topdressing, assuming that each household plants maize on at least one hectare out of its total land holding.

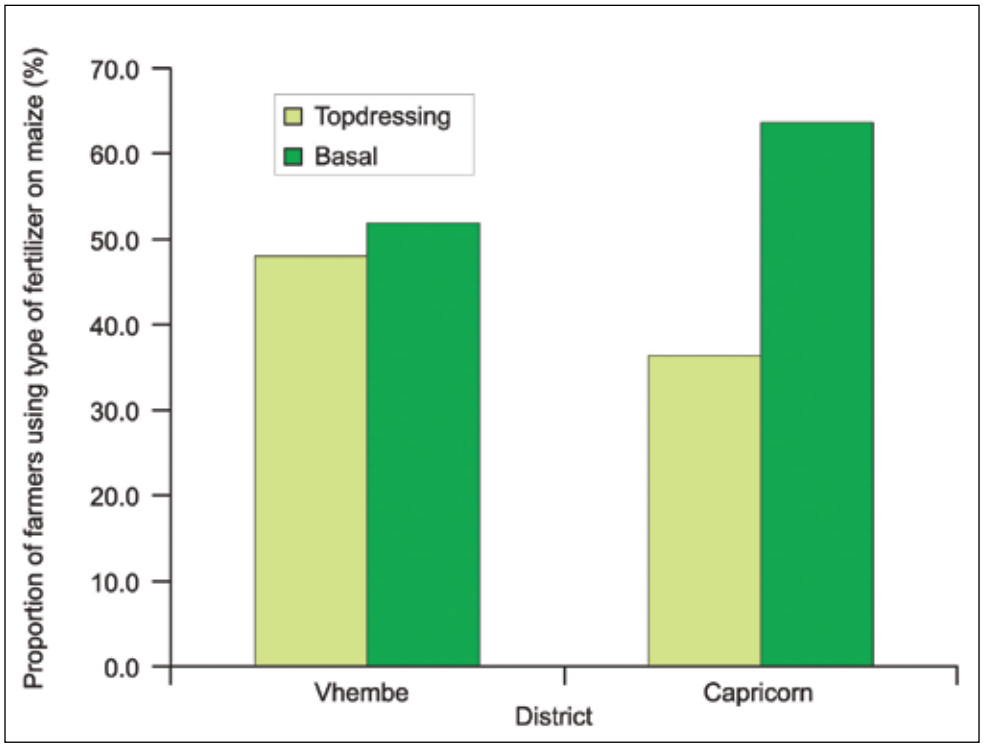

Figure 3. Use of different fertilizer types on maize in two districts of the Limpopo Province in 2006/07

Table 5. Classification of quantities of fertilizer use per household in Vhembe and Capricorn

Categories of fertilizer quantity (kg)	Proportion of farmers applying stated amount (%)			
	Basal		Topdressing	
	Vhembe	Capricorn	Vhembe	Capricorn
Less than 50	30.8	64.6	50.0	32.3
50–100	26.9	16.7	23.1	29.2
101–150	11.5	13.5	0	15.6
151–200	3.8	3.1	0	12.5
201–250	7.7	1.0	11.5	4.2
Above 250	19.2	1.0	15.4	6.3

Source: ICRISAT survey data (2007)

A distribution frequency of the amounts of fertilizer shows a clear pattern that has been hidden by the averages. In Capricorn, more than half of the sample (65%) used less than 50 kg of basal fertilizer whereas only 2% of the farmers used more than 200 kg of the basal fertilizer (Table 5). This small group of farmers represent the semi-commercial farmers who do not qualify as smallholder farmers but the quantity of fertilizer is high enough to distort district averages. In Vhembe the use of topdressing is high though half of the farmers use less than 50 kg whereas more than a quarter (27%) of the farmers used more than 200 kg of topdressing (Table 5). This behavior is greatly influenced by the presence of many small-scale irrigation schemes in Vhembe. In terms of the market demand, basal fertilizer should be stocked in Capricorn and more of topdressing in Vhembe.

3.4. Fertilizer use in the Limpopo Province

3.4.1. Sources of fertilizer

In the 2006/07 cropping season, farmers mainly bought fertilizer from the local Progress Milling depots. The other sources of fertilizer included urban wholesalers, local and distant retail shops as well as the local depot of a competitor company called Northern Transvaal Kooperasie (NTK). In some areas of Vhembe where there were irrigation schemes, the NTK depots were much closer compared to Progress Milling depot and most farmers would source fertilizer from NTK. A description of the main sources of fertilizer in the survey area is given in Box 1.

Box 1. Sources of fertilizer for smallholder farmers in Limpopo Province

Urban wholesalers – these consist of the manufacturing companies, such as SASOL Nitro, and agricultural input wholesalers, Progress Milling and NTK. They are located in most urban areas of the province and allow individual buyers to buy at lower prices.

SASOL Nitro – is a fertilizer manufacturing firm headquartered in Johannesburg, South Africa. It was established in 1950 and is a division of SASOL Chemical Industries. It comprises three business units: Ammonia, Explosives, and Fertilizer. The bulk of its products are supplied to South African markets. The company has a workforce of 30000 people and is the largest in Limpopo Province.

Progress Milling – is a large private-sector grain milling and trading firm. It is a retailer that purchases fertilizer from SASOL Nitro. Progress Milling has established a network of depots and uses trained staff to distribute small packs of fertilizers to farmers. Its depots are conveniently located throughout the province.

NTK – is well-established cooperative that provides essential inputs (fertilizer) and sells products on behalf of its members. Though NTK was initially formed by the white community it has expanded into rural areas in line with changes in the political climate in South Africa. NTK also offers credit to its members and it is the biggest competitor of Progress Milling in terms of the services it provides.

Local depots – Progress Milling has more than 100 depots located in Limpopo Province. NTK is also well networked in terms of location of depots and also offers the same services as Progress Milling except for the grain exchange program, which provides storage for the farmer's maize and allows them to access or sell their maize as needed.

