PROTEIN RESEARCH FOUNDATION



2020-2021

RESEARCH REPORT

PROTEIN RESEARCH FOUNDATION

Vision

The PRF strives to make a significant contribution to the promotion of local production of protein on a sustainable basis, in order to satisfy the growing demand for protein for animal production purposes as well as the optimal utilisation thereof, which will lead to an increase in the standard of living of all people in the Republic of South Africa.

Mission

The PRF contributes to the realisation of its vision for the provision and utilisation of protein by means of the pro-active stimulation and funding of applicable purposeful research, as well as the promotion and implementation of such research results by means of technology transfer, in order to fulfil the increasing demand for protein as well as its optimal utilisation in the Republic of South Africa for animal nutrition.

The PRF subscribes to…….

- A balanced, objective approach, which is sensitive to the developmental needs of the RSA.
- A critical awareness of the latest developments regarding protein supply and utilisation.
- The promotion of cost-effective research.
- The dynamic promotion of the implementation of research results.
- The effective sustainable utilisation of natural agricultural resources.
- The reduction of foreign exchange payable for imports and creation of job opportunities by replacing imported protein as far as possible with locally produced protein.

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RESEARCH REPORT 2020-2021

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1. INTRODUCTION

During the 2020-2021 financial year the Board of Trustees once again succeeded in their efforts to achieve the Trust's objectives as set out in the Trust Deed.

- Objectives of the Trust

The founding objectives and requirements of the Trust are to place the reserve funds earmarked for the financing of protein research, as provided for in Section 20(5) of the Agricultural Research Act of 1990, as well as all future donations provided for in Section 20(5)(c) of the Agricultural Research Act of 1990, in trust for research purposes to be allocated in the Republic of South Africa, as the Trustees may determine from time to time, for the purpose of research in either of the following fields:

(a) Protein Research

Research on protein sources destined for animal feed either of animal origin or from oilseeds and other protein rich plants.

(b) Oilcake Research

Research related specifically to the oilseed protein value chain.

1.1 Board of Trustees

The Trust is administered and managed by a Board of Trustees convened from various disciplines. During the 2020-2021 year the Board comprised the following Trustees:

Mr AP Theron	-	Expert	:	Representative - Organised Agriculture - Producer of Protein Crops (Chairperson)
Dr E Briedenhann	-	Expert	:	Representative - Oilseeds Processors and Representative - Animal Feed Manufacturers (Vice-Chairperson)
Prof RM Gous	-	Expert	:	Discipline - Protein Consumers
Mr GT du T Keun	-	Expert at the discretion of the Board		
Prof FH Meyer	-	Expert	:	Discipline - Agricultural Economics

(i) General Overview

During the reporting period 1 March 2020 to 28 February 2021, the Trust met six (6) times. Two (2) of the meetings were combined with those of the Technology Committee.

During the period under review, R4 394 375 was approved in respect of research projects, technology transfer and bursaries.

The trust fulfilled the duty of funding and managing research projects and technology transfer, both of which form part of the core business of the PRF as set out as objectives in the Trust Deed. Furthermore, the facilitation of the Soybean Value Chain discussions continued, which made an important contribution to the Soybean Industry.

(ii) Financial Overview

(a) Investment and Management of Trust Funds

Two (2) portfolio managers, Foord and Old Mutual Wealth, manage the PRF trust funds.

The performance of the respective portfolio managers is monitored and reviewed constantly. Apart from regular discussions, the Fund Managers are requested to deliver a presentation to the Board of Trustees at least annually.

(b) Audit

Ashton Chartered Accountants are currently charged with auditing the financial affairs of the PRF.

Once again, the auditors issued an unqualified audit report. The report noted the efficient operation and management of the affairs of the PRF by all concerned.

Together with the auditors, the financial and administrative systems, and specifically the financial reporting systems, are reviewed and upgraded in order to ensure financial stability and corporate governance.

1.2 Executive Committee

During the reporting period 1 March 2020 to 28 February 2021, the Executive Committee met six (6) times.

The Executive Committee may be considered an extension of the Board and provides recommendations relating to policy matters. This Committee is also responsible for financial and marketing matters.

The Executive Committee consisted of the following members:

Mr AP Theron	-	Chairperson, Chairperson of the Board
Dr E Briedenhann	-	Vice-Chairperson of the Board and Chairperson of the Technology Committee
Prof FH Meyer	-	Board Member

1.3 Technology Committee

During the reporting period 1 March 2020 to 28 February 2021, the Technology Committee met four (4) times. Two (2) of the meetings were combined meetings with those of the PRF Board.

The Technology Committee consisted of the following members:

- Dr E Briedenhann (Chairperson)
- Mr AP Theron
- Prof RM Gous
- Dr J Dreyer (Co-opted Member)

The functions of the Technology Committee are as follows:

- The Technology Committee is one of four Board standing committees and reports directly to the Board.

- The Technology Committee is responsible for evaluating and selecting all research projects, promoting technology transfer, visiting researchers and research projects, identifying gaps and new topics relating to research projects and identifying new sources of supply and utilisation of protein for animal feeds.

1.4 Soybean Working Group

During the reporting period 1 March 2020 to 28 February 2021, the Soybean Working Group met four (4) times.

The functions of the Soybean Working Group involve the following:

- Discussion of industry matters in the interest and to the benefit of the soybean industry.
- Identification of research projects and technology transfer to the benefit of the soybean industry.

1.5 Canola Working Group

During the reporting period 1 March 2020 to 28 February 2021, the Canola Working Group met three (3) times.

The functions of the Canola Working Group involve the following:

- Discussion of industry matters in the interest and to the benefit of the canola industry.
- Identification of research projects and technology transfer to the benefit of the canola industry.

1.6 Canola Planning Committee

During the reporting period 1 March 2020 to 28 February 2021, the Canola Planning Committee met three (3) times.

The Canola Planning Committee consisted of the following members:

- Mr AP Theron (Chairman)
- Dr E Briedenhann
- Mr C Cumming
- Mr K Blanckenberg
- Mr F le Roux

The functions of the Canola Planning Committee involve the following:

- Discussion of industry matters and recommendations to the PRF committees as these relate to research, technology transfer, liaison and any other action required for the promotion of canola production.

1.7 Soybean Value Chain

During the reporting period 1 March 2020 to 28 February 2021, the Soybean Value Chain met three (3) times.

The PRF is responsible for the facilitation of these discussions. Various actions were identified that were to the benefit of the Soybean Industry.

2. DISCIPLINES REPRESENTED ON THE BOARD

In the Trust Deed provision is made for representatives from various disciplines which may include the following:

- Animal feed manufacturers' industry
- Oilseed crushing industry
- Fish meal manufacturers' industry and marine research
- Plant Production
- Organised Agriculture
- Agricultural Economics

3. LIST OF PROJECTS FINALISED DURING 2019-2020

Five (5) projects were finalised during the year, but the final reports are expected only in the first half of 2020.

3.1 **Dr PA Swanepoel** - “Performance of a dual disc and tine planter, soil quality, residue management and rate of nitrogen placement with seed for canola production”, University of Stellenbosch.

3.2 **Dr SA Oosthuyse** - “Improving the yield and quality of soybean stands by adopting the remedial measures technique”, Hort Research SA.

3.3 **Mr JP van Zyl** - “The influence of planting date and row width on recommended planting density and yield of soybeans in the North Eastern Free State”, University of the Free State.

4. PROJECTS FINANCED 2020-2021

4.1 PRF CANOLA YIELD COMPETITION; C Cumming, Contractor, Protein Research Foundation

After a successful competition in the Swartland in 2019, it was decided to continue with the "whole farm" format to the competition. Because of extremely unfavourable climatic conditions that persisted in the Southern Cape in 2019, too few producers entered the competition and it was cancelled.

In 2020 conditions for grain production were much more favourable, especially in the Southern Cape, and an extremely successful competition was run. Large areas of the Southern Cape were blessed with good summer rain which contributed to good sub-soil moisture. The conservation tillage practices that have been widely adopted in the region assisted in providing adequate soil moisture for early planting and crop establishment.

The first good rains in the Swartland were only experienced in early June, making conditions at crop establishment less than ideal. Uneven initial germination resulted, but good follow up rains changed the situation so that the Swartland ended with an average rainfall season. The Southern Cape, on the other hand, continued to receive good rain and cool, moist conditions in the later season contributed to excellent yields being realised.

A total of 13 producers entered the Swartland competition, 8 in the under 150 ha planted category and 5 in the over 150 ha planted category. In the <150 ha section Melt van der Westhuizen won with 3,16 ton/ha average over 67 ha, followed by Andries Louw with 3,05 ton/ha over 104 ha. The average yield for the 8 competitors in the <150ha category was 2,33 ton\ha. When one takes into account that the long-term average yield for the Swartland is around 1,4 ton\ha, the significance of this result comes into perspective.

The over 150 ha planted category was won by Sakkie Rust, who produced an average yield of 2,16 ton/ha on 807 ha. He was followed by Eduard Loubser with 2,00 ton/ha on 473 ha.

Fewer producers entered the Southern Cape leg of the competition, 3 in the <150 ha category while 2 producers entered in the >150 ha category. In the <150 ha category Johannes Beukes produced 3,07 ton/ha average on 92 ha with Christiaan le Roux second with 2,79 ton\ha on 98 ha. The over-150 ha category was won by Franco le Roux who

produced 2,79 ton/ha average on 1308 ha, a truly remarkable achievement. Niel Neethling managed 2,47 ton/ha on 207 ha.

These amazing results corroborate the following deductions:

- That canola producers are giving the crop its rightful management attention by doing the right things at the right time;
- That canola is no longer being grown as a stop-gap solution to herbicide resistance problems, but has reached its rightful place as an important crop rotation tool in the producers' arsenal;
- That producers are learning the finer points of critical actions and timing to maximise yields, and last but not least;
- That the hybrid cultivars available to producers have production capacity beyond our wildest expectations. Ask Piet Lombard who runs the vitally important cultivar evaluation program what he perceives to be the upper level of their production potential.

The fact that the favourable climatic season played a big part in the results achieved by the competitors must not detract from the importance of the competition in lifting the general awareness of producers to best management practises being employed.

4.2 CANOLA TECHNOLOGY TRANSFER; C Cumming, Contractor, Protein Research Foundation

After many aborted attempts, all due to COVID -19 restrictions, the PRF was finally able to host an extremely successful information day on 28 May 2021 at the Hopefield Sporting Club, Hopefield.

The day was attended by 76 persons from the Agricultural Chemical Industry, canola producers, seed and implement representatives, ag-business personnel and university students. The agenda was dominated by presentations from researchers from the Department of Agriculture Western Cape (DAWC) on latest developments in the control of sclerotinia and blackleg, cultivar evaluation, cover crops and the effects of climate

change and risk management. The state of the oilseeds market and practical results undertaken to determine yield loss at harvest were also covered.

Many delegates commented on the standard of the presentations and expressed their gratitude to the PRF for, despite all the odds, being able to present the day.

Many thanks must go to the Hopefield Sport club for their assistance, the locals who saw to the sound system and last but not least, to the caterers for the day ending meal provided.

4.3 AN EVALUATION OF CONTINUOUS CASH CROP PRODUCTION (INCLUDING SMALL GRAINS, CANOLA AND OTHER ALTERNATIVE BROADLEAF CROPS) UNDER CONSERVATION AGRICULTURE PRINCIPLES ON THE HIGH POTENTIAL SOILS OF THE RIVERSDALE FLATS; JA Strauss and W Langenhoven, Western Cape Department of Agriculture

2020 was the 9th year of production on the new trial. Six cash crop systems are tested including shortened canola rotations and cover crops. A total of 60 plots were planted. The 6 systems tested are replicated 3 times and all crops within each system are represented in the field each year.

All protocols developed during the annual technical committee meeting in February 2020 were followed and the integrity of the trial layout was upheld.

Riversdale received very little summer rainfall which resulted again in a dry start to 2020 production season. Only 64 mm fell from January to the end of April. In 2017 a new weather station was installed at the research site which is managed by the Department of Agriculture. A total of 260 mm was received from April to the end of September.

Wheat production - SST0117 was planted at Riversdale at 60 kg/ha. A total of 38 kg N/ha was applied to each plot (8 kg N/ha at planting and 30 kg N/ha top-dressing). Wheat yields at Riversdale averaged 4505 kg/ha. This was 1773 kg/ha more than in 2019.

Canola production - Alpha TT was planted at Riversdale at 3 kg/ha. A total of 38 kg N/ha was applied to each plot. Nitrogen at plant was 8 kg/ha and a topdressing of 30 kg/ha was applied at the end of July. Canola yields at Riversdale averaged 2150 kg/ha which was 253 kg/ha more than the 2019 average.

Barley production – Hessekwa, Kadie and Elim was planted at Riversdale at 53 kg/ha. Barley yields at Riversdale averaged 4131 kg/ha. This average yield was 844 kg/ha more than in 2019.

Lupin production - Lupin plots were replaced with peas, planted at rate of 80 kg/ha. No plots were harvested.

Cover crops - Saia oats and field peas were planted during 2020 at seeding rates of 30 kg/ha and 80 kg/ha, respectively.

Economics - It proved to be a very good production year in 2020 year. All systems tested showed a positive gross margin above direct allocated production costs.

