Genetically Modified Cotton in South Africa: The Solution for Rural Development?

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Introduction

In South Africa, cotton is usually grown by commercial farmers. Since 1997 this cash crop has been selected as a carrier wave for small-scale farming development in Northern KwaZulu, the Northern Province and the Mpumalanga Lowveld. Recently cotton has become a new focus of interest because it is the first genetically modified (GM) crop introduced into small-scale farming systems on the African continent, that is in the Makhatini Flats production area. Generally this modern biotechnology (Bt) is well-suited for high-tech farming systems, but now it has also made an appearance in low-input management agricultural systems. This poses a number of questions about the validity and the agro-economic impact of the introduction of Bt technology.

The three studies presented in this document attempt to answer the following questions:

- Does the Bt technology respond to small-scale farmers' needs given the present context?
- Does Bt technology reduce the impact of agriculture-limiting factors?
- What is the optimal potential for Bt cotton production?
- What is the effect of Bt technology on minimum-input field management?

The first subject is not directly linked with GM analysis but gives a broad survey of the limiting factors in small-scale cotton farming. The last two report on Bt cotton behaviour under distant cultivation practices.

Acknowledgements

This document would not have been written was it not for the sponsorship of the Rockefeller Foundation and the technical aid from the Department of Agricultural Economics at the University of Pretoria. In particular we would like to thank Chris Nolte and all Clark Cotton technical staffwho facilitated the study on GM cotton in optimum field conditions.

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Analysis of the limiting factors in small-scale South African cotton farming

Jean-Luc Hofs
Pr. Johan Kirsten

Small-scale cotton farming in South Africa today

The importance of small-scale cotton farming

Comparing to other African countries, South Africa has one of the lowest percentages of small-scale farmers growing cotton. The reason for this is found in the history of this country. Prior to 1994 the government did not actively promote agriculture as a viable economic concern for black communities. A few large-scale development projects, such as the Makhatini Flats Scheme, did exist, but these were mainly used as displays for the benefit of the international community.

The annual average area of small-scale farmland under cotton is around 10.000 ha, but this varies from year to year (fig. 1). The major cotton fields in small-scale farming are managed under rain-fed conditions. The small-scale farming area under irrigated cotton is marginal and has been decreasing since 1995.

Fig. 1: Fluctuations in the area planted (in ha) by small-scale cotton growers

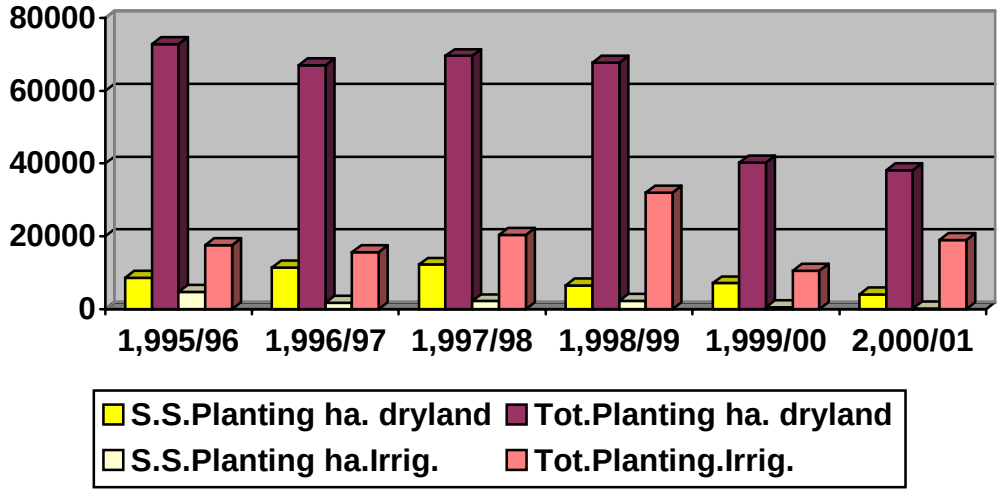
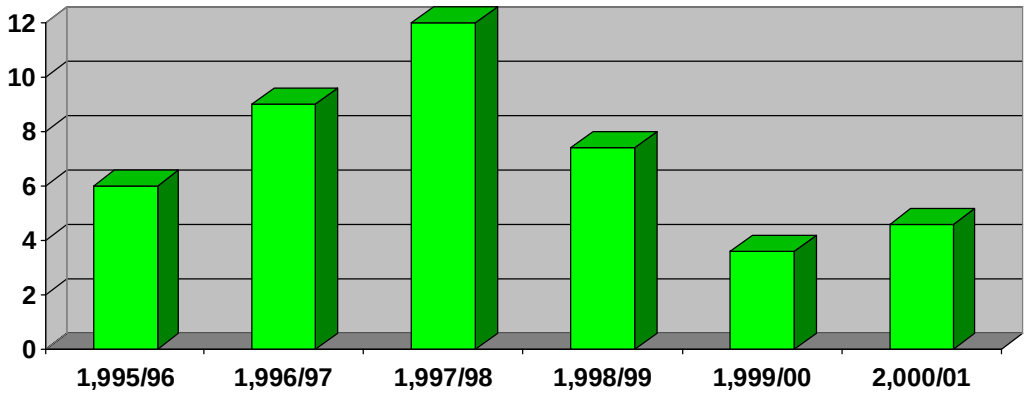


Figure 2 reflects the trends in cotton yield grown by small-scale farmers in relation to the national production.

