Trip report : South Africa

30 April – 7 May 2005

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Cirad-ca/URP « Systèmes rizicoles pluviaux »

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TRIP REPORT : SOUTH AFRICA

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Itinerary

Saturday 30 April:	Antananarivo-Johannesburg (Air Madagascar) Johannesburg-Pietermaritzburg (drive with R. Fowler)
Monday 2 May:	Pietermaritzburg-Karkloof-Pietermaritzburg (drive with R. Fowler)
Tuesday 3 May:	Pietermaritzburg-Winterton (drive with R. Fowler)
Wednesday 4 May:	Winterton-Pietermaritzburg (drive with R. Fowler)
Thursday 5 May:	Pietermaritzburg-Cedara-Potchefstroom (drive with R. Fowler)
Saturday 7 May:	Potchefstroom- Johannesburg (drive with J. v/d Berg) Johannesburg-Antananarivo (Air Madagascar)

Terms of reference

1. To explore ways that IPM and cover crops may help to disrupt disease and insect pest cycles currently affecting maize, wheat and soybean grown under No-Till;
2. To identify related research projects; some of which may benefit from collaboration between RSA and CIRAD researchers.

Institutions & Persons met

1. Cedara, ARC/GCI, Richard Fowler, Agronomist
2. Karkloof, Kwazulu-Natal No-Till Club, Robin Denny, Secretary
3. Karkloof, Kwazulu-Natal No-Till Club, Aubrey Venter, Dept of Agriculture (retd.).
4. Winterton, Kwazulu-Natal No-Till Club, Anthony Muirhead, Farmer
5. Winterton, Kwazulu-Natal No-Till Club, Joos Solms, Farmer
6. Winterton, Kwazulu-Natal No-Till Club, Albert Mazibuko, Farmer
7. Winterton, PPRI (Pretoria), Dr S. Staphorst, Soil biologist
8. Winterton, PPRI (Pretoria), Dr Jacomina Bloem, Soil biologist
9. Winterton, PPRI (Stellenbosch), Dr Sandra Lamprecht, Soil biologist
10. Winterton, Dept of Agriculture, Eve Du Preez, Plant pathologist
11. Winterton, Farmer's Weekly, Lloyd Phillips, Journalist
12. Cedara, The Royal Veterinary and Agricultural University (KVL), Denmark, Adrian Bolliger, Soil scientist

13. Cedara, Dept of Agriculture, Alan Manson, Soil scientist

14. Cedara, Dept of Agriculture, Guy Thiboud, Soil scientist

15. Pietermaritzburg, University of Natal, Professor Marc Laing, Plant pathologist

16. African Centre for Crop Improvement, UKZNP, Professor Walter A.J. de Milliano, African Cereals Specialist

17. Potchefstroom, ARC/GCI, Hannalene Du Plessis, Entomologist

18. Potchefstroom, ARC/GCI, Tom Drinkwater, Entomologist

19. Potchefstroom, ARC/GCI, Herman Loubser, Agronomist

20. Potchefstroom, University of the North-West, Johnnie van den Berg, Entomologist

Background

This mission was a response to an invitation sent to CIRAD, on behalf of both the No-Till Club of Kwazulu-Natal (KZN-NTC), and the Agricultural Research Council-Grain Crops Institute (ARC-GCI) by Richard Fowler (ARC-GCI). Olivier Husson was the scientist initially targeted, but as he was not available and that crop protection aspects were central, I proposed to replace him.

This process started in Oct 2003, during the « Sustainable Soil Health Workshop » which was hosted by University of Natal at Pietermaritzburg, and also involved University of Free State & Cornell University, and where O. Husson was the keynote speaker. To meet the need to work in multidisciplinarity, internationally (overcoming language barriers to access the information on the web), and to bring the farmers into the equation, the CS3 (Consortium for sustainable soil systems) initiative was devised as a concerted thrust to promote the adaptation & adoption of conservation agriculture in RSA. It has unfortunately been staggering for the last 1 ½ year. This mission was seen as an opportunity to revive the process, and addressing the need for a NTC research committee.

As the last days of the visit (at Potchefstroom) were devoted to matters of particular interest to me (black beetle problems on rainfed rice ; sorghum stem borer problems in Central Africa ; head-bug problems in West Africa vs Southern Africa), the mission was co-financed by CIRAD (airfare), ARC-GCI (car rental & fuel, part of accommodation costs) and KZN-NTC (part of accommodation costs).