Fertilizer was mainly bought from urban wholesalers and local depots. The opening up of Progress Milling depots to supplying fertilizer resulted in fertilizer being available to the smallholder farmer, thus addressing the access constraint. It was revealed that though local depots provided fertilizer to many farmers (44%) in the past 5 years, urban wholesalers were the most popular option supplying fertilizer

to almost 55% of the farmers. However, this changed within the past two seasons with local depots dominating the fertilizer market for smallholder farmers with market share of 60% (Figure 4). This is because of the convenience to the farmers of having the option to buy fertilizer closer to their homesteads. There has been a notable decline in the distances that farmers travel in search of fertilizer in the past 2 years. The average distance travelled by farmers has gone down less than 5 km due the proximity of depot locations. This could be a result of the combined effort of the consortium previously described that aimed at enhancing fertilizer availability and accessibility by smallholder farmers.

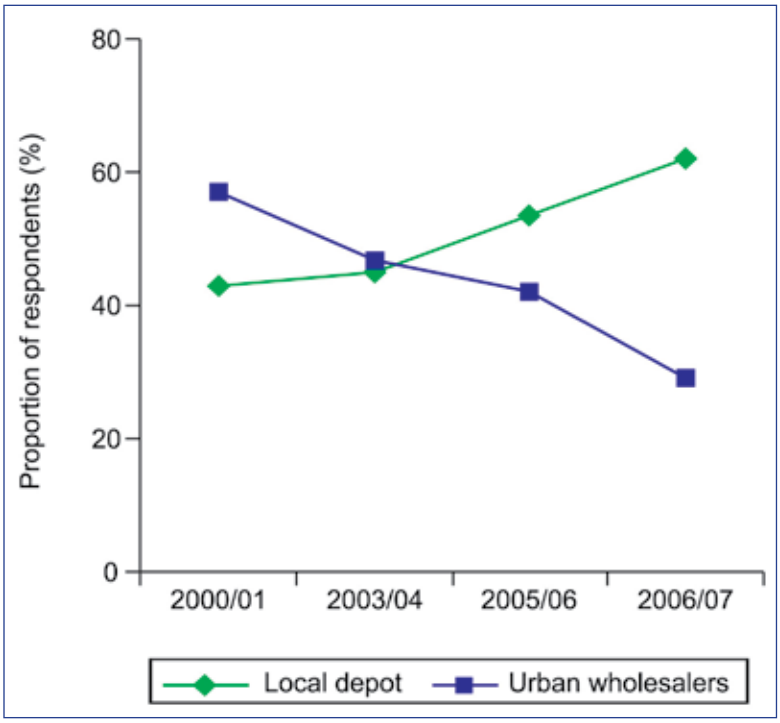

Figure 4. Changes in fertilizer sources over time

3.4.2 Changes over time on fertilizer sources

The survey revealed that in the past 5 years urban wholesalers were the most popular option (38%) for supplying fertilizer followed by Progress

Milling local depots implying that farmers travelled far in search of fertilizer (Figure 5). The initiative of supplying fertilizer through Progress Milling depots was born of a partnership between Sasol Nitro, Progress Milling, and ICRISAT. The partnership strengthened over the years, which saw more fertilizer being supplied through Progress Milling local depots and more depots providing fertilizer of different pack sizes. Generally, more farmers are now buying fertilizer from local depots which are close to their homesteads compared to distant markets. The point is that there is a growing confidence in fertilizer being available in Progress Milling local depots. This has translated into an increase in the volume of fertilizer sold through Progress Milling local depots. Starting with a seasonal average of 15 tons from the period 1999 to 2003, sales have risen to 96 tons in 2005/06 and 140 tons in 2006/07.

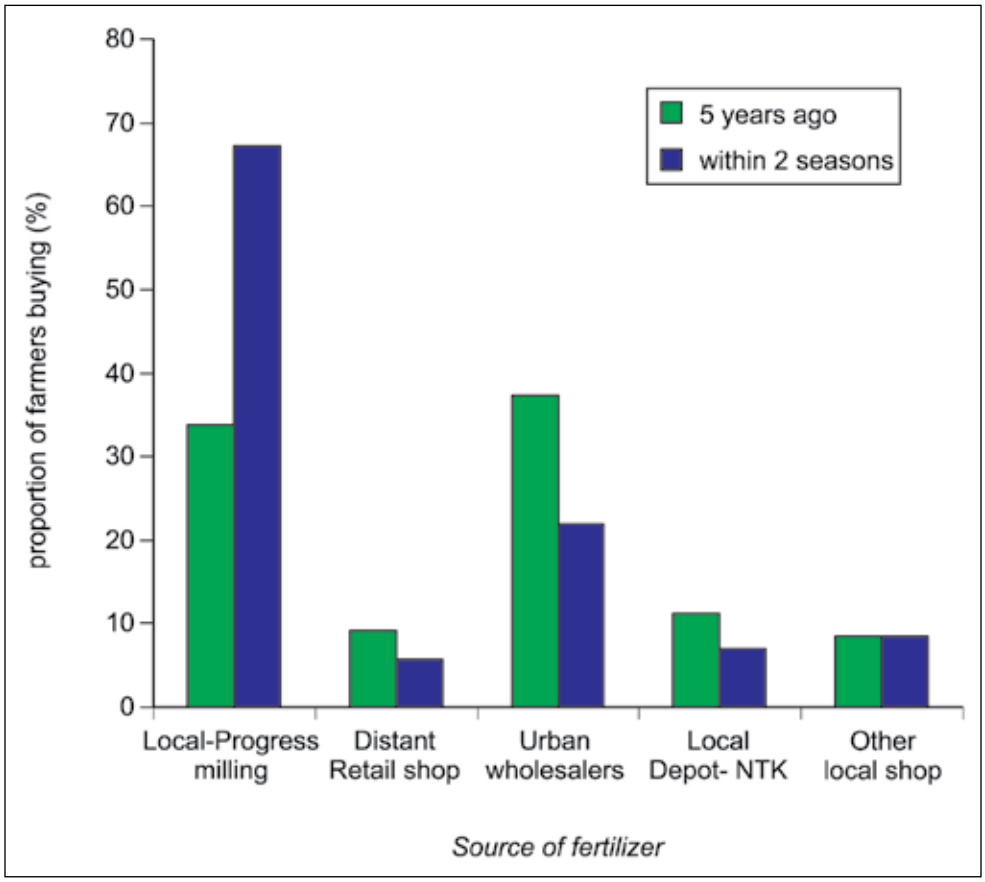

Figure 5. Proportion of farmers acquiring fertilizer from different sources over time