Small-scale cotton farming took a hike in the period 1995-1997 but has declined over the past three years. The main reason for this decline is the stagnation of the seed-cotton selling price around 2.50 R/kg as a result of a low world price for cotton. There are other limiting factors which will be discussed below.

Fig. 2: Market % of small-scale cotton crop (source: Cotton SA)



Small-scale cotton farming: Not uniformly spread throughout the country

The map of the cotton production areas (fig. 3) shows the distribution of small-scale cotton farming areas over the 9 provinces of South Africa. During the growing season of 1999/2000, KwaZulu Natal, and in particular the Makhatini Flats represented 85 % of the total number of small-scale cotton growers in the country. Tonga also has quite a sizeable number of cotton growers: there are 500 active small-scale cotton farmers. Then there are some farmers growing cotton in Taung, and there are a few in the vicinity of the cotton research centre in Rustenburg.

These figures reflect the present situation. It must be noted, however that there might be more cotton growers than these numbers suggest. It is expected that more accurate information will be provided trough the national census, which will take place in October 2001. Table 1 shows the estimated production for 2000-2001.

Fig. 3: Cotton production areas and number of small-scale farmers in 1999-2000.

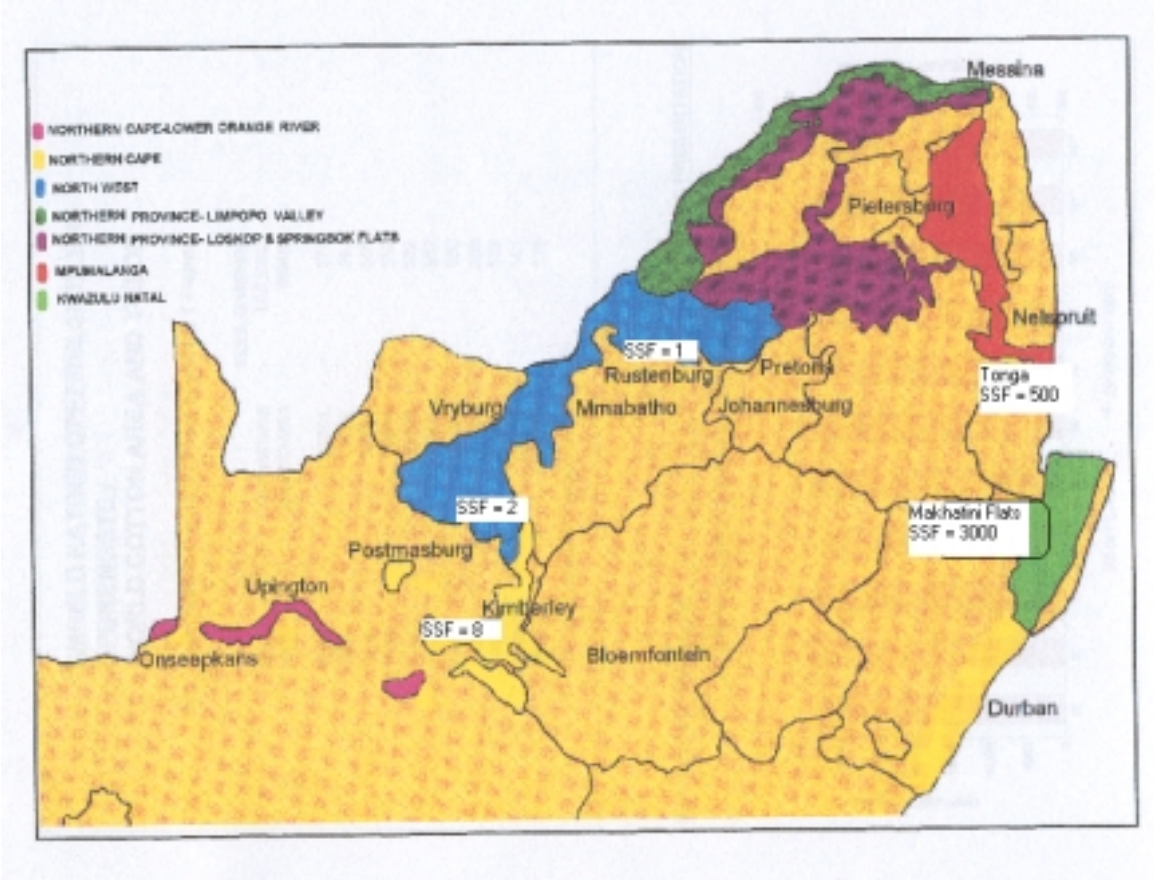
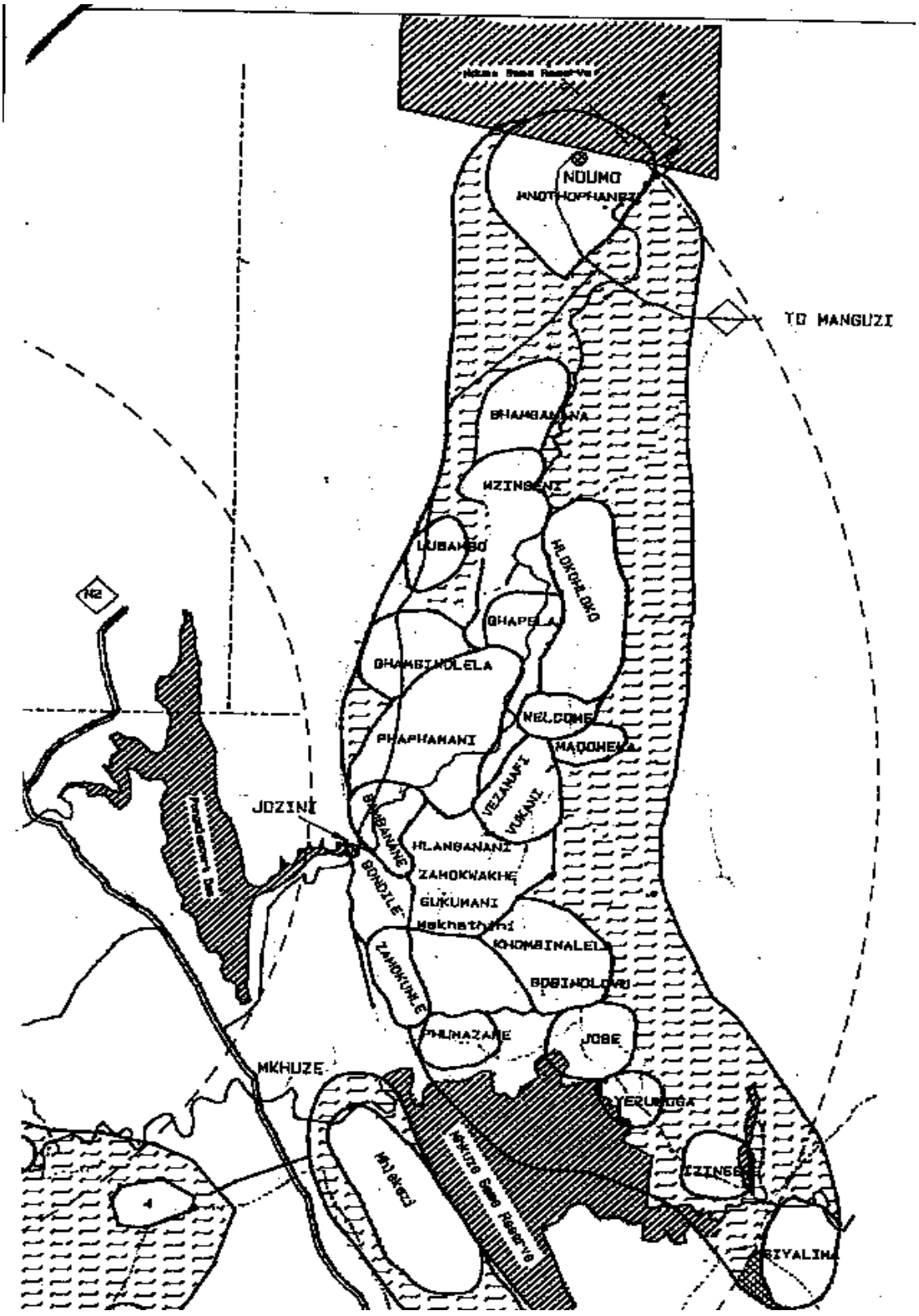


Table 1: estimation of small-scale cotton production in 2000-2001

Production area	Estimated surface (ha)	Estimated production (tons lint)
KwaZulu Natal	2978	945.6
Tonga	850	306.0
Brits	0	0
Taung	70	71.6
Other	0	0
Total	3898	1323.2