4.4 PROJECTED PROTEIN REQUIREMENTS FOR ANIMAL COMSUMPTION IN SOUTH AFRICA: D Strydom and W de Jager, University of the Free State, E Briedenhann, Protein Research Foundation

Introduction

The Protein Research Foundation (PRF) has as its main objective the replacement of imported protein with domestically produced protein. After many years of investigating numerous alternatives, the focus changed mainly to where the largest impact could be made, namely soybeans and canola.

Growth in the domestic availability of oilcake is a good measure of the extent to which the PRF is achieving its objectives by way of supporting the industry with research, new technology and technology transfer. The targets that will need to be met in the future for the PRF to continue to emulate the great progress that has been made thus requires projections of future oilcake demands and what will be required to obtain self-sufficiency, as well as when this goal is likely to be met.

For progress to be accurately measured, various models have been developed and used over the years. The APR model, chosen for this purpose, considers changes in per capita consumption of meat, milk and eggs as projected by BFAP as well as population growth, and the quantity of meat, milk and eggs that are predicted to be imported and exported are also considered. Projected future prices of major raw materials are considered, as well as the availability of raw materials, mainly those that are derived as by-products from various agricultural processing industries.

The genetic improvement in animal performance has a substantial impact on productivity, therefore such changes are an important factor incorporated into the model, which calculates the quantity of feed required as well as raw material breakdown for these feeds.

There are several animals that are not producers of meat, milk or eggs that consume a substantial amount of animal feed, including protein. The feed consumption of these animals, including the protein materials consumed, also needs to be accounted for.

By making use of least cost linear programming and considering transport costs of raw materials across various regions of the country, the model has the ability to formulate the actual feeds required by all animals in South Africa, given the constraints of the quantity of each raw material available domestically. The result is an accurate prediction both of protein requirements currently and projected, both domestically and imported, in the future.

Results

Current scenario

On the local market, South Africa progressed in terms of substituting imported soybean oilcake with local oilcake. South Africa produced 70 % of the total requirement in 2020, whereas in 2009 this was only at a 16 % level. The projection for 2023 is 97 % and will increase to 100 % in 2029. However, substitution is highly dependent on efficient infrastructure and logistical support, providing local raw materials to coastal areas at competitive levels. The usage of oilcake is also very sensitive in terms of prices and competition of raw materials containing protein. For instance, an increase in lucern production or wet milling by-products directly affects the usage of oilcakes.

Table 1: Historical usages of soybean oilcake (local and imported soybeans processed in South Africa)

Year	Local soybean oilcake (ton)	Total soybean oilcake (ton)	Local %
2001	121 140	598 070	*20*
2002	141 520	616 593	*23*
2003	120 000	705 352	*17*
2004	119 280	616 596	*19*
2005	92 080	740 558	*12*
2006	210 000	849 678	*25*
2007	303 280	1 115 280	*27*
2008	253 200	1 261 791	*20*
2009	181 600	1 111 172	*16*
2010	251 840	1 083 640	*23*
2011	301 600	1 291 069	*23*
2012	347 760	1 271 341	*27*
2013	469 360	1 197 978	*39*
2014	565 280	1 232 687	*46*
2015	765 287	1 254 120	*61*
2016	768 800	1 218 001	*63*
2017	836 285	1 267 098	*66*
2018	766 795	1 150 521	*66*
2019	820 000	1 218 000	*67*
2020	849 700	1 213 700	*70*

Source: APR model

The increase in local oilcake production from locally produced soybeans will make South Africa increasingly self-sufficient in protein requirements.

Table 2: Local vs. imported soybean oilcake

Year	Local Soybean Oilcake (From local soybeans) ton	Local Soybean Production (required) ton	Total Soybean Oilcake Requirements ton	Local Soybean Production (required) ton self-sufficiency	% Local
2020	849 700	1 062 125	1 213 700	1 517 125	70
2023	1 187 436	1 484 295	1 218 087	1 522 608	97
2029	1 427 406	1 784 257	1 427 406	1 784 257	100

Source: APR model

Total oilcake requirements in South Africa are estimated at 1 213 700 tons in 2020 vs. a local production of 849 700 tons locally produced or 70 % of requirements. The soybean requirement of 1 517 125 tons excludes full fat soybeans and those for human consumption. This production is needed in order to obtain 1 213 700 tons of oilcake.

Soybean oilcake produced in South Africa in 2020 provided 70 % of the country's soybean oilcake requirements (**Table 2**). The forecast is that this will increase to 100 % in 2029. To be competitive against imports, logistics remains a challenge and must be considered if these levels are to be reached. In order to satisfy local demand, 1 784 257 tons of soybeans is needed.

According to the model, feed requirements will increase to 14 544 284 tons in 2029 and 12 973 505 tons in 2022. Soybean oilcake requirement will be 1 218 087 tons by the year 2023 and 1 427 406 by 2029 (**Table 2**).

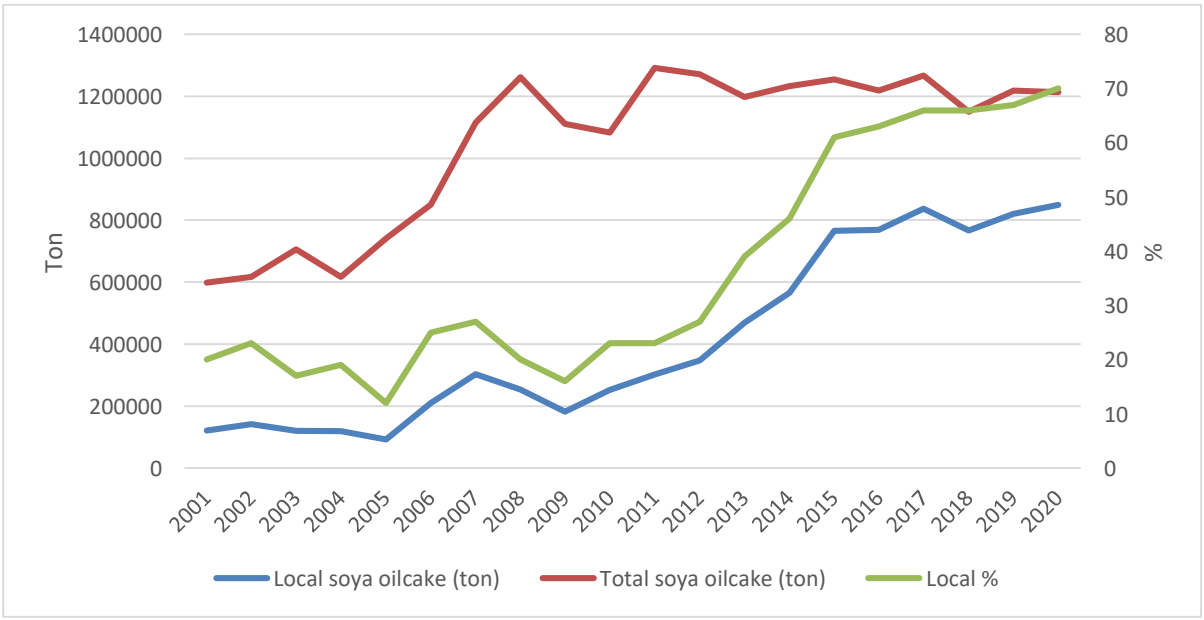


Figure 1: Growth in self-sufficiency in terms of soya oilcake

Conclusion

The prospect of needing more feed for animal protein in South Africa in the future looks promising. However, it is highly dependent on a number of factors. With broilers and pigs becoming increasingly efficient, and hence needing less feed per unit of gain, it is imperative that demand for poultry meat and pork is increased. Part of this additional demand would be met by replacing imports of animal protein such as poultry with locally-produced protein, and by developing an export market for some of our animal products. This is the focus of the masterplan currently being developed for government and which is expected to play an important role in sustainability.

Another factor of importance is the price and competitiveness of raw materials. In order for locally-produced proteins to remain competitive the raw material price will tend towards export parity levels, which means that much work will be needed to increase the feasibility of producing raw materials at these levels. As production increases there will be an opportunity to export such products, which may even extend to the exportation of processed product.

The protein raw material basket is highly complex and any slight change in the cost or availability of a given raw material will have an impact on the utilisation of oilcake, specifically soybean oilcake.

Logistics and biosecurity will play an important role in the future: if inland products cannot be delivered price-competitively to coastal consumers, imports will continue. If exports of animal products do not increase there will be pressure on their utilisation in South Africa which will have a direct impact on production.

If all of the above fall into place, South Africa can become totally self-sufficient in protein for animal feed, and there is still some space to further increase soybean production.

Table 3: Self-sufficiency of total oilcake and oilcake

	2020	2023	2029
Total Oilcake	79 %	98 %	99,7 %
Soya Oilcake	70 %	97 %	100 %

4.5 INCOME AND COST BUDGETS FOR SUMMER AND WINTER CROPS IN SOUTH AFRICA; D van der Westhuizen, The Bureau for Food and Agricultural Policy (BFAP)

Historically, the Protein Research Foundation (PRF), Grain South Africa (GSA), the Bureau for Food and Agricultural Policy (BFAP) and agribusinesses have published their individual cost of production budgets which focus on summer- and winter crops produced in South Africa's key agro-ecological zones, both under dryland- and irrigation cultivation. Given the existing activities associated within the organisations and the extent of the coverage of South African agricultural production, these initiatives have been combined and integrated since 2017. The main objectives are:

- To consolidate the three programs in collaboration with various agribusinesses in South Africa;
- To generate comprehensive crop income and cost budgets for the key summer- and winter growing regions;
- To generate sensitivity analysis for the selected crops based on the latest macroeconomic trends, BFAP Baseline underlying assumptions and international- & domestic updates.

During the 2020/21 project timeframe, the following output has been delivered:

- August / September 2020: Compiled the cost and income budgets for the 2020/21 summer crop in collaboration with various agribusinesses in the summer crop producing regions. The enterprise budgets were finalised followed by a report on the respective results. A total of 12 agro-ecological areas were covered, covering 37 crop budgets for dryland and irrigation production systems.
- October 2020: The crop budgets were utilised to generate a summer crop scenario report, in collaboration with Grain SA. The report covered a macro-economic and market overview (international, regional and domestic), the performance of the South African agricultural sector, inputs costs, enterprise performance and sensitivity and scenario relating to crop grades and transport differentials.

- March 2021: Compiled the cost and income budgets for the 2021 winter crop in collaboration with various agribusinesses in the winter crop producing regions. The enterprise budgets were finalised followed by a report on the respective results. A total of 14 agro-ecological areas were covered, covering 43 crop budgets for dryland and irrigation production systems.

- May 2021: The crop budgets were utilised to generate a winter crop scenario report, in collaboration with Grain SA. The report covered a macro-economic and market overview (international, regional and domestic), the performance of the South African agricultural sector, inputs costs, enterprise performance and sensitivity and scenario relating to crop grades (wheat and barley) and the performance of wheat in the Eastern Free State region.

- May 2021: An article was written for the Oilseeds Focus magazine focusing on area shifts expected for the 2021 winter crop season followed by crop performance and sensitivity.

- May 2021: The annual BFAP Baseline outlook publication was finalised where the crop budgets were updated and presented in specific scenarios and analytics.

BFAP would like to express their gratitude to the PRF for the continuous support to generate the summer and winter crop budgets for a variety of South African enterprises.

4.6 THE INFLUENCE OF WEED AND HERBICIDES ON THE GROWTH AND YIELD OF SOYBEANS; WF van Wyk, Contractor, Protein Research Foundation

A weed is any plant which grows in a place where it is not supposed to grow - like soybean in a maize field, morning glory in a flower garden, etc. The aim of this trial was to establish the efficiency of pre-emergence and post-emergence herbicides on the growth of weeds and the yield of the soybeans. Diclosulam and alachlor were used in a pre-emergence treatment while Glyphosate was used as a post-emergence herbicide at 6 and 10 weeks after crop emergence.

The weed spectrum on the trial site is not large and consists mainly of a few broadleaf weeds like *Datura stramonium*, *Tribulus terrestris* and *Amaranthus hybridus* and also

grass weeds like *Eleusine coracana* and *Cyperus esculentus*. With the application of the glyphosate at 10 weeks, weeds were already established but were well controlled.

The yield in the first two seasons of the treatment with no weed control was about 500 kg/ha less than the other treatments. In the last season however the yield of this treatment was second best. The reason for this strange result is, perhaps, because the continuous rain experienced at the time caused the soil to be so waterlogged that the roots of the soybeans grew out of the soil in order to get air. In spite of the presence of weeds there were enough roots to withdraw water from the profile which favoured soybean yield.

KEYWORDS: Herbicides, weeds, diclosulam, alachlor

Introduction

Weeds are considered to be the number one problem in all soybean-producing countries. Even with advanced technology, producers still report great losses due to weeds. Weeds are solely responsible for an estimated decrease of 37 % in soybean yield whilst disease and other agricultural pests account for a yield loss of 22 %.

