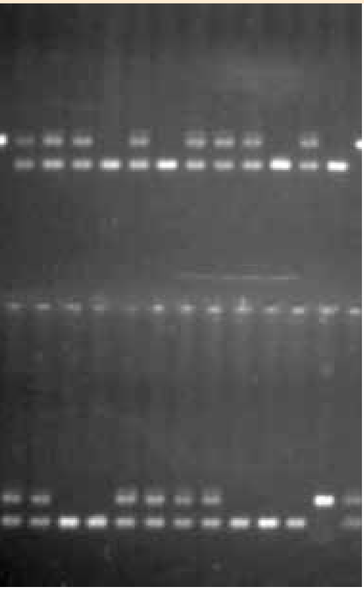
2019

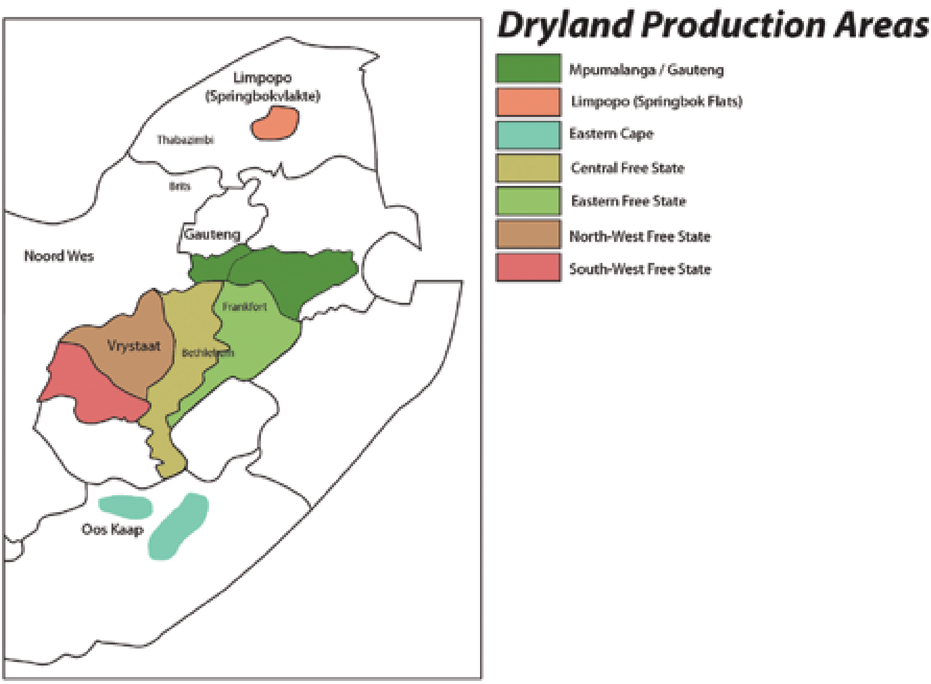
ARC • LNR

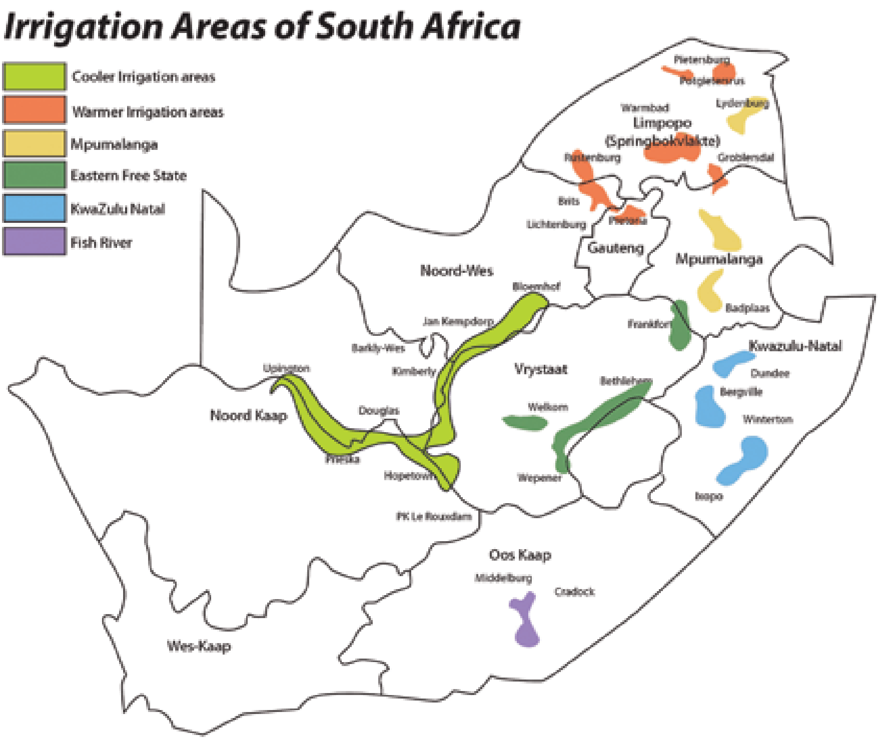


GUIDELINE

PRODUCTION OF SMALL GRAINS IN THE SUMMER RAINFALL AREA

ARC-SMALL GRAIN


Dryland Production Areas
Mpumalanga / Gauteng
Limpopo (Springbok Flats)
Eastern Cape
Central Free State
Eastern Free State
North-West Free State
South-West Free State
Limpopo
(Springbokvlakte)
Thabazimbi
Brits
Gauteng
Noord Wes
Frankfort
Vrystaat
Bethlehem
Oos Kaap


Irrigation Areas of South Africa
Cooler Irrigation areas
Warmer Irrigation areas
Mpumalanga
Eastern Free State
KwaZulu Natal
Fish River
Pietersburg
Potgietersrus
Warmbad
Lydenburg
Limpopo
(Springbokvlakte)
Rustenburg
Groblersdal
Brits
Lichtenburg
Pretoria
Gauteng
Mpumalanga
Noord-Wes
Bloemhof
Badplaas
Jan Kempdorp
Frankfort
Kwazulu-Natal
Barkly-Wes
Kimberly
Vrystaat
Dundee
Upington
Bethlehem
Bergville
Welkom
Noord Kaap
Douglas
Winterton
Prieska
Hopetown
Wepener
Ixopo
PK Le Rouxdam
Oos Kaap
Middelburg
Cradock
Wes-Kaap

GUIDELINES:
FOR THE PRODUCTION OF SMALL GRAINS
IN THE SUMMER RAINFALL REGION
2019

Compiled by:

ARC-Small Grain

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SABBI

ISBN: 978-0-621-47089-5

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Data Editing:

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Shereno Printers

Tel: (012) 344 2817

- **ARC-Small Grain would like to thank the Winter Cereal Trust for the financial support from which the research results were determined.**

TABLE OF CONTENT

FOREWORD

Increasing agricultural productivity in an effort to become or remain financially viable in our competitive and global marketing environment is at the heart of every role player in our small grains value chains.

For South Africa to become food secure on a household and national level, your continuous production of basic foods and raw material for beverages such as wheat and barley amongst others is imperative.

The 2019 Production Guideline as proven by its many annual predecessors is the most important decision-making database with up-to-date information. The information contained is based on a sound objective and scientifically proven replicated trials (2-4 years data), and is representative of all major production areas and should be used when making the correct cultivar choice in a specific production area.

Performance data of each cultivar is supported by disease, insect and weed control information as well as related crop production practices, soil, water and fertilisation management recommendation.

The information in this publication will certainly lower your risks and increase your productivity and cost efficiency.

Most importantly, do remember that productivity and profitability are not measured in ton/ha, but in profit/ha. Only the latter will ensure our competitiveness.

Dr Toi Tsilo

Senior Research Manager

ACKNOWLEDGEMENTS

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GENERAL CROP MANAGEMENT

The aim of this publication is to highlight the management of the wheat crop in a sustainable crop rotation system to increase the competitiveness of the crop. Although there is not one single best management practice for all situations, this publication will discuss the principles of the growth and management of the wheat crop, so that applicable management decisions can be made as the specific situation arises.

The major consideration in dryland wheat production is profitability. The traditional wheat- fallow-wheat system that had been followed for many years had become unprofitable, mainly due to soil water availability restrictions and increased disease occurrence. This system has also led to degradation of soils via decreased organic carbon (humus), and increased soil acidity and soil erosion. Increased profitability can only be achieved by maximising the yield potential of the crop/soil/climate combination, while input costs are also strictly managed.

In striving to achieve greater productivity with the available resources invested in crop production, and not necessarily higher total production, it is important to consider a few basic principles of crop management.

- **Soil selection** is critical, requiring each land to be reviewed individually to realise its potential;
- Analyse soil samples to evaluate **the fertility status** of the soil;
- Follow an **effective liming** programme;
- Do **fertilisation planning** including all important plant mineral elements;
- Apply appropriate **soil cultivation methods.** These include: alleviation of compaction layers, crop residue management, weed control and seedbed preparation, with the main aim of maximising soil water conservation in the soil profile. Each soil cultivation input must have a specific objective;
- Plant a number of **cultivars** with a high yield potential and relevant disease and insect resistance;
- Calibrate **planters** to ensure the correct seeding density, fertiliser application and planting depth for seed germination;
- Select the optimal **planting time** for a particular cultivar, and plant at the recommended seeding density to ensure optimal emergence and seedling establishment;
- Follow an effective **spraying programme** for control of weeds, insects and diseases during the growing season;
- **Timely harvest** of the crop and post-harvest storage can impact on optimal yield and grain quality;
- **Effective marketing** of the grain for successful financial management.

Crop Rotation Management

From an economical and agronomical viewpoint it is beneficial to cultivate wheat in a suitable crop rotation system. Grain yields are increased, while weed, insect and disease problems are reduced.

Yield limiting factors

The major factors that limit crop yields are:

- Unsuitable soil selection;
- Restricted soil water availability and climatic stresses;
- Low soil fertility and nutritional deficiencies;
- Plant diseases;
- Weed competition;
- Insects;
- Sub-optimal planting dates and cultivar choices;
- Poor seed germination and crop establishment.

These factors arise because of poor cultivation methods, inappropriate soil selection and low water retention practices, soil water accumulation, and crop rotation.

Long-term rotations require planning

Good crop rotation planning is the single most important management practice determining yields and profitability. It is an investment in risk aversion. A well planned and managed crop rotation system decreases input costs, increases yields and spreads production risks.

What is the best crop rotation system?

There is not one single crop rotation system that will be suitable for all production regions. Every farmer must plan and develop a long-term system that is adaptable and sustainable, incorporating the principles of agronomic management and farm planning. The choice of crop for each field must be based on an objective determination of gross income, input costs, field, and crop rotation history.

A crop rotation system for any given situation will be determined by:

- The objectives and attitude of the farmer;
- The different enterprises on the farm and relevant commodity prices;
- The cash flow and economics of the cultivated crops;
- Agronomic management principles;
- Soil depth, structure and texture;

- Soil fertility status and acidity;
- Total rainfall and distribution in the growing season;
- Spectrum of weeds occurring in the fields;
- The rotation of nitrogen fixing and nitrogen dependent crops;
- Occurrence of plant diseases;
- The prevention in the build-up of soilborne diseases;
- Available machinery and equipment;
- Livestock needs and fodder flow requirement.

Benefits of a sustainable crop rotation system

Reduced diseases

A factor emerging as a major threat to wheat yields and thus income in recent years, is the increasing incidence of root diseases. The only practical control strategy is a well planned and managed crop rotation system, which is aimed at eliminating annual grasses and volunteer wheat, which may serve as a source of inoculum for these diseases at least 12 months prior to crop establishment.

Decrease weed burden

Weeds compete with crops for water, nutrients, sunlight, and field space and can significantly reduce yields. Weeds limit grain yields by approximately 20% annually. By alternating crops and rotating herbicides, it is possible to control a wider spectrum of weeds. Effective weed control in one crop often means that the following crop can be grown without the need for expensive selective herbicides. Rotating crops and herbicides reduces the potential for herbicide resistance to develop in target species, for example wild oats. This can also reduce the potential for herbicide residue accumulation in the soil.

Increased soil fertility

The aim of a suitable crop rotation is to include a nitrogen-fixing crop (legumes) that replenishes the nitrogen exploited by the grain cropping phases. Yield and grain protein increases in wheat, following legume crops have been widely demonstrated. The accumulation of soil organic material and residual nitrogen in the soil, is linked to the recovery of soil structure and increased soil water accumulation capability, which in turn favours improved yields.

Increased profits

The inclusion of a legume in the crop rotation system generally increases profitability by increasing grain yields. Economic sustainability is also ensured, because production risks are spread over different crops and growing seasons.

MANAGEMENT OF WHEAT PRODUCTION

Good yields and profitability can only be achieved through careful planning and management. Higher yields imply higher profits, since production costs per ton of grain declines relatively as yields increase.

Avoid having an inflexible approach to crop management. Learn to adapt and revise management strategies as the cropping environment, yield potential, commodity prices and input costs changes.

What determines wheat yield?

Total grain yield per hectare is the result of:

- The number of plants per hectare;
- The number of ears per plant;
- The number of grains per ear;
- Individual grain weight.

Above-mentioned yield components and eventually grain yield is determined during the three main development phases and relevant growth stages. It is possible that a yield component that kicks in at a later growth phase, partially compensate for reductions in a yield component determined at an earlier development stage. The development stages for the different yield components overlap to some degree in their respective effect on potential grain yield, and they are determined in a definite sequence, as indicated in the following schematic representation (Figure 1).

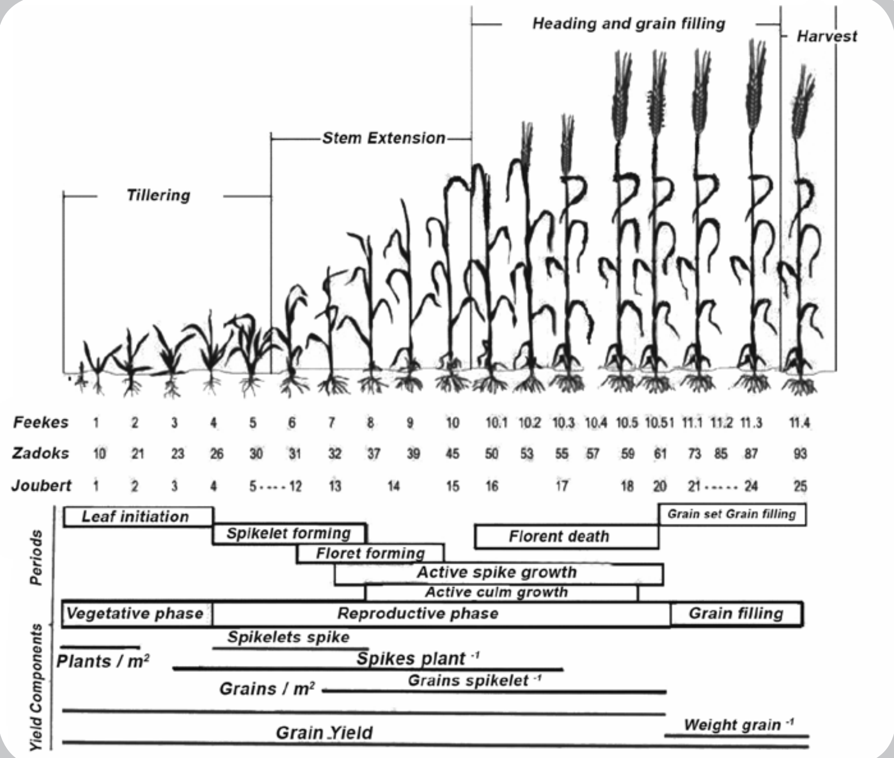
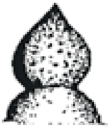


Figure 1. Growth and development stages of wheat during the growing season

**Adapted from:*

- *Ohio Agronomy guide 14th edition.*
  Bulletin 472-05.
- *Slafer & Rawson, 1994*
- *Wheat growth and physiology.A.Acevedo, P.Silva & H.Silva, 2002. FAO Corporate document respository (www.fao.org).*
- *Bread wheat, 2002 (B.C. Curtis, S. Rajaram & H.Gomez MacPherson, eds.) FAO Plant Productions and Protection Series, no 30, Rome, 2002.*

Growth stages (sketches according to dr Gideon Joubert)



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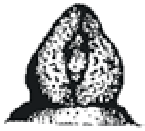

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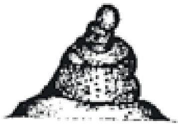

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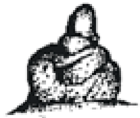

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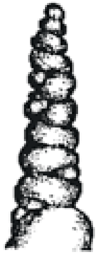

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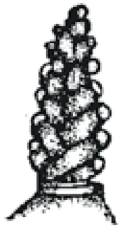

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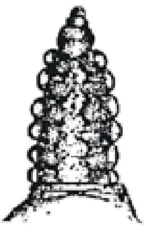

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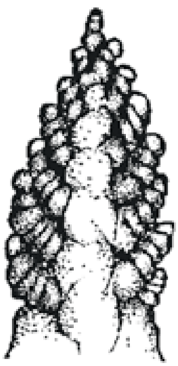

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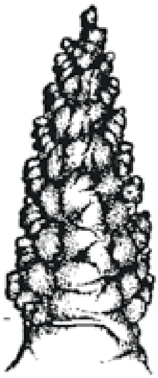

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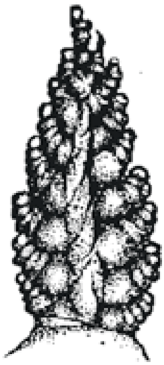

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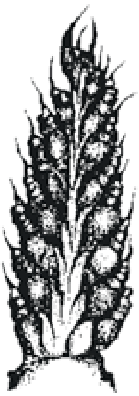
Growth stages (continues)



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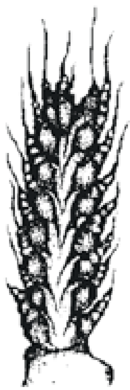

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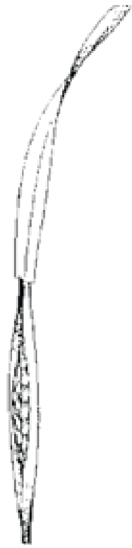

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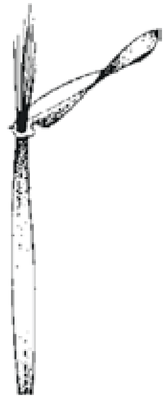

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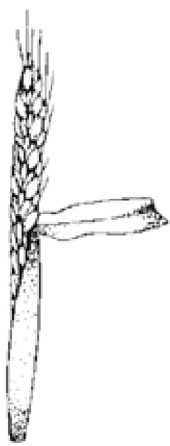

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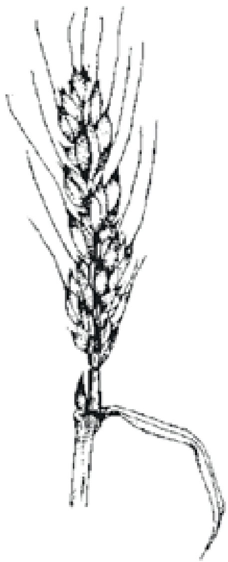

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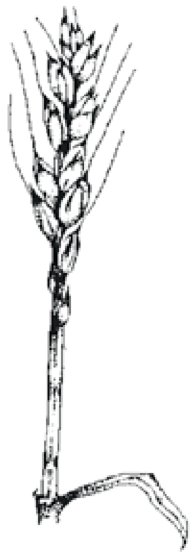

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Growth Stages (continues)

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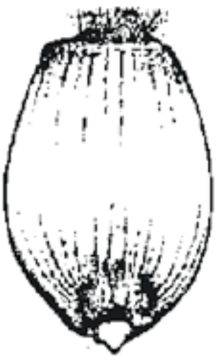

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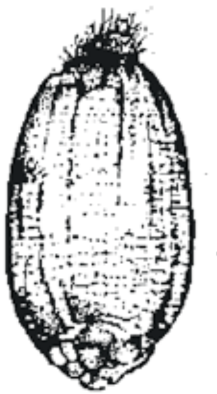

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Growth stages (photos by Robbie Lindeque)

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GS13

Growth stages (continues)


GS14


GS15


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GS22


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GS25

Factors influencing yield components

Management phase	Factors	Yield components
Planting	Seed density (kg/ha) Thousand kernel mass Seed germination percentage Seed vigour Coleoptile length Soil structure and texture Seedbed preparation Soil water content at planting Planting method / depth Fertiliser application at planting Seed treatment	Number of plants established per hectare
Vegetative and reproduction phase	Cultivar Planting date Soil fertility (N, P, K, pH) Soil water availability Temperature (minimum and maximum) Insects / weeds / diseases	Number of tillers/ ears per hectare
Grain filling	Cultivar Nitrogen availability Soil water availability Temperature (maximum and /or cold damage) Diseases/insects	Kernels per ear and single kernel weight

Establish target yields

Set a realistic target yield for your cropping programme, taking into consideration all the available resources. Target yields form the foundation for crop management decisions. Cultivar selection, fertiliser rates, herbicide and insecticide applications and especially the yield planning and other management decisions can only be made with the aid of target financial objectives.

Various factors should be considered when setting a target yield:

- Experience: historical yield data of the past five years;
- Plant available water: sum of stored soil water at planting plus average growing season effective rainfall; and
- Use long-term climate projections.

The risk associated with your selected yield target should be carefully considered. Profit is the compensation for taking risks, but be realistic: certain management practices and target yield goals have a higher risk component.

Achieving target yields

The key management decisions to achieve target yields and to maximise profits include the following:

- Total farm planning including soil selection;
- A well planned crop rotation system;
- effective management of plant available soil water;
- soil analysis for a relevant fertilisation and liming programme;
- Setting realistic target yield;
- Application of effective soil cultivation practices;
- Informed cultivar selection;
- Use of high quality seed;
- correct planting dates and seedling densities of selected cultivars;
- Appropriate planter speed and planting depth;
- monitor the crop development and note observations;
- make timely decisions on weed, insect and disease control;
- timely harvest of grain crop;
- Develop a financially sound marketing strategy;
- Apply sound agronomic management principles.

SOIL TILLAGE GUIDELINES

Objectives of soil tillage

Soil is cultivated to produce favourable conditions for establishment of the wheat crop. Such conditions include soil in which sufficient water is stored for germination and early plant development. This is achieved by maximising the amount of water that infiltrates the soil and by reducing weeds and volunteer plants growing during the water-harvesting season. Tillage is also used to eliminate compaction and manage excess stubble.

Traditionally, weeds were controlled by means of mechanical cultivation such as ploughing with a mouldboard plough (conventional tillage) or by means of shallow cultivation with the aim to kill weeds while retaining stubble on the surface (conservation tillage). Another planting method, namely minimum-till (also called no-till) in which the seed is directly sown in untilled soil, has become available due to cost effective means of killing weeds with broad spectrum herbicides (chemical cultivation) and the availability of planting machines that can be used in high stubble conditions. Whichever system the producer chooses, good crop establishment and economical factors remain the main issues that need to be considered.

Conventional tillage

Conventional tillage is recommended for a wheat-on-wheat cropping system in which the risk of root disease is high and the risk of wind and water erosion minimal. The use of a mouldboard plough causes the top soil layer to be inverted and leaves virtually no stubble on the soil surface. It effectively kills germinated weeds but brings weed seeds from deeper layers to the soil surface where it germinates. Mouldboard ploughing should always be followed with secondary cultivation to get rid of clods and new weed infestations.

Conventional tillage is usually carried out in the following manner:

Step 1: Harvest (December - January)

Step 2: Disc as soon as soil conditions allow. If a lot of residue is left on the surface, repeat. In years of exceptional straw (> 3,0 ton/ha grain yield), burning of the residue can be considered.

Step 3: Plough between end of January and end of February in the drier areas and between mid February and the end of March in the wetter areas. The timing of the cultivation depends on the soil water situation. Ploughing must be done so that there is a good chance to still receive substantial rain after the cultivation to replace water lost during the operation. On the other hand, ploughing must be left as late as possible so that the minimum subsequent cultivations will be needed for weed control. If possible, the plough must be fitted with a row of small tines at the rear, or a harrow must be attached in order to seal the surface layer and break clods behind the plough.

Step 4: A sweep or harrow should be used directly behind the plough, or as soon as possible after ploughing, to break clods and to seal the surface layer to prevent evaporation.