Source: Cotton SA

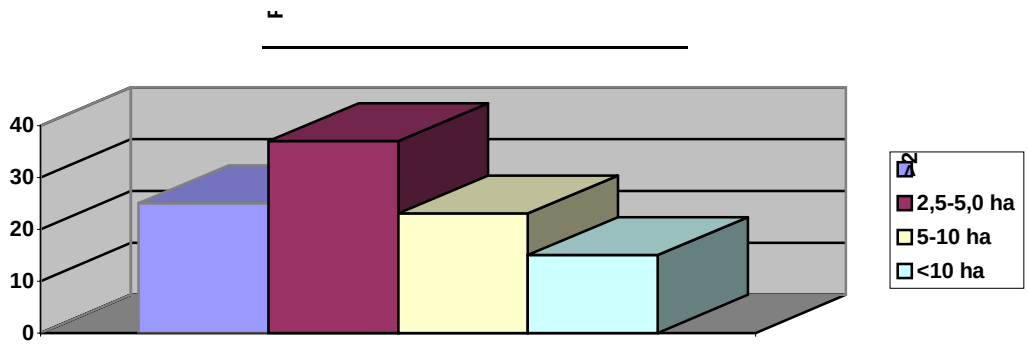
Fig. 4: Small-scale cotton growing communities on the Makhatini Flats



Typology of a small-scale farming unit

Generally it is assumed that the average area available per farm unit is 2 ha. Caution must be taken when this figure is interpreted because there is much variation between

individual farms (from 0.5 ha to 20 ha). As shown in figure 5, the group with an area between 2.5 and 5.0 ha is mostly found on the Makhatini Flats.



A recent study carried out by the Universities of Pretoria and Reading indicates that 76 % of the farmer-planters are older than 40 and 48% of the farmers are women.

Additional labour is made up of women belonging to the family. In quite a number of cases, that is, on farms up to 5 ha, the farmer resorts to hiring outside labour in the neighborhood. 27% of the farmers own cattle, but the use of animal draught is very rare in cotton production areas.

In the majority of the cases, particularly in Mpumalanga and KwaZulu Natal, the land does not belong to the farmer but has been given to him in concession by the tribal authority.

Most small-scale farmers prefer to plant food crops like maize or beans. The fact that maize is very sensitive to drought determines the choice in favour of cotton cropping. Small-scale cotton farming generates erratic yields, which vary from 600 to 1200 kg of seed-cotton/ha. This provides an average net income of 170 US$/ha. This relatively low revenue is less inhibiting than it might appear given that 25% of the families have additional, non-farm income. The average small-scale farm has no special infrastructure and very rarely has tools.

The small-scale farmers' working group (SSFWG)

In 1998, in order to respond to the government action plan aiming at the development of disadvantaged communities, Cotton SA (former Cotton Board) set up a consulting structure involving public research (ARC), private companies (DeltaPine, Novartis, etc.), cotton companies and ginners (Clark Cotton and NSK), NGO’s, farmers' unions and governmental institutions (Land Bank, Provincial Governments). The objective was to undertake a study on small-scale cotton farming development, aiming at defining priorities in development, and facilitating the establishment of cotton growing projects.

Limiting factors in small-scale cotton farming

A survey conducted by Mike Ogg (2000) identified a number of problems and needs related to the provincial extension services. Afterwards Cotton Sa, through its SSFWG, did a SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis for small-scale cotton farmers in South Africa, and used this as the basis for discussion in the SSFWG framework.

Main limiting factors detected by provincial authorities

Figure 6: Major problems in the provinces

Problem / Province	Input costs	Organisational	Financing	Training	Irrig. scheme	Access to land	Cotton prices	Drought risk
KZNatal	■	■	■					
Northern		■	■	■	■			
Gauteng	■		■	■		■		
Mpuma.			■				■	■
NorthWest				■				

■ : Main limiting factor encountered

As figure 6 reflects, problems and priorities vary per province. Mpumalanga and KwaZulu Natal have the most developed structures and best performing farmer associations. Nevertheless, financing and training remain the key problems in most provinces. In Mpumalanga the drought risk exposes the cotton grower to a new threat, namely that he might become non-creditworthy and will be unable to receive credit.

The situation in the North West Province is quite varied. In Taung, a small community of small-scale farmers has been growing cotton under irrigation for quite some time and have succeeded well at a technical level despite poor financial management. Another group has just begun cultivating cotton near Rustenburg. The marginality and the novelty of the crop make that the problems farmers are facing have not yet been analysed extensively by the Provincial Government.

Institutional factors

The slow land reform process is one of the major hindrances for development. Instances of this are:

- The inadequate tangible support by the National Department of Agriculture for small-scale farmers.
- The lack of sufficient provincial financial funds for focussed action.
- The need to improve access to productive land.

- The lack of farmers' ownership of the land they farm.
- The lack of formalised land tenure.
- The waste of resources caused by parallel functioning of different farmers' associations.
- The lack of effective training.
- The total collapse of the irrigation scheme in some areas in the Northern Province caused by lack of commitment of the Provincial Government.