Weed control is an important practice for the assurance of desirable yields. The literature recently reported the density and distribution of weed species in soybean plantings to be responsible for great yield loss. This is due to weed species competing for sunlight, water, and nutrients, and could also affect the harvesting process as the quality of soybeans depends on the level of invasiveness and species.[2] Current studies of weed biology are changing mainly due to the effect of agricultural practice on weeds, crop systems and the environment.[3] Other important biological factors which impact decisions regarding weed management include weed and crop density, demographic variation, weed-crop competition and reproductive biology.[4]

Selection and adaptability of weed populations occur at the level of the individual. Weeds interfere with crop production and the consequent yield loss is directly caused by competition between the heterogeneous weed phenotype and the homogeneous crop phenotype.[5] The weed population in a field consists of a heterogeneous collection of genotypes and phenotypes which allow spaces left by the crop to be taken advantage of. Weed species react to these opportunities with remarkable illustrations of adaptability, such as phenotypic plasticity (modification), density-dependent deaths (change in plant population), density-independent deaths (diseases, predators, stress factors) and

chemical inhibition of neighbouring plants through allelopathic interference.[6] If all else fails, the seeds of weeds can remain dormant in the soil and extend their lives in the soil bed for several years whilst awaiting the right opportunity to grow.[7]

The identification of weeds immediately after emergence is of vital importance as the efficacy of most herbicides is heavily linked to the size of the weed. All abovementioned characteristics of weeds are important for the management of weeds in soybeans. After the identification of weeds, there are three more questions to be answered:

- What are the available tools for weed management?
- How should they be used to decrease interference by weeds?
- When should they be used?

The available tools are those used to decrease competition between weeds and crops and thus include traditional methods of management, whether physical or chemical. Currently, based on numerous cases providing resistance, consideration is being given to no-tillage systems, crop rotation systems, the use of cover crops, direct control of specific weed species at times when the crop is not present (in the winter), and GMO soybeans which provide resistance against several active ingredients with different functions.

Many of these tools are easy to use and usually have a great impact. No-tillage, for example, changes weed management completely as the covering layer decreases the survival of weeds.[8, 9, 10] The benefits of no-tillage to improve soil quality, rather than conventional tilling, are generally accepted, these being the improvement of the physical, chemical, and biological characteristics of the soil.[11] Crop rotation is another management tool and is often overlooked by the producer. It has immense value in enabling variation in chemical control. Other types of chemical mediums can be applied which eventually prevent resistance.[12]

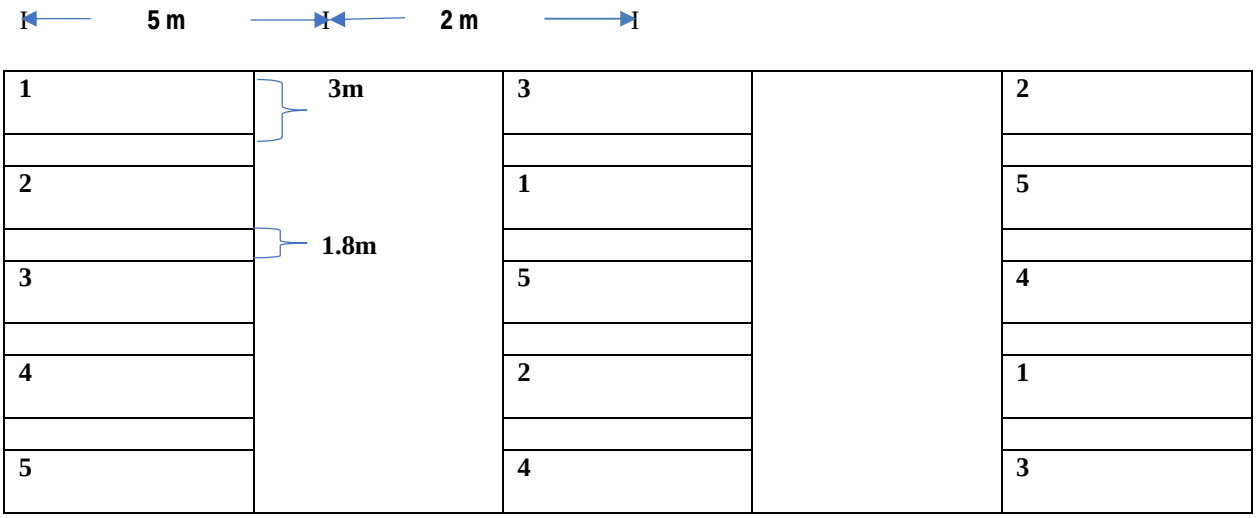
The use of cover crops between two main crops is part of the conservation practice and this has made a great breakthrough in weed management. Cover crops enable the use of selective herbicides and simplify the control of “difficult weeds”.[13]

To answer the question whether these tools should be used, there are different opinions. Many specialists recommend, for example, that chemical control only be used when the weeds cause an economic loss. However, it would seem to be preferable to control weeds continuously, even in fallow periods and when pressure from weeds is low. It is claimed that contrary to pests and pathogens which attack crops in epidemic cycles, weeds are endemic and are constantly present in the soil whether from seed or vegetative reproduction.[14]

Methods and materials:

The trial was planted on 18/11/2018, 23/10/2019 and 1/12/2020, respectively, for the 3-year trial period, at the experimental farm of the University of Pretoria. Row widths were 75 cm in order to avoid early canopying and therefore interfering with the aim of the trial, and the plant density at harvest was 280 000 plants/ha. The MG 4.6 Cultivar of Agricol DM 5953 rsf was used in the trial. Herbicides were applied by using a knapsack sprayer fitted with a flat fan nozzle.

The trial design is given in Figure 1. The wide distances (2 m and 1.8 m) between plots were chosen to avoid herbicide drifting from one plot to another.



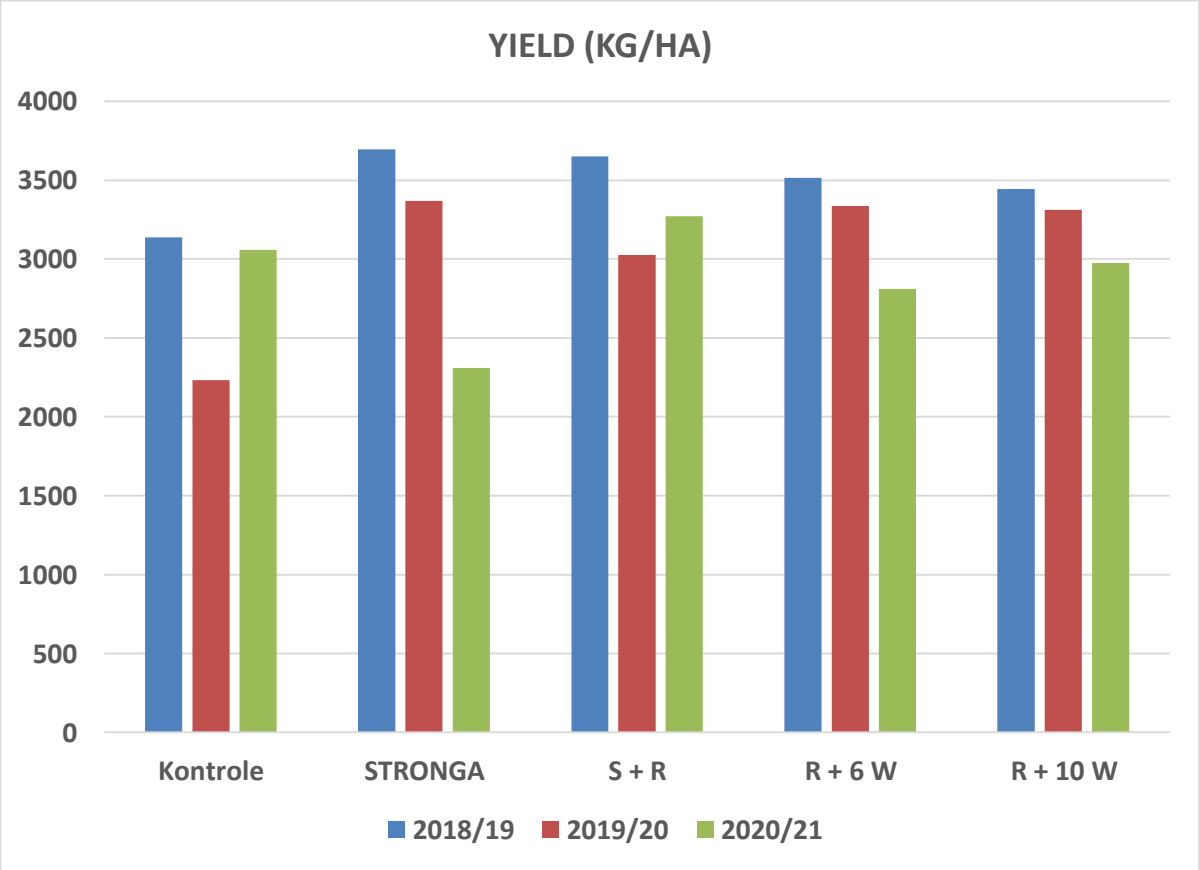
LEGEND: Treatments 1 = no control, 2 = pre-emergence control with diclosulam and alachlor(Strongarm), 3 = As 2 but followed by a glyphosate application at 2 weeks after emergence, 4 = glyphosate application at 6 weeks after emergence and 5 = glyphosate application at 6 weeks after emergence.

FIGURE 1. Trial design of the weed control trial

There were 5 treatments with 3 replications planted in a randomized block design.

Results:

In the first year of the trial, yield dropped marginally in those treatments where glyphosate was applied late in the season. However, in the second year the opposite occurred perhaps due to the large amount of rain, with soybeans not being affected by competition from weeds to that stage. The control treatment was however unable to avoid the weed pressure for the whole season. Only in the second year was there a drop in yield where both a pre-emergence and a post-emergence herbicide was used compared with a pre-emergence herbicide alone. A summary of the yield on the different treatments over the three years is given in Figure 2.



LEGEND: STRONGA - diclosulam + alachlor, S + R = Strongarm + RoundUp, +6 and +10 = 6 and 10 weeks after emergence of crop

FIGURE 2. Comparison of the yields with different treatments for the 3 year trial period.

Discussion:

Considering the very wet conditions prevailing in seasons two and three of the trial it is proposed that only the results of the first season should be used to draw any conclusions. According to Figure 1, yield was lowest on the control treatment, where no weed control was attempted, and highest where pre-emerge control was practiced. However, the difference in yield between the four treatments was less than 250 kg/ha and the treatments were therefore not significantly different from one another.

4.7 THE INFLUENCE OF POTASSIUM ON THE GROWTH AND YIELD OF SOYBEANS; WF van Wyk, Contractor, Protein Research Foundation

The three aims of the trial, conducted over a three-year period, were to establish (1) the influence of potassium on soybean yield, (2) the amount of potassium removed from the soil by a 1 ton/ha yield of soybeans, and (3) the amount of potassium needed to increase the soil-K by 1 mg/kg. The content of potassium in soil is regarded as being high when this exceeds 80 mg/kg K in sandy soil, 150 mg/kg K in loamy soil, and 200 mg/kg K in clay soil.

Six treatments were applied in the trial. A control treatment was included, where no K was applied to the soil; three rates of application of K were applied, namely, 100, 200 and 300 kg K/ha; a treatment was included in which 100 kg K was applied /ha but the plot was not planted with soybeans and was kept clean from weeds, in order to determine the amount of K needed to increase soil-K by 1 mg/kg; the sixth treatment involved the application of 100 kg K/ha in a strip between every second pair of rows, at a depth of 20 cm in order to produce a K-rich environment. Potassium chloride was used as the source of K, which contains 50 % K.

Rainfall was near-optimum for only the first year of the trial, with water being added by irrigation when drier conditions prevailed in that first season. During the second and third years, rainfall was excessive for at least four weeks of each season, with more than 150 mm of rain being measured. This led to the likelihood of leaching of potassium, as has been reported in many scientific papers. For example,, the treatment where no crop was planted, but 100 kg K was applied, showed a 25 mg/kg increase in K in season 1, but in seasons 2 and 3 the content remained the same at a soil-K of about 104 mg/kg. The

conclusion, from the results of season 1, is that, to increase soil-K by 1 mg/kg, an application rate of 4 kg K/ha is needed.

The lowest yield (3397 kg/ha) was on the control treatment where no K was applied and the highest (5274 kg/ha) on the treatment where K was applied in a strip between rows at a depth of 15 cm, followed closely (5076 kg/ha) by the treatment where 300 kg of K/ha was applied.

In the treatment where no K was applied the soil-K dropped from 79 to 62 mg/kg, with a yield of 3397 kg/ha. The amount of K used per ton yield was therefore 79 - 62 = 17 mg/kg / 3.397 ton = 5 mg/kg. To replace the amount of K used per ton of soybean seed produced, 5 x 4 = 20 kg K would be needed per ha. From the data observed in this trial it appears that at least 100 kg K should be applied per ha for all crops used in the rotation.

Keywords: Glycine max; Potassium; Soil-K, Deep placement.

Introduction:

Potassium (K) can account for up to 10 % of dry plant mass and is thus the most common inorganic cation in plants.[1] Extensive research has been conducted regarding the function of K in plants. It has been concluded that K is an important macro-element for metabolic growth and assists with the control of stress factors.[2] Potassium also performs an important function in enzyme activation, stabilization of protein synthesis, as well as maintenance of the cytoplasm pH.[3] Chloroplasts are responsible for the absorption of sunlight for use in the process of nutrient production whilst cytoplasm is responsible for cell growth and thus the growth of the entire plant.[4] The average functioning of the plant structures depends on the mobility of K as it enables the movement of other ions such as H^+, sugars, and nitrates, throughout the entire plant.

Potassium deficiency in soil is less common than a deficiency of phosphorus.[5] The majority of deficiencies in soya are observed late in the season, between flowering and pod fill, when K is required in large quantities.[6] As K is highly mobile within the plant, it is necessary to apply it as an inorganic fertilizer in order to prevent depletion during translocation in the plant.