Step 5: Shallow sweep cultivations may be used to prepare the seedbed and to control weeds, when necessary

Step 6: Plant according to guidelines. If possible, use a planter fitted with tines for the following reasons: effective band placing of fertiliser in wet soil to enhance uptake by the roots and breaking of shallow compacted soil layers caused by tillage after ploughing.

It is important to adjust the press-wheel according to the moisture situation in the soil. The drier the soil, the greater the pressure that must be applied.

Conservation tillage

Conservation tillage is highly recommended in all areas where the risk of wind and/ or water erosion is high, because of the low clay content of these soils. These areas are usually less prone to the root disease, "Take-all", as the rainfall is lower and the soils are well drained. Conservation tillage can also give good results in high rainfall areas if used in a crop rotation system where wheat is alternated with different crops. Wheat should never be planted in half incorporated wheat straw in high rainfall areas and under irrigation. Under dryland conditions farmers in the North Western Free State producing on deep sandy soils on a shallow water table, have been implementing reduced tillage successfully for many years. A dry climate, high yield potential and resulting high residue levels are ideally suited to reduced tillage systems. Conservation tillage may be carried out in the following manner:

Step 1: Harvest (November - December)

Step 2: Weed control (if soil moisture permits) with a harrow, sweep or V-blade depending on the amount of residue required on the soil surface. Chemical weed control may be used instead of cultivations.

Step 3: Deep tillage in March or April with a tine implement (ripper/chisel plough) to break compacted layers, if needed. Timing is essential in order to reduce the number of secondary cultivations, as all further cultivation will re-compact the soil. If possible a roller should be fitted to the implement in order to seal the soil surface after the operation.

Step 4: Seal the soil surface directly after or as soon as possible after deep tillage with a sweep, harrow or V-blade (if roller is not fitted to tine implement).

Step 5: Control weeds and prepare the seedbed with a shallow tillage just before planting, if necessary.

Step 6: Plant according to guidelines. If possible use a planter fitted with tines for the already mentioned reasons.

The amount of straw left on the surface at planting should be determined by the risk for water and wind erosion. In high risk areas, as much as possible must be left on the surface in order to break wind speed and limit run off water. However, excessive straw will cause problems at planting as it will pack between the planter units.

No-till (Direct seeding)

The increasing use of crop rotation systems and the development of new technology has created new opportunities to implement direct seeding systems successfully. The current high cost of diesel and the reduction in the price of glyphosate based herbicides, makes reduced tillage methods even more attractive to producers.

No-till has been established successfully in many areas in South Africa, including some parts of the Winter Rainfall Region and some irrigation schemes, especially in KwaZulu-Natal. In the Eastern Free State the use of these systems is more problematic due to high disease pressure, but with good management these problems can be overcome.

One of the main aims of direct seeding is to minimise disturbance of the soil surface in order to prevent surfacing and germination of new weed seeds and to maximise covering of the surface by residue. This further suppresses the germination of weeds and enhances the uptake of water by the soil. A properly functioning no-till planter is then used to open a narrow slot by pushing away crop residues from the plant row. Ideally a tine is used for proper fertiliser placement and breaking of surface and sub-soil compaction.

What are the secrets for successful implementation?

Crop rotation

Direct seeding can only be established within crop rotation systems, whether in double cropping under irrigation or in multi-year rotations as found under dryland production in the Summer Rainfall Area. Monoculture quickly leads to the build-up of diseases, pests and weeds. The abundance of suitable substrate in the form of crop residue, will increase the risk of these problems even further.

Residue cover

Sufficient residue cover is a prerequisite for any direct seeding system to function properly. Without sufficient residue cover of at least 30%, none of the advantages of the system, except maybe fuel saving, can be achieved while most of the disadvantages are still likely to occur. Research has clearly shown that residue partially mixed into the soil has a negative impact on production and that for success to be achieved the residue must remain on the surface and be as evenly spread as possible. To achieve this goal the use of residue spreaders on the combine harvester is of utmost importance. In marginal areas where insufficient residue is produced by the crop itself, cover crops can be used as a possible solution to the problem.

Micro-organisms and roots

The work of the plough in direct seeding systems is replaced by the activity of earthworms, micro-organisms and degeneration of plant roots. The activities of these organisms create channels in the soil through which the soil is aerated and through which water can penetrate the soil. The accumulation of organic material that also takes place, increases soil fertility and improves the physical structure of the soil. Unfortunately it takes a long time for populations of these organisms to build up to levels at which this work is done effectively - a time during which the crop may look worse than usual and yields may drop. Producers who have persevered using direct seeding, affirm that a turning point is achieved when soil conditions improve and yield increases accordingly.

What problems can be expected?

Pests and diseases

Some pests and diseases flourish when high residue cover is present and monitoring, planning and management has to be at much higher levels than for conventional methods. As an example the weed spectrum can change, pests that were not serious in the past can become important and diseases like take-all and Septoria can suddenly appear. As already mentioned, crop rotation is one of the most important factors in the control of pests and diseases and must always be an integral part of any direct seeding system.

The use of agro-chemicals can be expected to increase due to the foreseeable increase in pests and diseases. One of the cornerstones of direct seeding is the use of broad spectrum herbicides such as glyphosate to replace shallow tine cultivations. As always, all agro-chemicals should be used according to the instructions on the label and producers must be aware of the increased risks associated with their use.

Nutrient disorders

Thick residue covers can induce the accumulation of nutrients to toxic levels in the topsoil. These relationships have not been fully investigated and more research is needed to establish the relationship between the uptake of calcium, magnesium, potassium and other nutrients, especially under irrigation.

Reduction of seedling vigour

It is well known that seedling vigour decreases under direct seeding conditions. This is associated with the lower soil temperatures experienced by the plant due to the residue cover. Using slightly higher seeding rates that will result in a marginal cost increase, can compensate for this. Improved planting methods, especially when suitable seeding equipment is used instead of broadcasting, can dramatically reduce the seeding rate.

Increase in nitrogen fertilisation

The risk of a nitrogen negative period is increased due to the residue on the surface and lower levels of nitrogen recycling in the system as a result of less cultivation. Application of nitrogen during planting must be sufficient to ensure that the young plant has access to sufficient levels of the nutrient. This implies that slightly higher levels of nitrogen will be used in comparison to conventional tillage. Once again, nitrogen levels can be lowered if fertiliser application is switched to more accurate band placing and if nitrogen applications are split.

Yield reduction

Most producers experience an initial reduction in yield when making the change to direct seeding. However, when the saving on input costs is taken into account, direct seeding remains profitable in most cases. These yield reductions can usually be linked to problems with compaction and/or diseases. Once the presence of compacted layers are established, these layers will have to be broken by using a suitable tine implement. After that, the producer can continue with direct seeding.

One of the factors that the farmer must take into account is that his fields may not seem as homogeneous as they did before direct seeding, especially with regards to plant height and colour. This can be limited to the minimum by addressing all above-mentioned problems and by creating optimum growing conditions for the plant. Application of precision farming principles to address problem areas will be particularly helpful.

What are the pitfalls?

Acidity

One of the main problems farmers practising direct seeding have to deal with, is soil acidity. Once in a direct seeding system, it is difficult for the farmer to make a decision on the need to cultivate the land in order to incorporate lime. It is therefore of utmost importance to correct the soil pH to optimal levels before changing over to the direct seeding system. Afterwards re-acidification needs to be managed and checked on a regular basis to prevent the situation deteriorating to dangerous levels. This principle also applies to phosphate and potassium.

Compaction

Direct seeding does not imply no-traffic - as a matter of fact, no-till fields still carry quite regular traffic in the form of heavy combine harvesters, planters, fertiliser applicators and spraying equipment. The inclusion of controlled traffic will therefore be advantageous. Compaction can further be minimised by carefully regulating tyre size and pressure and by making use of aerial applications where possible. Attention to creating optimum circumstances for biological activity, optimal root development as well as good crop rotation (crops with different types of root systems) will help to reduce the rate of compaction. When compaction however becomes a limiting factor, it must be alleviated by deep tillage with tines.

The animal factor

Due to the need for residue cover, direct seeding systems do not usually integrate well with the animal factor. Fields used for direct seeding should not be grazed due to the loss of residue cover that will occur and the compacting effect of the animals. The exception to this is the grazing of clover in the winter rainfall region due to practical considerations. Changing to direct seeding influences the whole farming system and not just the fields that are included. Incorporating cover crops, which can be harvested , can be used to supplement fodder, particularly if they are planted after the summer crop.

Where does one start?

It makes a lot more sense to ‘’grow into” direct seeding system rather than to try and change the whole farming system at once. As there are currently still many unanswered questions, producers are encouraged to identify a particular field, preferably one close to the house, which can be monitored daily. Problems should be discussed with other producers and agriculturists and the producers should adopt a “learn as you go ” approach. Remember there are currently no real “experts” to consult or any fixed recipes to follow. In many cases, common sense will provide the best route to follow.

What are the responsibilities?

- As stated earlier, the following conditions are extremely important before you start implementing a direct seeding system:
- All limiting soil factors must be eliminated beforehand, especially soil acidity.
- No compaction must be presented in any soil layer.
- A well worked out crop rotation system must be available to ensure crop establishment,
- Fencing must be in place to prevent animals from grazing in the no-till fields.
- The producers must have access to a crop sprayer in order to replace cultivations for weeds control (sweep, shallow tine) with a herbicide application.

Cover crops

In cases where there is not enough residues available the use of cover crops to produce enough material can be considered. This may be especially relevant for dryland conditions where long fallow periods occur and crop residue disappears quickly during the summer months. These cover crops can, if harvested, also contribute towards the fodder flow programme.

Summary

Soil tillage is one of the important production practices over which the farmer has full control. The effect of tillage cannot be predicted for a season. Therefore the farmer has to plan his actions to solve specific problems. Unnecessary cultivations cost money, time and effort, while valuable soil water is lost in the process. Such cultivations also cause recompaction, that has to be addressed later.

GUIDELINES FOR SMALL GRAIN CULTIVAR CHOICE

Cultivar choice is an important production decision and if planned correctly, could contribute greatly to reducing risk and optimising yields. The decision is complicated by all the different factors that contribute to the adaptability, yield potential, agronomic characteristics and disease risks of the current commercially available cultivars. The correct cultivar choices contribute to management of risk and achieving optimal grain yield in a given situation.

To fully utilise this cultivar diversity and to make an informed decision, it is important that the producer know the beneficial and limiting characteristics of each cultivar. For this reason, additional information regarding cultivar characteristics, long-term yield data and relative yields are made available to the producer.

There are a few important guidelines that the producer must consider when deciding on cultivar choice:

- Plant a range of cultivars to spread production risks, especially in terms of drought and disease occurrence;
- Utilise the optimum planting spectrum of the cultivars in an area;
- Do not, within one season, replace a well-known cultivar with a new and unknown cultivar. Rather plant the new cultivar alongside the stalwart for at least one season to compare them and to get to know the new cultivar;
- Cultivars that are able to adapt to specific yield potential conditions should be chosen;
- Revise cultivar choice annually to adapt to changing circumstances, as well as to consider new cultivars; and
- Take the disease/insect resistance levels as well as the quality characteristics of each recommended cultivar into consideration when finalizing your cultivar choice annualy.

Plant Breeders' Rights (Act 15 of 1976)

This act renders legal protection to breeders and owners of cultivars. The awarding of rights procedure stipulate that cultivars must be new, distinguishable, uniform and stable, and protection is granted for a 20 year period. The rights of the owner/breeder entail that no party may multiply propagating material (seed), process it for planting, sell it, import it, export it and keep it in stock without the necessary authorization or license of the holders of right. The act makes provision for the court to grant compensation of R10 000-00 to the holder of the Plant Breeders' Rights in cases of breaching of rights.

Seed certification and Table 8, as described in the Plant Improvement Act

The main aim of certification of seed is to ensure the proper maintenance of cultivars. Seed laws and regulations prescribe the minimum physical requirements, while certification of seed strives to achieve high standards of genetic purity and other quality requirements. Seed certification is a voluntary action that is managed by SANSOR on behalf of the Minister of Agriculture. However, if a cultivar is listed in Table 8, it is subject to compulsory certification. This scheme specifically guarantees cultivar purity, as well as good seed quality, renders protection and peace of mind to the buyer (producer), as well as an improved control system for acting on complaints and claims. The costs involved are a minimal price to pay for peace of mind to both buyer and seller of certified seed.

Remember that all retained seed looses the accountability of owner of the cultivar in relation to seed quality and performance of the cultivar.

Factors determining cultivar choice

Cultivar choice is an economic decision by which the producer aims to achieve the highest return with the lowest risk. Factors determining cultivar choice are thus fundamental to this decision. The most important factors are briefly discussed and for this reason a table is included that characterise the released cultivars.

Yield potential

The genetic yield potential of the available cultivars is higher than the yields currently realised under commercial conditions. These differences in yields are mainly due to environmental conditions (climatic and production conditions), crop management decisions, disease, insect and weed pressures.

Cultivars differ in their yield reaction to changing yield potential conditions. Some cultivars perform better at a lower yield potential, while others utilise higher potential conditions better. The ideal cultivar would yield the highest at all yield potential conditions. This would indicate excellent adaptability, but usually high yield is negatively related to other economically important factors, such as protein content, baking quality and hectolitre mass. It is especially important that under dryland conditions the producer should know the yield potential of his farm and fields according to soil, climate and managerial ability. Thereby a realistic target yield can be determined, that will aid cultivar choice and also other production options like fertiliser planning.

Grading and quality

According to the grading system promulgated under the Act on Agricultural Products, only one bread wheat class exists with four grades, namely B1, B2, B3 and B4, that are determined according to the protein content of the grain, the hectolitre mass and the falling number (Table 1). Hectolitre mass and especially protein content are largely determined by the environment during the grain filling period to maturity, and also by management practices including soil water and fertiliser management.

Table 1. Classes and grades of bread wheat

Grading regulation for Bread wheat - Class B			
Grade	**Minimum protein (12% moisture)**	**Minimum hectolitre mass (kg/hl)**	**Minimum falling Number (seconds)**
B1	12	77	220
B2	11	76	220
B3	10	74	220
B4	9	72	200
Utility	8	70	150
Class others	Do not comply to the above-mentioned or any other grading regulations		

All bread wheat cultivars mentioned in these guidelines qualify for all grades depending on the protein content, hectolitre mass and falling number.

Hectolitre mass

Hectolitre mass is a density parameter, and gives a direct indication of the potential flour extraction of the grain sample. Flour extraction is a critical parameter to the miller as it largely influences profitability.

Hectolitre mass is therefore part of the grading regulations that determines the grade of the grain delivered. Although this characteristic is genetically associated with a particular cultivar, it is affected by environmental conditions during the grain filling period. In particular in regions where extreme soil water and heat stresses occur during this critical period, when continuous rain events happen during harvest, and when diseases like rust and head blight infect the crop, losses can be suffered due to the downgrading of the grain, because of low hectolitre mass values. The large price differences between the B-grades and Utility grade can therefore influence cultivar choice if these conditions occur regularly in a specific region. Optimum soil water and temperature conditions during grain filling also favour the development of high hectolitre mass values.

Grain protein content

A high protein content (>11%) is necessary to ensure that the commercial bakery can produce a loaf of bread that will meet consumer requirement. Therefore, grain protein is part of the grading regulations of harvested grain. The cultivars available for commercial production have acceptable genetic grain protein composition, but grain protein content is determined by the relationship between nitrogen availability and grain yield, which is affected by management practices, in particular fertilisation.

Falling number

Falling number is an indication of the alpha-amylase enzyme activity in the grain. High alpha-amylase activity (low falling number) is an indication that the starch molecules have to a large extent been broken down to sugars (maltose especially) and that such grain is unacceptable for commercial milling and baking purposes.

Preharvest sprouting tolerance

This refers to the tolerance a cultivar has against germination in the ear during physiological maturity prior to harvesting. Genetic variation exists between cultivars for preharvest sprouting resistance. It is important to note that none of the available cultivars will sprout in the ear under normal conditions. Certain cultivars are, however, more prone to preharvest sprouting than others under continuous rain and high humidity conditions during the harvest period.

Diseases and insects

The occurrence of diseases and insects in a region and the susceptibility of cultivars to these diseases and damage by insects must be considered in cultivar planning. In this way, risk and input costs (chemical spraying costs) can be reduced (see the Diseases and Insect Control Section). Keep in mind that the intensity can change from year to year and in certain exceptional situations also the susceptability.

Seed quality

Buy high quality seed (without shriveled and broken seeds) with a germination percentage of 90% or higher. When the producer buys more expensive hybrid seed, the additional seed costs must be recovered through higher yields. Hybrid cultivars are especially suited for high yielding conditions, which these cultivars can utilise with the correct management practices. Under the generally lower yield potential dry land conditions, it will probably benefit the producer to plant seed of the cheaper pure line cultivars. Plant the chosen cultivar at the recommended seeding density and also be aware of the coleoptiles length of a cultivar when planting deeper into a dry seedbed.

Straw strength

The lodging of spring wheat cultivars often leads to yield losses. It is usually a problem when high yield potential conditions occurs, but factors such as wind and storm occurrence, high seeding densities, row widths and excessive nitrogen fertilisation also play a role. In areas and situations where lodging is widespread, cultivars prone to lodging must be managed carefully. Chemical growth regulators are available on the market that can limit lodging significantly by limiting plant height. These products can be considered for cultivars with high yield potential prone to lodging in high yielding conditions. There are also cultivars available with genetic resistance to lodging.

Aluminium tolerance

In acidic soils [pH (KCl) <4,5 and acid saturation >8%] in certain wheat producing areas, the Al^{3+}-concentration levels in the soil reach levels toxic to the root growth and development of certain wheat cultivars. Cultivars differ in their tolerance to these harmful levels of aluminium. If these acidic soils are to be planted, it would aid the producer to adapt his cultivar choice to manage this production risk (see table for aluminium tolerant cultivars). Although a corrective liming programme is the only sustainable long-term solution, tolerant cultivars can be considered as an interim measure (see Fertilisation Guidelines).

Photoperiod and vernalisation

Photoperiod and vernalisation control the growth period and are important factors determining cultivar adaptation. Cultivars must be chosen that are adapted to climatic conditions such as growing season length, planting spectrum, rainfall pattern during the growing season, soil water availability at planting, temperature during the growing season and the first and last frost dates. In this regard, the cultivars have been evaluated and this is reflected in the recommended optimum planting spectrum for each cultivar. Ideally, the choice of cultivars to be planted must cover the available planting spectrum of the specific region, so that the period from maturity to harvesting is increased to some extent. The growth period of a cultivar also gives an indication when the cultivar will be in the anthesis and grain filling growth stages.

Shatterproof

This factor refers to the measure of how well the ripe kernel is attached to the ear, as well as to what extent the chaff of the spikelet covers and protects the kernel. Certain cultivars are more susceptible to bird damage and losses due to shattering before and during harvesting. These cultivars must be carefully evaluated in regions where bird damage to the crop is a major concern, as well as areas where strong winds occur during maturity and harvest.

RECOMMENDATION AND SUMMARY OF RESULTS FOR DRYLAND PRODUCTION – 2018

The most promising cultivars of all institutions involved in the small grain industry are included annually in the National Small Grain Cultivar Evaluation Programme of the ARC-Small Grain. The results are evaluated and the guidelines for cultivar choice revised annually by a committee consisting of officials from the ARC- Small Grain, various Departments of Agriculture, Sensako, K_2, SABBI, PANNAR, SANSOR, SAB Maltings (Pty) Ltd and the Universities of the Free State and Stellenbosch. The following guidelines for cultivar choice are a summary of the results per region and only cultivars of which at least two year's data are available are included.

The guidelines act as reference within which more specific recommendations should fall. With the compilation of the guidelines, the following factors were considered:

- Grain yield
- Adaptability and yield stability
- Grain quality
- Disease resistance
- Agronomic characteristics such as lodging, threshability, preharvest sprouting, etc.

The following tables were drawn up after considering the above-mentioned factors and include the following:

- Cultivar and class division
- Optimum planting date of each cultivar.
- Optimum planting density for the optimum planting date. Planting density in kilogram per hectare is also influenced by thousand kernel mass and planting date.
- Only applicable to grain production
- Cultivars are not listed according to yield potential

The above-mentioned committee revises the guidelines annually for the next season. The characteristics of cultivars and production guidelines for dryland and irrigation conditions in the summer rainfall region for 2019 are summarised below.

It is important to note that all the field trials are executed in accordance with the production practices followed in the specific production region. The result is that all cultivars are tested in conditions which are similar to those where producers will eventually produce such cultivars.

Some of the important aspects are as follows:

- All seed used in the trials were treated with "Vitavax" against the smut diseases
- Spraying programmes for the control of diseases, weed and insects are mostly done by producers themselves. If not, the function is performed by the project team, in accordance with production practices in the specific region
- Planting dates and planting densities of all cultivars are standardised according to recommendations for the relevant region. The thousand kernel mass of each cultivar is used to calculate the seeding rate in plants/m^2 to ensure this.

Characteristics of cultivars

In selecting the correct cultivar to produce in a specific region, it is important to take into account certain characteristics other than the yield performance. These characteristics include agronomic characteristics of the cultivars recommended in the area (Table 1), data on the disease susceptibility of the cultivars (Table 2) and information on the Russian wheat aphid resistance of cultivars (Table 3).

Table 1. Agronomic characteristics of wheat cultivars recommended for cultivation under dryland conditions in the summer rainfall region

Cultivar	Yield potential	Growth length	Straw Strength	Preharvest sprouting tolerance	Aluminium tolerance $	Hectolitre mass
Elands (PBR)	Medium to high	Medium	**	T	S	***
Gariep	Low to high	Medium	**	T	S	***
Koonap (PBR)	Medium to high	Medium	***	T	T	***
Matlabas (PBR)	Medium to high	Long	***	T	MT	**
PAN 3111 (PBR)	Medium to high	Long	***	M	MT	***
PAN 3118 (PBR)	Low to high	Long	**	M	T	***
PAN 3120 (PBR)	Medium to high	Long	***	T	T	***
PAN 3161 (PBR)	Low to high	Long	***	S	T	**
PAN 3195 (PBR)	Medium to high	Long	***	S	T	**
PAN 3198 (PBR)	Medium to high	Long	***	M	T	**
PAN 3368 (PBR)	Medium to high	Medium	***	T	S	***
PAN 3379 (PBR)	Medium to high	Short	***	M	T	***
Senqu (PBR)	Medium to high	Medium	***	T	S	**
SST 3149 (PBR)	Medium to high	Long	***	T	S	***
SST 316 (PBR)	Medium to high	Medium	***	T	MT	**
SST 317 (PBR)	Medium to high	Medium to Long	***	T	S	***
SST 347 (PBR)	Medium to high	Long	***	T	S	***
SST 356 (PBR)	Medium to high	Medium	***	M	MT	**
SST 374 (PBR)	Medium	Short to Medium	**	T	S	**
SST 387 (PBR)	Medium to high	Long	***	M	S	**

** Moderate* *** Good* ****Excellent* *T- Tolerant`* *MT- Moderate Tolerance* *M- Moderate* *S - Sensitive*

PBR: Cultivars protected by Plant Breeders' Rights

$ Based on ALMT1 marker presence and seedling screening of cultivars

Table 2. Disease resistance or susceptibility of wheat cultivars recommended for cultivation under dryland conditions in the summer rainfall region.

Cultivar	Stem rust	Leaf rust	Stripe rust
Elands (PBR)	MR	S	MS
Gariep	R	S	S
Koonap (PBR)	R	S	R
Matlabas (PBR)	S	S	S
PAN 3111 (PBR)	R	S	MR
PAN 3118 (PBR)	R	S	S
PAN 3120 (PBR)	R	MS	MS
PAN 3161 (PBR)	R	MS	MR
PAN 3195 (PBR)	R	S	MR
PAN 3198 (PBR)	R	R	MR
PAN 3368 (PBR)	MR	MS	MR
PAN 3379 (PBR)	MS	MS	MS
Senqu (PBR)	R	MS	R
SST 3149 (PBR)	MR	R	R
SST 316 (PBR)	MR	S	R
SST 317 (PBR)	MR	S	R
SST 347 (PBR)	MR	MS	MS
SST 356 (PBR)	MS	S	R
SST 374 (PBR)	MS	S	MS
SST 387 (PBR)	R	S	R

S = Susceptible *MS = Moderately susceptible* *R = Resistant*

MR = Moderately resistant

PBR: Cultivars protected by Plant Breeders' Rights

Variation in rust races may affect cultivars differently. Reactions given here are based on existing data for the most virulent rust races occurring in South Africa. Distribution of races may vary between production regions.