Field visits & discussions

Karkloof

At Karkloof, we visited the farms of René Stubbs, Mark Benson and Charlie McGillavray, and saw a No-Till trial presented by Guy Thiboud.

At R. Stubbs', we saw a field of dryland maize where stooling rye had been sown for grazing after silage cut. RS has also tested earlier other cover crops (black oats, vetch and triticale), but prefers rye. Since he has moved to no-till, analyses said that microflora in the river below his field was back to normal.

At M. Benson's (presentation by Tom Matchett), we were shown a soybean field where wheat/triticale/stooling rye/oats had been sown after soybean harvest, with tentative seed production for next year.

G. Thiboud's experiment (in its 4th year) dealt with N X surface lime (quality-quantity) and rotation. This is partly based on hesitation/questioning about the relevance of CA on acidic soils if there is a need to plough lime in. Acidity problems were solved by increased earthworm activity favoured by liming, plus calcium nitrate formation by the roots of the crop.

At C. McGillavray's, the field had been cropped to silage maize. Infestation by *Bromus* spp. was high and he was considering killing it and using it as mulch for the next crop.

The main concern of farmers, which emerged during the general discussion following field visits at Karkloof, is to know how to produce more cost effectively, in saving on herbicides, insecticides & fertilizers, and particularly be provided insights on alternative crops (rotations) that could break the cycle of diseases and pests of maize-soybean-wheat, while improving soil fertility and having possible positive allelopathy effects on weeds, and generating income (marketability aspects).

Farmers usually spray fungicides preventively rather than curatively. With two sprays on maize, they have no more problems with Gray leaf spot (GLS). In any case, they did not have serious pest or disease (GLS on maize, Fusarium on wheat or Sclerotinia on soybean) problem this year although it was very humid (ca. 1,000 mm). As for pests, as Bt maize is widely grown, it helps a lot on stalk borer control.

At Karkloof, commercial formulations of Trichoderma (Eco-T: Plant Health Products) are commonly used and thought to be effective particularly under stress conditions. They were studied by Mark Laing (University of Natal) and are used as a drench, seed dressing, also another strain for foliage against Botrytis. Farmers at Karkloof do not complain of significant mycotoxin problems in their crops, and have not noticed those problems to be linked to glyphosate application.

Winterton

At Winterton, we visited the farms of Anthony Muirhead and Arthur Mann and saw a No-Till trial presented by Guy Thiboud. We also visited the following day the small-scale farm of Albert Mazibuko.

At A. Muirhead's, infiltration rate in No-Till was measured and found to be as high as 1,000 mm in 4 hrs. AM actually stressed the absence of run-off after big rains, added with an increase of Organic Matter (humus) after 10 years of NT maize-soybean rotation. Diplodia was the main disease we saw on maize, with some Fusarium. AM would like to know why with the same practices, he has Fusarium in some lands, not in others. Last year, he had Fusarium incidence on wheat following soya bean

The first field visited at A. Mann's had been under No-till for 6 years, and under soybean for 2 years, with wheat following soybean. Soybean had been harvested. AM indicated he hardly ever had Fusarium on wheat on his farm, but observed last year drying of wheat on spots ("Take all"-like symptoms). Zimbabwean farmers told him that he should never have planted wheat after soybean. The second field was an irrigated maize field under No-till for 5 years. AM mentioned a big yield difference due to 5 days difference in planting date between two parts of the field (which was visible from the stalks remaining after harvest).

Guy Thiboud's no-till trial compared various N applications and tillage systems on maize (no rotation). On part of the trial, differences in sprays for rust control under no-till (disease spray timing: 5 sprays vs 3 sprays) translated into 50 % cob size difference.

Albert Mazibuko's farm is about 2 ha, under no-till (continuous maize) for the last 5 years (following AM's advice and backstopping). After 3 years however, he got Diplodia (which he never had as seriously before), and decided to plough one of his fields this year because he thought higher disease incidence was due to no-till. He also tested several varieties (PAN 6043 ; PAN 677 ; Pioneer 3253 & 6480) and found the last two to be most resistant. He will plant common bean on another field next year, and might consider the suggestion of trying to intercrop it with maize. He also asked if he can be learnt how to train himself and his co-farmers to no-tillage (request to be addressed by RF). The main problem for no-till is that he cannot keep cattle from feeding on crop residues. An unpalatable cover crop sown before maize harvest might be a solution.