There are various processes that contribute to the inaccessibility of potassium in soil. Potassium in the soil solution is available immediately for absorption by the plant, yet is dependent on soil erosion, cultivation history, and past fertilizer application. Potassium at the exchange level of clay particles is readily available depending on the quantities of K present at these positions as Ca and Mg compete more effectively and are more readily bonded for exchange. Non-exchangeable K accounts for the greatest part of soil-K and is caught between the layers of clay particles.

Factors influencing the unavailability of K include soil moisture, soil type, soil aeration, clay type, and the cation exchange ability of the soil. High soil moisture levels increase the mobility of K and, consequently, increase its availability through the process of diffusion to the roots for absorption.[9]

The absorption of K by legumes is higher than that of Ca, Mg, or P.[10] This implies that the presence of K ought to be higher in the plant tissue.[11] The absorption of Potassium varies far more from week to week than, for example, Mg, N, or P, depending on the growth stage of the soybean plant.[12] Research has shown that K-fertilization increases yield and enables greater absorption of N, P, Ca and Mg.[13] Absorption during the pod fill stage is much higher than during the vegetative and early reproductive stages.[2]

There are many farmers who choose to fertilize only the rotation crop and not the soybeans. In the past, with maize harvests of 4-5 ton/ha, one could manage to do this, but potassium is one of the elements that has to be monitored continuously in the soil for optimal soybean harvests.

American researchers use the following formula to calculate the Optimum K in soil for soybeans, where CEC is cation exchange capacity:

Optimum soil-K = 75 + (2.5 X CEC)

Therefore, applied to the soil to be used in the study, it would be 75 + (2.5 X 3.6) = 84 mg/kg for a soil with 21 % clay. Other researchers use an index figure calculated as follows:

K-index = (Ca + Mg) / K (These values are in me% of $cmol_c\ kg^{-1}$)

According to this formula, the abovementioned study would have a K-index of (1.9611 + 1.0783)/0.2506 = 20.

According to earlier research (late nineties and early twenties), this index should remain under 28 in order to prevent the potassium from being restrictive. In South Africa, an index between 10 and 20 is considered to be “normal”. These figures are currently being disputed following the extreme applications of potassium by the new world record holder for soybean yield.[13, 15]

Materials and Methods:

Six treatments were applied in the trial. A control treatment was included, where no K was applied to the soil; three rates of application of K were applied, namely, 100, 200 and 300 kg K/ha; a treatment was included in which 100 kg K/ha was applied but the plot was not planted with soybeans and was kept clean from weeds, in order to determine the amount of K needed to increase soil-K by 1 mg/kg; the sixth treatment involved the application of 100 kg K/ha in a strip between every second pair of rows, at a depth of 20 cm in order to produce a K-rich environment. Potassium chloride was used as the source of K, which contains 50 % K.

Soil samples were taken from all the plots before planting and after harvesting. The K-content of the soil used for the trial was between 79 and 81 mg/kg K. Phosphorus levels were adequate, at between 35 and 50 mg/kg.

Plot sizes were 5 m x 3 m with 1.8 m between plots in order to avoid “stealing” of potassium of plants from one treatment to another. Four 75 cm rows were planted by hand at a density of 280 000 plants/ha on 18 November 2018 for the 1st year of the trial. The second year the trial was planted on 23rd October and in the third year on the 1st of December. The cultivar used was DM 5953 rsf which is a MG 4.2. The potassium was applied by hand as Potassium Chloride (50) and incorporated with a small rotovator. In the second and third seasons there were problems with seedling diseases such as Pythium but harvesting took place in areas where less damage had been done to the soybeans.

Data recorded:

- Pre-plant and post-harvest soil samples were taken and analysed.
- Leaf analysis at R1
- Seed moisture after threshing
- Yield

Trial Design:

5m **2m**

K1-DEEP		**K1-DEEP**		**K1-DEEP**
K0	**3.0m**	**K3**		**K2**
K1		**K0**		**K1-CLEAN**
	1.8m			
K2		**K1-CLEAN**		**K1**
K3		**K2**		**K0**
K1-CLEAN		**K1**		**K3**

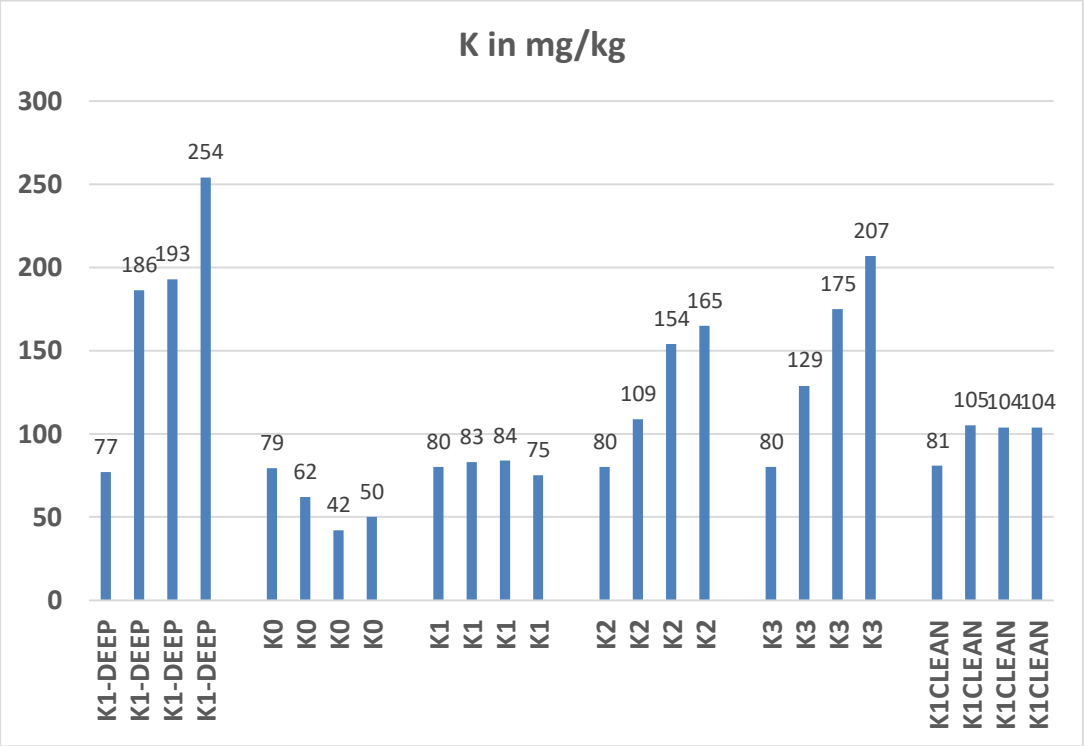
Legend: K0 = 0 kg K, K1 = 100 kg K, K2 = 200 kg K, K3 = 300 kg K, K1-clean = 100 kg K (no crop) and K1-DEEP = 100 kg K in a band in the centre of every second pair of rows, 15 cm deep.

Results:

The K-content of the soil on K1 (100 kg K/ha) remained the same from the time of planting the trial in 2018 until after the last harvest in 2021. It seems therefore that if more K is applied Soil-K will increase, as can be seen at K1-DEEP, K2 and K3 (Figure 1).

The K0 treatment, where no K was applied, showed an immediate decrease in soil-K whereafter it stabilised at about 45-50 mg/kg K.

Where no crop was planted (K1 CLEAN), but 100 kg K was applied each year, the soil-K increased only in the first year and remained the same thereafter, at about 105 mg/kg K. The most likely explanation is that K leached from the soil because of the heavy rainfall (>250 mm in a month) experienced during the last two years of the trial. The question remains of why this did not occur in the other treatments where a crop was planted - did the K remain in the plant rather than leaching out?



LEGEND: First K1-Deep is analysis pre-plant in 2018, second KI-DEEP is analysis pre-plant in 2019, Third K1-DEEP is analysis pre-plant in 2020 and fourth K1-DEEP is post-harvest in 2021. The same apply for KO, K1, K2, K3 etc.

FIGURE 1. Potassium contents of the different treatments over 3 years.

In Figure 2 the yields of the five treatments are summarised for the 3-year period.

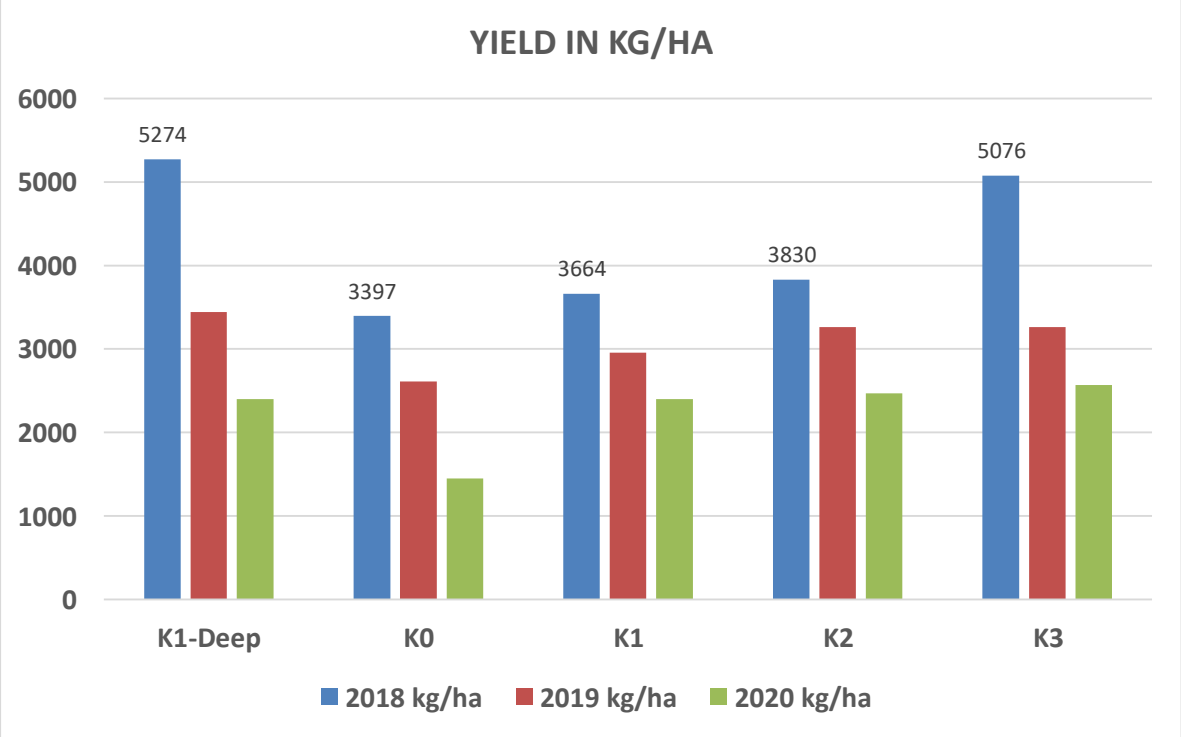


Figure 2. Yields on the five treatments in the 3-year period from 2018/19 to 2020/21

Yields in the first year of the trial were excellent but then decreased considerably in the following years. The reason for this drop in yield may be due to seedling diseases brought about by heavy rains in the 2019 and 2020 seasons. Of interest is that, when an outside factor like disease begins to play a roll, it levels the playing field and the yields of all except the control treatment were the same at about 2.3 tons/ha.

In the K1 Clean treatment (Fig. 3) soil-K increased from 80.8 to 105.3 (= 24.5) mg/kg by applying 100 kg of K. Therefore, to increase soil-K by 1 mg/kg an application rate of 100/24.5 = 4.08 kg K/ha is required.

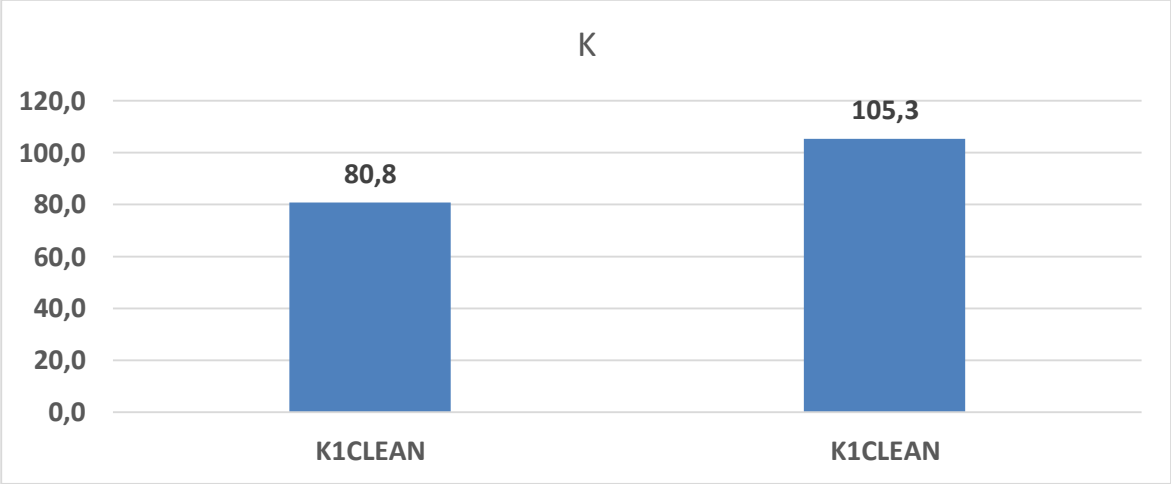


Figure 3. Soil-K contents of the treatment where no crop was planted before and after application of 100 kg K/ha

In the K0 treatment, where no K was applied, soil-K decreased from 79 – 62 (= 17) mg/kg K in the first season (Fig. 1) with a yield of 3397 kg/ha (Fig. 2), or by 17/3.397 = 5 mg/kg per ton of soybeans. To replace the amount used per ton, 5 x 4.08 = 20 kg K would be needed per ha.