Table 3. Russian wheat aphid resistance or susceptibility of wheat cultivars recommended for cultivation under dryland conditions in the summer rainfall region.

Cultivar	RWASA1	RWASA2	RWASA3	RWASA4	RWASA5
Elands (PBR)	R	S	S	S	S
Gariep	R	S	S	S	S
Koonap (PBR)	R	S	S	S	S
Matlabas (PBR)	R	S	S	S	S
PAN 3111 (PBR)	S	S	S	S	S
PAN 3118 (PBR)	S	S	S	S	?
PAN 3120 (PBR)	S	S	S	S	?
PAN 3161 (PBR)	R	R	R	R	S
PAN 3195 (PBR)	R	S	R	S	S
PAN 3198 (PBR)	R	S	S	S	?
PAN 3368 (PBR)	R	R	R	R	S
PAN 3379 (PBR)	R	R	R	R	?
Senqu (PBR)	R	S	S	S	S
SST 3149 (PBR)	R	S	S	S	S
SST 316 (PBR)	R	R	R	S	S
SST 317 (PBR)	R	R	R	S	S
SST 347 (PBR)	R	S	R	S	S
SST 356 (PBR)	R	S	S	S	S
SST 374 (PBR)	R	R	R	R	S
SST 387 (PBR)	R	S	S	S	S

S = Susceptible *MS = Moderately susceptible* *? = unknown*

Resistance against RWASA1 and RWASA2 was tested in glasshouse only

Resistance against RWASA3 and RWASA4 was tested in both glasshouse and field

RWASA5 was observed in the field for the first time during the 2018 season. Resistance against RWASA5 was tested in the glasshouse during 2018

PBR: Cultivars protected by Plant Breeders' Rights

The information in Table 3 must be interpreted using the map in the chapter "Insect control" indicating the distribution of Russian wheat aphid biotypes in South Africa

Planting dates and seeding rates

The recommended planting dates and seeding rates for wheat cultivars, as decided upon at the meeting of the National Cultivar Evaluation Workgroup, are given in the following figures:

Table 4. Optimum planting date and planting densities for wheat in the Eastern Free State.

Cultivar	Planting date (weeks)																Plant density (kg/ha)
	May				June				July				August				
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	
Elands (PBR)																	25-40
Gariep																	15-30
Koonap (PBR)																	15-30
Matlabas (PBR)																	15-30
PAN 3111 (PBR)																	15-30
PAN 3118 (PBR)																	15-30
PAN 3120 (PBR)																	15-30
PAN 3161 (PBR)																	20-25
PAN 3195 (PBR)																	20-25
PAN 3198 (PBR)																	15-30
PAN 3368(PBR)																	25-40
PAN 3379(PBR)																	25-40
Senqu (PBR)																	15-30
SST 3149 (PBR)																	25-40
SST 316 (PBR)																	25-40
SST 317 (PBR)																	25-40
SST 347(PBR)																	25-40
SST 356(PBR)																	25-40
SST 374(PBR)																	30-40
SST 387(PBR)																	25-40

PBR: Cultivars protected by Plant Breeders' Rights

Table 5. Optimum planting date and planting densities for wheat in the Central Free State.

Cultivar	Planting date (weeks)																Plant density (kg/ha)
	April				May				June				July				
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	
Elands (PBR)							■	■	■	■	■						25-40
Gariep							■	■	■	■	■	■	■	■			15–30
Koonap (PBR)								■	■	■	■						15-30
Matlabas (PBR)					■	■	■	■	■	■	■						15-30
PAN 3111 (PBR)					■	■	■	■	■								15-20
PAN 3118 (PBR)					■	■	■	■	■								15-20
PAN 3120 (PBR)				■	■	■	■	■									15-20
PAN 3161 (PBR)					■	■	■	■	■	■							20-25
PAN 3195 (PBR)					■	■	■	■	■								15-20
PAN 3198 (PBR)					■	■	■	■	■								15-20
PAN 3368 (PBR)								■	■	■	■	■					25-30
PAN 3379 (PBR)							■	■	■	■	■	■	■				25-40
Senqu (PBR)							■	■	■	■	■	■	■	■			15-30
SST 3149 (PBR)				■	■	■	■	■	■	■							20-30
SST 316 (PBR)							■	■	■	■	■	■	■	■			25-40
SST 317 (PBR)					■	■	■	■	■	■	■	■					20-30
SST 347 (PBR)				■	■	■	■	■	■	■	■						20-30
SST 356 (PBR)							■	■	■	■	■	■	■	■			25-40
SST 374 (PBR)									■	■	■	■	■	■	■	■	30-40
SST 387 (PBR)					■	■	■	■	■	■	■	■					20-30

PBR: Cultivars protected by Plant Breeders' Rights

Table 6. Optimum planting date and planting densities for wheat in the North Western Free State.

Cultivar	Planting date (weeks)																Plant density (kg/ha)
	April				May				June				July				
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	
Elands (PBR)																	25-40
Gariep																	20-30
Koonap (PBR)																	20-30
Matlabas (PBR)																	20-30
PAN 3111 (PBR)																	15-20
PAN 3118 (PBR)																	15-20
PAN 3120 (PBR)																	15-20
PAN 3161 (PBR)																	20-25
PAN 3195 (PBR)																	15-20
PAN 3198 (PBR)																	15-20
PAN 3368 (PBR)																	20-30
PAN 3379 (PBR)																	20-30
Senqu (PBR)																	20-30
SST 3149 (PBR)																	20-30
SST 316 (PBR)																	25-40
SST 317 (PBR)																	25-40
SST 347 (PBR)																	25-40
SST 356 (PBR)																	25-40
SST 374 (PBR)																	30-40
SST 387 (PBR)																	20-30

PBR: Cultivars protected by Plant Breeders' Rights

Table 7. Optimum planting date and planting densities for wheat in the South Western Free State.

Cultivar	Planting date (weeks)																Plant density (kg/ha)
	April				May				June				July				
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	
Elands (PBR)					■	■	■	■	■	■							20-30
Gariep					■	■	■	■	■	■	■	■					15-20
Koonap (PBR)					■	■	■	■	■	■							15-30
Matlabas (PBR)					■	■	■	■	■	■	■						15-30
PAN 3111 (PBR)				■	■	■	■										15-20
PAN 3118 (PBR)				■	■	■	■										15-20
PAN 3120 (PBR)			■	■	■	■											15-20
PAN 3161 (PBR)					■	■	■	■									20-25
PAN 3195 (PBR)				■	■	■	■										15-20
PAN 3198 (PBR)				■	■	■	■										15-20
PAN 3368 (PBR)					■	■	■	■	■	■							20-30
PAN 3379 (PBR)							■	■	■	■	■	■					20-25
Senqu (PBR)					■	■	■	■	■	■	■	■					15-30
SST 3149 (PBR)		■	■	■	■	■	■	■									20-30
SST 316 (PBR)					■	■	■	■	■	■	■						25-40
SST 317 (PBR)					■	■	■	■	■	■							20-30
SST 347 (PBR)			■	■	■	■	■	■									20-30
SST 356 (PBR)					■	■	■	■	■	■	■						25-40
SST 374 (PBR)					■	■	■	■	■	■	■	■	■				30-40
SST 387 (PBR)				■	■	■	■	■	■	■							20-30

PBR: Cultivars protected by Plant Breeders' Rights

Table 8. Optimum planting date and planting densities for wheat in Mpumalanga.

Cultivar	Planting date (weeks)												Plant density (kg/ha)
	May				June				July				
	1	2	3	4	1	2	3	4	1	2	3	4	
Elands (PBR)													25-40
Gariep													20-30
Koonap (PBR)													20-30
PAN 3111 (PBR)													20-30
PAN 3118 (PBR)													20-30
PAN 3161 (PBR)													20-30
PAN 3195 (PBR)													20-30
PAN 3198 (PBR)													20-30
PAN 3368 (PBR)													25-40
PAN 3379 (PBR)													25-40
SST 3149 (PBR)													25-40
SST 316 (PBR)													25-40
SST 317 (PBR)													25-40
SST 347 (PBR)													25-40
SST 356 (PBR)													25-40
SST 374 (PBR)													30-40
SST 387 (PBR)													25-40

PBR: Cultivars protected by Plant Breeders' Rights

Summary of results obtained during 2018

The results obtained in the cultivar evaluation programme in the summer rainfall area over the last seasons (2015 to 2018) are summarised in the following tables.

The value of this information is that cultivar performance can be evaluated for a specific season, as well as over the medium term. The variation in climatic conditions between seasons, and the unpredictability thereof, necessitates cultivar choices that will decrease the risk as far as possible.

If this information is interpreted with other cultivar characteristics, discussed earlier, more informed decisions can be made on the group of cultivars that will perform the best.

Eastern Free State (earlier planting)
Average yield (ton/ha) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Elands	1.90	14	2.18	17	2.86	16	1.94	19	2.22	14	2.31	14	2.04	14
Gariep	1.84	17	2.25	15	2.99	15	2.23	13	2.33	11	2.36	12	2.04	13
Koonap	1.98	9	2.09	19	2.53	21	2.05	16	2.16	15	2.20	17	2.03	15
Kougas	1.86	16	2.19	16	2.82	18					2.29	15	2.03	18
Kubetu	2.17	4	2.88	2									2.52	3
Matlabas	2.39	2	2.45	7	3.67	2	2.29	7	2.70	3	2.84	3	2.42	5
PAN 3111	2.24	3	2.97	1	3.76	1	2.29	8	2.81	1	2.99	1	2.61	1
PAN 3118					3.35	12	2.44	1						
PAN 3120					3.55	7	2.32	6						
PAN 3161	2.57	1	2.63	5	3.43	10	2.33	5	2.74	2	2.88	2	2.60	2
PAN 3195	2.07	6	2.65	4	3.59	5	2.39	4	2.68	4	2.77	4	2.36	6
PAN 3198			2.55	6	3.23	13	2.40	3						
PAN 3368	1.92	12	2.14	18	2.78	19	2.08	14	2.23	13	2.28	16	2.03	17
PAN 3379					2.85	17	2.05	15						
Senqu	2.03	7	2.28	12	2.66	20	2.01	18	2.24	12	2.32	13	2.15	9
SST 3149	1.79	19	2.28	12	3.44	9	2.28	9	2.45	10	2.50	11	2.03	16
SST 316	1.95	10	2.26	14	3.56	6	2.25	11	2.51	7	2.59	9	2.11	12
SST 317	1.87	15	2.40	9	3.53	8	2.03	17	2.46	9	2.60	8	2.14	10
SST 347	1.95	11	2.40	9	3.38	11	2.27	10	2.50	8	2.58	10	2.17	8
SST 356	1.83	18	2.39	11	3.65	4	2.24	12	2.53	6	2.62	7	2.11	11
SST 387	2.01	8	2.40	8	3.67	3	2.42	2	2.62	5	2.69	6	2.20	7
SST 398	1.91	13												
Wedzi	2.15	5	2.74	3	3.20	14					2.69	5	2.44	4
Mean	**2.02**		**2.43**		**3.26**		**2.23**		**2.48**		**2.56**		**2.22**	
LSD_t(0,05)	**0.10**		**0.11**		**0.21**		**0.16**		**0.07**		**0.08**		**0.08**	

Eastern Free State (earlier planting)
Average hectolitre mass (kg/hl) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Elands	77.46	8	75.40	12	80.24	14	79.77	5	78.22	6	77.70	9	76.43	10
Gariep	77.15	10	75.75	11	81.60	2	79.16	9	78.42	4	78.17	6	76.45	9
Koonap	78.87	4	76.56	6	80.81	6	79.44	7	78.92	3	78.75	3	77.72	4
Kougas	78.69	5	76.58	5	80.66	8					78.64	4	77.64	5
Kubetu	79.06	3	77.81	2									78.44	3
Matlabas	77.81	7	76.01	9	80.07	17	77.40	17	77.82	8	77.96	8	76.91	7
PAN 3111	77.42	9	76.37	7	80.61	10	78.88	12	78.32	5	78.13	7	76.90	8
PAN 3118					81.43	4	79.62	6						
PAN 3120					81.44	3	81.46	2						
PAN 3161	76.90	12	75.85	10	79.67	19	79.21	8	77.91	7	77.47	10	76.38	11
PAN 3195	76.73	14	74.64	15	80.41	12	78.17	14	77.49	11	77.26	11	75.69	14
PAN 3198			76.14	8	79.40	20	79.81	4						
PAN 3368	76.83	13	74.83	14	79.40	20	78.97	10	77.51	10	77.02	13	75.83	13
PAN 3379					81.18	5	81.59	1						
Senqu	76.72	15	74.95	13	80.11	16	78.96	11	77.69	9	77.26	11	75.84	12
SST 3149	79.15	2	78.02	1	80.58	11	78.36	13	79.03	2	79.25	2	78.59	1
SST 316	74.59	17	73.76	18	80.12	15	77.16	18	76.41	14	76.16	16	74.18	16
SST 317	75.48	16	74.19	17	80.40	13	77.48	16	76.89	12	76.69	14	74.84	15
SST 347	79.43	1	77.46	3	82.87	1	80.58	3	80.09	1	79.92	1	78.45	2
SST 356	74.08	18	73.21	19	79.78	18	76.44	19	75.88	15	75.69	17	73.65	18
SST 387	73.89	19	74.38	16	80.77	7	77.58	15	76.66	13	76.35	15	74.14	17
SST 398	77.01	11												
Wedzi	78.14	6	76.71	4	80.63	9					78.49	5	77.43	6
Mean	**77.13**		**75.72**		**80.58**		**78.95**		**77.81**		**77.70**		**76.41**	
LSD_t(0,05)	**0.66**		**0.92**		**0.41**		**0.75**		**0.37**		**0.41**		**0.58**	

Eastern Free State (earlier planting)
Average protein content (%) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Elands	14.79	12	14.22	11	14.89	12	14.91	10	14.70	7	14.63	9	14.51	11
Gariep	15.29	2	14.09	16	15.08	11	14.74	16	14.80	5	14.82	6	14.69	6
Koonap	15.15	4	14.79	4	15.56	2	15.80	1	15.33	1	15.17	1	14.97	2
Kougas	15.27	3	14.52	6	15.32	7					15.04	5	14.90	4
Kubetu	14.65	17	13.86	17									14.26	18
Matlabas	15.09	5	15.64	1	14.55	13	15.59	2	15.22	2	15.09	4	15.37	1
PAN 3111	15.33	1	13.38	19	13.94	17	14.43	18	14.27	14	14.22	15	14.36	16
PAN 3118					15.16	9	15.21	6						
PAN 3120					15.44	3	15.34	4						
PAN 3161	14.84	9	14.35	9	13.99	16	14.78	14	14.49	10	14.39	12	14.60	8
PAN 3195	14.72	15	14.15	12	13.54	20	14.53	17	14.24	15	14.14	16	14.44	13
PAN 3198			14.28	10	15.34	6	15.40	3						
PAN 3368	14.71	16	14.66	5	15.98	1	15.16	7	15.13	3	15.12	2	14.69	7
PAN 3379					15.12	10	14.94	9						
Senqu	14.35	19	14.39	8	15.42	4	14.87	12	14.76	6	14.72	7	14.37	15
SST 3149	15.02	7	14.92	3	15.35	5	14.84	13	15.03	4	15.10	3	14.97	2
SST 316	15.03	6	13.79	18	13.27	21	15.04	8	14.28	13	14.03	17	14.41	14
SST 317	14.77	13	14.41	7	14.15	15	15.29	5	14.66	8	14.44	11	14.59	9
SST 347	14.81	11	14.94	2	14.17	14	14.25	19	14.54	9	14.64	8	14.88	5
SST 356	15.02	7	14.14	14	13.55	19	14.77	15	14.37	12	14.24	13	14.58	10
SST 387	14.84	9	14.15	12	13.70	18	14.88	11	14.39	11	14.23	14	14.50	12
SST 398	14.77	13												
Wedzi	14.56	18	14.11	15	15.18	8					14.62	10	14.34	17
Mean	**14.90**		**14.36**		**14.70**		**14.99**		**14.68**		**14.63**		**14.63**	
LSD_t(0,05)	**0.66**		**0.74**		**0.42**		**0.62**		**0.33**		**0.38**		**0.49**	

Eastern Free State (earlier planting)
Average falling number (s) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Elands	338	7	282	6	265	10	344	8	307	5	295	17	310	5
Gariep	326	13	227	14	239	20	339	11	283	12	264	13	277	13
Koonap	321	14	299	1	329	1	342	10	323	2	316	1	310	6
Kougas	339	6	259	9	248	17					282	9	299	8
Kubetu	317	15	224	15									271	14
Matlabas	329	11	265	8	280	5	333	14	302	7	291	6	297	9
PAN 3111	333	8	158	18	260	15	360	2	278	13	250	15	245	17
PAN 3118					240	19	342	9						
PAN 3120					264	12	336	12						
PAN 3161	345	4	256	12	241	18	364	1	302	6	281	10	301	7
PAN 3195	331	10	196	16	292	3	331	15	287	11	273	12	263	15
PAN 3198			252	13	198	21	355	6						
PAN 3368	309	18	271	7	269	9	318	17	292	8	283	8	290	11
PAN 3379					278	6	355	5						
Senqu	347	3	297	3	273	8	348	7	316	4	306	5	322	3
SST 3149	328	12	259	10	265	11	301	19	288	10	284	7	294	10
SST 316	359	1	295	4	294	2	358	3	327	1	316	2	327	1
SST 317	316	16	256	11	264	13	328	16	291	9	279	11	286	12
SST 347	310	17	189	17	261	14	315	18	269	14	253	14	250	16
SST 356	344	5	297	2	278	7	357	4	319	3	307	4	321	4
SST 387	304	19	128	19	254	16	336	13	255	15	229	16	216	18
SST 398	333	9												
Wedzi	351	2	295	5	292	4					312	3	323	2
Mean	**330**		**248**		**266**		**340**		**296**		**267**		**289**	
LSD_t(0,05)	**24.30**		**22.67**		**19.44**		**15.92**		**11.10**		**13.24**		**16.69**	

Eastern Free State (later planting)
Average yield (ton/ha) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Elands	2.20	5	2.76	9	4.39	5	2.55	5	2.97	4	3.12	5	2.48	8
Gariep	2.27	2	2.61	12	4.25	9	2.34	13	2.86	7	3.04	7	2.44	12
Koonap	2.47	1	2.51	14	3.94	16	2.38	11	2.82	10	2.97	12	2.49	5
Kougas	1.87	16	2.19	17	3.94	17					2.66	17	2.03	17
Kubetu	2.19	6	2.60	13									2.39	14
PAN 3111	2.18	7	2.79	7	4.12	11	2.24	15	2.83	9	3.03	8	2.49	6
PAN 3118					3.93	18								
PAN 3161	2.05	12	2.94	2	3.99	14	2.59	4	2.89	6	2.99	11	2.49	3
PAN 3195	1.96	14	2.90	5	4.37	6	2.49	8	2.93	5	3.08	6	2.43	13
PAN 3198			2.94	3	4.13	10	2.52	7	3.20	1	3.53	1	2.94	1
PAN 3368	2.21	4	2.74	10	3.73	19	2.44	10	2.78	13	2.90	13	2.48	9
PAN 3379					3.98	15	2.63	2						
Senqu	2.08	10	2.91	4	4.10	12	2.35	12	2.86	8	3.03	9	2.49	3
SST 3149					2.81	20								
SST 316	2.07	11	2.95	1	4.48	4	2.60	3	3.02	3	3.16	4	2.51	2
SST 317	1.81	17	2.14	18	4.49	3	2.47	9	2.73	15	2.81	16	1.97	18
SST 347	1.93	15	2.48	15	4.27	7	2.26	14	2.74	14	2.89	14	2.21	15
SST 356	2.12	9	2.84	6	4.07	13	2.20	16	2.81	12	3.01	10	2.48	10
SST 374	2.27	3	2.62	11	4.81	1	2.52	6	3.06	2	3.23	2	2.44	11
SST 387	2.03	13	2.28	16	4.26	8	2.67	1	2.81	11	2.86	15	2.16	16
SST 398	1.79	18												
Wedzi	2.18	7	2.79	8	4.67	2					3.21	3	2.49	7
Mean	**2.09**		**2.67**		**4.14**		**2.45**		**2.89**		**3.03**		**2.41**	
LSD_t(0,05)	**0.12**		**0.12**		**0.24**		**0.15**		**0.08**		**0.09**		**0.08**	

Eastern Free State (later planting)
Average hectolitre mass (kg/hl) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Elands	77.44	8	79.53	8	79.63	3	80.38	2	79.25	3	78.87	6	78.49	8
Gariep	78.22	6	80.81	3	80.52	1	78.70	9	79.56	1	79.85	1	79.52	4
Koonap	78.19	7	79.76	6	80.01	2	79.85	3	79.45	2	79.32	2	78.98	7
Kougas	78.47	5	79.66	7	78.63	8					78.92	5	79.07	6
Kubetu	79.13	2	81.59	1									80.36	1
PAN 3111	78.74	3	81.09	2	76.08	19	77.60	11	78.38	6	78.64	7	79.92	3
PAN 3118					77.99	11								
PAN 3161	76.34	14	78.19	15	76.49	18	79.28	5	77.58	12	77.01	17	77.27	15
PAN 3195	77.07	9	78.84	10	77.45	16	77.67	10	77.76	9	77.79	11	77.96	11
PAN 3198			78.26	14	77.36	17	79.44	4	78.35	7	77.81	10	78.26	9
PAN 3368	76.84	12	77.78	18	77.80	13	78.97	7	77.85	8	77.47	14	77.31	14
PAN 3379					79.63	3	80.76	1						
Senqu	77.06	10	79.28	9	79.20	6	78.91	8	78.61	4	78.51	8	78.17	10
SST 3149					73.21	20								
SST 316	75.59	16	77.81	17	77.89	12	79.15	6	77.61	10	77.10	16	76.70	17
SST 317	75.91	15	78.50	12	78.20	9	77.29	12	77.48	13	77.54	13	77.21	16
SST 347	79.19	1	80.80	4	77.67	14	76.57	16	78.56	5	79.22	4	80.00	2
SST 356	74.64	18	77.99	16	79.07	7	77.18	13	77.22	15	77.23	15	76.32	18
SST 374	76.97	11	78.41	13	78.18	10	76.87	14	77.61	11	77.85	9	77.69	12
SST 387	76.39	13	78.75	11	77.48	15	76.60	15	77.31	14	77.54	12	77.57	13
SST 398	75.56	17												
Wedzi	78.55	4	80.02	5	79.26	5					79.28	3	79.29	5
Mean	**77.24**		**79.28**		**78.09**		**78.45**		**78.17**		**78.23**		**78.34**	
LSD_t(0,05)	**0.58**		**0.61**		**0.58**		**0.64**		**0.32**		**0.35**		**0.42**	

Eastern Free State (later planting)
Average protein content (%) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Elands	14.92	13	15.18	7	14.81	11	13.35	16	14.57	13	14.97	9	15.05	7
Gariep	14.28	18	15.56	1	14.72	12	15.06	11	14.91	9	14.85	10	14.92	12
Koonap	15.12	10	15.36	5	15.11	6	15.99	1	15.40	2	15.20	4	15.24	5
Kougas	15.56	1	15.22	6	15.18	5					15.32	3	15.39	4
Kubetu	14.45	17	14.65	14									14.55	18
PAN 3111	15.23	9	14.78	10	15.00	7	15.23	5	15.06	6	15.00	7	15.01	8
PAN 3118					15.86	2								
PAN 3161	15.05	12	14.93	9	15.00	7	15.21	6	15.05	7	14.99	8	14.99	9
PAN 3195	14.89	14	14.71	12	14.48	14	15.14	8	14.81	11	14.69	13	14.80	13
PAN 3198			15.41	3	15.42	4	15.28	4	15.37	3	15.42	2	15.41	3
PAN 3368	15.46	2	15.52	2	15.89	1	15.03	13	15.48	1	15.62	1	15.49	1
PAN 3379					14.53	13	14.86	14						
Senqu	15.27	7	14.96	8	15.00	7	15.06	11	15.07	5	15.08	5	15.12	6
SST 3149					15.76	3								
SST 316	15.08	11	14.40	17	13.98	18	13.96	15	14.36	15	14.49	15	14.74	16
SST 317	15.25	8	14.69	13	13.14	20	15.40	3	14.62	12	14.36	16	14.97	10
SST 347	14.80	15	14.77	11	14.48	14	15.79	2	14.96	8	14.68	14	14.79	14
SST 356	15.36	4	14.21	18	14.82	10	15.09	10	14.87	10	14.80	11	14.79	14
SST 374	14.75	16	14.42	16	13.20	19	15.11	9	14.37	14	14.12	17	14.59	17
SST 387	15.43	3	15.41	3	14.39	16	15.20	7	15.11	4	15.08	5	15.42	2
SST 398	15.35	5												
Wedzi	15.30	6	14.61	15	14.37	17					14.76	12	14.96	11
Mean	**15.09**		**14.93**		**14.76**		**15.05**		**14.93**		**14.91**		**15.01**	
LSD_t(0,05)	**0.78**		**0.65**		**0.66**		**1.00**		**0.40**		**0.42**		**0.53**	