The general discussions at Winterton were attended by Jacomina Bloem & Dr Staphorst, soil biologists from ARC-Plant Protection Research Institute (PPRI), Pretoria, and Sandra Lamprecht (PPRI-Stellenbosch). S. Lamprecht stressed the need for rotations to break pest and diseases problems (for instance, rotating maize with wheat should be avoided with respect to Fusarium problems, since both are grasses). On the other hand, lots of sprays have a detrimental effect on soil biology. However, SL thinks that as soil is a very much buffered system, it would be difficult to bring in Trichoderma (which is currently not used at Winterton anyway).

At Arthur Mann's, she thinks the 5 day difference in planting might have coincided with a difference in disease outbreak, maybe Macrophomina (Anthracnose), symptoms of which could be seen on crop residues.

A major request was again to have a look at crops in rotations and summer cover crops like sunn hemp. Farmers need to know what is amount of N brought by each crop. Alan Manson is to have a look at what are the potential options as winter crops alternate to wheat (Canola ? Sunflower ? Lupin ?).

During the final planning/programming meeting at Winterton, the main pest & disease problems were listed for the three major crops.

Pests & Diseases	**Maize**	**Soybean**	**Wheat**
Cutworms (Lep. Noctuidae)	+	+	
Stalk borers (*Chilo partellus* & *Busseola fusca*)	+		
Boll worms (*Helicoverpa armigera*)	+	+	
Wattle white grubs (*Schizonychia* sp.)		+	
GLS (*Cercospora zeae-maydis*)	+		
Russian & black oat aphids (*Diuraphis noxia* & *Rhopalosiphum itobion padi ?*)			+
Rust (*Phakopsora pachyrhizi* on soybean; … on cereals)	+	+	+
Cob rot	+		
Northern corn blot	+		
Diplodia	+		
Fusarium	+		+
Root diseases (*Rhizoctonia* spp.; *Pythium* spp.; etc.)	+		
Sclerotinia (*Sclerotinia sclerotiorum*)		+	
Take-all (*Gaeumannomyces graminis*)			+

Because of high clay content (40-50%), there is no nematode problem in general in the No-Till Club area. For M. Laing, entomopathogenic nematodes could help in cutworm biological control. Although they were mentioned, stalk borers are well taken care of by Bt GM Maize.

For GLS, rust & Northern corn blot, besides genetic option (except for soybean rust), leaf diseases can be chemically controlled. GLS increases with N application. Three fungicides are available as seed treatment for take-all.

A project was designed to address soil-borne disease problems, that would involve ARC-PPRI (Lamprecht & Staphorst), ARC-GCI (Fowler + ?), UN Prof Laing, and KZN DoA (Eva Du Preez). It will be conducted on Winterton farmers' fields (places to be identified), and will involve a demonstration with soil sterilization (fumigation) and biological control. Root diseases will have to be identified, although evaluation of control can start since it is assumed that at least *Rhizoctonia* & *Pythium* are there for sure.

Cedara

At Cedara, the visit guided by Alan Manson showed that quite a few tests are conducted on cover and fodder crops, including vetch, clover (several varieties) and other legumes. Several varieties of Napier grass are also multiplied, and Vetiver grass grown as hedge-rows.

Potchefstroom

At ARC Potchefstroom, I first met Dr Hannalene Du Plessis, whose major emphasis now, although she is in charge of cereal entomology research at GCI, is, after sunflower pests, on groundnut leafminer. For her sorghum head-bugs and midge have so far been ignored, while they could be an unnoticed problem. Gaucho has been drawn from the market for sunflower seed treatment in RSA, due to its poor systemic effect after germination (which is understandable since sunflower is a dicot). However, she was surprised to hear from me that imidacloprid is held responsible for sub-lethal effects on bees in France.

Tom Drinkwater (maize black beetle specialist) tested Cruiser (Thiametoxam) as a seed treatment, and found it much less effective on maize than Imidacloprid (less systemically translocated). Acetamiprid was found to be very phytotoxic, even as a seed treatment.