Discussion:

It is evident from Table 1 that the amount of 20.8 kg K which is needed to replace the amount lost in producing a ton of soybean seed on the K0 treatment is comparable to the amounts needed by the other treatments, suggesting that between 20 and 24 kg K should be applied per ha for each ton yield of soybean seed. It must be stated that, in these trials, soybean stover was removed from the site before the next crop was planted.

In the third season the treatment with no K exhibited severe K deficiency symptoms and the yield was less than 1500 kg/ha. It is therefore essential that potassium is applied regularly in order to keep soil-K content at an optimal level. From the data observed in this trial, and given that maize removes about 3.5 kg K/ha, it appears that at least 100 kg K should be applied per ha for all crops used in the rotation.



Figure 4. Photograph of treatment where zero K was applied appears no different from others around it which received 100 and 300 kg/ha. Soil K, after this photograph was taken, dropped from 80 - 62 mg/kg.

TABLE 1. Calculation of amount of K required to replace K used per ton soybean seed per hectare

	TREATMENT			
	0 – K	**100 – K**	**200 – K**	**300 - K**
Soil-K after K-application	**79.3**	**105**	**130**	**155**
Soil-K 2019 after harvesting	**62**	**83**	**109**	**129**
Difference (mg/kg)	**17.3**	**22**	**21**	**26**
K used per ton soybeans	**17.3 / 3.397 = 5.09 mg/kg**	**22 / 3.664 = 6.00 mg/kg**	**21 / 3.830 = 5.48 mg/kg**	**26 / 5.076 = 5.12 mg/kg**
Amount of K required to replace K used per ton soybeans	**5.09 x 4.08 = 20.8 kg K**	**6.0 x 4.08 = 24.5 kg K**	**5.48 x 4.08 = 22.4 kg K**	**5.12 x 4.08 = 20.9 kg K**

4.8 CULTIVAR EVALUATION OF SOYBEANS IN THE WESTERN DRY LAND PRODUCTION AREA OF SOUTH AFRICA; GP De Beer and WF van Wyk, Contractors, Protein Research Foundation

The past season was certainly the best soybean season the west has ever experienced.

The trials were planted at Schweizer Reneke (2 planting dates), Hoopstad, Leeudoringstad and Baberspan (Between Delaryville and Sannieshof).

The trial at Schweizer Reneke was planted on the 11 November and 7 December 2020 using the farmer's planter. One replication was planted from MG 4.7 to 7.1 and the other two replications were randomised.

The trials at Leeudoringstad were planted on the 18 November 2020, Baberspan on 26 November 2020 and Hoopstad on 24 November 2020. These three trials were planted with the ARC planter. All these trials were randomised differently.

The pressure wheel on the ARC planter had to be replaced because the soybeans had difficulty in emerging from the sandy soils. At Baberspan, 30 mm of rain fell the day after the trial was planted, so the soil crusted and had to be broken with rakes.

The trials consist of 30 cultivars from a MG 4.7 to MG 7.1. All the cultivars in the trials were indeterminate except for LS 6851 R and P61T38 R, which were determinate.

The trial at Leeudoringstad had a mean yield of 1842 kg/ha. The cultivar with the highest yield, of 2348 kg/ha, was RA 660 R (MG 6.0) and that with the lowest yield, of 1232 kg/ha, was Pan 1555 R (MG 5.7). Yields in this trial were unimpressive because the soil became waterlogged due to the amount of rain that fell during the season.

The first trial at Schweizer Reneke (PD 1) had a mean yield of 3903 kg/ha. The cultivar with the highest yield, of 4765 kg/ha, was PAN 1644 R (MG 6.7) and that with the lowest yield, of 2795 kg/ha, was PAN 1479 R (MG 4.7).

The second trial at Schweizer Reneke (PD 2) had a mean yield of 2345 kg/ha. The cultivar with the highest yield, of 2954 kg/ha, was RA 565 R (MG 5.5) and that with the lowest yield, of 1849 kg/ha, was DM 5351 RSF (MG 5.1).

The trial at Hoopstad had a mean yield of 3171 kg/ha. The cultivar with the highest yield, of 5315 kg/ha, was RA 568 R (MG 5.8) and that with the lowest yield, of 1795 kg/ha, was P61T38 R (MG 6.1). Problems were encountered during planting of this trial with some rows not receiving inoculant, which seriously constrained growth and yield of some plants leading to large differences in yield between replicates.

The trial at Baberspan had a mean yield of 1751 kg/ha. The cultivar with the highest yield, of 3320 kg/ha, was DM 5953 RSF (MG 4.8) and that with the lowest yield, of 1187 kg/ha, was RA 568 R (MG 5.8). Farmers in this area practice no-till which may have created a limiting layer in the soil making it difficult for the roots to penetrate the soil adequately, which could account for the low yields here.

4.9 THE USE OF CULTIVATION PRACTICES IN SOYBEAN TO AVOID *SCLEROTINIA* INFECTION; WF van Wyk, Contractor, Protein Research Foundation

Sclerotinia stem rot (SSR) caused by *Sclerotinia sclerotiorum*, is one of the most important diseases of soybeans. Disease management is complicated by the long-term survival of sclerotia in the soil and the absence of resistance in commercial cultivars. Furthermore, the lifecycle of *S. sclerotium* in soybean fields is highly dependent on weather conditions, leading to sporadic occurrences of the disease and an aggregated distribution within fields. Cultivation practices such as altering row spacing and plant populations, along with chemical control, are all part of disease management to control the disease. Incomplete efficacy of chemicals and a lack of understanding of application timing for fungicides are some of the constrained control measures.

The response of two soybean cultivars to Sclerotinia stem rot, caused by *Sclerotinia sclerotiorum* was assessed in field trials in 2018 - 2020 to obtain information aimed at controlling the disease. Two identical trials were conducted at two different sites in Mpumalanga, South Africa. The sites were at Stoffberg (irrigation) and Wonderfontein (dryland). The two cultivars used were MG 4.6 (DM 5953 rsf) and MG 6.2 (PAN 1623). Cultivar differences in disease incidence were related to maturity group. Cultivars differed in all three seasons, with the earlier-maturing cultivar DM 5953 rsf exhibiting virtually no disease. It seems that early-maturing cultivars can avoid the disease because when they start to flower the plants are still relatively short, and micro-conditions for the development of the disease are not favourable. Disease development in the late-maturing cultivar (PAN 1623) was determined by favourable sclerotinia developing criteria during the R1 and R2 growth stages.

Trials were also planted at 3 different planting dates from October to December in order to try to make sure that conditions will be favourable for the developing of the disease at, at least one planting date. Conditions were however good at all planting dates for the two sites. Yield loss from stem rot (*Sclerotinia*) may be reduced by planting cultivars that are earlier maturing.

Keywords: Glycine max; *Sclerotinia sclerotiorum*; incidence; early maturing; late maturing

Introduction:

Sclerotinia sclerotiorum (Lib.) de Bary has a broad geographic incidence with a variety of hosts, including many agronomy crops.[1] The pathogen infects more than 400 plant species worldwide. *S. sclerotiorium* cause Sclerotinia Stem Rot (SSR) on soybeans (Glycine max(L.) Merr. and is seen as one of the most important diseases in decreasing yields in America[2] and Brazil.[3] In the 2016-2017 season, both countries produced more than 100 million tons (Mt) of soybeans. In America, the annual estimated loss in yield in 28 States was 1.6 Mt from 1996 to 2009.[4,5] The disease is wide-spread in the South, South-East and Central-West regions in Brazil.[6] The incidence of the disease in Brazil increased since 2008 with an estimate 6.8 million ha which were infected – the equivalent of 22.5 % of the harvested area in 2013/14.[3] Epidemics in the 2013/14 season in South Africa in crops of sunflower and soybeans caused up to 60 % of infection and 65 % yield loss in certain areas.[7]

Managing the disease using rotation with non-host crops is limited because of the vast number of hosts which exist and the fact that sclerotinia can survive up to 10 years in the soil. Management decisions involving agronomy, such as cultivar choice, proper irrigation management, planting dates and plant populations, can assist in decreasing the intensity of the disease.[8,9,10]

For the disease to develop three factors must be present at the same time:
Firstly, the environmental conditions must be favourable; secondly, a susceptible cultivar which is in the flowering stage must be present; and thirdly, ascospores of *S. sclerotiorum* must be present. *S. sclerotiorum* can survive in soil for between 5 and 10 years. When soil is under shadow (canopy), humid and cool conditions (4-16 ^{0}C), the sclerotia in the upper 5 cm of the soil will germinate and apothecia (mushroom-like structures) will form.[11,12]

Apothecia are small (3-6 mm) light-brown mushroom-like structures which form millions of ascospores.[13] Ascospores colonize the dying petals on the plant and simultaneously use it as food source and infect the plant when moving through the wound left by the petal on the stem of the plant. This type of germination of sclerotinia is known as carpogenic germination and is the method by which soybeans are infected. [14] Another germination method, namely myceliogenic germination, where mycelium and hyphae

remain under the ground and the sclerotia infect the plant on the lower end of the stem where roots are formed. This is how sunflower is infected.[14]

The control of sclerotinia with fungicides is difficult because the target area cannot be reached due to a very dense canopy when the disease develops and soybean plants (especially indeterminant growers) flower over a long time period.[15] The best way to control sclerotinia is to try and manage the disease. The following methods can be applied in an effort to manage the disease or to avoid yield losses.

Recordkeeping

Monitoring of the disease when outbreaks occur on certain fields over years and annual recordkeeping of climate conditions is important to give an idea of how and when the disease develops and how it correlates with certain factors like overcast weather, cold nights, continuous rain and others.[16]

Cultivation practices

Crop rotation

A minimum of 2-3 years rotation with a non-host crop such as maize and small grain is needed to decrease the amount of sclerotinia in the soil.[17] In fields with a history of sclerotinia it is preferable that susceptible broadleaf crops only be planted every third to fourth year.[18]

Cultivation

The impact of cultivation on the development of sclerotinia in inconsequential, although many studies show that fewer apothecia appear, with less drastic incidences of the disease, in no-till fields.[16] Deep cultivation, as with a plough, can initially prevent germination of the sclerotia but, because the sclerotia can survive for longer than five years in the soil, new follow-up cultivation practices such as seedbed preparation etc. can bring the apothecia again within 5 cm of the soil surface where it can germinate. While there are more sclerotia in no-till fields near the soil surface they break down more rapidly than in conventional cultivation methods.[16]

Management of the canopy of soybeans

Early planting, narrow rows, high plant populations and high soil fertility are all factors that cause early canopying which is advantageous for the spread of the disease but, on the other hand, all of these factors are also needed for better yields.[16]

Plant population

High plant populations (>400 000/ha) cause a very dense canopy which promotes the development of the disease, therefore choose plant populations where maximum yields are still possible.[15,19]

Row width

Soybeans in narrow row-widths cause quicker canopying of the rows. Row widths of more than 50 cm may decrease the disease but not the yield.[18]

Planting date, Maturity Group and plant properties

Planting late season cultivars too early, and planting cultivars with bushy structures and which lodge easily are all factors which increase the disease.[20]

Soil fertility and fertilisation

High soil fertility and nitrogen-rich fertilisers such as in poultry and “kraal” manure promote the development of the disease.[15]

Weed control

Many of the broadleaf weeds in soybeans are hosts of sclerotinia. If there is not good weed control a high density of weeds can cause the micro-climatic conditions to develop that are advantageous for the disease.[21]

Cover crops

The use of small grains like oats, wheat, rye or barley with soybeans stimulates the early germination of sclerotinia in contrast to the case when soybeans are planted alone. The effect of these cover crops on soil moisture and fertility must, however, be taken into consideration.[16]

Irrigation management

Too much irrigation when soybeans are flowering is not recommended. Low free water in the canopy will reduce the chances of plants being infected. Disproportionately high irrigation is better than proportionately low amounts of irrigation. Between R1 and R3 the presence of free water in the canopy can lead to infection.[18]

Cultivar choice

There is no soybean cultivar that is resistant to sclerotinia. Some cultivars, however, are less susceptible to the disease while others still achieve good yields under sclerotinia infection. The breeding of resistant cultivars is difficult because such resistance is controlled by multiple genes. Differences in the length of the growth season (or maturity group) can play a big role in avoiding sclerotinia. Short-season cultivars are still small when they start flowering and therefore conditions are not favourable for infection with the disease. When conditions are suitable, the growth stage has passed and the plants are in the reproduction stage R3-R4. As there are no plants that are still flowering at this stage, there are no infection sites and the disease will not influence these cultivars.[19]

Chemical control

Fungicides

Fungicides with three different modes of action are available but none of these is systemic, where the fungicide will spread throughout the plant once some part of the plant has been touched by the spray.[16] This means that the pathogen must be targeted directly, which is almost impossible through a dense canopy, even if water is sprayed at 600 l per ha.[16]

Herbicides

The labels of herbicides that contain Lactofen as the active ingredient (Cobra, Phoenix) state that this may suppress the occurrence of the disease. These herbicides do not directly inhibit the sclerotinia but can decrease infection when present. Lactofen is able to modify the canopy and can delay or decrease flowering, which then results in an environment that is less suitable for the disease, or which decreases the availability of potential infection sites.[22]

Timeliness of applications

A fungicide must be applied at the correct growth stage of the plant to increase its effectiveness. Application in the R1 - stage results in better control than in the R3 - stage. Effectiveness of fungicides decrease to a great extent when symptoms of the disease are seen.[23]

Covering

Sufficient plant covering deep into the canopy where infections start, is important to manage sclerotinia. Flat fan nozzles with a drop size of 200-400 µm give the best covering on soybeans.[25]

Expectations of control

Complete control of sclerotinia by making use of only fungicides is not achievable and therefore it has to be seen as only one potential component of an integrated sclerotinia control program.[23]

Biological control

Contans (*Coniothyrium minitans*) is a commercial, biological product which was developed to control sclerotinia in soils. The best time for application is just before planting or after harvesting on the plant residue of the previously infected crop, and then to incorporate this residue into the upper 5 cm of the soil. It should be incorporated at least 3 months before flowering to have the biggest impact.[24]

4.10 DATA-INTENSIVE FARM MANAGEMENT (DIFM) PROJECT IN SOUTH AFRICA; Ms M Delport, BFAP

Introduction

The project was successfully implemented in the summer planting season of 2020/2021, following visits by the research teams to the farms of:

- Mr Gerrit Roos (Wonderfontein) in Mpumalanga;
- Mr Jaco Minnaar (Henneman) in the Free State;

- Mr Ralf Küsel (Paul Pietersburg) in KwaZulu Natal;
- Mr Jozeph du Plessis (Schweizer-Reneke) in North West; and
- Mr Niël Rossouw (Ottosdal) in North West.