Economic and infrastructural factors

The main issue farmers complain about is the limited access to credit or funding. Because farmers generally do not own the land they are farming and cannot deposit collateral, it is difficult for farmers to borrow money from banks and other financial institutions. Even when funding is possible through the Land Bank, the procedural delay does not allow the farmer/grower to plant at the right time. The micro-loan[1] availability system placed at small grower disposal during the 2000-2001 season did not allow farmers to get enough cash to cover all production costs. Table 2 gives the availability of loans related to previous loan repayments.

Table 2: Land Bank loans available for small-scale cotton farmers

Farmer class/ statement of previous repayment	New loan (Rand) available per cultivated hectare	Conversion in US$
100 % repaid	1290	161
70 % repaid	1020	127
50 % repaid	552	69
0 % repaid	0	0
New farmer	552	69

It has been established that most small-scale farmers have little knowledge of financial and credit management. Very few of them keep account books, although they do seem to know their expenses and profits.

According to the SSFWG, the production costs of cotton in South Africa seem to be higher in comparison with other small-scale cotton farming set-ups elsewhere in Africa. This statement, however, deserves to be duly analysed and further corroborated by facts and figures. An ICAC publication of 1998 shows that South African small-scale cotton farming has intermediate production costs in relation to other African countries. Information shown in figures 7 and 8 presents interesting details that counterbalance the SSFWG observations.

Fig. 7: Cotton production and insecticide costs (in US$) in 7 African countries

[1] Small growers may open a credit account at Land Bank. Vunisa facilitates the procedure.

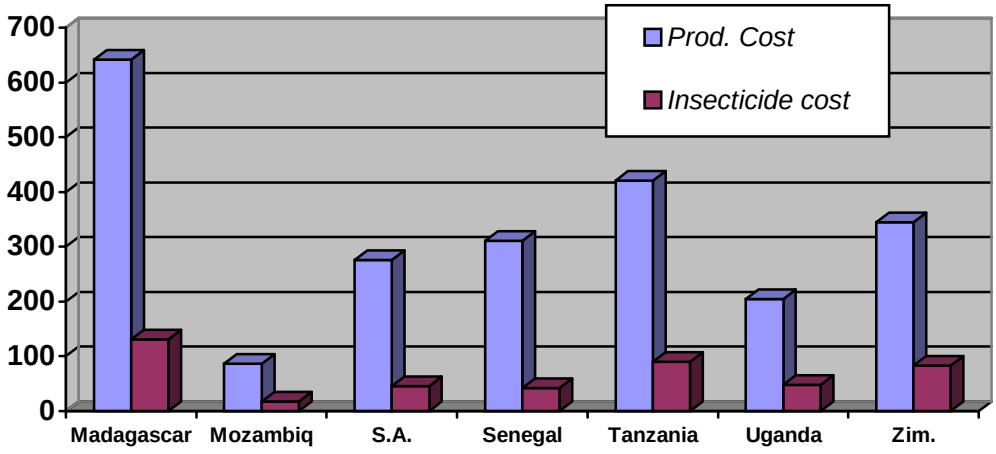
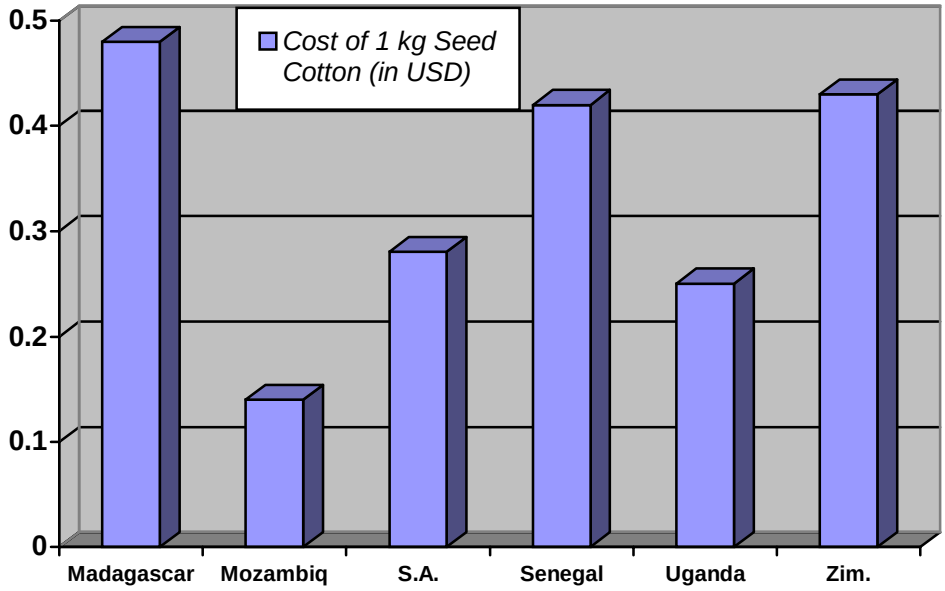


Fig. 8: Production cost (in US$) of 1 kg of seed cotton in 6 African countries



An additional limiting factor pointed out by the SSFWG is the lack of implements and lack of availability of contractors needed for soil preparation. This problem can be solved in several ways. One is, the ginning industry could give support in ploughing small-scale farmer fields. Another solution is that animal draught, which at present is under-utilised, can be developed and popularised.