3.4.3. Most commonly used types of fertilizer in Limpopo Province

The majority of the farmers (90.4%) used NPK (2:3:2) as a basal fertilizer and 71.2% used CAN/LAN as topdressing (Box 2). A few farmers with specific crop fertility requirements used other types of fertilizers to address specific nutrient deficiencies in the soil.

Box 2. Fertilizer types and state of usage

CAN/LAN (Calcium ammonium nitrate/lime ammonium nitrate) are topdressing fertilizers. They contain 28% nitrogen, 4% magnesium, and 6.8% calcium. CAN/LAN is in the form of whitish to light brown granules which are 2–5 mm large. Its granulation ensures a quick and exact dosing. The fertilizer has excellent physical–mechanical properties and properties for storage.

NPK are phosphoric fertilizers. These are basal fertilizers which are also called fruit-and-flowering fertilizers. They vary in composition. NPK 2:3:2 is the most common that contains 6% nitrogen, 9% phosphorous, and 6% potassium.

3.4.4. Fertilizer application methods used in the Limpopo Province

Different methods were used to apply fertilizer depending on whether it was basal fertilizer or topdressing. The main methods used by the sampled farmers were banding, broadcasting, and spot application. A detailed description of these methods is given in Box 3.

Basal fertilizer is usually applied at the time of planting and the most common method used was banding (44%). Broadcasting was equally important for applying basal fertilizer because 36% of the farmers who applied topdressing used this method. Topdressing is applied when the crop is knee-high or six weeks after planting. Targeted application methods were commonly used to apply the fertilizers. Spot application using free hand was most popular method for topdressing followed by spot application using a bottle top. This is a technique that is learned from extension or even fertilizer sellers because some provide the measuring scoop. However, spot application using free hand was also used by many

farmers (31%) to apply basal fertilizer (Table 6). Some of the farmers used multiple methods of applying fertilizer and were therefore counted more than once. Spot application of topdressing fertilizer using a bottle top is a technique referred to as microdosing and this was deliberately promoted by ICRISAT in Zimbabwe as well as South Africa particularly the Limpopo Province.

Box 3. Fertilizer application methods

Banding – This refers to either deep or surface band. Deep banding involves the application of concentrated solid/ liquid fertilizer within rows below the soil surface from 5–38 cm deep. The method requires that fertilizers containing immobile nutrients such as phosphorous, potassium and zinc be placed in a band at the aforementioned depth below the soil surface. Surface band applications concentrate solid or liquid forms of mobile nutrients (nitrogen) within a band at the soil surface. This banded fertilizer may be incorporated with either a primary or secondary tillage operation. Surface bandwidths vary, but the strips normally cover from 25–30% of the soil surface. Banding with incorporation overcomes the problem of fertilizer being stranded in dry surface soil and concentrates nutrients within a specific soil volume.

Broadcasting – This refers to the application of nutrients to the soil surface. Applications usually precede any tillage that is used. This application method usually provides the most uniform distribution of nutrients within a given soil volume. In the Limpopo Province, farmers use the method for both basal application and topdressing.

Spot application – This is the application of fertilizer/nutrient/herbicide on planting station (to single plants/small groups of plants) and is used either where discrete plants are targeted or where broadcast application is not possible, feasible, or desirable.

Fertigation – Fertigation is when fertilizer or nutrients are added to irrigation water. It is a contraction of fertilization and irrigation. The most common nutrient applied by fertigation is nitrogen. Elements applied less often include phosphorus, potassium, sulphur, zinc, and iron.

Table 6. Farmers using different methods of fertilizer application on maize

Method of application	Proportion of households applying fertilizer (%)	
	Topdressing (n=109)	Basal (n=97)
Broadcast	6	36
Banded	6	44
Spot application (bottle top)	12	9
Spot application (free hand)	78	31

Source: ICRISAT survey data (2007)

3.4.5 Pricing of fertilizer

The investment outlay required to buy a 10 kg pack is one-fifth the investment required to buy a 50 kg bag of fertilizer. The investment required to buy a 50 kg bag might be equivalent to the price of a goat whereas the cost of a 10 kg bag would be the same as the price of a chicken. However, the price per unit between a small pack and the 50 kg pack is not very different (Table 7). The price for the small packs was an administrative price agreed upon by Sasol Nitro and Progress Milling in a bid to promote small packs of fertilizer. If the price was determined by the market, the price per kg would increase as the pack sizes were reduced because of increased packing costs. However, in this survey, farmers were still paying the same price per kg for both pack sizes. Therefore, it is the total investment to buy a particular pack size rather than the cost of fertilizer per kg that would influence a farmer's decision. In general, the compound fertilizer NPK (2:3:2) was more expensive for the smaller packs compared to CAN/LAN.

Table 7. Average price of different pack sizes by fertilizer type (2006/07)

Fertilizer type	Price for different pack sizes in kg (Rands)		
	10	20	50
CAN/LAN	30.5	61.00	151.23
NPK (2:3:2)	33.3	65.00	150.01
CAN/LAN (Price/kg)	3.05	3.05	3.02
NPK (2:3:2) (Price/kg)	3.33	3.25	3.00

Source: ICRISAT survey data (2007)

The small packs were only supplied through Progress Milling depots. The 50 kg bags were supplied through a variety of sources. For the purpose

of comparing prices, a 50 kg bag will provide the price to be used in the analysis. Urban wholesalers provided the cheapest source of both CAN/LAN and the compound fertilizer NPK (2:3:2) relative to the other sources. This is as expected because wholesalers buy direct from the manufacturer and sell in bulk though in actuality they were breaking the bulk and selling to individuals. The other local retail shops provided a cheaper source of CAN/LAN than Progress Milling and NTK (Table 8). The other local sources of fertilizer include retail shop selling fertilizer or that which is procured from the extension officer. It would seem that the 50 kg bags provided a cheaper option of buying fertilizer for the farmers but there is a hidden cost. By virtue of volume and weight of the 50 kg bag added by the distance, it becomes inevitable to avoid paying for transport.