Heteronychus moves from the surrounding grasses to maize fields. "South African" *H. arator* is highly attracted by light and its populations can therefore be satisfactorily followed by ligh trapping (which is not the case of "our" *H. arator rugifrons* in Madagascar).

In Pretoria, CSIR (Council for Scientific and Industrial Research) is working on genetic transformation of maize by putting genes coding for trypsin inhibitors that would express in the seedlings. This was confirmed to me by Johnnie v/d Berg (Professor at the School of Environmental Sciences and Development, North West University) who was to provide me contact addresses of the scientists involved in this research.

Both T. Drinkwater and J. v/d Berg are involved in the assessment of the effect of Bt-Maize on stalk borers. Exotic *Chilo partellus* is controlled 100% by Bt-Maize, whereas the control is not 100% effective on native *Busseola fusca*. Observations by JvdB & TD show that the second generation of *Busseola* enters the cob thru the husks (with very little feeding on the same), and not by the top thru the silks. It can then bore into the stem from the cob down to its hibernation site. So the plans of the firm to have the toxins expressed in the top silks is likely not to be effective (at the moment, Bt toxins are not expressed in the reproductive parts, pollen or seeds, for obvious ecological reasons). To JvdB, there is a scope for Bt Maize hybrids even for small-scale farmers, e.g. on irrigated schemes.

JvdB is very active in research on the stimulo-diversionary strategy ("push-pull" approach) for controlling stalk borers in maize-based farming systems. In South Africa however, he thinks that at the moment, there is little scope for developing the "push" component (using for instance silver-leaf Desmodium as a repellent), because it would hamper the use of tractors, which is very common, even at the small-farm level. On the other hand, the "pull" component alone helps a lot in reducing stalk-borer pressure on maize fields. Fields should be bordered with Vetiver grass or with Napier grass, but not with wild sorghums. Vetiver grass is highly attractive for stem borer egg-laying, but do not allow further larval development, since it does not have a stem proper, and not even a flower peduncle since it does not flower under North West conditions. Napier grass, especially the varieties that have trichomes which hamper stalk-borer larvae movements (larvae may feed on leaves but cannot then bore into the stems) is also a "true" "trap plant". This is not so with wild sorghums (*Sorghum sudanense*), which true are attractive, but also allow larval growth and further move to the maize field.

For him, there is a need to clarify the identity of "Napier grass" (*Pennisetum purpureum*) used in the push-pull strategy in Kenya (by ICIPE) and South Africa, since there could be a confusion with Bana grass (the interspecific *P. purpureum* X *P. glaucum* sterile hybrid). Bana grass is actually a creation of Potchefstroom research station, and JvdB thinks that what I saw at Cedara was actually Bana rather than Napier grass. The production of viable seeds could be a distinctive criterion, but unfortunately even Napier does not flower under North West conditions. I mentioned that the Bana grass we have in Madagascar seems to be attractive to Maliarpha separatella but is not a satisfactory trap crop (since it allows stalk penetration and further larval development).

As for sorghum head-bugs, so far, *Eurystylus oldi* was not found on sorghum panicles, although a comprehensive survey has been conducted. For sorghum head insect samplings, JvdB and his Masters student use a D-Vac® backpack motor fan for suction sampling of insect populations. It provides very reliable results, but it is very costly and requires two persons to be operated satisfactorily.

We were however able to recognize other hemipteran bugs of which mirids like *Campylomma* sp. and *Creontiades* sp. JvdB was to keep me informed of the outcome of upcoming samplings at resource-poor farms level further north.

Seminars

I presented myself and my field of expertise at Karkloof and Winterton country clubs (Powerpoint presentation titled: "IPM and its possible uses by and advantages to conservation agriculture farmers in South Africa").

This presentation was adapted to try to partly meet M. Laing's (high) expectations for the presentation at University of Natal [title: "CIRAD's DMC approach (with particular reference to pest management) and its possible application to no-tillage farming in South Africa"]

At ARC-GCI/Potchefstroom, my presentation was titled "IPM and its possible uses by and advantages to conservation agriculture in South Africa".

The last two presentations, which included some of the slides of Olivier Husson's 2003 presentation, were particularly well received, and, particularly at Pietermaritzburg, initiated a long discussion on the adoption issue, and the need for participatory research particularly at the small farm level. RF indicated that the only case worldwide of significant adoption of no-till by small-scale farmers was from Paraguay.