Eastern Free State (later planting)
Average falling number (s) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Elands	340	3	270	10	276	9	341	10	306	5	295	6	305	7
Gariep	313	18	250	18	251	16	347	6	290	12	271	15	282	17
Koonap	327	10	283	2	304	2	333	11	312	3	305	2	305	6
Kougas	343	2	265	11	269	10					292	7	304	9
Kubetu	325	11	275	6									300	11
PAN 3111	336	6	275	6	218	19	329	13	290	14	276	14	306	3
PAN 3118					264	12								
PAN 3161	339	5	253	16	255	14	345	8	298	9	282	11	296	12
PAN 3195	319	14	301	1	223	18	324	14	292	11	281	12	310	2
PAN 3198			260	13	256	13	353	2	290	13	258	17	260	18
PAN 3368	316	17	264	12	281	8	321	16	295	10	287	10	290	13
PAN 3379					302	3	345	7						
Senqu	336	6	275	8	289	7	348	3	312	2	300	5	305	4
SST 3149					230	17								
SST 316	345	1	276	3	290	6	332	12	311	4	304	3	310	1
SST 317	329	9	275	4	312	1	348	4	316	1	305	1	302	10
SST 347	317	16	258	14	267	11	355	1	299	8	281	13	288	14
SST 356	339	4	270	9	254	15	347	5	303	7	288	9	305	8
SST 374	322	12	253	15	298	4	342	9	304	6	291	8	287	15
SST 387	322	12	251	17	214	20	324	14	277	15	262	16	286	16
SST 398	318	15												
Wedzi	335	8	275	4	296	5					302	4	305	5
Mean	**329**		**268**		**267**		**340**		**300**		**287**		**297**	
LSD_t(0,05)	**15.57**		**18.89**		**20.90**		**21.40**		**9.80**		**10.80**		**12.23**	

North Western Free State (earlier planting)
Average yield (ton/ha) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Elands	2.26	18	1.18	14	2.49	10	2.36	17	2.07	12	1.98	14	1.72	17
Gariep	3.14	9	1.07	17	2.50	9	2.73	14	2.36	8	2.24	9	2.11	11
Koonap	2.56	13	1.05	18	2.01	19	2.18	19	1.95	14	1.87	16	1.80	15
Kougas	3.01	10	1.29	12	2.22	16					2.17	10	2.15	10
Kubetu	3.42	6	2.05	1									2.73	4
Matlabas	3.42	5	1.76	4	3.37	2	3.50	5	3.01	2	2.85	2	2.59	5
PAN 3111	3.67	3	1.89	3	2.78	7	3.65	2	3.00	3	2.78	3	2.78	1
PAN 3118					3.70	1	3.58	3						
PAN 3120					3.11	4	3.49	6						
PAN 3161	3.84	1	1.64	6	2.29	15	3.40	8	2.79	4	2.59	5	2.74	3
PAN 3195	3.67	2	1.37	10	2.04	17	3.54	4	2.65	6	2.36	8	2.52	6
PAN 3198			1.09	16	2.32	14	3.43	7						
PAN 3368	2.27	17	0.88	19	1.97	20	2.33	18	1.87	15	1.71	17	1.58	18
PAN 3379					1.73	21	3.34	9						
Senqu	2.32	16	1.15	15	2.37	13	2.42	16	2.06	13	1.95	15	1.73	16
SST 3149	2.79	12	1.34	11	2.37	12	2.52	15	2.26	10	2.17	11	2.07	12
SST 316	2.49	15	1.43	7	2.03	18	2.96	11	2.23	11	1.98	13	1.96	13
SST 317	2.97	11	1.40	8	2.81	6	2.78	13	2.49	7	2.39	7	2.19	9
SST 347	3.21	8	1.65	5	3.19	3	3.00	10	2.76	5	2.68	4	2.43	7
SST 356	2.51	14	1.22	13	2.48	11	2.86	12	2.27	9	2.07	12	1.87	14
SST 387	3.57	4	1.99	2	3.07	5	3.78	1	3.10	1	2.87	1	2.78	2
SST 398	2.26	19												
Wedzi	3.29	7	1.37	9	2.65	8					2.43	6	2.33	8
Mean	**2.98**		**1.41**		**2.55**		**3.04**		**2.46**		**2.30**		**2.23**	
LSD_t(0,05)	**0.16**		**0.11**		**0.22**		**0.18**		**0.09**		**0.10**		**0.09**	

North Western Free State (earlier planting)
Average hectolitre mass (kg/hl) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Elands	76.85	11	76.83	10	75.93	11	77.91	5	76.88	5	76.54	7	76.84	9
Gariep	77.33	5	78.18	3	76.23	10	76.42	16	77.04	4	77.25	5	77.75	6
Koonap	78.39	3	77.32	8	76.86	4	77.50	9	77.52	2	77.52	4	77.85	5
Kougas	79.76	1	77.72	4	75.64	13					77.71	2	78.74	1
Kubetu	76.94	9	79.22	1									78.08	2
Matlabas	77.10	7	76.03	14	75.86	12	77.32	10	76.58	6	76.33	8	76.57	11
PAN 3111	77.20	6	78.57	2	77.42	3	78.63	3	77.96	1	77.73	1	77.89	4
PAN 3118					77.90	2	77.63	7						
PAN 3120					78.87	1	79.22	1						
PAN 3161	77.69	4	75.53	17	75.34	14	77.70	6	76.56	7	76.19	10	76.61	10
PAN 3195	74.91	17	76.45	11	74.94	16	76.63	13	75.73	12	75.43	14	75.68	15
PAN 3198			76.08	13	76.49	8	77.07	11						
PAN 3368	75.96	14	75.26	19	73.76	19	77.55	8	75.63	13	74.99	15	75.61	17
PAN 3379					76.65	6	78.78	2						
Senqu	76.85	11	76.11	12	74.03	18	76.43	14	75.86	10	75.66	12	76.48	12
SST 3149	76.95	8	76.94	9	75.07	15	75.45	19	76.10	8	76.32	9	76.95	8
SST 316	75.90	15	75.92	15	71.80	21	75.77	17	74.85	14	74.54	16	75.91	13
SST 317	76.10	13	75.50	18	74.86	17	76.93	12	75.85	11	75.49	13	75.80	14
SST 347	76.86	10	77.38	6	76.67	5	78.38	4	77.32	3	76.97	6	77.12	7
SST 356	75.15	16	75.68	16	72.61	20	75.57	18	74.75	15	74.48	17	75.42	18
SST 387	73.98	19	77.33	7	76.32	9	76.43	14	76.01	9	75.88	11	75.65	16
SST 398	74.50	18												
Wedzi	78.56	2	77.47	5	76.56	7					77.53	3	78.02	3
Mean	**76.68**		**76.82**		**75.71**		**77.23**		**76.31**		**76.27**		**76.83**	
LSD_t(0,05)	**0.93**		**0.61**		**1.48**		**0.52**		**0.51**		**0.66**		**0.52**	

North Western Free State (earlier planting)
Average protein content (%) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Elands	13.62	4	15.31	4	15.53	14	14.67	3	14.78	4	14.82	5	14.47	4
Gariep	12.81	11	14.55	12	14.72	21	13.94	15	14.00	13	14.03	15	13.68	11
Koonap	13.59	5	15.36	3	16.44	1	14.94	1	15.08	2	15.13	2	14.47	3
Kougas	12.06	18	14.94	7	15.44	15					14.15	13	13.50	14
Kubetu	12.77	12	13.65	18									13.21	16
Matlabas	12.82	10	14.79	10	16.08	3	14.37	9	14.52	7	14.56	7	13.81	8
PAN 3111	12.33	16	13.64	19	15.36	17	13.24	18	13.64	15	13.78	17	12.99	17
PAN 3118					15.91	8	14.18	12						
PAN 3120					16.10	2	14.53	5						
PAN 3161	12.25	17	15.49	2	15.78	9	14.30	11	14.45	8	14.51	8	13.87	7
PAN 3195	12.62	14	14.83	9	15.55	13	13.61	17	14.15	10	14.33	9	13.73	10
PAN 3198			15.78	1	16.03	5	14.54	4						
PAN 3368	13.83	3	15.20	6	15.66	12	14.87	2	14.89	3	14.90	3	14.52	2
PAN 3379					14.83	20	12.88	19						
Senqu	13.22	6	14.78	11	15.97	7	14.52	6	14.62	6	14.66	6	14.00	6
SST 3149	13.02	9	14.10	15	15.44	15	13.65	16	14.05	12	14.19	12	13.56	12
SST 316	13.97	2	14.50	13	16.03	5	14.38	8	14.72	5	14.83	4	14.24	5
SST 317	12.39	15	14.45	14	15.72	10	14.35	10	14.23	9	14.19	11	13.42	15
SST 347	13.03	8	14.07	16	15.17	18	14.08	13	14.09	11	14.09	14	13.55	13
SST 356	14.95	1	15.26	5	16.05	4	14.46	7	15.18	1	15.42	1	15.11	1
SST 387	11.88	19	13.92	17	15.69	11	14.01	14	13.88	14	13.83	16	12.90	18
SST 398	13.05	7												
Wedzi	12.71	13	14.84	8	15.16	19					14.24	10	13.77	9
Mean	**13.00**		**14.71**		**15.65**		**14.19**		**14.42**		**14.45**		**13.82**	
$LSD_t(0,05)$	**1.16**		**0.73**		**0.49**		**0.55**		**0.37**		**0.46**		**0.66**	

North Western Free State (earlier planting)
Average falling number (s) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Elands	361	14	349	1	337	2	396	3	361	1	349	2	355	5
Gariep	354	18	310	16	284	19	356	19	326	15	316	16	332	17
Koonap	365	9	334	6	304	12	379	9	345	9	334	11	349	8
Kougas	368	8	344	5	331	4					348	5	356	3
Kubetu	365	9	329	12									347	9
Matlabas	370	6	345	4	340	1	364	17	355	3	352	1	357	2
PAN 3111	372	5	293	19	290	15	398	2	338	12	318	15	332	16
PAN 3118					301	13	376	12						
PAN 3120					270		375	13						
PAN 3161	378	2	349	2	318	7	394	4	359	2	348	4	363	1
PAN 3195	364	11	307	17	273	20	380	8	331	14	314	17	335	15
PAN 3198			328	13	289	16	377	10						
PAN 3368	359	17	304	18	309	10	374	14	336	13	324	14	331	18
PAN 3379					287	18	398	1						
Senqu	378	1	332	8	296	14	386	6	348	5	335	9	355	6
SST 3149	369	7	333	7	322	6	369	15	348	4	341	6	351	7
SST 316	374	3	317	15	306	11	389	5	346	6	332	12	345	12
SST 317	359	16	330	11	327	5	366	16	346	8	339	7	344	14
SST 347	363	13	330	10	315	9	359	18	342	10	336	8	346	10
SST 356	360	15	331	9	287	17	381	7	340	11	326	13	345	11
SST 387	373	4	317	14	315	8	377	11	346	7	335	10	345	13
SST 398	326	19												
Wedzi	364	12	348	3	333	3					348	3	356	4
Mean	**364**		**328**		**306**		**379**		**344**		**335**		**347**	
$LSD_t(0,05)$	**22.02**		**17.02**		**7.20**		**19.22**		**9.66**		**10.97**		**13.73**	

North Western Free State (later planting)
Average yield (ton/ha) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Elands	2.82	12	1.27	19	2.42	8	2.56	12	2.27	8	2.17	10	2.05	16
Gariep	2.93	8	1.42	14	2.47	5	2.60	11	2.35	5	2.27	7	2.17	9
Koonap	2.93	7	1.28	18	2.08	16	2.46	13	2.19	11	2.10	14	2.10	13
Kougas	2.92	9	1.48	11	2.09	15					2.16	11	2.20	8
Kubetu	2.88	10	1.84	4									2.36	4
Matlabas			1.98	2	2.94	1	2.64	10						
PAN 3111	4.03	1	2.15	1	2.36	10	3.46	1	3.00	1	2.85	1	2.66	1
PAN 3118					2.94	1	2.67	7						
PAN 3161	3.64	2	1.94	3	2.30	11	2.78	5	2.67	3	2.63	2	2.34	6
PAN 3195	3.48	3	1.56	8	2.44	6	3.08	2	2.64	4	2.49	4	2.52	2
PAN 3198			1.55	9	2.09	14	2.71	6						
PAN 3368	2.57	18	1.32	17	1.84	20	2.22	15	1.99	14	1.91	16	1.94	17
PAN 3379					1.96	18	2.82	4						
Senqu	2.79	14	1.38	15	2.49	4	2.07	18	2.18	12	2.22	8	2.09	14
SST 3149					1.71	21								
SST 316	2.71	16	1.59	7	2.02	17	2.17	17	2.12	13	2.11	13	2.15	10
SST 317	3.06	6	1.63	6	2.16	13	2.28	14	2.28	6	2.28	6	2.34	5
SST 347	2.80	13	1.36	16	2.42	7	2.20	16	2.20	10	2.20	9	2.08	15
SST 356	2.75	15	1.49	10	1.92	19	2.65	8	2.20	9	2.05	15	2.12	12
SST 374	2.83	11	1.45	13	2.19	12	2.65	8	2.28	7	2.16	12	2.14	11
SST 387	3.25	4	1.78	5	2.68	3	3.02	3	2.68	2	2.57	3	2.51	3
SST 398	2.64	17												
Wedzi	3.22	5	1.45	12	2.39	9					2.35	5	2.34	7
Mean	**3.01**		**1.58**		**2.28**		**2.61**		**2.36**		**2.28**		**2.24**	
LSD_t(0,05)	**0.19**		**0.15**		**0.17**		**0.17**		**0.08**		**0.10**		**0.12**	

North Western Free State (later planting)
Average hectolitre mass (kg/hl) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Elands	77.68	4	76.33	11	76.05	10	79.25	3	77.33	4	76.69	6	77.01	7
Gariep	76.62	11	77.09	8	75.61	12	78.45	8	76.94	6	76.44	8	76.86	9
Koonap	79.65	1	77.35	4	75.71	11	79.34	2	78.01	1	77.57	1	78.50	1
Kougas	78.19	2	77.22	7	77.18	3					77.53	2	77.71	3
Kubetu	77.01	8	78.33	1									77.67	4
Matlabas			76.96	9	75.16	14	76.38	18						
PAN 3111	77.64	5	77.47	3	76.80	5	79.40	1	77.83	2	77.30	5	77.89	2
PAN 3118					76.97	4	78.85	5						
PAN 3161	77.05	7	76.41	10	76.19	6	78.30	10	76.99	5	76.55	7	76.97	8
PAN 3195	75.50	15	76.33	11	75.12	15	78.53	7	76.37	9	75.65	11	75.92	13
PAN 3198			77.33	5	76.08	8	77.85	12						
PAN 3368	76.80	10	76.30	14	74.97	16	77.93	11	76.50	8	76.02	10	76.55	11
PAN 3379					76.08	8	78.90	4						
Senqu	77.28	6	76.31	13	75.22	13	78.75	6	76.89	7	76.27	9	76.80	10
SST 3149					66.67	21								
SST 316	76.06	12	75.95	16	72.88	19	77.10	15	75.50	12	74.96	14	76.01	12
SST 317	75.74	13	75.73	17	73.84	17	76.70	17	75.50	11	75.10	13	75.74	14
SST 347	77.01	8	77.62	2	77.67	1	77.13	14	77.36	3	77.43	4	77.32	6
SST 356	75.54	14	75.43	18	72.73	20	76.95	16	75.16	14	74.57	15	75.49	15
SST 374	74.45	16	75.06	19	73.80	18	77.43	13	75.18	13	74.44	16	74.76	16
SST 387	72.95	18	76.22	15	76.19	6	78.45	8	75.95	10	75.12	12	74.59	17
SST 398	74.21	17												
Wedzi	77.70	3	77.27	6	77.48	2					77.48	3	77.49	5
Mean	**76.50**		**76.67**		**75.16**		**78.09**		**76.54**		**76.20**		**76.66**	
LSD_t(0,05)	**1.25**		**0.65**		**2.42**		**0.57**		**0.44**		**0.52**		**0.63**	

North Western Free State (later planting)
Average protein content (%) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Elands	12.10	16	14.79	6	15.51	16	14.51	11	14.23	8	14.13	10	13.45	12
Gariep	12.46	12	14.52	9	14.90	19	14.13	14	14.00	10	13.96	13	13.49	10
Koonap	13.02	6	15.18	1	16.30	3	14.72	5	14.81	2	14.83	1	14.10	4
Kougas	13.25	2	14.90	4	16.20	5					14.78	3	14.08	5
Kubetu	13.17	4	13.79	19									13.48	11
Matlabas			14.19	14	16.21	4	14.69	7						
PAN 3111	11.68	18	13.81	18	15.54	14	14.04	15	13.77	14	13.68	16	14.46	2
PAN 3118					16.08	8	14.78	3						
PAN 3161	12.75	8	14.35	13	16.16	6	14.64	9	14.48	6	14.42	7	15.05	1
PAN 3195	11.99	17	14.42	12	15.70	11	13.56	17	13.92	13	14.04	11	13.21	16
PAN 3198			14.76	7	16.40	2	14.75	4						
PAN 3368	12.56	9	14.82	5	16.00	9	14.66	8	14.51	5	14.46	6	13.69	8
PAN 3379					14.58	21	13.34	18						
Senqu	12.55	10	14.60	8	15.53	15	14.70	6	14.35	7	14.23	8	13.58	9
SST 3149					15.70	11								
SST 316	13.30	1	14.96	3	15.97	10	14.80	2	14.76	3	14.74	4	14.13	3
SST 317	13.21	3	14.19	14	16.10	7	14.57	10	14.52	4	14.50	5	13.70	7
SST 347	12.23	15	14.00	17	15.47	17	14.16	12	13.96	11	13.90	14	13.12	17
SST 356	12.99	7	15.00	2	16.46	1	14.84	1	14.82	1	14.82	2	14.00	6
SST 374	12.30	13	14.45	10	14.86	20	14.14	13	13.94	12	13.87	15	13.38	13
SST 387	12.54	11	14.17	16	15.70	11	14.03	16	14.11	9	14.14	9	13.36	14
SST 398	13.04	5												
Wedzi	12.24	14	14.43	11	15.23	18					13.97	12	13.34	15
Mean	**12.63**		**14.49**		**15.74**		**14.39**		**14.30**		**14.28**		**13.74**	
LSD_t(0,05)	**1.25**		**0.59**		**0.53**		**0.95**		**0.41**		**0.44**		**0.61**	

North Western Free State (later planting)
Average falling number (s) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Elands	363	14	320	9	342	5	311	10	334	5	341	7	341	7
Gariep	366	10	308	16	313	14	312	9	325	10	329	13	337	13
Koonap	365	12	318	11	353	1	316	4	338	3	345	3	341	6
Kougas	370	4	329	2	340	7					346	2	349	1
Kubetu	371	3	323	7									347	3
Matlabas			324	6	331	12	304	15						
PAN 3111	368	6	292	19	283	21	313	5	314	14	314	16	296	17
PAN 3118					291	20	317	3						
PAN 3161	375	1	335	1	347	3	313	6	343	1	352	1	332	15
PAN 3195	374	2	301	18	310	16	307	14	323	11	328	14	338	12
PAN 3198			326	3	335	10	324	1						
PAN 3368	352	18	306	17	315	13	294	18	317	13	324	15	329	16
PAN 3379					305	19	312	8						
Senqu	363	13	320	10	351	2	320	2	338	2	345	4	341	7
SST 3149					310	16								
SST 316	367	7	315	12	336	8	313	7	333	7	339	8	341	9
SST 317	369	5	326	3	335	9	302	16	333	6	343	5	347	2
SST 347	366	9	314	13	312	15	297	17	322	12	331	12	340	10
SST 356	362	15	321	8	343	4	309	12	334	4	342	6	342	5
SST 374	356	17	312	15	341	6	308	13	329	8	336	10	334	14
SST 387	365	11	325	5	310	16	310	11	327	9	333	11	345	4
SST 398	358	16												
Wedzi	367	7	312	14	332	11					337	9	339	11
Mean	**365**		**317**		**325**		**310**		**329**		**337**		**338**	
LSD_t(0,05)	**13.65**		**16.62**		**18.42**		**14.36**		**8.60**		**9.80**		**11.37**	

Central Free State (earlier planting)
Average yield (ton/ha) of entries during the full or partial period from 2016 - 2018

Cultivar	2018	R	2017*	R	2016	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Elands	1.53	14	1.68	13	2.07	19	1.76	14	1.61	13
Gariep	1.44	19	1.65	15	2.13	17	1.74	16	1.55	17
Koonap	1.58	9	1.55	18	2.11	18	1.75	15	1.57	16
Kougas	1.51	17	1.72	9	2.78	3	2.00	7	1.61	12
Kubetu	1.68	6	1.91	4					1.79	7
Matlabas	1.77	4	1.84	5	3.17	1	2.26	2	1.81	5
PAN 3111	1.87	2	2.59	1	2.74	6	2.40	1	2.23	1
PAN 3118					2.50	11				
PAN 3120					2.49	12				
PAN 3161	2.11	1	1.68	11	2.75	5	2.18	3	1.90	2
PAN 3195	1.69	5	2.04	2	2.57	10	2.10	6	1.86	3
PAN 3198			1.62	16	2.32	15				
PAN 3368	1.55	11	1.61	17	2.03	20	1.73	17	1.58	15
PAN 3379					1.88	21				
Senqu	1.61	8	1.68	11	2.25	16	1.85	12	1.65	10
SST 3149	1.45	18	1.51	19	2.58	9	1.84		1.48	18
SST 316	1.52	15	1.67	14	2.46	14	1.88	11	1.59	14
SST 317	1.52	16	1.81	6	2.64	8	1.99	8	1.66	8
SST 347	1.57	10	1.69	10	2.68	7	1.98	9	1.63	11
SST 356	1.54	12	1.75	8	2.47	13	1.92	10	1.65	9
SST 387	1.61	7	1.99	3	2.77	4	2.12	5	1.80	6
SST 398	1.54	13								
Wedzi	1.86	3	1.78	7	2.88	2	2.17	4	1.82	4
Mean	**1.63**		**1.78**		**2.49**		**1.98**		**1.71**	
LSD_t(0,05)	**0.09**		**0.14**		**0.18**		**0.09**		**0.08**	

Due to severe drought conditions during the growing season no results are available for 2015
*** Only Petrus Steyn data**

Central Free State (earlier planting)
Average hectolitre mass (kg/hl) of entries during the full or partial period from 2016 - 2018

Cultivar	2018	R	2017*	R	2016	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Elands	77.09	6	75.20	15	78.20	10	76.83	8	76.15	9
Gariep	75.42	13	77.13	5	79.45	2	77.33	6	76.28	8
Koonap	78.07	3	77.00	8	78.78	5	77.95	3	77.54	3
Kougas	77.53	5	77.03	7	79.42	3	77.99	2	77.28	4
Kubetu	78.26	2	77.98	3					78.12	2
Matlabas	76.83	7	77.13	5	77.96	13	77.31	7	76.98	7
PAN 3111	75.88	12	78.48	1	78.07	11	77.48	5	77.18	5
PAN 3118					78.72	6				
PAN 3120					78.71	7				
PAN 3161	76.33	8	75.68	12	77.55	17	76.52	11	76.01	11
PAN 3195	74.23	17	76.25	10	77.63	15	76.04	12	75.24	14
PAN 3198			75.80	11	77.53	18				
PAN 3368	75.17	14	74.85	18	76.94	20	75.65	16	75.01	16
PAN 3379					77.48	19				
Senqu	76.28	10	75.65	13	78.53	8	76.82	9	75.97	12
SST 3149	76.33	8	74.88	17	76.28	21	75.83		75.61	13
SST 316	74.16	18	75.28	14	77.99	12	75.81	15	74.72	17
SST 317	75.06	15	74.98	16	77.90	14	75.98	13	75.02	15
SST 347	78.38	1	78.08	2	79.75	1	78.74	1	78.23	1
SST 356	73.68	19	74.45	19	77.62	16	75.25	17	74.07	18
SST 387	74.83	16	77.23	4	78.27	9	76.78	10	76.03	10
SST 398	76.18	11								
Wedzi	77.78	4	76.45	9	78.97	4	77.73	4	77.12	6
Mean	**76.18**		**76.29**		**78.18**		**76.83**		**76.25**	
LSD_t(0,05)	**0.64**		**1.15**		**0.67**		**0.43**		**0.57**	