Table 8. Price of 50 kg bag from different sources

Source		Average cost of a 50 kg bag (Rand)	
		CAN/LAN	NPK (2:3:2)
Local depot	Progress Milling	152.30	149.55
	NTK	148.83	155.50
	Other (extension agent)	143.00	149.16
Distant retail		150.25	161.00
Urban wholesalers		148.83	148.21

Source: ICRISAT survey data (2007)

3.4.6. Transporting fertilizer

About half of the farmers who bought fertilizer also paid for transport costs. The most common means of transport used was a motor vehicle; however, most farmers had to hire the vehicle or truck as a group. In some cases, farmers were provided with free transport by the seller for buying in bulk. A few of the farmers used their own transport for which they had to pay for fuel (Figure 6).

All the farmers who bought single 10 kg packs did not pay the transport cost because they carried the fertilizer on their heads. Only 30% of those who bought 20 kg packs paid for transport since the majority could conveniently hand carry the bags. However, all the 50 kg bags required a separate transport arrangement depending on where the fertilizer was bought. Farmers buying from the local depot would use wheelbarrows, scotchcarts and their own motor vehicles. At two of the local depots, a

truck was arranged to provide deliveries at no cost to farmers buying as a group. Farmers buying fertilizer from town (urban wholesalers) had to incur an additional cost in transport and this was determined by the distance from the source and whether the farmer bought in bulk or not.

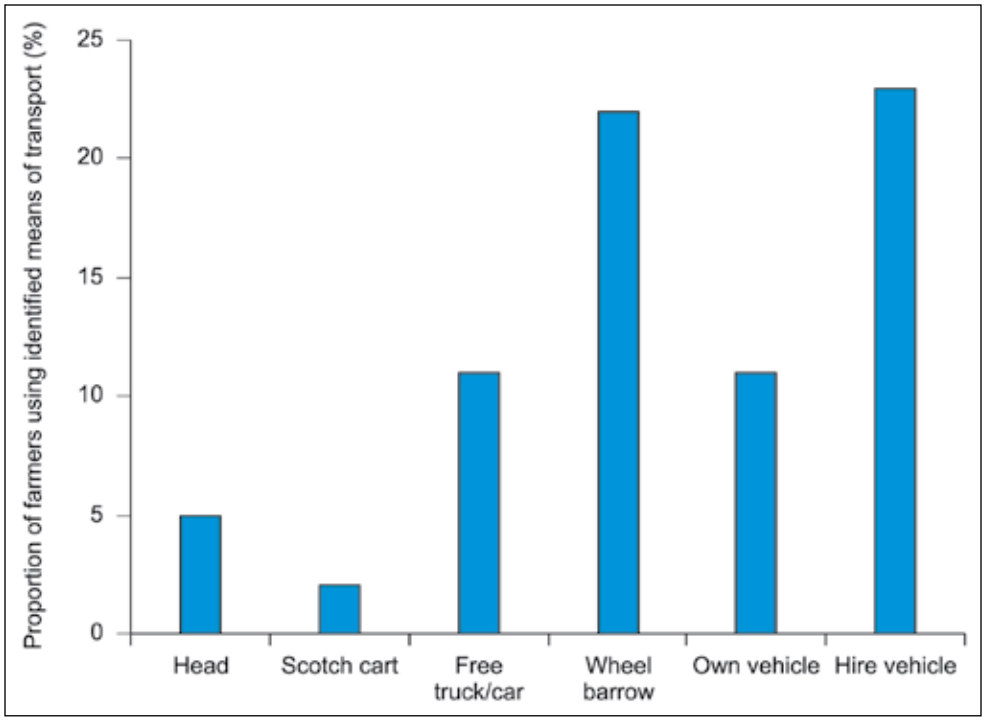

Figure 6. Proportion of farmers using various means of transport.

According to survey findings, the contribution of transport to the total cost of fertilizer of a 50 kg bag from urban wholesalers in Vhembe and Capricorn was 13% and 8% respectively. The transport cost per unit of those who used hired trucks was relatively lower because those who used their own cars quoted the same cost even if they may have used the same truck to ferry other goods. Hiring charges were fixed for each 50 kg bag carried from town and these charges varied from place to place. Hired trucks were relatively more expensive in Vhembe because of the distance of urban wholesalers from the villages whereas in Capricorn most of the villages were closer to town. The availability of fertilizer at local depots is a welcome relief especially to the farmers in Vhembe because they are farther away from town.

3.5. Fertilizer purchasing pattern

The traditional 50 kg bags dominated sales with almost 90% of the sample buying both basal and topdressing fertilizer. Fewer than 5% of farmers bought the 10 kg bags and this could have been a result of unavailability of 10 kg packs at the required time among other factors. Of the ten depots that were selected, only half sold different pack sizes; the other half sold 50 kg bags exclusively. The following analysis of fertilizer use experience will only apply to those farmers who bought fertilizer from the depots selling variable pack sizes. The analysis of fertilizer use experience will be applied across each pack size. The idea is to assess the experience of the farmers who bought the small and large packs. Most of the farmers (75%) who bought the 10 kg pack had less than 5 years of using fertilizer and the remainder had between 5 and 10 years of fertilizer use experience (Table 9). More than half of the farmers who bought 20 kg bags are fairly new in the practice of using fertilizer. It can be noted that the majority of those buying 50 kg packs have quite some experience in using fertilizer of between 5 and 10 years.