No-till systems with cover crops are also investigated on sugar cane, with research on 5 edible crops that can be intercropped including sweet potato.

Conclusions

No-tillage as currently practiced in KZN does ensure permanent cover in most cases, and several attempts/research are made by farmers to improve/diversify the systems (e.g. test of several cover crops or consideration of using weeds as mulch as seen at Karkloof).

However, it lacks some of the components of "DMC" as understood at CIRAD, in that it relies heavily on chemicals, both fertilizers and pesticides (the latter being sprayed systematically rather than on thresholds), and that "true" rotations are seldom part of the systems. On the other hand, adoption of stalk borer resistant Bt-Maize hybrids are responsible in part for a drastic reduction of pest problems, while no-till is sometimes held responsible for an increase in disease pressure. Still, farmers recognize many advantages to no-till and are not going to move away from it.

Although I am not a specialist of GMO issues, I am providing in appendix a table detailing what (to me) are the pro's and con's of GM herbicide- and insect-resistant crops.

In this context, the IPM approach that CIRAD developed for small-scale DMC farms, which requires time for biological equilibria to take place, minimal use of chemicals, and no use of GMO, cannot be directly applied. On the other hand, as soils under such systems are not yet buffered, applications of beneficial antagonist organisms such as Trichoderma could be successful.

Since my field of expertise did not cover disease problems of the specific crops grown in KZN, this mission rather provided and opportunity for farmers & scientists (ARC & Universities) to sit together and set up research plans. I am however providing as an appendix to this report general principles on the effects of DMC on crop diseases, and results of a quick literature search on this matter, relating to the main diseases on wheat, soybean & wheat in KZN.

Many of the questions raised would have required the input of a general systems agronomist like Olivier Husson. The possibility of having him go to RSA later this year should be further investigated, so as to also discuss, with CIRAD Representative in South Africa, Sylvain Perret, that I was unfortunately not able to meet, the future prospects of CIRAD-RSA institutions, and particularly the link between the CS3 initiative and the GFAR-DMC program. It could also be an opportunity for him to join a small workshop to discuss further approaches for PwP (Plant without Plowing) technology transfer to small-scale farmers, following recent insights provided by Adrian Bolliger on these issues.

Acknowledgements

I am grateful to Richard Fowler and ARC for organizing the whole visit and sponsoring part of this visit, and both to him and his wife for their excellent hospitality at Pietermaritzburg. Thanks are also due to the No-Till Club of Kwazulu Natal, particularly A. Laurens, R. Denny, A. Muirhead and J. Solms for sponsoring my stay in KZN, and to Prof. Johnnie van den Berg for assisting me when at Potchefstroom.

Appendix 1. Pro's and Con's of Genetically Modified Crops as part of IPM or DMC strategies

We are considering only crops genetically engineered to be resistant to pests/diseases (e.g Bt-Rice, Corn or Soybean) or to herbicides (e.g. "Glyphosate"-ready corn).

	Pro's	**Con's**	**Observations**
Bt Insect-resistant crops	Drastic reduction in pesticide sprays	Speeding up of Bt resistance apparition	
	100% effective on cryptic pests	Resurgence of secondary pests requiring pesticide control	100% effective on Chilo, but not 100% on late stages/attacks of Busseola, which may then be exposed (like Helicoverpa bollworms or Mythimna army-worms), to sub-lethal doses
	No direct adverse effects on consumers and beneficials		The environmental risk of having resistance genes disseminated through pollen to other crops or weeds is minimal for maize which does not have wild relatives in Africa
Herbicide (glyphosate) resistant crops	Very simple usage for farmers	Increased use of herbicides	Requires high technicity for optimum dosage applications Possible adverse effect of glyphosate on increased mycotoxin content in grains
		Speeding up of glyphosate resistance apparition	
		Increased dependence towards private firms	
		Resurgence of secondary weeds requiring alternate herbicide control	The environmental risk of having resistance genes disseminated through pollen to other crops or weeds is minimal for maize which does not have wild relatives in Africa

Appendix 2. General principles of DMC effects on disease infection & incidence on crops