Due to severe drought conditions during the growing season no results are available for 2015
*** Only Petrus Steyn data**

Central Free State (earlier planting)
Average protein content (%) of entries during the full or partial period from 2016 - 2018

Cultivar	2018	R	2017*	R	2016	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Elands	13.16	13	15.93	2	14.96	4	14.68	3	14.55	5
Gariep	13.22	10	15.06	13	14.80	6	14.36	7	14.14	10
Koonap	13.31	7	15.88	4	15.13	2	14.77	1	14.60	4
Kougas	13.69	1	15.57	7	14.19	9	14.48	5	14.63	2
Kubetu	12.96	17	15.11	11					14.04	14
Matlabas	13.44	4	15.84	5	13.21	20	14.16	10	14.64	1
PAN 3111	13.08	15	14.39	19	13.11	21	13.53	17	13.74	18
PAN 3118					14.03	12				
PAN 3120					14.15	11				
PAN 3161	12.84	19	15.39	8	14.43	8	14.22	9	14.12	12
PAN 3195	13.09	14	15.00	14	13.69	18	13.93	14	14.05	13
PAN 3198			16.43	1	14.85	5				
PAN 3368	13.38	5	15.59	6	15.21	1	14.73	2	14.49	6
PAN 3379					14.57	7				
Senqu	13.21	11	15.15	10	15.09	3	14.48	4	14.18	8
SST 3149	13.60	2	15.21	9	13.88	16	14.23		14.41	7
SST 316	13.59	3	14.66	17	14.19	9	14.15	11	14.13	11
SST 317	13.23	9	14.84	16	14.03	12	14.03	13	14.04	14
SST 347	13.30	8	15.92	3	13.92	14	14.38	6	14.61	3
SST 356	13.20	12	15.09	12	13.83	17	14.04	12	14.15	9
SST 387	12.96	17	15.00	14	13.41	19	13.79	16	13.98	16
SST 398	13.37	6								
Wedzi	13.06	16	14.52	18	13.91	15	13.83	15	13.79	17
Mean	**13.25**		**15.29**		**14.22**		**14.22**		**14.24**	
LSD$_t$(0,05)	**0.52**		**1.11**		**0.82**		**0.46**		**0.49**	

Due to severe drought conditions during the growing season no results are available for 2015
*** Only Petrus Steyn data**

Central Free State (earlier planting)
Average falling number (s) of entries during the full or partial period from 2016 - 2018

Cultivar	2018	R	2017*	R	2016	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Elands	342	6	256	9	301	16	300	8	299	7
Gariep	338	9	234	17	292	20	288	17	286	13
Koonap	327	13	292	1	325	3	314	1	309	2
Kougas	348	3	250	12	322	4	307	4	299	6
Kubetu	321	16	260	6					290	12
Matlabas	330	11	236	16	327	2	297	10	283	16
PAN 3111	347	4	258	7	302	14	302	7	302	5
PAN 3118					295	19				
PAN 3120					309	9				
PAN 3161	359	1	209	19	312	7	293	13	284	15
PAN 3195	330	10	255	10	297	18	294	12	293	10
PAN 3198			232	18	287	21				
PAN 3368	328	12	257	8	301	15	295	11	292	11
PAN 3379					310	8				
Senqu	350	2	261	5	305	12	305	6	305	3
SST 3149	306	17	246	13	317	6	290		276	17
SST 316	339	7	284	2	305	13	309	3	311	1
SST 317	321	15	267	4	308	10	298	9	294	9
SST 347	304	19	244	15	322	5	290	15	274	18
SST 356	338	8	272	3	308	11	306	5	305	4
SST 387	327	13	245	14	299	17	290	14	286	14
SST 398	305	18								
Wedzi	344	5	253	11	334	1	310	2	298	8
Mean	**332**		**253**		**308**		**299**		**294**	
LSD_t(0,05)	**16.35**		**35.18**		**15.13**		**10.55**		**14.13**	

Due to severe drought conditions during the growing season no results are available for 2015
*** Only Petrus Steyn data**

Central Free State (later planting)
Average yield (ton/ha) of entries during the full or partial period from 2016 - 2018

Cultivar	2018	R	2017*	R	2016	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Elands	1.57	12	1.79	7	2.50	14	1.95	11	1.68	10
Gariep	1.55	14	1.72	11	2.71	5	1.99	10	1.63	14
Koonap	1.68	8	1.73	10	2.36	16	1.92	13	1.70	7
Kougas	1.62	11	1.54	17	2.53	12	1.90	15	1.58	15
Kubetu	1.83	2	1.80	5					1.81	
PAN 3111	1.66	9	1.87	2	2.67	8	2.07	5	1.76	5
PAN 3118					2.25	19				
PAN 3161	2.14	1	1.63	16	3.08	1	2.28	1	1.89	1
PAN 3195	1.71	7	1.97	1	2.91	2	2.20	2	1.84	2
PAN 3198			1.78	8	2.40	15				
PAN 3368	1.74	6	1.66	13	2.69	7	2.03	7	1.70	8
PAN 3379					2.63	10				
Senqu	1.79	4	1.80	4	2.69	6	2.09	4	1.80	4
SST 316	1.63	10	1.68	12	2.67	8	1.99	8	1.66	12
SST 317	1.51	18	1.76	9	2.56	11	1.94	11	1.63	13
SST 347	1.52	17	1.63	15	2.32	17	1.82	16	1.58	16
SST 356	1.55	14	1.85	3	2.91	3	2.10	3	1.70	9
SST 374	1.78	5	1.31	18	2.50	13	1.86		1.55	17
SST 387	1.56	13	1.79	6	2.80	4	2.05	6	1.68	11
SST 398	1.54	16								
Wedzi	1.83	2	1.66	14	2.26	18	1.92	13	1.75	6
Mean	**1.68**		**1.72**		**2.60**		**2.01**		**1.70**	
LSD_t(0,05)	**0.11**		**0.13**		**0.17**		**0.11**		**0.09**	

Due to severe drought conditions during the growing season no results are available for 2015
*** Only Petrus Steyn data**

Central Free State (later planting)
Average hectolitre mass (kg/hl) of entries during the full or partial period from 2016 - 2018

Cultivar	2018	R	2017*	R	2016	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Elands	76.29	7	76.97	7	78.07	2	77.11	4	76.63	6
Gariep	75.99	9	77.22	5	77.41	4	76.87	5	76.61	8
Koonap	77.74	3	76.85	9	78.54	1	77.71	1	77.30	4
Kougas	77.87	2	77.30	3	77.49	3	77.55	2	77.59	2
Kubetu	77.50	4	77.60	1					77.55	
PAN 3111	76.24	8	77.00	6	75.04	14	76.09	8	76.62	7
PAN 3118					75.92	11				
PAN 3161	76.74	5	74.45	16	75.95	10	75.71	10	75.60	11
PAN 3195	76.52	6	77.55	2	74.48	17	76.18	7	77.04	5
PAN 3198			75.97	14	75.23	13				
PAN 3368	75.85	10	76.17	13	75.52	12	75.85	9	76.01	10
PAN 3379					76.38	7				
Senqu	75.64	12	76.75	10	77.10	5	76.50	6	76.20	9
SST 316	74.34	15	76.20	11	74.45	18	75.00	13	75.27	13
SST 317	74.80	13	75.25	15	74.50	16	74.85	15	75.03	15
SST 347	73.95	17	73.57	18	76.39	6	74.64	16	73.76	17
SST 356	73.67	18	76.20	11	74.81	15	74.89	14	74.94	16
SST 374	75.85	10	74.40	17	76.01	9	75.42		75.13	14
SST 387	74.17	16	76.92	8	74.21	19	75.10	12	75.55	12
SST 398	74.72	14								
Wedzi	78.55	1	77.27	4	76.13	8	77.32	3	77.91	1
Mean	**75.91**		**76.31**		**75.98**		**76.05**		**76.16**	
LSD_t(0,05)	**0.79**		**1.33**		**1.12**		**0.74**		**0.73**	

Due to severe drought conditions during the growing season no results are available for 2015
*** Only Petrus Steyn data**

Central Free State (later planting)
Average protein content (%) of entries during the full or partial period from 2016 - 2018

Cultivar	2018	R	2017*	R	2016	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Elands	14.89	1	15.05	6	15.13	6	15.02	2	14.97	3
Gariep	14.13	13	16.21	1	14.51	13	14.95	3	15.17	1
Koonap	13.82	17	16.18	2	15.65	1	15.22	1	15.00	2
Kougas	14.58	4	14.62	14	14.90	8	14.70	7	14.60	10
Kubetu	14.08	14	14.42	16					14.25	
PAN 3111	14.51	8	15.03	7	14.27	17	14.60	11	14.77	4
PAN 3118					15.62	2				
PAN 3161	13.94	15	15.03	7	14.22	18	14.40	14	14.49	13
PAN 3195	14.29	10	14.62	14	14.52	12	14.48	13	14.46	14
PAN 3198			15.91	3	15.51	4				
PAN 3368	14.69	2	14.73	12	15.26	5	14.89	5	14.71	6
PAN 3379					14.49	14				
Senqu	14.53	6	14.64	13	15.53	3	14.90	4	14.59	11
SST 316	14.5	9	14.16	17	14.29	16	14.32	16	14.33	15
SST 317	14.55	5	14.88	10	14.95	7	14.79	6	14.72	5
SST 347	14.29	10	14.00	18	14.76	9	14.35	15	14.15	17
SST 356	14.24	12	14.99	9	14.34	15	14.52	11	14.62	9
SST 374	13.59	18	15.76	4	14.73	11	14.69		14.68	8
SST 387	14.53	6	14.85	11	14.10	19	14.49	12	14.69	7
SST 398	14.66	3								
Wedzi	13.94	15	15.13	5	14.75	10	14.61	9	14.54	12
Mean	**14.32**		**15.01**		**14.82**		**14.68**		**14.63**	
LSD_t(0,05)	**0.69**		**1.37**		**0.55**		**0.42**		**0.65**	

Due to severe drought conditions during the growing season no results are available for 2015
*** Only Petrus Steyn data**

Central Free State (later planting)
Average falling number (s) of entries during the full or partial period from 2016 - 2018

Cultivar	2018	R	2017*	R	2016	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Elands	321	5	231	15	363	6	305	11	276	13
Gariep	311	10	246	12	349	12	302	13	278	12
Koonap	318	8	315	2	368	2	334	1	316	2
Kougas	326	3	241	13	358	8	308	8	283	10
Kubetu	305	13	302	4					304	
PAN 3111	292	16	286	6	341	16	306	9	289	7
PAN 3118					332	17				
PAN 3161	340	1	167	18	378	1	295	14	254	17
PAN 3195	311	11	324	1	316	19	317	4	317	1
PAN 3198			175	17	346	13				
PAN 3368	309	12	232	14	331	18	291	16	271	15
PAN 3379					359	7				
Senqu	320	6	250	11	363	4	311	6	285	9
SST 316	321	4	289	5	365	3	325	3	305	4
SST 317	304	14	254	10	350	11	303	11	279	11
SST 347	284	18	258	8	341	15	295	15	271	14
SST 356	326	2	256	9	363	4	315	5	291	6
SST 374	319	7	221	16	352	10	298		270	16
SST 387	297	15	277	7	344	14	306	9	287	8
SST 398	292	17								
Wedzi	313	9	311	3	357	9	327	2	312	3
Mean	**312**		**257**		**351**		**308**		**288**	
LSD_t(0,05)	**19.25**		**34.10**		**14.90**		**11.20**		**16.73**	

Due to severe drought conditions during the growing season no results are available for 2015
*** Only Petrus Steyn data**

Table 1. Agronomic characteristics of wheat cultivars under irrigation

Cultivar	Growth period	Hectolitre mass	Straw strength	Aluminum tolerance $	Pre-harvest sprouting
Baviaans (PBR)	Long	**	**	S	T
Duzi (PBR)	Medium	**	**	S	M
Kariega	Long	**	**	S	T
Koedoes (PBR)	Short	**	***	S	T
Krokodil (PBR)	Long	*	**	S	M
PAN 3400 (PBR)	Short-Medium	**	**	S	M
PAN 3471 (PBR)	Medium	***	**	S	S
PAN 3497 (PBR)	Long	***	**	S	T
PAN 3515 (PBR)	Medium	**	**	S	M
PAN 3623 (PBR)	Short-Medium	***	**	S	M
Renoster (PBR)	Short	**	***	MT	M
Sabie (PBR)	Long	**	**	S	T
SST 806 (PBR)	Medium	***	**	S	S
SST 8135 (PBR)	Short-Medium	**	***	S	M
SST 8154 (PBR)	Short	**	**	S	T
SST 8156 (PBR)	Medium	**	**	S	S
SST 822 (PBR)	Short	**	***	T	S
SST 835 (PBR)	Medium	**	**	S	S
SST 843 (PBR)	Short	***	***	S	S
SST 866 (PBR)	Medium	**	**	S	M
SST 867 (PBR)	Long	**	***	S	T
SST 875 (PBR)	Short-Medium	***	**	S	M
SST 876 (PBR)	Long	***	***	S	S
SST 877 (PBR)	Long	**	***	S	T
SST 884 (PBR)	Short	**	***	S	S
SST 895 (PBR)	Medium	***	**	S	M

** Average* *** Good* **** Excellent* *T- Tolerant* *MT- Moderate Tolerance*
M- Moderate *S - Sensitive*

$ Based on ALMT1 marker presence and seedling screening of cultivars

PBR: Cultivars protected by Plant Breeders' Rights

Table 2. Disease resistance or susceptibility of wheat cultivars recommended for cultivation under irrigation.

Cultivar	Stem Rust	Leaf Rust	Stripe Rust
Baviaans (PBR)	S	MS	R
Duzi (PBR)	S	S	R
Kariega	S	MS	R
Koedoes (PBR)	MS	S	S
Krokodil (PBR)	MS	S	S
PAN 3400 (PBR)	MS	S	R
PAN 3471 (PBR)	S	MS	R
PAN 3497 (PBR)	S	S	R
PAN 3515 (PBR)	MS	R	R
PAN 3623 (PBR)	S	S	R
Renoster (PBR)	S	S	MS
Sabie (PBR)	S	MS	R
SST 806 (PBR)	S	MS	R
SST 8135 (PBR)	MS	MS	R
SST 8154 (PBR)	MS	S	R
SST 8156 (PBR)	MS	MS	R
SST 822 (PBR)	MS	MS	R
SST 835 (PBR)	MS	MS	MR
SST 843 (PBR)	MS	MS	R
SST 866 (PBR)	S	MS	R/MS
SST 867 (PBR)	S	MS	MR
SST 875 (PBR)	S	MS	R
SST 876 (PBR)	S	MS	MR
SST 877 (PBR)	S	MS	R/MS
SST 884 (PBR)	MR	S	R
SST 895 (PBR)	MS	MS	R

S=Susceptible MS= Moderately susceptible R=Resistant MR=Moderately resistant

/ = mixed for rust reaction

PBR: Cultivars protected by Plant Breeders' Rights

Variation in rust races may affect cultivars differently. Reactions given here are based on existing data for the most virulent rust races occurring in South Africa. Distribution of races may vary between production regions.

Seeding rate

Seeding rate is the most controllable factor that determines the number of ears/m^2. Seeding rate must also compensate for low germination, poor emergence and seedling establishment. Thousand kernel mass is an important characteristic that determines the number of kernels per kilogram seed, and this value can vary from ± 25 – 52 g per 1000 kernels. This can have a distinct effect on seeding rate (kg seed/ ha). Thousand kernel mass must be considered in determining seeding rate:

$$\text{Seeding rate (kg/ha)} = \frac{\text{plants/m}^2 \times \text{1000 kernel mass (g)} \times 100}{\text{germination \% / establishment \%}}$$

These calculations have been included in the plants/m^2 table (Table 6), where calculated seeding rate (kg/ha) at the range of thousand kernel mass values and target plants/m^2 at a 90% establishment % were done. The optimum plants/m^2 per cultivar for each region is included in the planting spectrum tables. With the optimum plants/m^2 and the 1000 kernel mass of the seedlot, the applicable seeding rate (kg seed/ha) can be determined.

Table 3. Kilogram seed per hectare at different plant populations at 90% establishment percentage

TKM	Seeds per square meter										
	150	175	200	225	250	275	300	325	350	375	400
32	53	62	71	80	89	98	107	116	124	133	142
33	55	64	73	83	92	101	110	119	128	138	147
34	57	66	76	85	95	104	113	123	132	142	151
35	58	68	78	88	97	107	117	126	136	146	156
36	60	70	80	90	100	110	120	130	140	150	160
37	62	72	82	93	103	113	123	134	144	154	165
38	63	74	84	95	106	116	127	137	148	158	169
39	65	76	87	98	108	119	130	141	152	163	173
40	67	78	89	100	111	122	133	144	156	167	178
41	68	80	91	103	114	125	137	148	160	171	182
42	70	82	93	105	117	128	140	152	163	175	187
43	72	84	96	108	119	131	143	155	167	179	191
44	73	86	98	110	122	134	147	159	171	183	196
45	75	88	100	113	126	138	150	163	175	188	200
46	76	89	101	114	127	139	152	164	177	190	202
47	78	91	103	116	129	142	155	168	181	194	207
48	79	92	106	119	132	145	158	172	185	198	211
49	81	94	108	121	135	148	162	176	189	202	216
50	83	96	110	124	138	151	165	179	193	206	220

Table 4: Optimum planting date and planting densities for wheat in the Cooler Central irrigation areas

Cultivar	Petrusville Hopetown	Bothaville Wesselsbron Bultfontein	Douglas Prieska	Vaalharts	Modderriver Kimberley Barkley-West	Ventersdorp Klerksdorp Lichtenburg	Recommended kg seed/ha	Plants/m^2
Baviaans (PBR)	1/6-30/6	1/6-20/6	1/6-25/6	1/6-25/6	1/6-25/6	1/6-30/6	80-110	200-275
Duzi (PBR)	1/6-15/7	1/6-15/7	10/6-20/7	15/6-10/7	10/6-20/7	10/6-15/7	100-130	250-300
Kariega	1/6-30/6	1/6-20/6	1/6-25/6	25/5-25/6	1/6-25/6	1/6-30/6	80-110	175-250
Koedoes (PBR)	15/6-31/6	25/6-31/7	30/6-31/7	20/6-15/7	15/6-25/7	25/6-25/7	100-130	250-300
Krokodil (PBR)	1/6-15/7	1/6-15/7	1/6-15/7	1/6-30/6	1/6-30/6	1/6-10/7	100-130	275-350
PAN 3400 (PBR)	10/6-25/7	10/6-20/7	15/6-25/7	20/6-15/7	15/6-25/7	15/6-20/7	80-120	185-265
PAN 3471 (PBR)	1/6-15/7	1/6-15/7	10/6-20/7	15/6-10/7	10/6-20/7	10/6-15/7	75-110	170-255
PAN 3497 (PBR)	1/6-30/6	1/6-20/6	1/6-25/6	1/6-25/6	1/6-25-6	1/6-30/6	75-110	170-255
PAN 3515 (PBR)	1/6-15/7	1/6-15/7	10/6-20/7	15/6-10/7	10/6-20/7	10/6-15/7	75-110	170-255
PAN 3623 (PBR)	10/6-25/7	10/6-20/7	15/6-25/7	20/6-15/7	15/6-25/7	15/6-20/7	80-120	170-255
Renoster (PBR)	15/6-31/6	25/6-31/7	30/6-31/7	20/6-15/7	15/6-25/7	25/6-25/7	80-120	175-275
Sabie (PBR)	1/6-30/6	1/6-20/6	1/6-25/6	25/5-25/6	1/6-25/6	1/6-30/6	80-110	175-250
SST 806 (PBR)	7/6-20/7	15/6-31/7	15/6-20/7	15/6-14/7	10/6-20/7	10/6-14/7	120-140	275-325
SST 8135 (PBR)	15/6-20/7	1/7-14/8	25/6-31/7	20/6-21/7	20/6-21/7	1/07-31/7	130-150	300-350
SST 8154 (PBR)	15/6-31/7	1/7-10/8	30/6-31/7	20/6-15/7	15/6-25/7	1/7-20/7	160-200	300-375
SST 8156 (PBR)	7/6-20/7	15/6-31/7	15/6-20/7	15/6-14/7	10/6-20/7	10/6-14/7	120-140	300-350
SST 822 (PBR)	7/6-20/7	15/6-31/7	15/6-20/7	15/6-14/7	10/6-20/7	10/6-14/7	120-140	275-325
SST 835 (PBR)	15/6-31/7	1/7-14/8	25/6-31/7	20/6-21/7	15/6-31/7	1/7-31/7	130-150	300-350
SST 843 (PBR)	1/6-15/7	10/6-15/7	1/6-14/7	15/6-10/7	1/6-15/7	7/6-14/7	120-140	275-325
SST 866 (PBR)	1/6-15/7	1/6-15/7	1/6-30/6	1/6-30/6	1/6-30/6	1/6-10/7	120-140	275-325
SST 867 (PBR)	7/6-20/7	15/6-31/7	15/6-20/7	15/6-14/7	10/6-20/7	10/6-14/7	120-140	275-325
SST 875 (PBR)	15/6-15/7	10/6-31/7	1/6-15/7	15/6-14/7	1/6-15/7	10/6-10/7	120-140	300-375
SST 876 (PBR)	1/6-15/7	1/6-15/7	1/6-30/6	1/6-30/6	1/6-30/6	1/6-10/7	100-120	275-325
SST 877 (PBR)	15/6-31/7	1/7-14/8	25/6-31/7	20/6-21/7	15/6-31/7	1/7-31/7	130-150	275-350
SST 884 (PBR)	7/6-20/7	15/6-31/7	15/6-20/7	15/6-14/7	10/6-20/7	10/6-14/7	120-140	275-325
SST 895 (PBR)	7/6-20/7	15/6-31/7	15/6-20/7	15/6-14/7	10/6-20/7	10/6-14/7	120-140	275-325

PBR: Cultivars protected by Plant Breeders' Rights

Table 5: Optimum planting date and planting densities for wheat in the Warmer irrigation areas