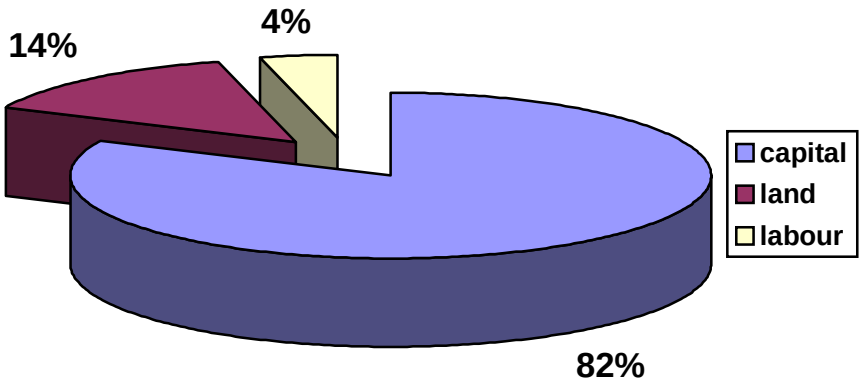
High input costs, particularly those caused by necessary mechanical inputs are also a major complaint of the small-scale agricultural sector.

Other complaints focus on the condition of the roads and the communication network in general. Mostly this is in poor condition and so reduces farmers' opportunities to be visited and trained by extension officers. This, however, is not considered a major hindering factor; some high-producing countries in Africa experience difficulties in this regard that are much worse than those in South Africa are. It must be borne in

mind that the improvement of the road and general communication infrastructure depends on political decisions and, thus, this could mean that communities might have to wait for a long time. The immediate solution to this problem is to provide the extension staff with better access to public or private funding. Such a policy will improve extension officer mobility, will better their technical knowledge trough training and acquisition of documents, and will strengthen training facilities for the farmers.

According to the farmers a major non-agronomic constraint is the lack of capital. Figure 9 shows that land ownership and labour are considered as secondary issues (Ismael et al, 2001).

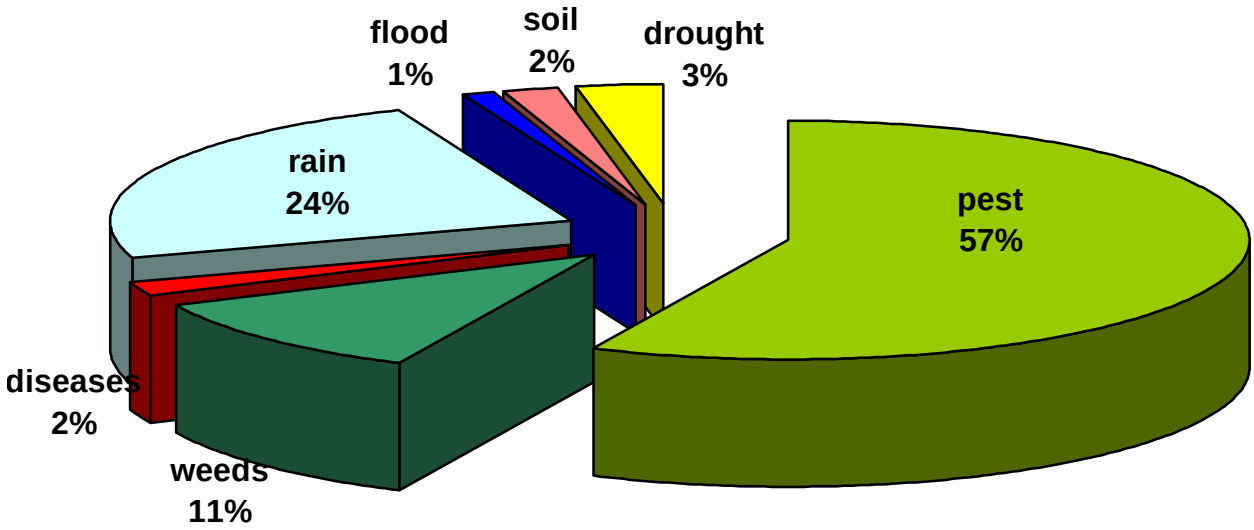
Figure 9: main economic constraints



Technical factors

The SWOT analysis reveals only one weak technical matter, that is, "the yield is low and erratic". In fact, this outcome is the result of a range of agronomic problems. It follows that the real causes must be defined more accurately. At the farming level the technical constraints are critical. The most important of these are the occurrence of pests, of excess rain and weeds (figure 10).