Data analysis and reporting to the farmers is taking longer than anticipated, and the preliminary results from two farms (Mr Jaco Minnaar and Mr Jozeph du Plessis) have been completed and are in the process of being discussed with the farmers. Trial design, implementation and results from three trials are discussed in subsequent sections.

Du Plessis, Schietfontein - Soybeans

Schietfontein is a 42.4 ha field dedicated for the DIFM soybean trial for the 2021 harvesting season. The farmer usually plants 300 000 plants per hectare and requested that the trial varies seeding rate between 150 000 and 450 000 plants per hectare, in 50 000 plants per hectare increments. The farmer plants pre-defined tracks of 6 rows, 6.85 m apart (average row width of 1.15 m). The equipment used includes:

- John Deere 6330 tractor;
- John Deere 1750 vacuum planting equipment;
- AgLeader precision agriculture software; and
- John Deere S660 combine harvester.

The trial design in the left-hand panel of Figure 2 was supplied to the farmer and was planted on 23 November 2020 (see the as-planted seeding rate on the right-hand panel). The planting was executed very accurately.

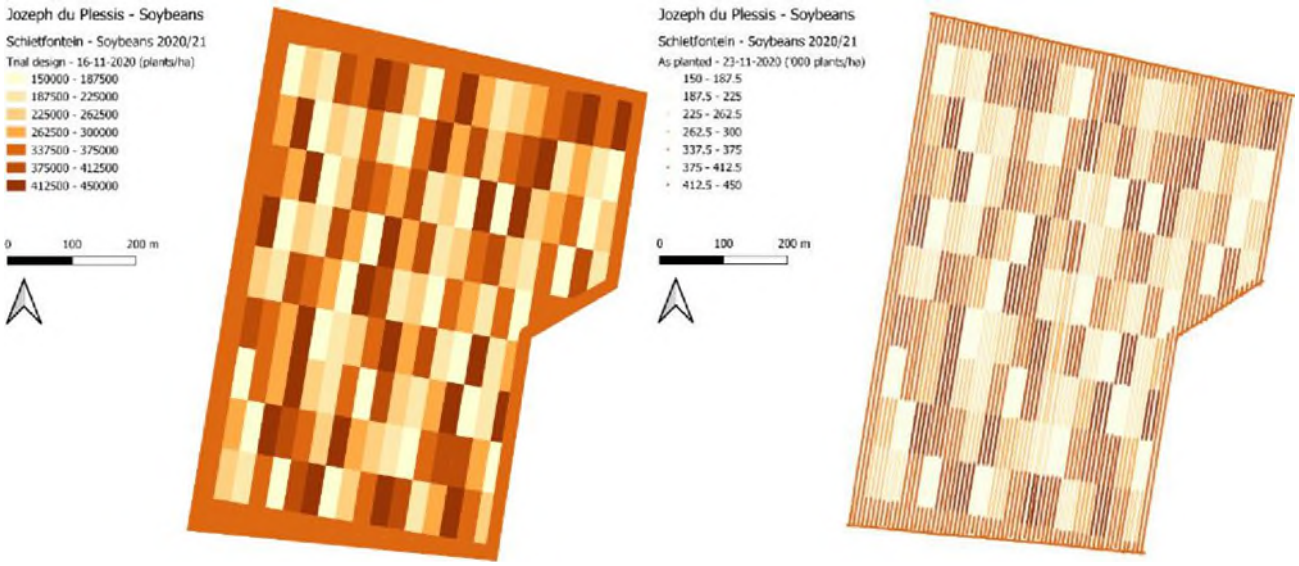


Figure 2: Trial design and application - Du Plessis, Schietfontein

Following an above-average season, the trial field was harvested on 5 April 2021 with an overall average yield of 3.5 t/ha. In the right-hand panel of Figure 3, the cleaned yield data are shown, consisting of 2460 subplots with consistent yield and seeding rate observations. A machine learning and clustering algorithm was run to generate the cleaned dataset, which is used for further statistical analysis.

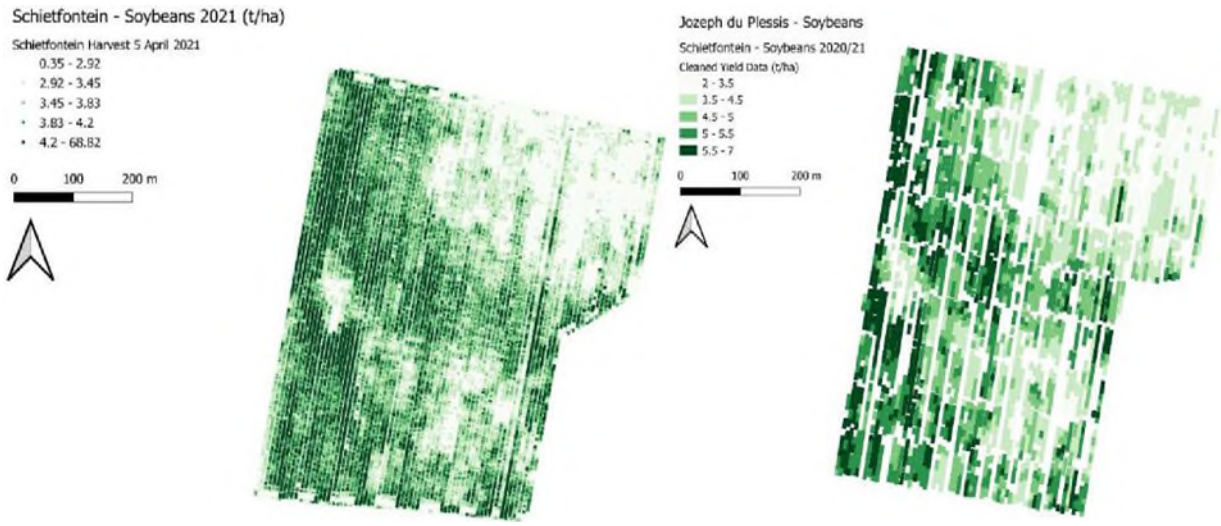


Figure 3: Harvest and Yield data - Du Plessis, Schietfontein

General additive models were fitted to the cleaned dataset for both yield- and profit-maximisation. Figure 4 depict the data with the resulting fitted curves, and also indicates the farmer's *status quo* rate (300 000 plants per hectare) and the yield maximising seeding rate of 422 000 seeds per hectare. If the famer were to increase seeding rate to 422 000 seeds/ha in a season with identical growing conditions as in 2020/2021, a projected increase of 0.15 t/ha could be achieved.

Figure 5 depicts the profit maximising seeding rate of 397 000 seeds per hectare and the model estimates that in a season with identical growing conditions to the 2020/2021 season, the farmer could have increased his profit by just under R1000/ha if the optimal flat rate was to be used.

Yield vs Seeding Rate

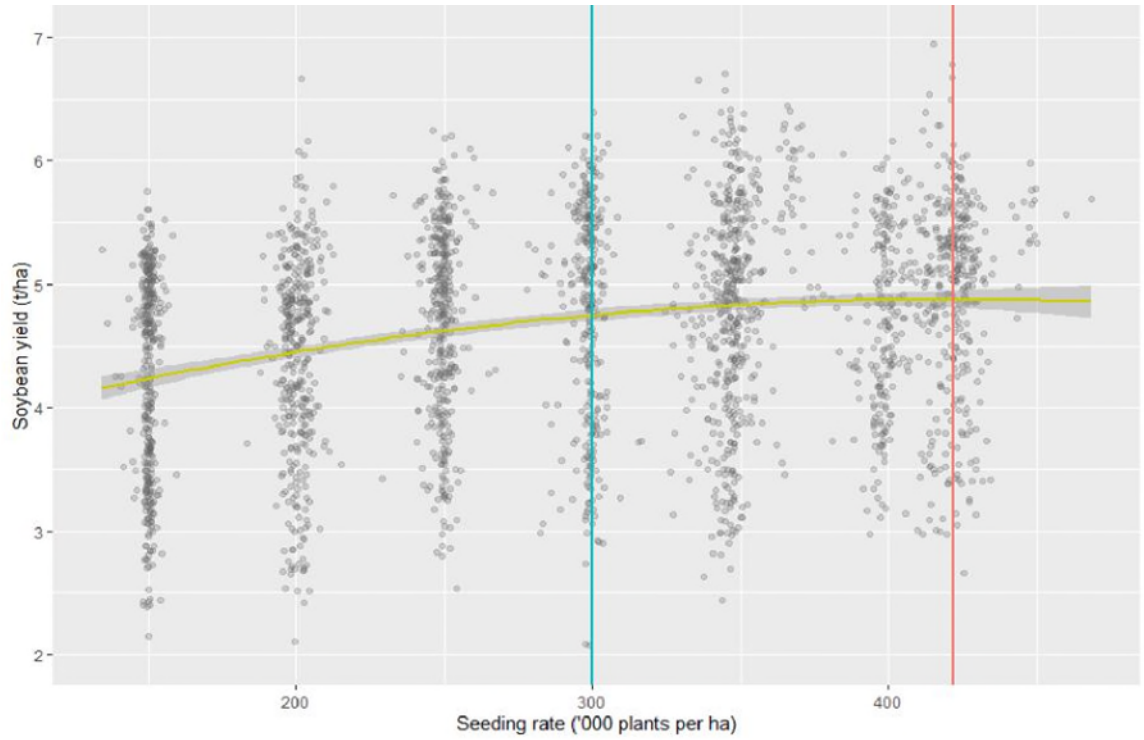


Figure 4: Yield maximising seed rate - Du Plessis Schietfontein

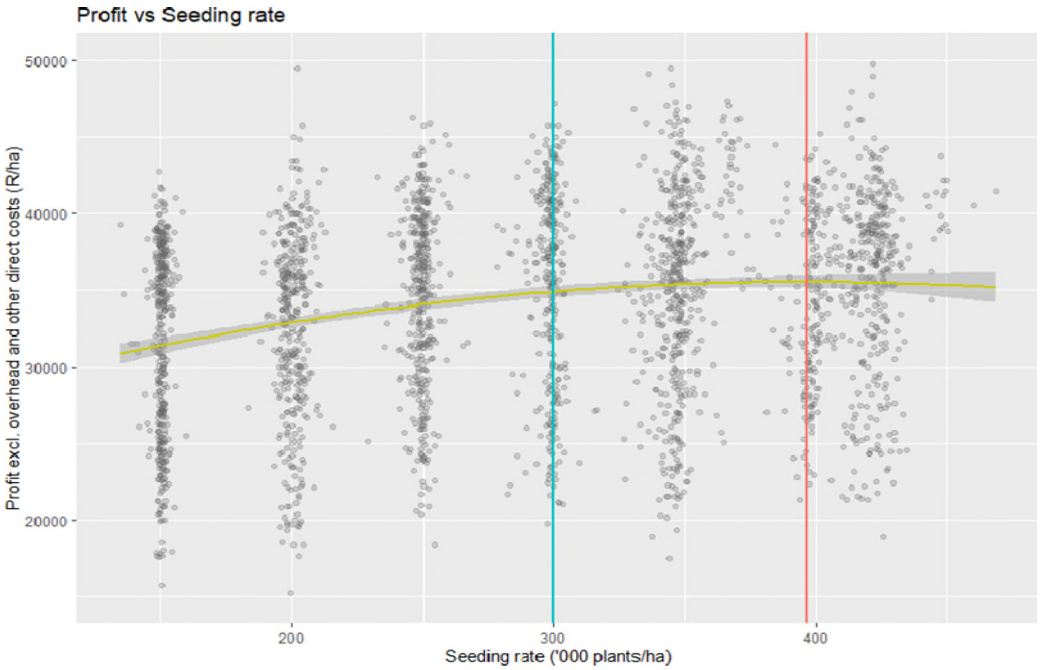


Figure 5: Profit maximising seeding rate - Du Plessis, Schietfontein

A geographical weighted regression was used to define site-specific management zones for seeding rate on the Du Plessis, Schietfontein field (see Figure 6).