Cultivar	Brits Marikana Rustenburg	Beestekraal Marico	Koedoeskop Makoppa	Groblersdal Marble Hall	Springbok Flats	Recommended kg seed/ha	Plants/m^2
Baviaans (PBR)	20/5-15/6	25/5-15/6	25/5-15/6	10/5-10/6	10/5-10/6	90-120	225-300
Duzi (PBR)	20/5-30/6	25/5-30/6	25/5-30/6	10/5-30/6	20/5-15/6	100-130	250-300
Kariega	20/5-15/6	25/5-15/6	25/5-15/6	10/5-10/6	1/5-25/5	80-120	225-275
Koedoes (PBR)	1/6-30/6	7/6-7/7	1/6-15/7	25/5-30/6	25/5-20/6	100-130	250-300
Krokodil (PBR)	20/5-20/6	25/5-20/6	25/5-20/6	10/5-15/6	10/5-15/6	130-150	300-375
PAN 3400 (PBR)	25/5-5/7	7/6-5/7	1/6-5/7	15/5-30/6	25/5-20/6	80-120	185-265
PAN 3471 (PBR)	20/5-30/6	25/5-30/6	25/5-30/6	10/5-30/6	20/5-15/6	75-110	170-255
PAN 3497 (PBR)	20/5-15/6	25/5-15/6	25/5-15/6	10/5-10/6	10/5-10/6	75-110	170-255
PAN 3515 (PBR)	20/5-30/6	25/5-30/6	25/5-30/6	10/5-30/6	20/5-15/6	75-110	170-255
PAN 3623 (PBR)	25/5-5/7	7/6-5/7	1/6-5/7	15/5-30/6	25/5-20/6	80-120	170-255
Renoster (PBR)	1/6-30/6	7/6-7/7	1/6-15/7	25/5-30/6	25/5-20/6	80-120	175-275
Sabie (PBR)	20/5-15/6	25/5-15/6	25/5-15/6	10/5-10/6	1/5-25/5	80-110	175-250
SST 806 (PBR)	20/5-30/6	20/5-30/6	20/5-30/6	10/5-14/6	15/5-15/6	120-140	275-350
SST 8135 (PBR)	20/5-30/6	1/6-30/6	25/5-30/6	10/5-20/6	20/5-15/6	120-140	280-325
SST 8154 (PBR)	1/6-7/7	7/6-7/7	1/6-15/7	15/5-30/6	25/5-20/6	130-150	300-350
SST 8156 (PBR)	20/5-30/6	20/5-30/6	20/5-30/6	10/5-14/6	15/5-15/6	120-140	280-325
SST 822 (PBR)	1/6-30/6	7/6-7/7	1/6-15/7	15/5-30/6	25/5-20/6	160-200	325-400
SST 835 (PBR)	20/5-30/6	1/6-30/6	25/5-30/6	10/5-20/6	20/5-15/6	120-140	275-325
SST 843 (PBR)	1/6-7/7	7/6-7/7	1/6-15/7	15/5-30/6	25/5-20/6	130-150	300-350
SST 866 (PBR)	20/5-30/6	20/5-30/6	20/5-30/6	7/5-14/6	15/5-15/6	120-140	275-325
SST 867 (PBR)	15/5-20/6	25/5-20/6	15/5-20/6	7/5-31/5	10/5-7/6	100-130	275-325
SST 875 (PBR)	20/5-30/6	1/6-30/6	25/5-30/6	10/5-20/6	20/5-15/6	120-140	275-325
SST 876 (PBR)	20/5-30/6	1/6-30/6	25/5-30/6	15/5-15/6	20/5-15/6	120-140	300-375
SST 877 (PBR)	15/5-20/6	25/5-20/6	15/5-20/6	7/5-31/5	10/5-7/6	120-140	275-325
SST 884 (PBR)	1/6-7/7	7/6-7/7	25/5-15/7	15/5-30/6	25/5-20/6	130-150	275-350
SST 895 (PBR)	20/5-30/6	1/6-30/6	25/5-30/6	10/5-20/6	20/5-15/6	120-140	275-325

PBR: Cultivars protected by Plant Breeders' Rights

Table 6: Optimum planting date and planting densities for wheat in the Warmer irrigation areas (continued)

Cultivar	Tarlton Hekpoort Magaliesburg	Badplaas Stofberg	Ohrigstad Steel poort Burgersfort	Limpopo	Waterberg	Recommended kg seed/ha	Plants/m²
Baviaans (PBR)	20/5-20/6	10/5-20/6	25/4-25/5	1/5-25/5	15/5-15/6	90-120	225-300
Duzi (PBR)	20/5-15/7	15/5-30/6	1/5-15/6	1/5-10/6	15/5-20/6	100-130	250-300
Kariega	20/5-20/6	10/5-20/6	25/4-25/5	1/5-25/5	15/5-15/6	80-120	225-275
Koedoes (PBR)	15/6-15/7	30/5-15/7	15/5-30/6	6/5-5/6	20/5-20/6	100-130	250-300
Krokodil (PBR)	20/5-30/6	20/5-30/6	1/5-15/6	1/5-31/5	15/5-20/6	130-150	300-375
PAN 3400 (PBR)	25/5-15/7	20/5-15/7	10/5-25/6	6/5-10/6	20/5-25/6	80-120	185-265
PAN 3471 (PBR)	20/5-15/7	15/5-30/6	1/5-15/6	1/5-10/6	15/5-20/6	75-110	170-255
PAN 3497 (PBR)	20/5-20/6	10/5-20/6	25/4-25/5	1/5-25/5	15/5-15/6	75-110	170-255
PAN 3515 (PBR)	20/5-15/7	15/5-30/6	1/5-15/6	1/5-10/6	15/5-20/6	75-110	170-255
PAN 3623 (PBR)	25/5-15/7	20/5-15/7	10/5-25/6	6/5-10/6	20/5-25/6	80-120	170-255
Renoster (PBR)	15/6-15/7	30/5-15/7	15/5-30/6	6/5-5/6	20/5-20/6	80-120	175-275
Sabie (PBR)	20/5-20/6	10/5-20/6	25/4-25/5	1/5-25/5	15/5-15/6	80-110	175-250
SST 806 (PBR)	20/5-30/6	15/5-30/6	1/5-31/5	1/5-31/5	10/5-20/6	120-140	275-325
SST 8135 (PBR)	10/6-14/7	15/5-30/6	1/5-31/5	1/5-7/6	15/5-25/6	120-140	275-325
SST 8154 (PBR)	15/6-20/7	15/5-31/7	15/5-30/6	07/5-14/6	20/5-30/6	130-150	300-350
SST 8156 (PBR)	20/5-30/6	15/5-30/6	1/5-31/5	1/5-31/5	10/5-20/6	120-140	275-325
SST 822 (PBR)	1/6-30/6	30/5-15/7	15/5-30/6	6/5-5/6	20/5-20/6	160-200	325-400
SST 835 (PBR)	10/6-15/7	15/5-30/6	1/5-31/5	1/5-7/6	15/5-25/6	120-140	275-325
SST 843 (PBR)	15/6-21/7	21/5-31/7	15/5-30/6	7/5-7/6	20/5-30/6	130-150	300-350
SST 866 (PBR)	20/5-30/6	15/5-30/6	1/5-31/5	1/5-31/5	10/5-20/6	120-140	275-325
SST 867 (PBR)	20/5-20/6	10/5-20/6	25/4-21/5	1/5-25/5	10/5-15/6	120-140	275-325
SST 875 (PBR)	10/6-14/7	15/5-30/6	1/5-31/5	1/5-7/6	15/5-25/6	120-140	275-325
SST 876 (PBR)	10/6-15/7	15/5-30/6	1/5-31/5	1/5-31/5	15/5-20/6	120-140	300-375
SST 877 (PBR)	20/5-20/6	10/5-20/6	25/4-21/6	1/5-25/5	10/5-15/6	120-140	275-325
SST 884 (PBR)	10/6-21/7	15/5-21/7	15/5-30/6	7/5-7/6	20/5-30/6	120-140	275-350
SST 895 (PBR)	10/6-15/7	15/5-30/6	1/5-31/5	1/5-7/6	15/5-25/6	120-140	275-350

PBR: Cultivars protected by Plant Breeders' Rights

Table 7: Optimum planting date and planting densities for wheat in the Eastern Highveld, Fishriver and Lower Orange River

Cultivar	Fishriver Elliot	Lower Orange River Louwna Tosca	Recommended kg seed/ha	Plants/m^2	Aliwal-North Smithfield	Eastern Highveld	Recommended kg seed/ha	Plants/m^2
Baviaans (PBR)	1/6-25/6	1/6-25/6	100-120	250-325	10/6-30/6	25/6-25/7	80-110	200-275
Duzi (PBR)	15/6-15/7	1/6-15/7	110-130	275-325	10/6-15/7	25/6-25/7	100-130	250-300
Kariega	1/6-25/6	1/6-25/6	80-130	250-300	10/6-30/6	25/6-25/7	80-110	175-250
Krokodil (PBR)	15/6-15/7	1/6-30/6	130-160	325-400	15/6-10/7	-	-	-
PAN 3400 (PBR)	20/6-25/7	10/6-25/7	120-140	300-350	20/6-25/7	30/6-5/8	80-120	185-265
PAN 3471 (PBR)	15/6-15/7	1/6-15/7	110-130	275-325	10/6-15/7	25/6-25/7	75-110	170-255
PAN 3497 (PBR)	1/6-25/6	1/6-25/6	100-120	250-300	10/6-30/6	25/6-25/7	75-110	170-255
PAN 3515 (PBR)	15/6-15/7	1/6-15/7	110-130	275-325	10/6-15/7	25/6-25/7	75-110	170-255
PAN 3623 (PBR)	20/6-25/7	10/6-25/7	120-140	300-350	20/6-25/7	30/6-5/8	80-120	170-255
Sabie (PBR)	1/6-25/6	1/6-25/6	80-130	250-300	10/6-30/6	25/6-25/7	80-110	175-250
SST 806 (PBR)	7/6-15/7	7/6-15/7	120-140	300-350	15/6-15/7	1/7-21/7	120-140	275-325
SST 8135 (PBR)	15/6-15/7	7/6-14/7	120-140	275-325	15/6-15/7	1/7-15/8	120-140	275-325
SST 8154 (PBR)	1/7-31/7	15/6-31/7	130-150	300-350	1/7-31/7	7/7-21/8	130-150	300-350
SST 8156 (PBR)	7/6-15/7	7/6-15/7	120-140	300-350	15/6-15/7	1/7-21/7	120-140	275-325
SST 822 (PBR)	1/7-31/7	30/6-30/7	160-200	350-400	30/6-31/7	25/6-15/8	180-200	300-375
SST 835 (PBR)	15/6-15/7	7/6-14/7	120-140	300-325	15/6-15/7	1/7-31/7	120-140	275-325
SST 843 (PBR)	1/7-31/7	15/6-30/7	130-150	325-400	1/7-31/7	7/7-21/8	130-150	300-350
SST 866 (PBR)	15/6-15/7	1/6-14/7	120-140	275-325	15/6-15/7	1/7-21/7	120-140	275-325
SST 867 (PBR)	1/6-30/6	24/5-30/6	120-140	275-325	7/6-30/6	25/6-21/7	100-120	275-325
SST 875 (PBR)	15/6-15/7	1/6-14/7	120-140	275-325	15/6-15/7	1/7-15/8	120-140	275-325
SST 876 (PBR)	15/6-15/7	15/6-15/7	130-160	300-375	15/6-15/7	25/6-31/7	120-140	275-325
SST 877 (PBR)	1/6-30/6	24/5-30/6	100-120	275-300	7/6-30/6	24/6-21/7	120-140	275-325
SST 884 (PBR)	1/7-31/7	10/6-30/7	130-150	325-375	21/6-31/7	1/7-21/8	130-150	300-350
SST 895 (PBR)	15/6-15/7	7/6-15/7	120-140	300-350	15/6-15/7	1/7-15/8	120-140	275-325

PBR: Cultivars protected by Plant Breeders' Rights

Table 8: Optimum planting date and planting densities for wheat in the Kwa-Zulu Natal

Cultivar	KwaZulu-Natal	Recommended kg seed/ha	Plants/m²
Baviaans (PBR)	1/6-30/6	100-120	250-300
Duzi (PBR)	1/6-30/6	100-130	250-300
Kariega	1/6-30/6	80-110	225-275
PAN 3400 (PBR)	10/6-5/7	80-120	185-265
PAN 3471 (PBR)	1/6-30/6	75-110	170-255
PAN 3497 (PBR)	1/6-30/6	75-110	170-255
PAN 3515 (PBR)	1/6-30/6	75-110	170-255
PAN 3623 (PBR)	10/6-5/7	80-120	170-255
Sabie (PBR)	1/6-30/6	80-110	175-250
SST 806 (PBR)	1/6-30/6	120-140	275-350
SST 8135 (PBR)	1/06-30/06	120-140	275-350
SST 8154 (PBR)	01/6-15/7	130-150	325-350
SST 8156 (PBR)	1/6-30/6	120-140	275-350
SST 822 (PBR)	25/6-30/7	160-200	325-400
SST 835 (PBR)	1/6-7/7	120-140	275-350
SST 843 (PBR)	15/6-30/7	130-150	325-375
SST 866 (PBR)	1/6-1/7	120-140	275-350
SST 867 (PBR)	1/6-30/6	120-140	275-350
SST 875 (PBR)	1/6-7/7	120-140	300-350
SST 876 (PBR)	1/6-30/6	120-140	275-350
SST 877 (PBR)	1/6-30/6	120-140	275-350
SST 884 (PBR)	15/6-15/7	130-150	300-350
SST 895 (PBR)	1/6-7/7	120-140	275-350

PBR: Cultivars protected by Plant Breeders' Rights

Cooler Central Irrigation Area (earlier planting)
Average yield (ton/ha) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Buffels							8.06	22						
Duzi	11.99	9	9.50	19	9.36	12	8.28	21	9.78	14	10.28	10	10.74	13
Koedoes	12.16	4	9.19	20			9.25	11					10.67	14
Krokodil	10.68	22	9.84	8	10.06	3	9.20	13	9.94	11	10.19	12	10.26	19
PAN 3400	12.64	2	9.72	13	10.12	1	9.90	1	10.59	1	10.83	1	11.18	3
PAN 3471	11.47	17	10.22	2	10.08	2	8.81	18	10.15	7	10.59	4	10.85	10
PAN3497	12.36	3	10.19	3	9.88	4	9.44	8	10.47	3	10.81	2	11.28	2
PAN 3515	11.70	15	10.42	1	9.15	14	9.18	14	10.11	8	10.42	8	11.06	4
PAN 3541	11.82	13												
PAN 3623	11.38	19	9.77	9	8.71	19	9.45	7	9.83	12	9.95	16	10.58	16
PAN 3644	11.56	16												
Renoster	12.07	7	9.52	17			8.90	16					10.80	12
Sabie	11.42	18	9.56	15	9.09	16	9.06	15	9.78	15	10.02	15	10.49	17
SST 806	12.65	1	9.91	6	9.76	5	9.70	3	10.51	2	10.78	3	11.28	1
SST 8125					9.56	9	9.74	2						
SST 8134							9.31	10						
SST 8135	12.04	8	10.08	5	9.63	7	9.55	5	10.33	4	10.58	5	11.06	4
SST 8154	11.89	12	9.73	12	8.95	18					10.19	13	10.81	11
SST 8155					9.13	15								
SST 8156	12.10	5	9.76	10									10.93	7
SST 835	12.10	5	9.75	11	9.57	8	9.56	4	10.25	5	10.47	7	10.93	8
SST 843	10.86	21	9.50	18	7.62	20	8.02	23	9.00	16	9.33	17	10.18	20
SST 866	11.29	20	9.57	14	9.64	6	8.79	19	9.82	13	10.17	14	10.43	18
SST 867							8.53	20						
SST 875	11.99	9	9.85	7	9.35	13	9.21	12	10.10	9	10.39	9	10.92	9
SST 877					9.09	17	8.83	17						
SST 884	11.79	14	9.54	16	9.45	10	9.50	6	10.07	10	10.26	11	10.66	15
SST 895	11.90	11	10.14	4	9.45	10	9.32	9	10.20	6	10.50	6	11.02	6
Mean	**11.81**		**9.79**		**9.38**		**9.11**		**10.06**		**10.34**		**10.81**	
$LSD_t(0,05)$	**0.60**		**0.49**		**0.44**		**0.26**		**0.24**		**0.30**		**0.38**	

Cooler Central Irrigation Area (earlier planting)
Average hectolitre mass (kg/hl) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Buffels							81.17	22						
Duzi	80.34	18	80.30	11	81.70	18	81.62	20	80.99	14	80.78	14	80.32	16
Koedoes	80.71	17	80.44	8			81.83	19					80.58	12
Krokodil	80.25	19	80.21	14	81.81	17	82.00	16	81.07	13	80.76	15	80.23	18
PAN 3400	81.33	6	80.19	15	82.50	8	83.49	3	81.88	6	81.34	9	80.76	9
PAN 3471	81.24	9	81.11	1	82.53	6	83.77	1	82.16	2	81.63	3	81.18	4
PAN3497	80.89	13	80.56	6	82.68	3	83.44	5	81.89	5	81.38	7	80.73	10
PAN 3515	80.89	13	80.15	16	82.31	10	82.38	13	81.43	11	81.12	11	80.52	15
PAN 3541	80.74	16												
PAN 3623	80.91	12	80.14	17	82.10	14	82.99	9	81.54	10	81.05	13	80.53	14
PAN 3644	81.26	8												
Renoster	79.53	22	80.05	19			81.06	23					79.79	19
Sabie	79.61	21	79.94	20	82.05	15	82.09	15	80.92	16	80.53	17	79.78	20
SST 806	82.14	1	80.57	5	82.93	1	83.64	2	82.32	1	81.88	1	81.36	1
SST 8125					82.69	2	83.28	6						
SST 8134							82.13	14						
SST 8135	81.45	5	80.30	11	82.54	5	83.48	4	81.94	4	81.43	5	80.88	8
SST 8154	81.02	11	80.12	18	82.28	11					81.14	10	80.57	13
SST 8155					81.23	20								
SST 8156	81.84	2	80.53	7									81.19	2
SST 835	81.46	4	80.90	2	82.57	4	83.28	6	82.05	3	81.64	2	81.18	3
SST 843	81.62	3	80.22	13	82.22	12	83.18	8	81.81	7	81.35	8	80.92	6
SST 866	80.75	15	80.43	9	82.11	13	81.87	18	81.29	12	81.10	12	80.59	11
SST 867							82.90	10						
SST 875	81.29	7	80.66	3	82.53	6	82.47	12	81.74	8	81.49	4	80.98	5
SST 877					82.01	16	81.26	21						
SST 884	80.23	20	80.36	10	81.42	19	81.89	17	80.98	15	80.67	16	80.30	17
SST 895	81.22	10	80.58	4	82.42	9	82.67	11	81.72	9	81.41	6	80.90	7
Mean	**80.94**		**80.39**		**82.23**		**82.52**		**81.61**		**81.22**		**80.66**	
LSD$_t$(0,05)	**0.54**		**0.80**		**0.62**		**0.61**		**0.34**		**0.41**		**0.52**	

Cooler Central Irrigation Area (earlier planting)
Average protein content (%) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Buffels							12.74	5						
Duzi	12.51	6	12.82	2	12.83	8	12.45	18	12.65	5	12.72	6	12.67	5
Koedoes	12.70	5	12.92	1			12.88	3					12.81	2
Krokodil	11.71	22	12.43	17	11.72	20	11.59	23	11.86	16	11.95	17	12.07	19
PAN 3400	12.45	8	12.61	9	12.90	6	12.51	17	12.62	6	12.65	7	12.53	8
PAN 3471	12.22	14	12.56	13	12.65	12	12.73	7	12.54	9	12.48	10	12.39	13
PAN3497	12.27	12	12.36	18	12.48	13	12.55	15	12.42	11	12.37	12	12.32	16
PAN 3515	11.96	21	12.09	20	11.97	19	12.44	19	12.12	15	12.01	16	12.03	20
PAN 3541	12.73	3												
PAN 3623	12.71	4	12.63	7	13.42	2	12.94	2	12.93	2	12.92	2	12.67	4
PAN 3644	12.28	11												
Renoster	12.18	16	12.76	4			12.61	13					12.47	9
Sabie	12.85	2	12.74	5	12.84	7	12.64	12	12.77	3	12.81	3	12.80	3
SST 806	12.03	20	12.50	14	12.68	11	12.33	20	12.39	12	12.40	11	12.27	17
SST 8125					12.32	15	12.54	16						
SST 8134							12.73	7						
SST 8135	12.30	10	12.50	14	12.71	10	12.65	10	12.54	8	12.50	9	12.40	12
SST 8154	12.43	9	12.78	3	13.20	3					12.80	4	12.61	6
SST 8155					12.26	16								
SST 8156	12.16	17	12.62	8									12.39	13
SST 835	12.21	15	12.66	6	12.22	17	12.7	9	12.45	10	12.36	13	12.44	11
SST 843	13.54	1	12.57	11	14.70	1	13.79	1	13.65	1	13.60	1	13.06	1
SST 866	12.13	19	12.32	19	12.15	18	12.18	22	12.20	14	12.20	15	12.23	18
SST 867							12.65	10						
SST 875	12.15	18	12.48	16	12.42	14	12.29	21	12.34	13	12.35	14	12.32	15
SST 877					12.81	9	12.74	5						
SST 884	12.27	12	12.61	9	13.03	5	12.56	14	12.62	6	12.64	8	12.44	10
SST 895	12.49	7	12.57	11	13.15	4	12.85	4	12.77	4	12.74	5	12.53	7
Mean	**12.38**		**12.58**		**12.72**		**12.61**		**12.55**		**12.56**		**12.47**	
LSD$_t$(0,05)	**0.44**		**0.45**		**0.34**		**0.52**		**0.23**		**0.25**		**0.32**	

Cooler Central Irrigation Area (earlier planting)
Average falling number (s) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Buffels							338	15						
Duzi	358	20	316	5	343	18	331	20	337	15	339	16	337	12
Koedoes	373	8	300	18			339	13					337	15
Krokodil	349	22	297	20	318	20	323	23	322	16	321	17	323	20
PAN 3400	363	18	306	15	359	11	335	18	341	13	343	13	335	18
PAN 3471	365	16	320	2	350	16	349	5	346	8	345	11	343	8
PAN3497	360	19	314	8	351	15	345	8	342	12	341	15	337	14
PAN 3515	363	17	305	16	357	12	333	19	339	14	342	14	334	19
PAN 3541	366	15												
PAN 3623	371	11	319	3	355	13	346	7	347	6	348	8	345	3
PAN 3644	379	1												
Renoster	356	21	317	4			330	21					336	16
Sabie	367	13	323	1	348	17	339	14	344	11	346	10	345	1
SST 806	375	5	314	7	371	1	352	2	353	1	353	1	345	4
SST 8125					371	2	342	11						
SST 8134							354	1						
SST 8135	367	14	307	14	370	4	350	3	348	5	348	9	337	12
SST 8154	372	10	314	6	359	10					348	7	343	6
SST 8155					353	14								
SST 8156	378	2	312	10									345	1
SST 835	373	8	313	9	368	5	344	9	349	3	351	3	343	5
SST 843	377	3	304	17	365	6	342	12	347	7	349	6	341	11
SST 866	374	7	309	13	363	9	337	16	346	9	349	5	342	10
SST 867							337	17						
SST 875	375	4	310	12	371	3	343	10	350	2	352	2	342	9
SST 877					340	19	327	22						
SST 884	375	6	311	11	364	8	348	6	349	4	350	4	343	7
SST 895	370	12	300	19	364	7	350	4	346	10	345	12	335	17
Mean	**368**		**311**		**357**		**341**		**344**		**345**		**339**	
LSD$_t$(0,05)	**10.90**		**10.60**		**10.20**		**10.95**		**5.40**		**6.20**		**7.70**	

Cooler Central Irrigation Area (later planting)
Average yield (ton/ha) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Buffels							6.68	23						
Duzi	10.39	11	9.67	3	9.58	3	7.52	20	9.29	12	9.88	7	10.03	9
Koedoes	11.06	3	9.52	8			9.25	3					10.29	3
Krokodil	10.24	16	9.36	13	9.51	4	8.74	10	9.46	8	9.71	10	9.80	13
PAN 3400	10.56	9	9.51	9	9.67	2	9.04	7	9.69	4	9.91	6	10.03	8
PAN 3471	10.11	18	9.49	10	9.47	5	8.80	9	9.47	7	9.69	11	9.80	14
PAN3497	10.17	17	9.03	18	9.43	9	8.34	16	9.24	13	9.54	14	9.60	17
PAN 3515	10.09	19	9.47	12	9.39	11	8.30	17	9.31	11	9.65	12	9.78	15
PAN 3541	10.68	8												
PAN 3623	10.93	4	9.57	7	9.45	6	9.25	4	9.80	3	9.98	4	10.25	5
PAN 3644	10.26	15												
Renoster	10.91	5	9.20	15			9.45	1					10.06	7
Sabie	9.34	22	9.10	16	8.91	17	7.40	21	8.69	16	9.12	16	9.22	20
SST 806	10.28	14	9.35	14	9.22	14	8.57	12	9.36	10	9.62	13	9.81	12
SST 8125					8.85	18	8.42	15						
SST 8134							8.95	8						
SST 8135	10.32	12	9.48	11	9.36	12	8.43	14	9.40	9	9.72	9	9.90	11
SST 8154	11.22	2	9.74	2	9.31	13					10.09	1	10.48	1
SST 8155					8.85	19								
SST 8156	10.43	10	8.98	19									9.70	16
SST 835	10.08	20	9.03	17	9.19	15	8.19	18	9.12	14	9.43	15	9.55	18
SST 843	9.70	21	8.96	20	8.49	20	8.43	13	8.89	15	9.05	17	9.33	19
SST 866	10.30	13	9.67	4	9.45	6	9.11	6	9.63	6	9.81	8	9.98	10
SST 867							6.74	22						
SST 875	10.71	7	9.74	1	9.45	8	8.65	11	9.64	5	9.97	5	10.23	6
SST 877					9.01	16	7.70	19						
SST 884	11.23	1	9.58	6	9.42	10	9.15	5	9.85	2	10.08	2	10.41	2
SST 895	10.91	5	9.62	5	9.69	1	9.25	2	9.87	1	10.07	3	10.27	4
Mean	**10.45**		**9.40**		**9.28**		**8.45**		**9.42**		**9.72**		**9.93**	
LSD$_t$(0,05)	**0.49**		**0.44**		**0.33**		**0.28**		**0.20**		**0.24**		**0.33**	