Effect on disease infection/incidence **Underlying DMC component at play**	**Positive**	**Negative**
Cessation of tillage	Stops extensive sub-surface distribution of inoculum of pathogens able to penetrate root system	Pathogenic inoculum no longer buried far from its usual entry point
Mulching	Prevents dispersal of pathogen propagules through rain splashing or wind-borne processes	Crop residue on soil surface supports survival of residue-borne pathogens
Rotations & crop associations	Breaks disease cycles Encourages diversity of soil microflora, which results in "disease-suppressiveness"	Distinct exception of take-all on wheat Antagonism with biocontrol agents (e.g Trichoderma)
Plant nutrition (water & nutrient uptake)	Reduces plant stress, improves physiological resistance, and decreases risk of disease through non-preference, tolerance, and compensation mechanisms	Reverse observed in case of competition

Some of the negative effects of no-till/DMC can be compensated by genetic issues.

Appendix 3. No-tillage/DMC and its interactions with specific diseases

A quick survey of the world literature on no-till effect on the major diseases affecting maize, wheat and soybean in KZN indicates:

Fusarium

In the UK, a long term comparative trial indicated the advantages of non-inversion tillage over ploughing on winter wheat infection with Foot Rot/Ear Blight (*Fusarium* spp.)(Hutcheon & Jordan, 1996, in Leake, 2001).

In Sweden, in monoculture of barley and oats, the leaf spot disease infestation increased in reduced tillage. However, when practising recommended crop rotation, the diseases were kept at an insignificant level. The problem with Fusarium and mycotoxins increased to some extent with reduced tillage. Fungicide treatment controlled the infestation of leaf spot diseases but had no effect on Fusarium (Torrensen et al., 1988).

In the US, research with maize, wheat or soybean as the previous crop indicated that Fusarium head blight severity was highest and yield lowest when wheat was planted after maize while severity is lowest and yield highest when wheat was planted after soybean (Dill-Macky & Jones, 1999, in Kuprinsky et al. 2002).

Sclerotina

Stem rot (*Sclerotinia sclerotiorum*) has a wide host range, causing sclerotinia disease on broadleaf crops and weeds. Canola/oilseed rape is highly susceptible to *S. sclerotium* (Leake, 2001; Kuprinski at al. 2002). With rare exceptions, this pathogen does not affect cereals and grasses.

In Germany, the effects of crop rotation and soil cultivation on decay of plant debris, inoculum of *S. sclerotiorum* and the incidence of diseases in a subsequent rapeseed crop were investigated in various field experiments over several years. Survival of sclerotia of *S. sclerotiorum* was enhanced when the inoculum was buried deeply by ploughing. Non-inversive tillage after rapeseed cropping enhanced the formation of apothecia in the first year, however, it strongly decreased the occurrence of apothecia in the second and third year (Wamhoff et al. 2001).

Reduced tillage is occasionally associated with reduced survival of *S. sclerotiorum* overwintering sclerotia, because it favours the bacteria that breakdown these structures (Nasser et al., 1995, in Kuprinsky et al. 2002).

Soil pathogens

Crop rotation is less effective with those organisms (*Fusarium* spp., *Pythium* spp. and *Sclerotinia* spp.) that have a wide host range and good survival mechanisms (Kuprinsky et al. 2002). However, the inclusion of pulse crop in rotations, especially with no-tillage, enhances the population and activity of beneficial soil organisms and minimizes the impact of cereal root diseases (Kuprinsky et al. 2002).

Take-all

This wheat disease is the exception to the trend of higher ability of soils under no-till for biological control of plant diseases. Continuous monocropping of wheat leads to an increased suppressiveness of the soil to the take-all fungus due to microbial activity (Cook & Baker, 1983, in Kuprinsky et al. 2002).

Insect pests

Bromus spp. grass serves as an alternate host to Russian wheat aphid (*Diuraphis noxia*), so care should be taken to actually kill it well before wheat planting if it is to be used as a dead mulch. Aphids are typically insects on which improved nutrition under no-till should result in induced resistance (Chaboussou, 1985, in Ratnadass et al. 2005).

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Appendix 4. Documents collected during the mission

Venter, A. (Ed.) 2000. A guide to no-till crop production in Kwazulu-Natal. Howick, RSA: No-Till Club. 210 p.

Van Wyk, P.S. & Smit, M.A. 1995. Soybean diseases & pests. ARC-LNR. 92 p.