Table 9. Proportion of farmers buying a given pack size by fertilizer use experience *(n=73)*

	Pack size (kg)		
Years of using fertilizer	10	20	50
Less than 5 years	75	50	30.4
5–10 years	25	16.7	39.1
11–20 years	-	33.3	21.7
Above 20 years	-	-	9.7

Source: ICRISAT survey data (2007)

Dimes and Carberry (2007) are in agreement with the findings. An analysis of the pattern of sales from randomly selected Progress Milling depots and the results show that where farmers were familiar with fertilizer use 50 kg bags dominated sales (Figure 7). However, about 20% of sales were nevertheless in small packs. In villages where use of fertilizer was uncommon, 99% of the sales were in small packs and the daily record of sales show that 10 kg packs were preferred to 20 kg packs (Figure 8).

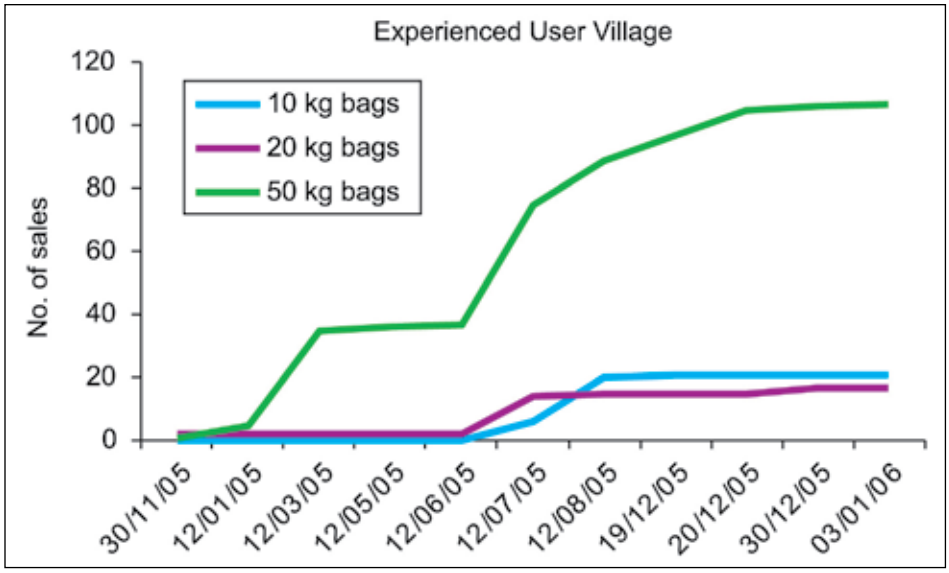

Figure 7. Daily fertilizer sales at Progress Milling depots at Perskebult during 2005/06 season

Source: Dimes and Carberry (2007)

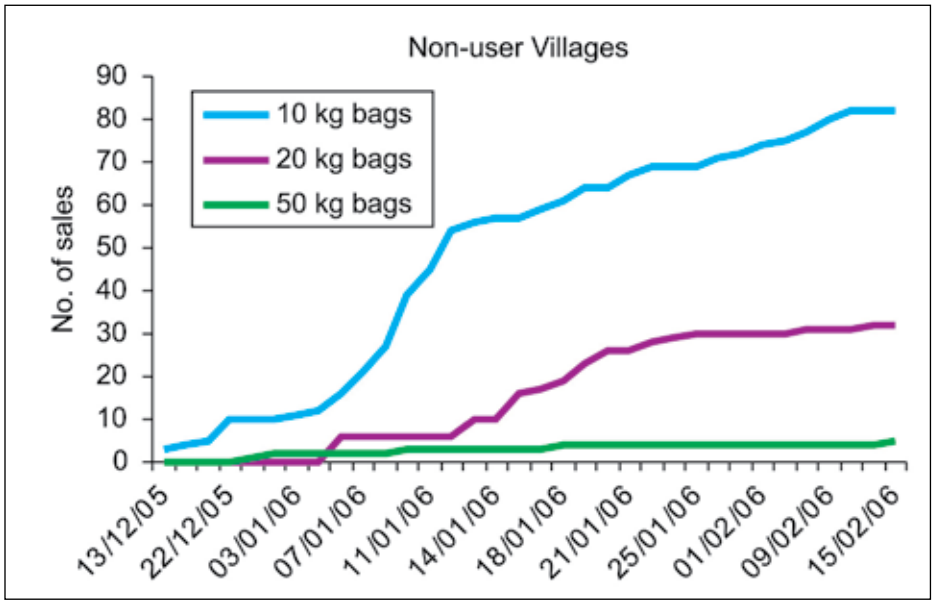

Figure 8. Daily fertilizer sales at Progress Milling depots at Motupa and Lenyenye in 2005/06 season

Source: Dimes and Carberry (2007)

It can be ascertained that first-time users of fertilizer who are still experimenting with the technology buy the small packs (especially the 10 kg packs). Farmers who have been using fertilizer for many years are likely to buy the 50 kg packs because they have gone beyond the trial stage; however, some first-time users opted for 50 kg packs. Small packs, therefore, provide an essential starting point for using chemical fertilizers.

3.6. Access to markets and information by buyers of fertilizer

3.6.1. Source of information on fertilizer availability

Farmers got to know about the availability of fertilizer from the local Progress Milling depot through various means. Most of the farmers got the information after they visited the shop for their day-to-day requirements. Extension officers were also instrumental in informing farmers about fertilizer availability at the local depot. There were no restrictions placed on the fertilizer at the Progress Milling depot. Farmers were free to buy any type as well as any quantity they required. The purchases made were a true reflection of the farmer's choice. This is different from Zimbabwe, a neighbor to South Africa, where a similar arrangement was made by a local fertilizer manufacturing company and ICRISAT. In Zimbabwe, there were restrictions on the fertilizer quantity to be purchased by each household because the supply of fertilizer was far outstripped by demand. Availability and affordability are major constraints in Zimbabwe whereas in Limpopo Province it is knowledge of fertilizer use which is the biggest constraint.