Cooler Central Irrigation Area (later planting)
Average hectolitre mass (kg/hl) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Buffels							79.88	22						
Duzi	80.35	18	80.37	6	82.46	15	80.88	20	81.02	14	81.06	13	80.36	15
Koedoes	81.04	12	80.53	4			82.66	4					80.79	3
Krokodil	80.65	15	79.71	12	82.66	11	82.71	3	81.43	7	81.01	14	80.18	16
PAN 3400	80.98	13	79.94	11	82.49	13	82.17	8	81.40	9	81.14	12	80.46	12
PAN 3471	81.10	10	80.37	6	83.23	5	82.65	5	81.84	3	81.57	5	80.74	6
PAN3497	80.64	16	79.13	19	83.03	7	81.87	10	81.17	13	80.93	15	79.89	17
PAN 3515	79.64	21	79.65	13	82.79	10	81.34	16	80.86	15	80.69	16	79.65	19
PAN 3541	80.30	19												
PAN 3623	81.08	11	80.49	5	83.41	3	83.02	2	82.00	2	81.66	3	80.79	3
PAN 3644	81.15	9												
Renoster	80.04	20	79.63	14			80.96	19					79.84	18
Sabie	79.36	22	78.98	20	81.87	19	81.37	15	80.40	16	80.07	17	79.17	20
SST 806	81.51	4	79.27	18	83.02	8	82.21	7	81.50	5	81.27	8	80.39	14
SST 8125					82.47	14	81.31	17						
SST 8134							80.99	18						
SST 8135	80.92	14	80.18	8	82.81	9	81.52	13	81.36	10	81.30	7	80.55	9
SST 8154	82.21	1	80.80	1	83.63	1					82.21	1	81.51	1
SST 8155					81.47	20								
SST 8156	81.72	2	79.35	17									80.54	11
SST 835	81.45	5	79.63	14	83.14	6	81.38	14	81.40	8	81.41	6	80.54	10
SST 843	81.64	3	80.73	3	83.61	2	83.87	1	82.46	1	81.99	2	81.19	2
SST 866	81.18	8	79.63	14	82.63	12	82.30	6	81.44	6	81.15	11	80.41	13
SST 867							80.50	21						
SST 875	81.36	7	79.96	10	82.41	16	81.67	12	81.35	12	81.24	9	80.66	7
SST 877					82.16	18	79.76	23						
SST 884	80.55	17	80.77	2	82.36	17	81.73	11	81.35	11	81.23	10	80.66	7
SST 895	81.42	6	80.12	9	83.25	4	81.98	9	81.69	4	81.60	4	80.77	5
Mean	**80.92**		**79.96**		**82.75**		**81.68**		**81.42**		**81.27**		**80.45**	
LSD$_t$(0,05)	**0.62**		**1.01**		**0.54**		**0.54**		**0.36**		**0.41**		**0.59**	

Cooler Central Irrigation Area (later planting)
Average protein content (%) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Buffels							13.21	13						
Duzi	11.89	4	12.27	2	12.40	3	13.17	15	12.43	3	12.19	3	12.08	3
Koedoes	11.90	3	11.98	8			13.49	5					11.94	4
Krokodil	10.85	22	11.56	20	11.44	20	11.75	23	11.40	16	11.28	17	11.21	20
PAN 3400	11.71	9	11.94	10	12.27	7	13.27	11	12.30	6	11.97	5	11.83	8
PAN 3471	11.38	16	11.80	14	11.95	15	13.06	18	12.05	12	11.71	14	11.59	16
PAN3497	11.44	12	11.61	18	12.09	11	13.19	14	12.08	11	11.71	13	11.53	17
PAN 3515	11.13	20	11.63	17	11.69	19	12.79	21	11.81	14	11.48	15	11.38	18
PAN 3541	11.33	19												
PAN 3623	12.18	2	12.29	1	12.95	2	13.71	2	12.78	2	12.47	2	12.24	2
PAN 3644	11.43	13												
Renoster	11.87	5	11.93	11			12.80	20					11.90	5
Sabie	11.76	6	11.77	15	12.38	4	13.52	4	12.36	5	11.97	6	11.77	10
SST 806	11.43	13	11.81	13	12.02	14	13.34	9	12.15	10	11.75	11	11.62	15
SST 8125					12.13	10	13.13	16						
SST 8134							13.39	7						
SST 8135	11.55	10	12.13	3	12.14	9	13.35	8	12.29	7	11.94	7	11.84	6
SST 8154	11.73	7	11.71	16	12.28	6					11.91	8	11.72	11
SST 8155					11.90	16								
SST 8156	11.46	11	12.13	3									11.80	9
SST 835	11.37	17	12.07	7	12.03	13	13.30	10	12.19	8	11.82	10	11.72	12
SST 843	13.07	1	12.12	5	13.65	1	14.40	1	13.31	1	12.95	1	12.60	1
SST 866	11.04	21	11.59	19	11.70	18	12.79	21	11.78	15	11.44	16	11.32	19
SST 867							13.62	3						
SST 875	11.34	18	12.09	6	11.73	17	12.93	19	12.02	13	11.72	12	11.72	13
SST 877					12.08	12	13.09	17						
SST 884	11.42	15	11.93	11	12.15	8	13.25	12	12.19	9	11.83	9	11.68	14
SST 895	11.73	7	11.95	9	12.37	5	13.44	6	12.37	4	12.02	4	11.84	6
Mean	**11.59**		**11.92**		**12.17**		**13.22**		**12.22**		**11.89**		**11.76**	
LSD$_t$(0,05)	**0.42**		**0.50**		**0.30**		**0.30**		**0.20**		**0.23**		**0.33**	

Cooler Central Irrigation Area (later planting)
Average falling number (s) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Buffels							342	21						
Duzi	347	16	365	2	354	16	343	18	352	11	355	12	356	12
Koedoes	352	11	363	10			350	12					357	9
Krokodil	318	22	337	20	329	20	335	23	330	16	328	17	328	20
PAN 3400	343	18	362	12	351	17	347	15	351	13	352	14	353	15
PAN 3471	349	14	365	6	358	13	363	5	359	7	357	11	357	10
PAN3497	339	20	353	19	358	13	346	16	349	14	350	15	346	19
PAN 3515	344	17	353	18	348	18	343	19	347	15	348	16	349	17
PAN 3541	354	9												
PAN 3623	361	4	358	17	363	7	372	1	363	1	361	6	359	7
PAN 3644	373	1												
Renoster	333	21	361	14			348	13					347	18
Sabie	342	19	362	13	356	15	348	13	352	12	354	13	352	16
SST 806	363	3	365	2	373	2	352	11	363	3	367	1	364	2
SST 8125					375	1	364	4						
SST 8134							369	2						
SST 8135	348	15	363	11	362	10	353	10	357	10	358	10	355	13
SST 8154	352	12	365	2	359	12					358	8	358	8
SST 8155					363	8								
SST 8156	366	2	365	2									366	1
SST 835	355	7	365	7	371	3	354	9	361	4	364	2	360	6
SST 843	354	8	367	1	367	5	365	3	363	2	362	3	360	5
SST 866	352	10	361	15	361	11	359	7	358	8	358	9	356	11
SST 867							339	22						
SST 875	349	13	361	16	369	4	357	8	359	6	360	7	355	14
SST 877					339	19	344	17						
SST 884	359	5	364	9	363	9	359	6	361	5	362	5	361	3
SST 895	358	6	364	8	364	6	342	20	357	9	362	4	361	4
Mean	**350**		**361**		**359**		**352**		**355**		**356**		**355**	
LSD$_t$(0,05)	**11.87**		**7.52**		**7.30**		**13.45**		**5.00**		**5.20**		**7.06**	

Warmer Northern Irrigation Area (earlier planting)
Average yield (ton/ha) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Buffels							7.17	21						
Duzi	8.58	16	8.61	6	7.20	11	7.54	18	7.98	9	8.13	10	8.59	11
Koedoes	9.52	6	7.85	11			8.18	11					8.69	10
Krokodil	9.85	2	7.75	12	8.14	1	7.95	15	8.42	5	8.58	4	8.80	7
PAN 3400	8.86	13	8.72	2	7.29	8	8.52	3	8.35	6	8.29	7	8.79	9
PAN 3471	8.57	17	7.69	14	6.50	20	7.84	17	7.65	13	7.59	14	8.13	15
PAN3497	7.61	22	7.55	15	6.90	15	8.26	10	7.58	14	7.35	15	7.58	18
PAN 3515	8.27	20	6.85	20	6.78	18	8.14	12	7.51	15	7.30	16	7.56	20
PAN 3541	8.80	14												
PAN 3623	9.73	3	8.67	4	7.79	3	8.32	9	8.63	2	8.73	2	9.20	2
PAN 3644	9.45	8												
Renoster	8.90	11	8.71	3			7.96	14					8.81	6
Sabie	7.75	21	7.40	18	6.73	19	6.93	22	7.20	16	7.29	17	7.58	19
SST 806	8.44	18	7.50	17	7.21	10	8.45	6	7.90	11	7.71	12	7.97	16
SST 8125					7.00	14	7.98	13						
SST 8134							8.37	7						
SST 8135	9.11	9	8.48	7	7.27	9	8.36	8	8.30	7	8.28	8	8.79	8
SST 8154	9.85	1	7.97	9	7.09	12					8.30	6	8.91	5
SST 8155					6.90	16								
SST 8156	8.87	12	7.51	16									8.19	14
SST 835	8.34	19	7.40	19	7.04	13	8.47	5	7.81	12	7.59	13	7.87	17
SST 843	8.71	15	7.96	10	7.60	6	7.50	19	7.94	10	8.09	11	8.34	13
SST 866	9.04	10	7.75	13	7.68	4	7.89	16	8.09	8	8.15	9	8.39	12
SST 867							6.85	23						
SST 875	9.52	7	8.62	5	7.62	5	8.48	4	8.56	3	8.59	3	9.07	3
SST 877					6.85	17	7.45	20						
SST 884	9.57	5	8.89	1	8.01	2	8.59	2	8.76	1	8.82	1	9.23	1
SST 895	9.71	4	8.26	8	7.57	7	8.63	1	8.54	4	8.51	5	8.99	4
Mean	**8.96**		**8.01**		**7.26**		**7.99**		**8.08**		**8.08**		**8.47**	
LSD (0,05)	**0.43**		**0.44**		**0.33**		**0.23**		**0.18**		**0.24**		**0.31**	

Warmer Northern Irrigation Area (earlier planting)
Average hectolitre mass (kg/hl) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Buffels							79.99	21						
Duzi	79.31	16	80.09	12	79.15	13	80.67	15	79.81	11	79.52	12	79.70	14
Koedoes	79.56	12	80.47	6			81.67	4					80.02	10
Krokodil	79.04	18	80.24	11	79.67	6	80.81	13	79.94	10	79.65	11	79.64	16
PAN 3400	79.15	17	80.44	7	78.88	14	80.75	14	79.81	11	79.49	13	79.80	12
PAN 3471	80.34	6	80.89	2	80.27	1	81.65	5	80.79	1	80.50	1	80.62	1
PAN3497	78.56	19	80.77	3	79.80	3	81.24	8	80.09	7	79.71	10	79.67	15
PAN 3515	79.54	13	79.44	19	79.37	11	80.85	12	79.80	13	79.45	14	79.49	17
PAN 3541	79.47	14												
PAN 3623	79.75	11	80.57	4	80.18	2	81.57	6	80.52	5	80.17	2	80.16	8
PAN 3644	80.48	4												
Renoster	78.33	20	79.51	18			80.09	19					78.92	18
Sabie	77.31	21	78.97	20	78.83	15	80.16	18	78.82	16	78.37	16	78.14	19
SST 806	80.98	1	79.89	14	79.55	8	81.74	3	80.54	3	80.14	3	80.44	3
SST 8125					78.73	17	80.46	17						
SST 8134							78.87	23						
SST 8135	75.32	22	80.35	10	79.30	12	81.36	7	79.08	15	78.32	17	77.84	20
SST 8154	79.46	15	81.19	1	79.65	7					80.10	4	80.33	5
SST 8155					78.47	19								
SST 8156	80.83	2	80.38	9									80.61	2
SST 835	80.66	3	79.59	17	79.77	4	81.21	9	80.31	6	80.01	7	80.13	9
SST 843	80.12	8	80.49	5	79.68	5	82.58	1	80.72	2	80.10	5	80.31	6
SST 866	79.84	9	79.85	15	79.53	9	80.66	16	79.97	9	79.74	8	79.85	11
SST 867							80.06	20						
SST 875	80.31	7	80.06	13	78.80	16	81.09	10	80.07	8	79.72	9	80.19	7
SST 877					78.70	18	79.00	22						
SST 884	79.81	10	79.63	16	78.32	20	80.92	11	79.67	14	79.25	15	79.72	13
SST 895	80.39	5	80.41	8	79.43	10	81.84	2	80.52	4	80.08	6	80.40	4
Mean	**79.48**		**80.16**		**79.30**		**80.84**		**80.03**		**79.67**		**79.80**	
LSD$_t$(0,05)	**3.11**		**0.92**		**1.03**		**0.60**		**0.81**		**1.16**		**1.49**	

Warmer Northern Irrigation Area (earlier planting)
Average protein content (%) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Buffels							12.07	3						
Duzi	10.64	6	11.51	5	12.09	19	11.82	10	11.52	8	11.41	11	11.08	6
Koedoes	11.42	2	11.59	3			11.99	6					11.51	2
Krokodil	10.28	21	10.87	19	12.19	18	10.70	23	11.01	16	11.11	17	10.58	20
PAN 3400	10.35	18	11.17	13	13.16	2	12.01	4	11.67	5	11.56	6	10.76	15
PAN 3471	10.42	15	11.34	8	12.69	6	11.48	16	11.48	9	11.48	9	10.88	9
PAN3497	10.22	22	11.01	17	12.21	17	12.01	4	11.36	12	11.15	16	10.62	18
PAN 3515	10.38	16	10.84	20	12.34	16	11.40	19	11.24	14	11.19	15	10.61	19
PAN 3541	10.57	10												
PAN 3623	10.67	5	11.46	6	12.48	12	12.21	2	11.71	3	11.54	7	11.07	7
PAN 3644	10.45	14												
Renoster	10.33	19	11.18	12			11.26	20					10.76	17
Sabie	10.47	13	11.40	7	13.03	3	11.96	7	11.72	2	11.63	4	10.94	8
SST 806	10.38	16	11.33	9	12.59	10	11.57	15	11.47	10	11.43	10	10.86	12
SST 8125					12.45	13	11.45	17						
SST 8134							11.75	11						
SST 8135	10.64	6	11.11	15	12.72	5	11.64	13	11.53	7	11.49	8	10.88	10
SST 8154	10.77	4	11.71	2	12.76	4					11.75	2	11.24	3
SST 8155					12.40	14								
SST 8156	10.57	10	11.12	14									10.85	13
SST 835	10.59	9	11.58	4	12.59	10	11.44	18	11.55	6	11.59	5	11.09	5
SST 843	12.17	1	12.08	1	13.90	1	13.34	1	12.87	1	12.72	1	12.13	1
SST 866	10.61	8	11.11	15	12.09	19	11.12	22	11.23	15	11.27	14	10.86	11
SST 867							11.94	8						
SST 875	10.29	20	11.28	10	12.65	8	11.21	21	11.36	13	11.41	12	10.79	14
SST 877					12.38	15	11.58	14						
SST 884	10.57	10	10.95	18	12.64	9	11.65	12	11.45	11	11.39	13	10.76	15
SST 895	11.07	3	11.21	11	12.67	7	11.84	9	11.70	4	11.65	3	11.14	4
Mean	**10.63**		**11.29**		**12.60**		**11.71**		**11.55**		**11.52**		**10.97**	
LSD$_t$(0,05)	**0.51**		**0.48**		**0.72**		**0.45**		**0.26**		**0.32**		**0.36**	

Warmer Northern Irrigation area (earlier planting)
Average falling number (s) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Buffels							352	14						
Duzi	336	9	345	19	318	6	352	15	338	8	333	9	340	13
Koedoes	340	8	359	9			365	2					350	7
Krokodil	313	21	302	20	274	20	312	23	300	16	297	17	308	20
PAN 3400	335	11	357	12	300	16	356	10	337	9	330	11	346	10
PAN 3471	320	19	353	14	307	14	355	11	333	12	326	15	336	17
PAN3497	323	17	349	17	307	13	360	5	335	11	327	14	336	16
PAN 3515	326	15	352	15	304	15	344	20	332	14	327	12	339	14
PAN 3541	343	7												
PAN 3623	319	20	357	13	296	19	354	12	331	15	324	16	338	15
PAN 3644	356	1												
Renoster	295	22	351	16			330	22					323	19
Sabie	323	18	346	18	313	11	349	17	333	13	327	13	334	18
SST 806	346	5	360	8	332	1	363	4	350	1	346	2	353	5
SST 8125					315	9	357	8						
SST 8134							357	9						
SST 8135	336	10	365	3	296	18	363	3	340	7	332	10	350	6
SST 8154	325	16	358	11	320	5					335	7	342	12
SST 8155					320	4								
SST 8156	356	2	362	6									359	1
SST 835	331	13	362	5	317	8	359	7	342	6	337	6	346	9
SST 843	348	3	367	2	324	2	351	16	347	3	346	1	357	3
SST 866	344	6	364	4	323	3	353	13	346	4	344	3	354	4
SST 867							344	20						
SST 875	328	14	361	7	311	12	345	19	336	10	333	8	345	11
SST 877					299	17	346	18						
SST 884	334	12	359	10	318	7	359	6	342	5	337	5	346	8
SST 895	348	4	368	1	314	10	368	1	349	2	343	4	358	2
Mean	**333**		**355**		**310**		**352**		**337**		**332**		**343**	
LSD$_t$(0,05)	**22.38**		**13.00**		**21.00**		**10.71**		**8.21**		**10.90**		**12.30**	

Warmer Northern Irrigation Area (later planting)
Average yield (ton/ha) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Buffels							7.11	20						
Duzi	8.00	6	6.84	15	7.86	4	7.75	13	7.61	8	7.57	9	7.42	10
Koedoes	7.91	10	6.44	19			7.95	6					7.17	18
Krokodil	7.75	12	6.84	16	7.45	12	8.36	2	7.60	9	7.35	13	7.30	13
PAN 3400	8.13	5	7.32	10	8.22	1	8.41	1	8.02	3	7.89	3	7.73	7
PAN 3471	7.59	16	7.02	13	7.67	8	7.86	9	7.54	11	7.43	11	7.31	12
PAN3497	7.04	21	7.42	8	7.38	16	7.84	10	7.42	12	7.28	14	7.23	17
PAN 3515	7.71	15	6.76	18	7.31	17	7.52	17	7.33	14	7.26	15	7.24	16
PAN 3541	7.76	11												
PAN 3623	7.99	7	7.30	11	8.00	3	7.76	12	7.76	5	7.76	5	7.64	9
PAN 3644	7.92	9												
Renoster	7.24	19	7.30	12			8.03	5					7.27	14
Sabie	6.84	22	6.79	17	7.12	19	6.92	22	6.92	16	6.92	17	6.82	20
SST 806	7.58	17	7.96	3	7.39	15	7.28	18	7.55	10	7.64	8	7.77	6
SST 8125					7.75	6	7.65	15						
SST 8134							7.92	7						
SST 8135	7.92	8	7.75	4	7.72	7	8.05	3	7.86	4	7.79	4	7.83	4
SST 8154	7.75	13	6.94	14	7.75	5					7.48	10	7.34	11
SST 8155					7.55	11								
SST 8156	7.73	14	7.63	5									7.68	8
SST 835	7.08	20	7.45	7	7.57	10	7.55	16	7.41	13	7.37	12	7.26	15
SST 843	7.44	18	6.40	20	6.94	20	7.15	19	6.98	15	6.93	16	6.92	19
SST 866	8.17	4	7.41	9	7.42	14	7.71	14	7.68	7	7.67	7	7.79	5
SST 867							6.77	23						
SST 875	8.22	3	7.49	6	7.45	12	7.88	8	7.76	6	7.72	6	7.85	3
SST 877					7.23	18	6.99	21						
SST 884	8.40	1	8.28	1	7.63	9	7.79	11	8.02	2	8.10	2	8.34	1
SST 895	8.25	2	8.19	2	8.03	2	8.04	4	8.13	1	8.16	1	8.22	2
Mean	**7.75**		**7.28**		**7.57**		**7.66**		**7.60**		**7.55**		**7.51**	
LSD$_t$(0,05)	**0.40**		**0.42**		**0.35**		**0.23**		**0.18**		**0.23**		**0.30**	

Warmer Northern Irrigation Area (later planting)
Average hectolitre mass (kg/hl) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Buffels							81.87	18						
Duzi	78.88	7	79.57	16	81.66	15	82.17	16	80.57	12	80.04	14	79.23	15
Koedoes	79.40	4	79.32	18			82.26	14					79.36	11
Krokodil	77.53	20	79.60	15	81.60	17	82.65	9	80.35	14	79.58	16	78.57	18
PAN 3400	78.67	11	79.92	14	81.94	11	83.05	5	80.90	9	80.18	12	79.30	13
PAN 3471	78.79	9	81.39	1	82.75	1	83.32	2	81.56	2	80.98	2	80.09	4
PAN3497	78.43	16	79.56	17	82.20	7	83.47	1	80.92	8	80.06	13	79.00	16
PAN 3515	77.83	19	80.14	13	80.96	20	82.18	15	80.28	15	79.64	15	78.99	17
PAN 3541	77.93	18												
PAN 3623	78.70	10	80.47	8	81.94	11	83.25	3	81.09	5	80.37	9	79.59	8
PAN 3644	78.47	14												
Renoster	76.59	22	78.63	20			81.12	21					77.61	20
Sabie	76.97	21	78.91	19	81.61	16	81.54	19	79.76	16	79.16	17	77.94	19
SST 806	78.95	6	81.28	2	82.30	6	83.14	4	81.42	3	80.84	4	80.12	3
SST 8125					82.20	7	82.33	12						
SST 8134							80.77	23						
SST 8135	78.67	11	80.47	8	82.01	10	82.83	8	81.00	6	80.38	7	79.57	9
SST 8154	79.42	3	81.05	3	82.46	5					80.98	2	80.24	2
SST 8155					81.34	19								
SST 8156	78.82	8	81.02	4									79.92	6
SST 835	77.98	17	80.56	7	82.51	3	82.31	13	80.84	11	80.35	10	79.27	14
SST 843	79.73	1	80.92	5	82.75	1	83.04	6	81.61	1	81.13	1	80.33	1
SST 866	78.47	14	80.17	12	82.50	4	82.34	11	80.87	10	80.38	8	79.32	12
SST 867							82.95	7						
SST 875	79.58	2	80.24	11	81.94	11	81.96	17	80.93	7	80.59	6	79.91	7
SST 877					81.51	18	81.41	20						
SST 884	78.55	13	80.30	10	81.85	14	81.11	22	80.45	13	80.23	11	79.43	10
SST 895	79.28	5	80.83	6	82.20	7	82.38	10	81.17	4	80.77	5	80.06	5
Mean	**78.53**		**80.22**		**82.01**		**82.32**		**80.86**		**80.33**		**79.39**	
LSD_t(0,05)	**1.00**		**1.25**		**0.75**		**0.68**		**0.52**		**0.66**		**0.88**	