The best estimate provided by the data and model is that, under growing conditions identical to those of the field in 2021, implementing the recommended site-specific seeding rate strategy would have increased profits by approximately R1360 per ha (relative to the *status quo* flat rate application). The data and model placed a 95 % level of statistical confidence that this profit gain would have been between approximately R1016 and R1704 per ha.

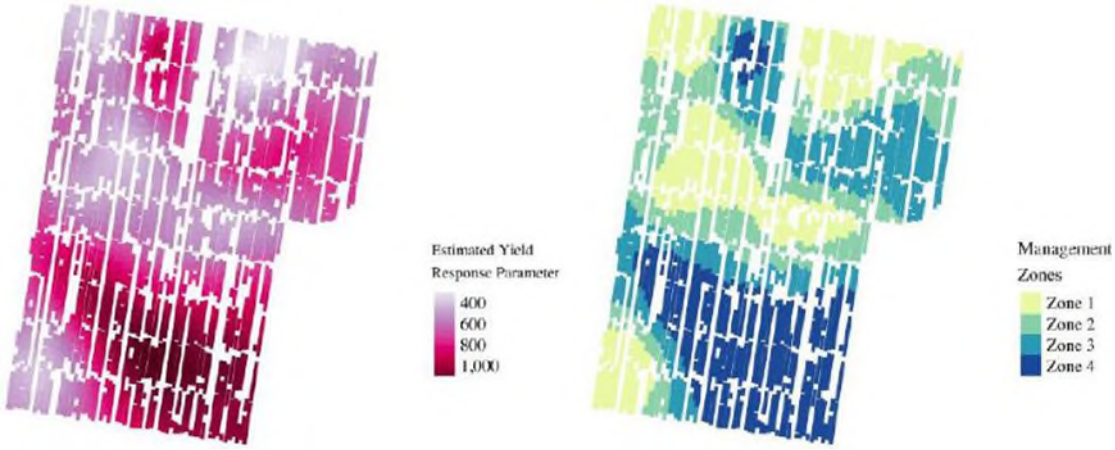


Figure 6: Site-specific management zones - Du Plessis, Schietfontein

Minnaar, Uitsny -Maize

Uitsny is a 57.5 ha field dedicated for the DIFM maize trial for the second year during the 2021 harvesting season. The farmer usually plants 18 000 plants per hectare and requested that the trial varies seeding rate between 10 000 and 50 000 plants per hectare. After applying Urea 46 pre-planting, the farmer usually applies 200 kg/ha of 15.10.6 fertilizer at planting. The trial design varied the “at planting fertilizer rate” between 90 and 300 kg/ha. The farmer plants 16, 3 ft rows and the trial grid is therefore designed to be 48 feet wide. The equipment used includes:

- John Deere tractor;
- Equalizer - John Deere Seedstar 2 & Greenstar Rate controller planting equipment; and
- John Deere S660 combine harvester.

The seeding rate trial design in the left-hand panel of Figure 8 was supplied to the farmer and was planted on 14 November 2020 (see the as-planted seeding rate on the right-hand panel). The fertilizer rate trial design and the as-applied data are depicted in Figure 7.

The planting was executed very accurately.

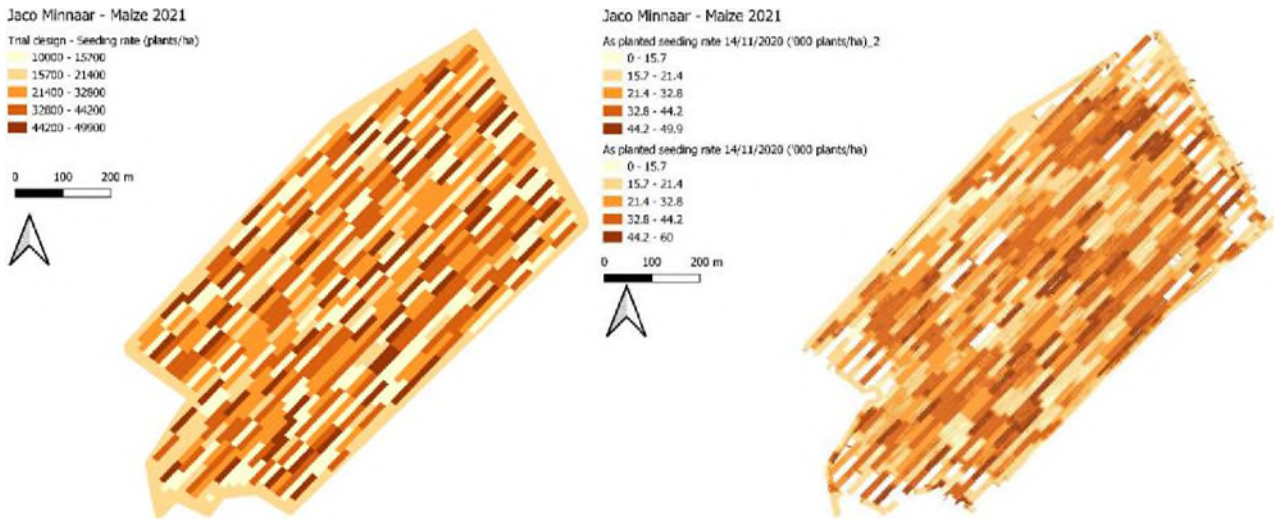


Figure 8: Trial design and seeding rate application - Minnaar, Uitsny

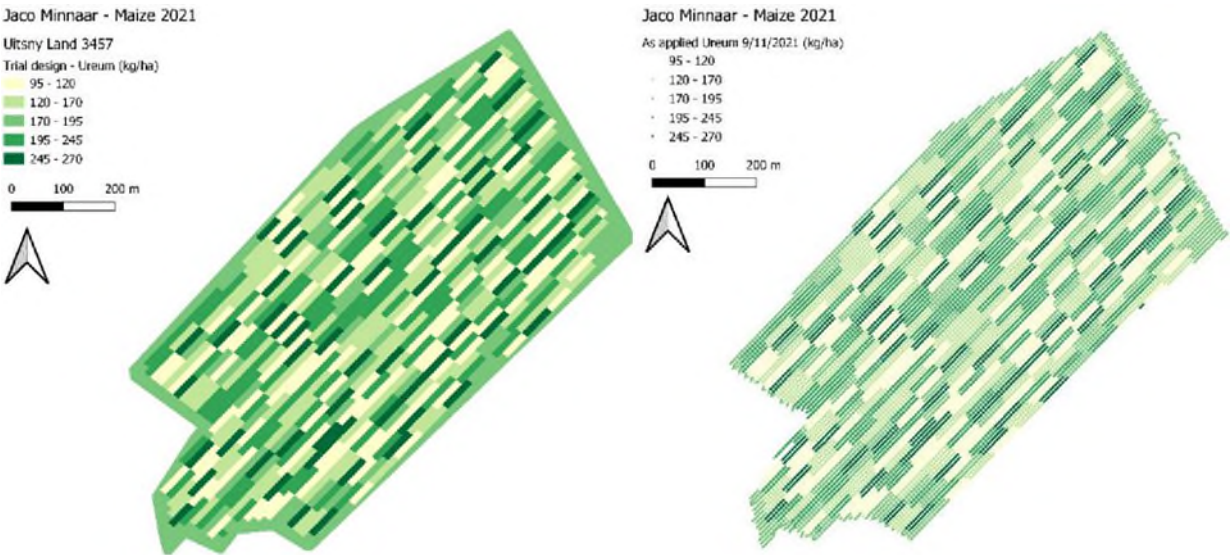


Figure 7: Trial design and fertilizer rate application - Minnaar, Uitsny

Following an above-average season, the trial field was harvested on 24 April 2021 with an overall average yield of 9.5 t/ha. In the right-hand panel of Figure 9, the cleaned yield data are shown, consisting of 3410 subplots with consistent yield and seeding rate observations. A machine learning and clustering algorithm was run to generate the cleaned dataset, which is used for further statistical analysis.

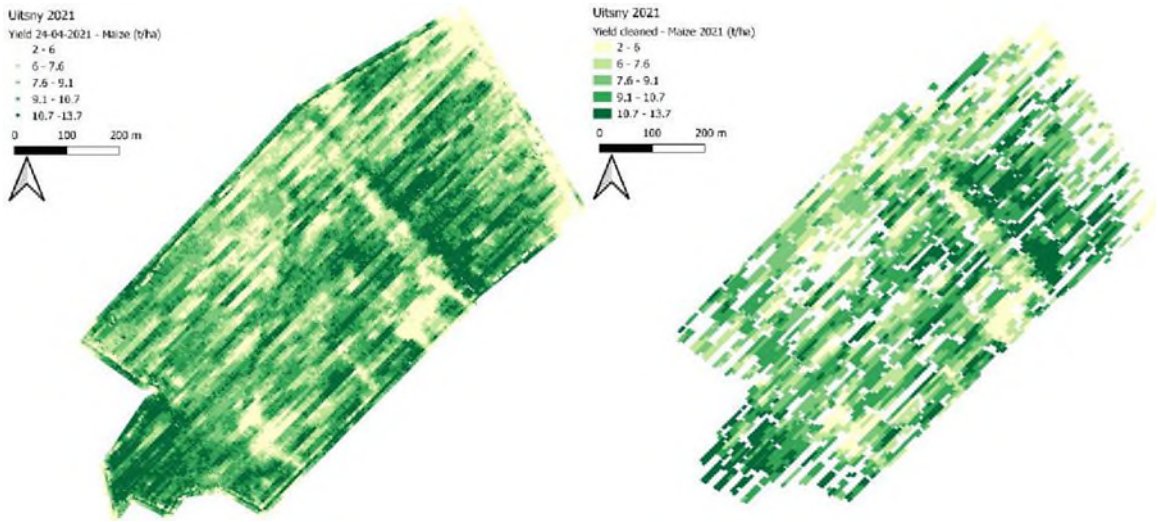


Figure 9: Harvested and cleaned yield data - Minnaar, Uitsny

General additive models were fitted to the cleaned dataset for both yield- and profit maximisation. Figure 10 depict the data with the resulting fitted curves, and also indicates the farmer's *status quo* seeding rate (18 000 plants per hectare) and the profit maximising seeding rate of 26 000 seeds per hectare. It is interesting to note here, that in 2019/2020, the profit maximising seeding rate was found to be 29 600 seeds per hectare. The results seem consistent in these two above-average rainfall seasons, that a higher seeding rate would have increased profits.

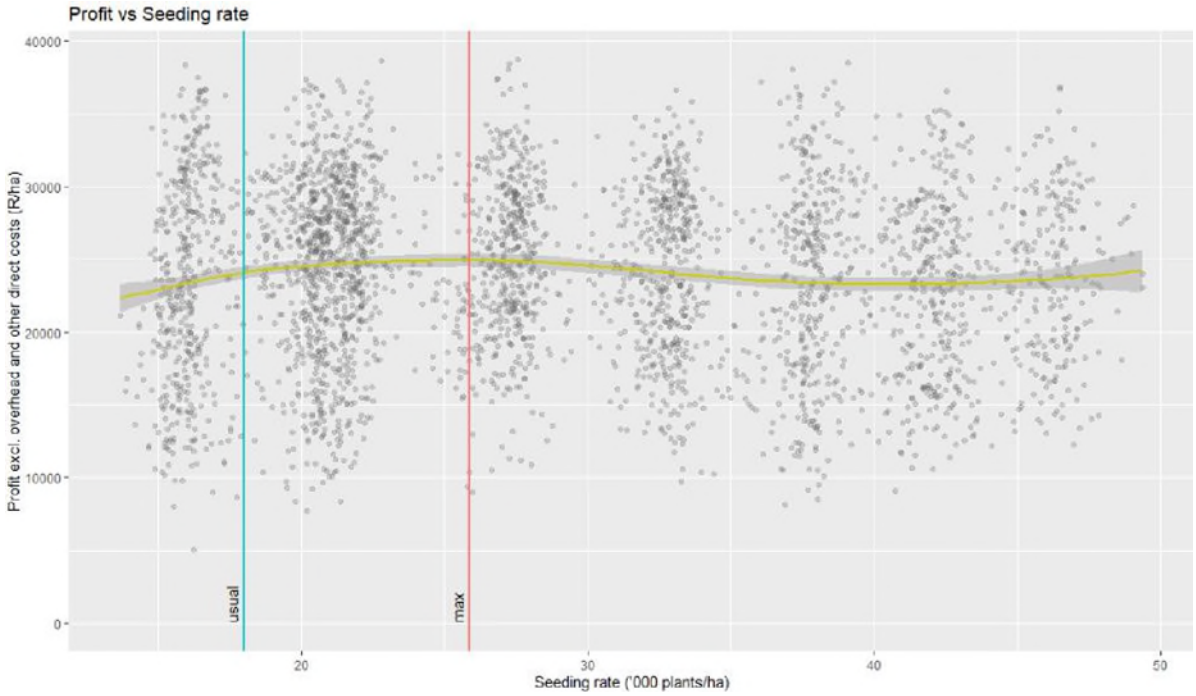


Figure 10: Profit maximising seeding rate - Minnaar, Uitsny

Figure 11 depicts the profit maximising fertilizer rate of 285 kg/ha. In the previous season's results, the highest fertilizer rate of 300 kg/ha was estimated to maximise profits. Both seasons' data are consistent in that higher fertilizer rates are recommended.