Half of the farmers in Vhembe were actively looking for fertilizer and as a result they discovered the availability of fertilizer at the local depot (Table 10). Extension agents remain a vital source of information to farmers in both districts. There are closer ties between Progress Milling and the farmers in Vhembe as compared to Capricorn because more farmers got information from Progress Milling. These could be attributed to the outreach programs in Vhembe and the fact that most of the depots are located far from urban centers. The local depot could be an important source of other services as well as information. In Capricorn, farmers provided information on the

availability of fertilizer to almost a quarter of the sample showing much reliance on farmer-to-farmer information networks (Table 10).

Table 10. Information source on fertilizer availability at the local depot

	Proportion of farmers using identified source of information (%)	
	Vhembe (n=18)	Capricorn (n=90)
Self finding	50	37
Extension agents	22	39
Other farmers	17	24
Progress Milling	17	2

Source: ICRISAT survey data (2007)

3.6.2. Changes over time on sources of information on fertilizer use

Farmers were asked to track the sources of information on how to use fertilizer from the time they started using fertilizer and the past two seasons. LPDA was distinguished from local extension because LPDA referred to a person coming from the government offices in Polokwane. The sources were weighted and the score was used to rank the sources in order of importance (Table 11).

Table 11. Information on fertilizer use by source (*n=126*)

	Initial (Rankings)		Past two seasons (Rankings)	
Source of information	Number of farmers(%)	Position ranking	Number of farmers (%)	Position ranking
Extension	66.7	1	77.6	1
Other farmers	55.0	2	63.6	2
Fertilizer seller	12.5	4	20.6	3
Family member	14.2	3	15	4
LPDA	5	5	6.5	5

Source: ICRISAT survey data (2007)

Extension advisory services have been rated as the most important source of information on fertilizer use. The importance of extension has been maintained over time and more farmers have turned to extension in the past two seasons than when they first started using fertilizer. "Other farmers" were cited as second-most important information source and the number of

farmers turning to that source for advice has increased within the past two seasons. A pronounced change on where farmers get information has been noted. Initially farmers would seek information from family members but the importance of this source of information has diminished, probably because of the limitations in farmer knowledge. Fertilizer sellers are increasingly becoming a source of information on fertilizer use and farmers are making inquiries of them. It is therefore important to equip fertilizer sellers with basic information to guide farmers in selecting and using fertilizer.

3.7. The role of extension, trials and training on fertilizer use

For a period of 25 years only 15 farmers were involved in farm trials, which were exclusively conducted by extension agents. In the same period there were only 32 farmers from the sample who received some training in soil fertility management from extension agents. Most of the trials and training (85%) were conducted starting from 2001 up to 2007. There seems to be an increase in the number of trials and trainings being conducted in Limpopo Province (Table 12; a tick indicates a confirmation but not number; several people could have been trained in a given year).

Table 12. Trials and training conducted over time

Activity	What was learned	Before 1990	1990-1995	1996-2000	2001-2005	2006-2007
Trials	Targeted application of soil nutrients		√		√	√
	Using crop residue to enhance soil fertility		√	√	√	
	Fertigation				√	√
Training	Targeted application of soil nutrients	√	√	√	√	√
	Use of different types of chemical fertilizers				√	√
	Using crop residue to enhance soil fertility				√	√
	Fertigation				√	

Source: ICRISAT survey data (2007)

There are only a few farmers who have received training on how to conduct trials. These have managed to change their way of farming by adopting banding, spot application, and use of a planter (Table 13). Banding was a popular technique for applying basal dressing because it avoided fertilizer waste. Spot application was economic and improved farmers' yields.

Farmers could reduce the risk of fertilizer burn by placing fertilizer beside instead of on top of the plant (targeted application).

Table 13. Changes emanating from training and farm trials

Variables	Vhembe (n = 13)		Capricorn (n=27)	
Soil fertility management change	**Basal**	**Topdressing**	**Basal**	**Topdressing**
Broadcasting to banding	6 (46)	3 (23)	12 (44)	NA
Broadcasting to spot application	2 (15)	5 (38)	3 (11)	16 (59)
Applying on top to beside the crop	NA	6 (46%)	NA	2 (7)
Adopted fertilizer	3 (23)	NA	5 (19)	2 (7)
Use of tractor drawn planter	2 (15)	NA	1(4)	NA
Reason for change	**Basal**	**Topdressing**	**Basal**	**Topdressing**
Banding not wasteful	1 (8)	NA	12 (44)	NA
Spot application not wasteful	NA	1 (5)	4 (15)	15 (56)
Better yields/ proper plant growth	5 (38)	6 (46)	3 (11)	3 (11)
Reduce risk of fertilizer burn	NA	1 (8)	NA	1 (4)
Targeted application of fertilizer	NA	3 (23)	NA	2 (7)
Following teachings	4 (31)	2 (15)	NA	2 (7)
Tractor more efficient	4 (31)	NA	4 (15)	NA

The numbers in brackets refer to the percentage of farmers implementing the change.
Source: ICRISAT survey data (2007)

3.8. Constraints to fertilizer use

At least 80% of the non-buyers have never attempted to use fertilizer because of a number of reasons stated (Table 14). The most important reason cited by farmers was that fertilizer was prohibitively expensive. The second constraint was a lack of information about fertilizer use ahead of unavailability of fertilizer in the local shops (Table 14).

Table 14. Reasons for never applying chemical fertilizer (n=43)

	Proportion of farmers citing reason (%)	Ranking
Fertilizer is too expensive/cannot afford it	90.7	1
Do not know enough about fertilizers	34.9	2
Fertilizer is not available locally	18.6	3
Fertilizer is too risky	9.3	4
Used alternative organic fertilizers	7.0	5
Soil is fertile, don't need it	7.0	5

Source: ICRISAT survey data (2007)

About a fifth of the non-buyers of fertilizer have used fertilizer before at some point in their farming life. These farmers know the importance of fertilizer but they stopped using fertilizer because of various reasons (Table 15.) The number one problem leading to their discontinuation of fertilizer use is that fertilizer became too expensive beyond what they could afford. The second reason is that they resorted to the use of organic manures instead. The third reason advanced by these farmers is that the rains are insufficient to sustain the use of chemical fertilizer.