Figure 10: main agronomic constraints



1) Insect pests

According to the farmers the main damaging pests are bollworm complex (62 %), aphids (21%) and jassids (17%). Depending on the size of their populations jassids can have a great negative impact on yields. In the nineties, a variety response was applied with hairy varieties of cotton (Ca223). Since the year 1998, Bt varieties with smooth leaves have been launched in small-scale farming environments, resulting in an increase of jassid-caused damage. At present, new DeltaPine hairy varieties are being tested in the South African national variety experiment. These cultivars will soon be modified with a Bt gene.

In spite of several (repeated) training courses given by a wide range of state institutes and private companies, 26% of the farmers tend to use more pesticides than recommended.

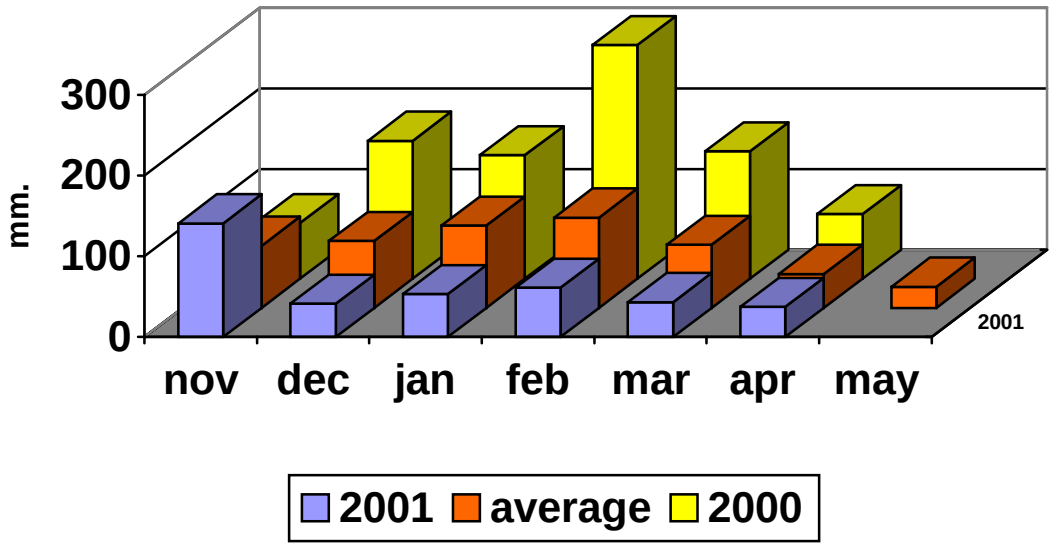
Since 2000, new insect pests have appeared in some places. The sting bug complex had caused serious damages in the regions of Pongola, Maputaland and Tonga. Sting bugs have not yet been determined completely. Scientists have guessed that several species are involved; the *Nezara sp.* and *Macrosternum sp*. have been captured in damaged fields. The insects only appear at the boll opening and so cause stains on the fiber. At the green boll stage, one section of the fruit shows a small round growth on the inside of the endocarp at the place where the insect feeds. For the moment, that is, until in-depth studies produce more conclusive results, Monocrotophos (750 ml/ha/200 litres water) seems to control the stingbug (Eulitz & Prinsloo, 2001).

Particularly on the Makhatini Flats the insecticide supply network has been improved much over the past few years, but it is virtually non-existent in other rural areas.

2) Climatic constraints

The eastern part of the cotton production area (Maputaland and Tonga), where the predominance of small-scale cotton farming takes place, receives an average rainfall of 520 mm during the growing season. Throughout the year and over the years the rainfall patterns vary considerably, though. Figure 11 shows this variability taking for two consecutive agricultural seasons (1999-2000 and 2000-2001).

Figure 11: 1999/2000 and 2000/2001 rainfall compared to average on Makhatini Flats



Temporary droughts may occur during the rainy season. This causes stress and Bt gene expression disorders in Bollgard® cultivars. Long periods of overcast weather can also affect production since this causes serious shedding of squares and flowers.

In other production areas like the North West Province and the Northern Province drought periods and early frost are restricting climatic factors for growing cotton.

3) Weed control

Weed control is currently done manually. The use of herbicide is not well known and adequate supplies are inaccessible. The only herbicide available on the Makhatini Flats is RoundUp which costs 160 Rands (20 US$) per 5 liters.

Weed species abound in the fields. Table 3 gives an overview of the species that can commonly be found.