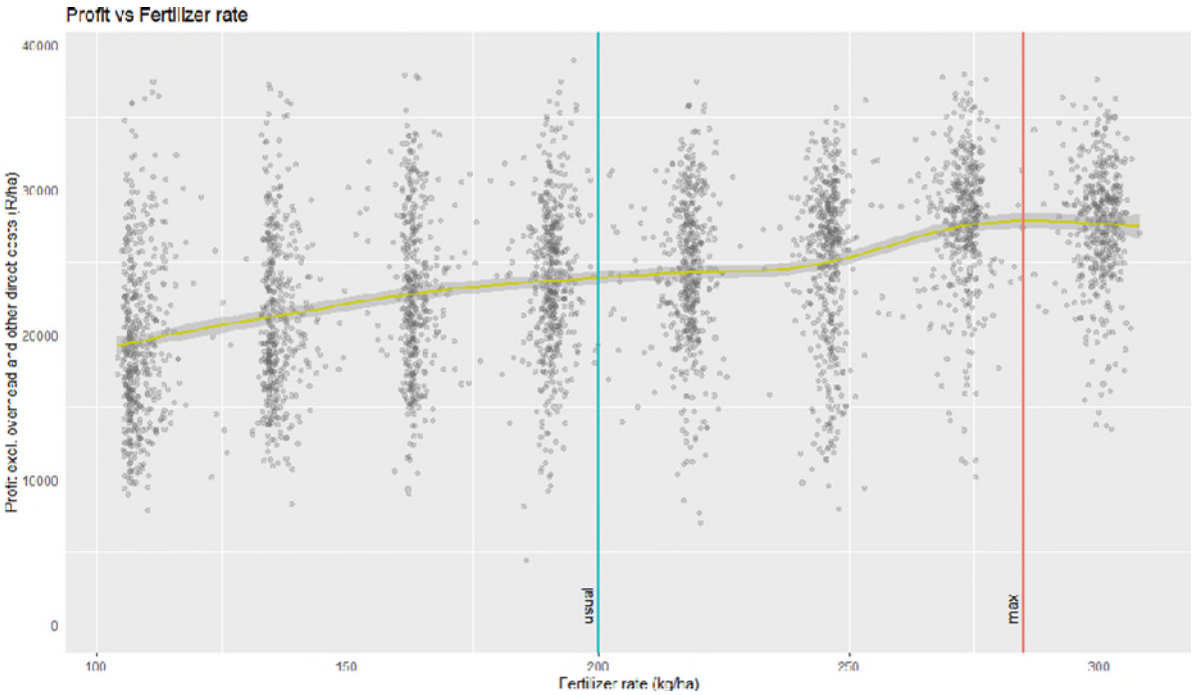


Figure 11: Profit maximising fertilizer rate - Minnaar, Uitsny

A geographical weighted regression was used to define site-specific management zones for seeding rate and fertilizer rate on the Minnaar, Uitsny field (see Figure 12).

The best estimate provided by the data and model is that, under growing conditions identical to those of the field in 2021, implementing the recommended site-specific seeding rate strategy (see left-hand side of Figure 12) would have increased profits by approximately R978/ha (relative to the *status quo* flat rate application). The data and model placed a 95 % level of statistical confidence that this profit gain would have been between approximately R703 and R1253/ha.

The best estimate provided by the data and model is that, under growing conditions identical to those of the field in 2021, implementing the recommended site-specific fertilizer rate strategy (see right-hand side of Figure 12) would have increased profits by approximately R3361/ha (relative to the *status quo* flat rate application). The data and model placed a 95 % level of statistical confidence that this profit gain would have been between approximately R2948 and R3773/ha. It is important to note here that the site-specific fertilizer strategy is actually a profit-maximising flat-rate strategy: the optimal fertilizer rate in the defined management zones is the same at 300 kg/ha.

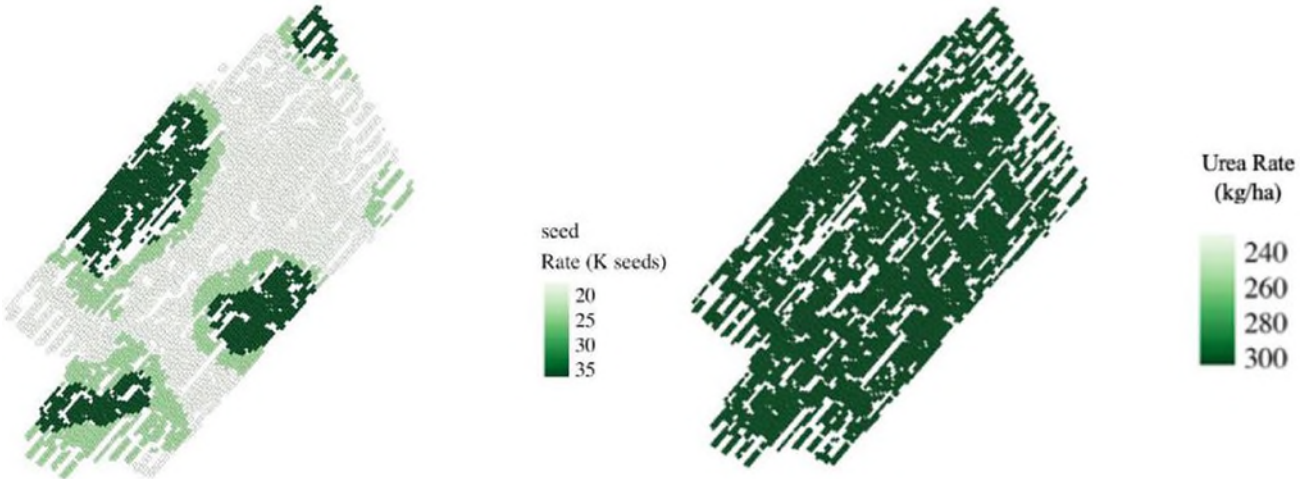


Figure 12: Site-specific crop management recommendation - Minnaar, Uitsny

Conclusions

- The South African farmers have implemented the complicated trial designs exceptionally well.
- Farmers can likely benefit from increasing seeding and fertilizer rates.
- Further research, in collaboration with the farmers' expertise, is required to evaluate the site-specific management recommendations from the data analysis and compare these to current management practices, soil corrections and soil quality-driven site-specific management strategies.

The research team is committed to sharing all results and findings with the farmers and we thank them for their co-operation to date. Following data processing, interpretation and further modelling, report write-up will be completed.

4.11 PRF WEBSITE; M du Preez and Y Papadimitropoulos, Protein Research Foundation and Tigme.com

The PRF website is continually being maintained and updated, with most of the time being spent on general page content updates and additions across the website's 17 content sections. On 28 February 2021 the website hosted a total of 1,158 HTML pages (excluding dynamically created pages).

The News Snippets page was overhauled in October 2020. A third column for Archive Quick links was added on the right of the page where older news snippets are categorised by year. The main article index - split into two columns - displays quick link titles of snippets posted during the last two years.

ICB Calculator App

In its capacity as a provider of valuable information to both producers and researchers via the web, the PRF is in the perfect position to offer more interactive functionalities to visitors.

With this in mind, a mobile application has been commissioned for the Income and Cost Budgets (ICB) where producers can use the ICB Calculator App on their mobile devices, in an internet browser or as a downloadable application on their computers.

The ICB Calculator App was officially launched in July 2020 and offers producers three options of use:

a) Download and install the app to run on a desktop or laptop computer, supporting 64 Bit Windows versions 7, 8, 8.1 and 10;

b) Launch it directly in a WebGL compatible internet browser such as Chrome, Firefox, Edge, Safari and Opera; and

c) Download the ICB Calculator App from the Android Play Store onto smart mobile devices.

During 2020/2021 there were ± 40 desktop downloads, the online browser web app received 87 launch requests and the Google Play Store statistics show approximately 9-12 active installations.

PHP 7.4

The PHP version on the PRF hosting server was upgraded to 7.4****** in August 2020. Even though it was only a minor version upgrade, the website framework and content were validated to ensure that there would be no errors on the website in anticipation of the upgrade.

*** PHP is the base programming language that is used to output website content to the browser. It is also used to process data stored in the MySQL database in order*

Website Visitor statistics

Reporting Year	Unique Visitors	Unique Visitors *Google values*		
	*Raw values**	*Visitors*	*Pages*	*Pages per visit*
2004	1 691			
2005	3 285			
2006	4 552			
2007	5 404	3 041	10 838	2.79
2008	11 104	5 274	18 829	2.82
2009	10 194	6 610	27 341	3.18
2010	11 812	6 054	23 347	2.98
2011	12 357	5 511	24 258	3.29
2012	16 306	6 909	28 206	3.12
2013	54 739	8 767	34 284	2.97
2014	54 590	10 189	39 363	3.03
2015	35 653	12 519	45078	3.60
2016	31 674	8 733	53 811	4.47
2017	47 373	6 901	20 514	2.18
2018	38 049	10 041	24 873	1.90
2019	45 787	10 444	23 628	1.78
2020	**27 317**	**9 632**	**24 169**	**1.93**

Google values show an increase in page views and a slight decrease in unique visitors. Pages per visit increased slightly. The most page views came from the following pages in order of percentage share:

a) Home page: 15.65 %;
b) Soy oilcake price average: 3.93 %;
c) Soybean Snippets: 2.95 %;
d) Development Plan for Canola 2018: 1.93 %; and
e) About Us: 1.90 %.

YouTube visitor statistics

Reporting Year	YouTube statistics		
	Views	*Watch time (hours)*	*Subscriber gain*
2014	611	28	+2
2015	1 900	74	+4
2016	8 400	256	+21
2017	23 000	568	+78
2018	35 000	716	+195
2019	27 900	660	+151
2020	**27 600**	**670**	**+163**

The PRF's YouTube channel had grown to almost 614 subscribers by the end of the year 2020.

5. STUDY GRANTS AND BURSARIES

The PRF bursary scheme was approved in 1994 and the first bursary for postgraduate studies was awarded for the 1995 academic year. We are proud to look back on a period of 24 years during which 78 bursaries were awarded to deserving candidates for Masters' and Doctorate studies. The aim of the bursary scheme is to train deserving candidates in the scientific method to allow them to contribute to high quality scientific research after completing their studies. This includes, in particular, research aimed at promoting the production of protein for animal consumption.

Students are also encouraged to publish their research results in scientific journals, popular magazines or both. Management summaries of theses and manuscripts are published on the PRF website and database.

Bursaries for Masters' studies are awarded for a period of two years and for three years in the case of Doctorate studies. Bursaries awarded for the current year, approved by the Technology Committee, were the following:

5.1 MSc Studies

5.1.1 **Mr A Liebenberg** (Second application). "Consideration for liming soil for canola production: Soil tillage, placement, form and fineness of lime", University of Stellenbosch.

5.1.2 **Mr DDV Lötter** (First application). "Saad ontkieming teenoor saad lewens-kragtigheid op verskillende canola kultivas van Suid-Afrika en hoe sekere abiotiese faktore dit beinvloed kiemkragtigheid vs lewenskragtigheid van canolasaad - impak op vestigingsukses vir produsente", University of Stellenbosch.

5.1.3 **Mr M Liebenberg** (First application). "Feedlot performance and rumen fermentation characteristics of feedlot cattle as affected by dietary protein quality and rumenally protected lysine and methionine supplementation", University of Pretoria.

5.2 PhD Studies

5.2.1 **Ms IR Crouse** (Second application). “Die ontwikkeling van stikstof bestuurstrategieë vir canola (*Brassica napus*) onder bewaringslandboupraktyke in die Wes-Kaap”, University of Stellenbosch.

5.3 Completed theses received

During the year under review, the following thesis was received from a bursary recipient who had successfully completed his studies.

5.3.1 **Mr JP van Zyl**, “Influence of planting techniques and maturity group on soybean (Glycine max L.) yield in different agro-ecologies”, MSc, University of the Free State.

6. ACHIEVEMENT AWARDS TO PROMOTE THE PRF VISION AND MISSION

Each year the PRF recognises individuals for their special contributions in support of the vision and mission of the PRF.

Awards are categorised as follows:

- Best Doctoral thesis;
- Best Masters thesis;
- Best article published in a scientific journal;
- An individual or organisation that has made an exceptional contribution in promoting the vision and mission of the PRF;
- A Board Member who has contributed significantly in promoting, over a period of time the activities of the PRF;

During the year under review, awards will be presented to and Ms Marlese Meiring in the category Best Masters thesis. The awards will be presented at an appropriate event during the year under review.

No other awards were made during the year.

7. CONCLUSION

It is with true gratitude that the PRF presents this research report. The results achieved fall within the requirements and objectives set by the PRF. This requires recognition of a large number of institutions and individuals.

Success is based on the hard work and dedication of PRF Board Members and staff, but definitely also the work done by co-workers and contractors. We also express unqualified appreciation to local and international co-workers, researchers and institutions, the press, fund managers, auditors, lawyers and web masters. We trust that this co-operation will continue in the New Year and over many years to come, leading to far-reaching and ever greater achievements.

ANDRIES P THERON
CHAIRPERSON

ANNEXURES

I LIST OF APPROVED PROJECTS IN 2020-2021

https://www.proteinresearch.net/index.php?page=last-years-approved-projects

II PRF STRUCTURES

https://www.proteinresearch.net/index.php?page=about-us

III LIST OF BURSARY APPLICATIONS: 1995 - 2021

Achievement awards since 1995 (proteinresearch.net)

IV LIST OF RESEARCH PROJECTS: 1976 - 2021

https://www.proteinresearch.net/index.php?page=projects-awarded-archive