Table 15. Reasons for stopping the use of chemical fertilizer (n=10)

	Proportion of farmers citing reason (%)	Ranking
Fertilizer is too expensive/cannot afford	90	1
Used alternative organic fertilizers	10	2
Drought/Insufficient rains	20	3
Fertilizer is not available locally	10	4
Soil still fertile	10	5

Source: ICRISAT survey data (2007)

The main reason for not using fertilizer was financial constraints ahead of insufficient knowledge about fertilizers (Table 14). Odhiambo (2005) also concluded that increased use of inorganic fertilizer among smallholder farmers in the Limpopo Province was constrained by the cash outlay required for purchasing fertilizer and affordability. Similarly, Mazvimavi (2006) confirms that the fact that the high price is the main reason for farmers not using fertilizer in Zimbabwe. Unavailability of fertilizer in local shops was the second reason for not using fertilizer ahead of lacking knowledge on fertilizer and lastly the risk of using fertilizer in dry areas.

3.9. Beyond fertilizer: Use of other soil fertility enhancements

Soil fertility enhancements are sources of nutrient for the farm field other than chemical fertilizers. In addition to manure, organic amendments such as bio-solids, food processing wastes, animal products, yard wastes, and many types of composted materials can be used. Survey findings revealed that farmers in Limpopo used cattle manure, chicken manure, goat manure, compost, dead leaves, and maize stover to enhance soil fertility. Cattle and

chicken manure are the most common types of soil fertility enhancements used by at least 30% of the sample. Transport of cattle manure was a major constraint (Odhiambo 2005). All farmers who used soil fertility enhancements first and foremost applied them to maize followed by other crops. In Mopani, the sample villages around the Lenyenye depot were formerly part of a tea plantation and the soils are inherently fertile, influencing this survey result. Only one farmer applied cattle manure and no other forms of soil fertility enhancement are used in the surveyed area of Mopani. Very few farmers (15%) apply soil fertility enhancement to the legume crops (Table 16). Vegetables are a common crop in Vhembe because of the irrigation schemes.

Table 16. Proportion of farmers applying soil fertility enhancement to crops

Crop	Vhembe (n= 20)	Capricorn (n=41)
Maize	100	100
Millet	5	7
Groundnut	–	5
Cowpea	–	5
Bambaranut	10	5
Vegetables	40	–

Source: ICRISAT survey data (2007)

3.10. Improvements suggested by farmers in the provision of fertilizer by Progress Milling

The following suggestions from farmers were meant to improve the efforts of the ICRISAT/Progress Milling/LPDA/SASOL Nitro consortium which aimed at improving fertilizer access and utilization in Limpopo Province. Farmers who preferred the traditional 50 kg bag did so because it would be enough to cover their entire field while those who preferred the smaller packs did so because of affordability, convenience for small plots including handling and transport. The key period when fertilizer is required is the beginning of the rainy season for the main summer dryland crops. About half of the farmers emphasized the need to have the major inputs on hand before the rains start. Fertilizer should be made available at the local depot between September and October. The most popular basal fertilizer was NPK (2:3:2). There was a high demand for the topdressing fertilizer in Vhembe district with 68% of the farmers requesting the supply of CAN/LAN. Farmers

suggested a variety of fertilizer types to be supplied because choice of fertilizer type depends on location and type of soil.

Knowledge about fertilizer application is still low in many places. In an earlier survey to characterize the depots, there were some extension officers who had never applied fertilizer. Information flow on available technologies is still weak and farmers were of the opinion that information on fertilizer use could be improved through trials and training. Farmers in Capricorn advocated trials and training whereas those in Vhembe suggested that extension meetings were important in providing this information. Almost 40% of the farmers agreed that advertising could be improved by using pamphlets or posters, but a few thought that fertilizer marketing was the responsibility of the seller of the input (Table 17). Some extension officers around some of the depots were not aware of the stocking of small packs in the depots. Yet, these are the people who are expected to animate farmers to apply fertilizers.

Table 17. Farmers suggestions on improved fertilizer delivery (n=108)

Item to be improved	Improvement sought	Number of farmers (%)
Pack size	Stock 50 kg bags, covers a large area and is economical	93
	Stock smaller packs because they are affordable and convenient for small plots	25
	Stock all pack sizes to allow for choice	5
Delivery period	September, October, and November	76
	June, July, and August	26
	March for backyard gardens	4
Fertilizer type	NPK (2:3:2), it is suitable for the soil	75
	CAN	32
	Provide many types of fertilizers to enable farmers to choose	29
Information on fertilizer use	Use trials and training to provide knowledge about fertilizer so as to change farmers' perceptions	52
	Provide more information through extension and meetings	48
	Use pamphlets to spread information	7
	Get information from other farmers	7
	Input sellers should provide information on fertilizer types suitable for specific crops and suitable methods of fertilizer application	5

Source: ICRISAT survey data (2007)

4. Conclusions

4.1. Soil fertility in southern Africa: Smallholder perspective

Smallholder farmers face a problem of soil fertility because the traditional practice of leaving the land fallow to regain its fertility is no longer sustainable. Use of chemical fertilizer is the surest way of restoring soil fertility but the uptake of technology is not as rapid as would be expected. Fertilizer use in southern Africa remains very low because of costs, availability, high risk due to uncertain rainfall and inappropriate fertilizer use recommendations. The population, which is not using or have quit using, fertilizer should be encouraged to use CAN for a start. The nitrogen fertilizer has the highest payoff and is therefore a good option for promoting fertilizer among smallholder farmers.