Table 3: Major damaging weeds in cotton

Broadleaf-weeds	Grasses
Acanthospermum australe *A.hispidum*	*Brachiaria eruciformis* *Chloris pycnothrix*

Amaranthus sp.	*C. virgata*
Bidens pilosa	*Cynodon dactylon*
Cleome monophylla	*Digitaria sanguinalis*
C. gynanadra	*Echinochloa colona*
Convolvulus arvensis	*E. crus-galli*
Datura ferox	*Eleusine indica*
D.stramonium	*Eragrostis aspera*
Galinsoga parviflora	*E. Cilianensis*
Hibiscus trionum	*Panicum laevifolium*
Ipomea purpurea	*P. maximum*
Nicandra physalodes	*Setaria verticillata*
Portulaca oleracea	*Targus racemosus*
Richardia brasiliensis	*Urochloa panicoides*
Schkuhria pinnata	
Solanum nigrum	
S. elaegnifolium	Reeds
Tagetes minuta	
Tribulus terrestris	*Cyperus rotondus*
Xanthium spinosum	
X. strumarium	

Source: IIC & personal survey

4) Varying planting dates

Due to the great variability of the date of the first rains, generally no recommendation is given regarding a date for early planting. Having said this, the recommended date for late planting in KwaZulu Natal is the 10th of December. Farmers who are dependent on mechanical ploughing services often do not plant on the right date. Frequently this is caused by delay in the delivery of the mechanical assistance required. These factors make that planting dates in small-scale farming systems are staggered over 2 months. Together with climatic constraints this management constraint causes an increased risk of insect proliferation in late crops.

5) Soil fertility and structure

The study conducted by the Universities of Pretoria and Reading reveals that only two percent of the farmers mention problems with soil fertility as a major constraint. The fact that the soil component is (nearly) completely left out of considerations regarding crop management demonstrates a severe lack in the farmers' knowledge and training.

- *Absence of rotation*

Very few small-scale (but also commercial) farmers alternate crops. Generally small-scale growers give as a pretext for non-rotation that their crop area is too small for rotation. Practices of mixed cropping or cover cropping have not been adopted in South Africa.

- *Poor knowledge about soil fertility*

The fact that, generally, chemical fertilisation is rarely used (only 4% of the farmers) is probably caused by the cost of these products. Table 4 indicates some of the prices of fertilisers available on the Makhatini Flats.

Table 4: price list of available fertilizers in small-scale farming

Name or composition	Price for a 50 kg bag	Conversion in US$
DAP	130	16.25
NPK 2/3/2	85	10.63
Urea (45%)	110	13.75

Kraal manure could be used in rural areas with live stock activities but even there using manure to fertilise fields is not common practice.

A survey on Makhatini flats conducted in 2000, indicates that farmers believe that the fertility of the soil remains at an optimum even after years of cultivation, and even though they are aware of 45% decrease in yields over a period of ten years.
So far, no data about organic matter content in the soil have been published. Generally soil analysis is unavailable at the small-scale farming level.

6) Effective plant population

The recommended seed quantity per ha is 10 kg for dryland conditions and 18 kg for irrigated schemes. Due to the seed price, farmers use a lower quantity of seed than recommended. Cotton growers who adopted Bt cultivars plant 45% of the recommended seed quantity. With regard to conventional seed, farmers use 55% of the recommended quantity.

Inadequate conditions of the cropping area have a dramatic influence on the yield. Under regular climatic conditions, a low plant population promotes weed growth and so causes high labour cost. In dryland management, research recommends 30 000 plants per ha under normal climatic conditions. But in cases where planting happens late, the plant population must be higher in order to force the plants to go faster through their growth cycle and so cause higher yields in a shorter growing period (ARC/IIC, 1996).

Skip-rowing is sometimes adopted by small-scale farmers without valid agronomic reasons for cotton cropping. Generally, this practice applies to maize in order to avoid drought stress. In the case of cotton, the well-developed tap-root system confers a better resistance to such factor. In the other hand, when the unplanted rows are included in the acreage, yields are about 80 per cent of those from a full stand of cotton (Munro, 1987).

Conclusion

The development of the small-scale cotton farming sector is not only a matter of improvement of the sector itself but is also dependent on general policies promoting small-scale agricultural development. After all, any positive change in this sector can only be sustainable if there is a good integration of cropping systems, which would include cash crops, food crops and livestock.

If Cotton SA aims at success in boosting the small-scale cotton sector, so that it will achieve a production that is 30% of the national production, it needs to work on 3 focus points. Cotton SA needs to play a role in:

- the facilitation of farmers' access to capital (better policies regarding credit systems, loans and repayment).
- the promotion of effective training.
- the promotion of appropriate research focusing on small-scale farmers, in which they need to be directly involved.

At this point the state of research must be seen as a limiting factor in small-scale development. The weakness of government-initiated research, the isolated research commissioned and driven by private companies or universities, and the lack of technological transfer in the field do not contribute effectively to an integrated and well-thought-out rural development plan. The technical constraints pointed out in this document are evidence of this. .

The National Government and the Provincial Governments have an important part to play in the financial and infrastructural support of small-scale cotton farming. Governmental involvement in cotton companies in South Africa would enhance their commitment and should, thus, be a prior condition to the development of such a programme.

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