4.2. Household characteristics and soil fertility improvements

In terms of age, experience in farming, household size, cattle ownership and quantities of cattle manure applied, the households in the sample were basically similar. The distinction between non-buyers and buyers of fertilizer could only be explained in terms of annual income earned, the education level attained, land size holding, number of extension meetings attended as well as the levels of cereal production in any given year. It also came out clear that farmers who used fertilizer were more conscious of soil fertility improvement practices because they even use more cattle manure compare to the non-buyers of fertilizer. Buyers of fertilizer have generally higher annual earnings and are more educated when compared to non-buyers of fertilizer. Information and knowledge is an important facet for promoting fertilizer use and it is those who use fertilizer who attend more extension meetings in search of knowledge. On-farm and on-station trials have proved from different sources that use of fertilizer increases cereal grain yield in southern Africa.

4.3. The role of small packs of fertilizer

Farmer's ability to purchase fertilizer can be enhanced through phased and incremental use via smaller and hence more affordable bags. Many

poor farmers are likely to begin using fertilizer through experimenting with small packs. The theory of change underlying small packs must be that the poor gradually expand their capacity to acquire fertilizer as yields rise. Small packs can be used to reduce the risk for poor farmers since the invested capital would be smaller compared to the 50 kg bag. The small fertilizer pack provides convenience and flexibility to farmers who wish to use less fertilizer. Small packs should therefore be included as an option but not necessarily be treated as the solution to the problem of non-use of fertilizers or declining productivity.

4.4. The role of small doses

Farmers who do not use any fertilizer because of the various reasons stated can be introduced to fertilizer through small doses. This is because even small quantities of fertilizer – half a beer bottle cap per plant applied at knee-high maize crop can make a difference in yield. Low rates of fertilizer may not be optimal in the sense that higher rates would give higher yields. However, fertilizer is expensive and low rates, even a third or quarter of normal recommended rates, can still give very substantial increases in yield. The concept of microdosing is based on the precision application of small doses. This has come after a realization that the recommended rates of 300 kg/ha are not only too high and risky in dry climates but also unaffordable by smallholder farmers.

4.5. The role of private–public–farmer partnership in creating fertilizer demand

The partnership that was initiated in 2004/05 serves to indicate how parties can work harmoniously for a common purpose but still be able to maintain their individual objective function. There has been a notable increase in the volume of fertilizer sales through community-based Progress Milling Depots. The number rose from 15 tons to 140 tons per season. Concurrently, there has been an increase in the amount of maize supplied to the depots because of increased productivity due to use of fertilizer.

4.6. The role of agricultural research and extension in promoting fertilizer use in the Limpopo Province

In Limpopo there is need to coordinate research efforts and disseminate the information to extension staff because this is crucial for technology transfer and adoption. Sasol Nitro has managed to conduct a number of on-farm participatory trials at several locations close to the depots as a way of promoting fertilizer use and this will generate new information to be incorporated with fertilizer recommendation rates. Agriculture extension is the main source of information on fertilizer use and also on sources of fertilizer. The involvement of extension workers in the management of farm trials and demonstration plots plays a pivotal role in ensuring that all new knowledge gained from trials in transferred to the end users (farmers).

4.7. Whither small packs?

Small packs provide options and choice to farmers but they are not necessarily the best option to accelerate productivity growth. The study has established that first time and second time users of fertilizer have a tendency to access smaller packs than larger packs because there is less risk involved. It can also be confirmed that small packs are convenient for farmers who require less than 50 kg of fertilizer for backyard gardens or small area crop production. Survey data also provides some evidence that small packs are convenient to transport. However, there is no basis to tie affordability and small pack access given the income spread of the farmers we are working with in South Africa. Data and information available at this stage cannot state whether small packs are economic or not. The full cost of the small pack production is not being deliberately transferred to farmers. This is a strategy of enticing farmers to buy fertilizer. All in all, dealing with small packs will serve the advantages stated but this should be supported with improved seed, knowledge, credit, and infrastructure.

5. Policy recommendations

Smallholder farmers need to be supported in their quest to increase agricultural productivity growth by providing the necessary infrastructure and support services. Farmers need to have easy and competitive access to

output markets so that they get a fair market price for their produce. Small packs provide a starting point for increasing fertilizer use and subsequently production. There is need to supply small packs in combination with bigger packs and not exclusively. As a result of the initiative by ICRISAT/SASOL Nitro/Progress Milling/LPDA, Sasol Nitro is now registered to produce 20 kg packs of fertilizer over and above the 50 kg which is an unplanned outcome of this study.

There is need to develop sustainable and strategic partnerships between the private and public sector and farmers through continuous consultation, networking and information sharing among key stakeholders on issues and policies that affect the agricultural sector. This can be achieved by providing a framework for greater understanding and broader commitment to the agriculture sector's goals, thus reducing the likelihood of inconsistency among stakeholders, enhancing efficient use of limited resources, promoting synergy and increasing program impact, especially on the poor. The partnership, which has already been initiated in the Limpopo Province, should be improved and scaled out to other goods and services. There is value in the process both within and outside of South Africa.

In the Limpopo Province, there is need to have clear fertilizer recommendations that are known to be effective and realistic. Research needs to revisit the subject of fertilizer recommendations so that these are more realistic. To consolidate farmer training in the use of fertilizer recommendations the extension department needs to provide the necessary education to farmers. To overcome the information and knowledge gap, there is a need to accelerate fertilizer trial regimes accompanied by introducing fertilizer. Trial results should be collected as information to be disseminated to extension workers and farmers. This could accelerate technology transfer and adoption of soil fertility management practices in the province. There should be regular farmer training workshops, demonstrations and field days to help enhance farmer's knowledge and skills in soil fertility management.

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About ICRISAT

ICRISAT
Science with a human face

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is a non-profit, non-political organization that does innovative agricultural research and capacity building for sustainable development with a wide array of partners across the globe. ICRISAT's mission is to help empower 600 million poor people to overcome hunger, poverty and a degraded environment in the dry tropics through better agriculture. ICRISAT belongs to the Alliance of Centers of the Consultative Group on International Agricultural Research (CGIAR).

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