Warmer Northern Irrigation Area (later planting)
Average protein content (%) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Buffels							13.11	3						
Duzi	12.87	4	12.75	4	11.93	14	12.78	10	12.58	5	12.52	5	12.81	4
Koedoes	12.40	19	13.13	2			12.85	6					12.77	5
Krokodil	11.95	22	12.04	20	11.48	20	11.75	23	11.81	16	11.82	17	12.00	20
PAN 3400	12.60	13	12.56	9	12.25	5	12.84	7	12.56	6	12.47	8	12.58	12
PAN 3471	12.60	13	12.30	14	12.03	12	12.47	19	12.35	12	12.31	11	12.45	14
PAN3497	12.47	16	12.25	16	12.10	10	12.76	12	12.40	11	12.27	13	12.36	17
PAN 3515	12.08	21	12.22	17	11.71	16	12.11	22	12.03	15	12.00	16	12.15	19
PAN 3541	12.72	8												
PAN 3623	12.93	3	12.92	3	12.45	2	12.89	5	12.80	2	12.77	3	12.93	3
PAN 3644	12.44	17												
Renoster	12.76	7	12.53	11			12.46	20					12.65	8
Sabie	12.87	4	12.58	8	12.39	4	12.83	9	12.67	3	12.61	4	12.73	6
SST 806	12.72	8	12.50	12	12.22	6	12.68	14	12.53	8	12.48	7	12.61	10
SST 8125					11.72	15	12.59	17						
SST 8134							12.84	7						
SST 8135	12.63	11	12.26	15	12.09	11	12.63	16	12.40	9	12.33	10	12.45	15
SST 8154	13.23	2	12.68	5	12.43	3					12.78	2	12.96	2
SST 8155					11.54	19								
SST 8156	12.67	10	12.62	6									12.65	8
SST 835	12.58	15	12.61	7	12.21	7	12.74	13	12.54	7	12.47	9	12.60	11
SST 843	14.16	1	13.85	1	13.06	1	13.92	1	13.75	1	13.69	1	14.01	1
SST 866	12.17	20	12.18	19	11.70	17	12.51	18	12.14	14	12.02	15	12.18	18
SST 867							13.19	2						
SST 875	12.62	12	12.21	18	11.64	18	12.24	21	12.18	13	12.16	14	12.42	16
SST 877					12.18	8	12.78	10						
SST 884	12.43	18	12.56	9	11.94	13	12.68	14	12.40	10	12.31	11	12.50	13
SST 895	12.83	6	12.50	12	12.18	8	12.92	4	12.61	4	12.50	6	12.67	7
Mean	**12.67**		**12.56**		**12.06**		**12.72**		**12.48**		**12.44**		**12.62**	
$LSD_t(0,05)$	**0.57**		**0.42**		**0.43**		**0.36**		**0.22**		**0.27**		**0.34**	

Warmer Northern Irrigation Area (later planting)
Average falling number (s) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Buffels							367	15						
Duzi	300	21	303	18	360	9	371	11	333	15	321	16	301	19
Koedoes	311	19	316	16			371	8					314	17
Krokodil	286	22	293	20	323	20	346	23	312	16	301	17	290	20
PAN 3400	337	7	325	11	348	17	367	16	344	9	337	9	331	9
PAN 3471	317	17	327	10	351	16	380	1	344	10	331	14	322	14
PAN3497	324	14	319	15	366	3	361	18	342	12	336	10	321	16
PAN 3515	332	11	315	17	351	15	355	21	338	14	333	13	323	12
PAN 3541	327	12												
PAN 3623	352	1	321	14	361	6	379	2	353	2	345	4	336	4
PAN 3644	343	2												
Renoster	306	20	299	19			364	17					302	18
Sabie	323	15	322	13	357	12	360	19	341	13	334	12	323	13
SST 806	338	4	336	3	373	1	369	14	354	1	349	1	337	2
SST 8125					369	2	377	3						
SST 8134							374	4						
SST 8135	338	6	331	9	355	13	371	10	348	7	341	6	334	8
SST 8154	325	13	324	12	345	18					331	15	325	11
SST 8155					362	5								
SST 8156	335	8	339	2									337	3
SST 835	339	3	342	1	360	8	371	9	353	3	347	2	341	1
SST 843	338	5	334	5	361	6	373	5	351	5	344	5	336	5
SST 866	332	10	336	4	354	14	373	5	349	6	341	7	334	7
SST 867							352	22						
SST 875	335	9	334	5	366	4	372	7	352	4	345	3	334	6
SST 877					333	19	357	20						
SST 884	312	18	332	8	359	10	370	12	343	11	334	11	322	15
SST 895	319	16	334	7	358	11	370	13	345	8	337	8	326	10
Mean	**326**		**324**		**356**		**367**		**344**		**336**		**324**	
LSD_t(0,05)	**20.81**		**11.82**		**12.73**		**10.12**		**6.59**		**8.11**		**10.75**	

Highveld Irrigation Area (earlier planting)
Average yield (ton/ha) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Buffels							6.95	23						
Duzi	8.16	6	6.83	14	6.67	17	8.17	19	7.46	14	7.22	13	7.49	12
Koedoes	7.72	15	6.80	16			8.25	18					7.26	18
Krokodil	7.54	20	7.19	10	6.85	15	8.66	10	7.56	12	7.19	15	7.36	15
PAN 3400	7.74	14	7.70	3	7.33	4	8.36	16	7.78	7	7.59	5	7.72	7
PAN 3471	7.99	11	7.86	1	7.34	3	8.48	15	7.92	3	7.73	3	7.92	3
PAN3497	7.37	21	7.52	7	8.38	1	9.51	1	8.19	1	7.76	1	7.45	14
PAN 3515	8.11	9	7.48	8	7.24	6	8.50	14	7.83	6	7.61	4	7.79	5
PAN 3541	8.92	1												
PAN 3623	7.96	12	7.04	12	6.94	12	9.02	4	7.74	9	7.32	10	7.50	11
PAN 3644	8.13	7												
Renoster	7.65	17	6.03	20			8.76	8					6.84	19
Sabie	7.56	18	6.98	13	6.89	13	8.10	21	7.38	15	7.15	16	7.27	17
SST 806	8.17	5	7.18	11	7.17	7	8.54	13	7.77	8	7.51	8	7.68	8
SST 8125					7.31	5	8.31	17						
SST 8134							9.26	2						
SST 8135	8.59	2	7.57	6	7.10	9	8.98	5	8.06	2	7.76	2	8.08	1
SST 8154	8.19	4	6.82	15	6.83	16					7.28	11	7.51	10
SST 8155					7.15	8								
SST 8156	7.69	16	7.79	2									7.74	6
SST 835	7.55	19	7.66	4	7.40	2	8.82	7	7.86	5	7.54	6	7.61	9
SST 843	7.03	22	6.24	19	6.64	19	8.12	20	7.01	16	6.64	17	6.64	20
SST 866	8.02	10	7.66	5	6.43	20	8.64	11	7.68	10	7.37	9	7.84	4
SST 867							8.88	6						
SST 875	7.96	13	6.59	18	7.05	10	8.72	9	7.58	11	7.20	14	7.28	16
SST 877					6.99	11	8.62	12						
SST 884	8.48	3	7.46	9	6.66	18	9.03	3	7.91	4	7.53	7	7.97	2
SST 895	8.13	8	6.80	17	6.89	14	8.05	22	7.47	13	7.27	12	7.46	13
Mean	**7.94**		**7.16**		**7.06**		**8.55**		**7.70**		**7.39**		**7.52**	
LSD_t(0,05)	**0.25**		**0.34**		**0.36**		**0.26**		**0.16**		**0.19**		**0.21**	

Highveld Irrigation Area (earlier planting)
Average hectolitre mass (kg/hl) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Buffels							81.64	20						
Duzi	81.34	19	78.94	16	81.28	12	80.88	23	80.61	16	80.52	14	80.14	17
Koedoes	81.85	13	79.09	15			83.47	14					80.47	14
Krokodil	80.85	20	78.53	19	80.69	16	83.19	16	80.82	15	80.02	17	79.69	19
PAN 3400	81.66	17	79.87	11	81.44	10	82.91	18	81.47	11	80.99	11	80.77	12
PAN 3471	83.22	1	81.02	5	82.31	2	84.40	5	82.74	2	82.18	2	82.12	2
PAN3497	83.16	2	81.65	1	83.33	1	83.72	11	82.97	1	82.71	1	82.41	1
PAN 3515	82.50	7	79.93	10	81.17	14	83.68	12	81.82	9	81.20	10	81.22	9
PAN 3541	82.71	4												
PAN 3623	81.84	14	78.93	17	80.11	18	84.50	4	81.35	12	80.29	15	80.39	15
PAN 3644	81.54	18												
Renoster	78.81	22	77.18	20			81.59	21					78.00	20
Sabie	80.48	21	79.72	12	81.78	6	81.47	22	80.86	14	80.66	13	80.10	18
SST 806	82.45	8	81.14	3	82.28	3	84.79	2	82.67	4	81.96	4	81.80	4
SST 8125					81.25	13	83.92	8						
SST 8134							83.05	17						
SST 8135	82.59	6	81.55	2	82.17	4	84.51	3	82.71	3	82.10	3	82.07	3
SST 8154	81.74	16	79.22	14	81.81	5					80.92	12	80.48	13
SST 8155														
SST 8156	82.65	5	80.77	6	80.66	17							81.71	5
SST 835	82.29	10	81.08	4	81.56	9	84.36	6	82.32	5	81.64	5	81.69	6
SST 843	81.83	15	80.12	9	81.75	7	85.01	1	82.18	6	81.23	9	80.98	11
SST 866	82.39	9	80.24	8	81.09	15	82.41	19	81.53	10	81.24	8	81.32	8
SST 867							83.66	13						
SST 875	82.01	11	80.77	6	81.62	8	83.85	9	82.06	7	81.47	6	81.39	7
SST 877					79.91	19	83.28	15						
SST 884	82.01	11	78.57	18	79.60	20	83.77	10	80.99	13	80.06	16	80.29	16
SST 895	82.96	3	79.42	13	81.40	11	83.99	7	81.94	8	81.26	7	81.19	10
Mean	**81.95**		**79.89**		**81.36**		**83.39**		**81.81**		**81.20**		**80.91**	
LSD$_t$(0,05)	**1.25**		**0.61**		**0.82**		**1.39**		**0.53**		**0.53**		**0.78**	

Highveld Irrigation Area (earlier planting)
Average protein content (%) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Buffels							11.64	7						
Duzi	12.25	2	12.10	7	13.49	10	11.38	16	12.31	4	12.61	4	12.18	2
Koedoes	12.10	3	12.24	5			11.61	9					12.17	3
Krokodil	11.26	20	11.70	18	12.56	20	10.73	23	11.56	16	11.84	17	11.48	20
PAN 3400	11.90	7	11.90	16	13.25	14	11.60	10	12.16	6	12.35	7	11.90	8
PAN 3471	11.55	10	11.99	12	13.23	15	11.25	19	12.01	11	12.26	12	11.77	11
PAN3497	11.04	21	12.05	9	12.79	18	11.73	6	11.90	15	11.96	16	11.55	19
PAN 3515	11.34	18	12.06	8	13.05	17	11.30	18	11.94	14	12.15	14	11.70	15
PAN 3541	11.03	22												
PAN 3623	11.95	5	12.04	11	13.95	2	12.08	3	12.51	2	12.65	3	12.00	5
PAN 3644	11.34	18												
Renoster	11.69	8	12.05	9			11.56	12					11.87	9
Sabie	11.55	10	11.60	20	13.53	9	11.87	4	12.14	8	12.23	13	11.58	18
SST 806	11.56	9	12.25	4	13.56	8	11.62	8	12.25	5	12.46	5	11.91	7
SST 8125					13.42	11	11.14	22						
SST 8134							11.86	5						
SST 8135	11.42	16	12.15	6	13.36	12	11.58	11	12.13	9	12.31	10	11.79	10
SST 8154	12.00	4	12.34	3	13.92	3					12.75	2	12.17	3
SST 8155					12.72	19								
SST 8156	11.54	13	12.39	2									11.97	6
SST 835	11.52	14	11.94	14	13.36	12	11.18	20	12.00	12	12.27	11	11.73	13
SST 843	13.59	1	12.57	1	15.07	1	13.45	1	13.67	1	13.74	1	13.08	1
SST 866	11.41	17	11.92	15	13.72	5	11.18	20	12.06	10	12.35	7	11.67	16
SST 867							11.45	14						
SST 875	11.55	10	11.76	17	13.11	16	11.41	15	11.96	13	12.14	15	11.66	17
SST 877					13.79	4	11.35	17						
SST 884	11.44	15	11.98	13	13.62	6	11.52	13	12.14	7	12.35	9	11.71	14
SST 895	11.91	6	11.63	19	13.61	7	12.20	2	12.34	3	12.38	6	11.77	11
Mean	**11.68**		**12.03**		**13.46**		**11.60**		**12.19**		**12.40**		**11.88**	
LSD$_t$(0,05)	**0.51**		**0.77**		**0.43**		**0.60**		**0.30**		**0.35**		**0.45**	

Highveld Irrigation Area (earlier planting)
Average falling number (s) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Buffels							325	12						
Duzi	358	19	237	15	281	18	311	20	297	14	292	15	297	15
Koedoes	370	10	244	10			331	6					307	10
Krokodil	329	22	199	18	239	19	305	22	268	16	256	17	264	20
PAN 3400	371	9	273	1	320	7	303	23	316	7	321	4	322	4
PAN 3471	360	17	216	17	304	12	310	21	297	13	293	14	288	17
PAN3497	354	20	238	14	317	8	325	12	309	9	303	9	296	16
PAN 3515	358	18	256	6	284	17	316	17	304	12	299	13	307	9
PAN 3541	370	12												
PAN 3623	368	13	194	19	238	20	325	11	281	15	267	16	281	18
PAN 3644	377	6												
Renoster	339	21	190	20			313	19					264	19
Sabie	364	15	248	8	303	14	329	7	311	8	305	8	306	12
SST 806	379	5	253	7	340	1	338	2	327	2	324	3	316	6
SST 8125					315	10	324	14						
SST 8134							316	18						
SST 8135	366	14	239	13	299	15	319	15	306	11	301	11	303	13
SST 8154	360	16	235	16	311	11					302	10	297	14
SST 8155					303	13								
SST 8156	387	1	267	3									327	1
SST 835	376	7	260	5	321	5	337	4	323	4	319	5	318	5
SST 843	382	4	242	11	321	6	331	5	319	6	315	6	312	7
SST 866	385	2	267	4	328	3	326	10	327	3	327	2	326	3
SST 867							328	8						
SST 875	370	10	246	9	326	4	337	3	320	5	314	7	308	8
SST 877					317	9	319	16						
SST 884	373	8	240	12	288	16	327	9	307	10	301	12	307	11
SST 895	383	3	270	2	333	2	342	1	332	1	329	1	327	2
Mean	**367**		**241**		**304**		**323**		**309**		**304**		**304**	
LSD (0,05)	**12.33**		**25.73**		**26.73**		**16.47**		**10.36**		**12.54**		**13.04**	

Highveld Irrigation Area (later planting)
Average yield (ton/ha) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Buffels							5.62	22						
Duzi	8.31	18	9.40	14	7.41	16	5.41	23	7.63	15	8.37	15	8.86	16
Koedoes	9.38	3	9.78	7			6.53	8					9.58	3
Krokodil	8.44	16	9.82	6	8.57	2	6.61	5	8.36	5	8.94	5	9.13	10
PAN 3400	8.82	11	10.20	2	7.79	14	6.58	6	8.35	6	8.93	6	9.51	5
PAN 3471	8.12	21	9.93	3	8.04	7	6.05	16	8.03	9	8.69	10	9.02	13
PAN3497	8.22	19	9.74	8	7.54	15	6.04	17	7.89	11	8.50	11	8.98	15
PAN 3515	8.12	20	9.27	15	7.81	12	6.06	14	7.82	13	8.40	14	8.70	19
PAN 3541	9.20	5												
PAN 3623	8.80	12	9.41	13	9.38	1	6.93	2	8.63	2	9.20	2	9.11	11
PAN 3644	8.47	15												
Renoster	9.12	7	9.26	16			6.49	10					9.19	9
Sabie	7.23	22	8.76	20	7.85	11	6.01	19	7.46	16	7.95	17	8.00	20
SST 806	9.34	4	9.66	9	8.08	5	6.70	3	8.44	3	9.03	4	9.50	6
SST 8125					8.04	6	6.02	18						
SST 8134							6.54	7						
SST 8135	8.97	9	9.47	12	7.90	10	6.61	3	8.24	7	8.78	8	9.22	8
SST 8154	8.87	10	9.82	5	7.79	13					8.83	7	9.35	7
SST 8155					6.73	20								
SST 8156	9.15	6	9.87	4									9.51	4
SST 835	8.48	14	9.54	10	8.22	4	6.51	9	8.19	8	8.75	9	9.01	14
SST 843	9.05	8	9.12	17	7.06	19	6.39	12	7.90	10	8.41	13	9.08	12
SST 866	8.53	13	8.99	19	7.33	17	6.06	15	7.72	14	8.28	16	8.76	17
SST 867							6.33	13						
SST 875	8.40	17	9.11	18	7.93	9	6.01	20	7.86	12	8.48	12	8.75	18
SST 877					7.21	18	5.81	21						
SST 884	9.72	1	9.47	11	7.94	8	6.39	11	8.38	4	9.04	3	9.60	2
SST 895	9.59	2	10.22	1	8.32	3	6.95	1	8.77	1	9.38	1	9.91	1
Mean	**8.74**		**9.54**		**7.85**		**6.29**		**8.10**		**8.70**		**9.14**	
LSD$_t$(0,05)	**0.41**		**0.50**		**0.45**		**0.21**		**0.20**		**0.27**		**0.32**	

Highveld Irrigation Area (later planting)
Average hectolitre mass (kg/hl) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Buffels							80.28	22						
Duzi	79.62	19	77.08	19	78.48	12	80.47	19	78.91	15	78.39	16	78.35	18
Koedoes	80.91	6	77.19	18			81.93	8					79.05	12
Krokodil	79.72	18	77.92	13	78.16	14	81.63	12	79.36	12	78.60	12	78.82	16
PAN 3400	80.17	17	77.92	13	77.53	17	82.03	7	79.41	11	78.54	13	79.05	13
PAN 3471	81.26	3	78.57	7	80.15	2	82.49	4	80.62	3	79.99	1	79.92	5
PAN3497	80.61	11	78.81	5	79.51	6	81.39	14	80.08	8	79.64	7	79.71	7
PAN 3515	78.66	21	78.18	11	78.34	13	80.83	16	79.00	14	78.39	15	78.42	17
PAN 3541	80.75	8												
PAN 3623	80.66	9	77.41	16	79.64	4	82.86	2	80.14	7	79.24	9	79.04	14
PAN 3644	80.63	10												
Renoster	79.06	20	76.82	20			80.37	21					77.94	19
Sabie	77.74	22	77.82	15	77.20	19	78.28	23	77.76	16	77.59	17	77.78	20
SST 806	81.17	5	78.97	3	79.81	3	82.77	3	80.68	2	79.98	2	80.07	3
SST 8125					78.83	9	81.34	15						
SST 8134							80.56	18						
SST 8135	80.86	7	79.53	1	78.55	11	81.79	6	80.18	6	79.65	6	80.20	1
SST 8154	80.36	14	78.34	8	78.81	10					79.17	10	79.35	10
SST 8155					77.30	18								
SST 8156	81.33	2	78.94	4									80.14	2
SST 835	80.43	13	78.98	2	79.54	5	82.14	6	80.27	5	79.65	5	79.71	8
SST 843	81.24	4	78.25	9	80.30	1	83.06	1	80.71	1	79.93	3	79.75	6
SST 866	80.27	16	78.19	10	77.94	15	81.89	9	79.57	10	78.80	11	79.23	11
SST 867							81.63	12						
SST 875	80.34	15	78.62	6	79.06	8	81.71	11	79.93	9	79.34	8	79.48	9
SST 877					76.44	20	80.42	20						
SST 884	80.50	12	77.36	17	77.70	16	80.83	16	79.10	13	78.52	14	78.93	15
SST 895	81.81	1	78.09	12	79.35	7	82.37	5	80.41	4	79.75	4	79.95	4
Mean	**80.37**		**78.15**		**78.63**		**81.44**		**79.76**		**79.13**		**79.24**	
LSD$_t$(0,05)	**0.88**		**0.93**		**0.86**		**1.22**		**0.50**		**0.52**		**0.64**	

Highveld Irrigation Area (later planting)
Average protein content (%) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Buffels							13.68	10						
Duzi	12.72	4	10.93	5	12.62	5	13.87	6	12.53	3	12.09	3	11.83	4
Koedoes	12.74	3	11.00	4			13.97	4					11.87	3
Krokodil	11.59	22	10.29	20	11.39	20	12.79	22	11.52	16	11.09	17	10.94	20
PAN 3400	12.28	13	10.64	11	12.59	7	13.37	16	12.22	6	11.84	7	11.46	10
PAN 3471	12.50	7	10.41	19	12.35	11	13.35	17	12.15	10	11.75	10	11.46	11
PAN3497	12.22	14	10.50	17	12.59	6	13.46	14	12.19	8	11.77	9	11.36	16
PAN 3515	12.08	18	10.76	6	11.88	18	12.67	23	11.85	15	11.57	14	11.42	14
PAN 3541	12.13	16												
PAN 3623	12.88	2	11.01	3	13.06	2	13.77	9	12.68	2	12.32	2	11.95	2
PAN 3644	12.18	15												
Renoster	12.42	9	11.02	2			13.48	13					11.72	5
Sabie	12.62	5	10.66	10	12.58	8	14.21	2	12.52	4	11.95	4	11.64	6
SST 806	12.31	11	10.69	9	12.42	10	13.32	18	12.18	9	11.81	8	11.50	9
SST 8125					12.07	17	13.23	20						
SST 8134							13.65	11						
SST 8135	12.07	19	10.70	8	12.16	16	13.39	9	12.08	13	11.64	13	11.39	15
SST 8154	12.32	10	10.57	15	12.17	15					11.69	11	11.45	13
SST 8155					12.69	4								
SST 8156	12.31	11	10.60	13									11.46	11
SST 835	12.49	8	10.75	7	12.27	14	13.27	19	12.20	7	11.84	6	11.62	7
SST 843	13.86	1	11.40	1	13.45	1	14.97	1	13.42	1	12.90	1	12.63	1
SST 866	12.09	17	10.52	16	12.34	12	13.54	12	12.12	11	11.65	12	11.31	18
SST 867							13.91	5						
SST 875	12.04	20	10.64	11	11.70	19	13.19	21	11.89	14	11.46	16	11.34	17
SST 877					12.75	3	13.79	8						
SST 884	11.84	21	10.42	18	12.28	13	13.83	7	12.09	12	11.51	15	11.13	19
SST 895	12.58	6	10.59	14	12.55	9	14.00	3	12.43	5	11.91	5	11.59	8
Mean	**12.38**		**10.71**		**12.40**		**13.60**		**12.25**		**11.81**		**11.55**	
LSD_t(0,05)	**0.52**		**0.56**		**0.40**		**0.49**		**0.26**		**0.30**		**0.39**	

Highveld Irrigation Area (later planting)
Average falling number (s) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Buffels							299	20						
Duzi	323	20	271	17	319	9	303	17	304	15	304	16	297	18
Koedoes	340	12	293	13			309	11					317	14
Krokodil	287	22	234	20	284	19	291	23	274	16	268	17	260	20
PAN 3400	343	9	298	9	324	8	314	4	320	5	322	6	321	10
PAN 3471	342	10	293	14	319	10	313	9	317	9	318	10	317	12
PAN3497	340	11	300	8	317	12	305	16	316	10	319	8	320	11
PAN 3515	340	13	294	11	296	18	297	21	307	14	310	12	317	13
PAN 3541	336	16												
PAN 3623	358	2	256	19	303	17	313	6	308	12	306	15	307	16
PAN 3644	350	7												
Renoster	320	21	269	18			299	19					294	19
Sabie	337	15	273	16	317	12	301	18	307	13	309	13	305	17
SST 806	356	5	301	7	332	4	323	1	328	2	330	2	329	3
SST 8125					325	6	317	2						
SST 8134							310	10						
SST 8135	357	4	288	15	282	20	305	8	308	11	309	14	322	7
SST 8154	336	17	306	4	315	14					319	9	321	9
SST 8155					305	16								
SST 8156	347	8	310	3									328	4
SST 835	359	1	294	12	334	2	314	3	325	3	329	3	327	5
SST 843	335	18	311	2	318	11	313	7	319	6	321	7	323	6
SST 866	339	14	303	6	326	5	309	12	319	7	323	5	321	8
SST 867							305	13						
SST 875	325	19	296	10	332	3	314	5	317	8	318	11	310	15
SST 877					312	15	296	22						
SST 884	355	6	304	5	324	7	305	14	322	4	328	4	330	2
SST 895	358	2	311	1	336	1	313	8	329	1	335	1	334	1
Mean	**340**		**290**		**316**		**307**		**314**		**316**		**315**	
LSD$_t$(0,05)	**19.62**		**25.50**		**30.54**		**8.32**		**10.84**		**14.35**		**16.06**	

KwaZulu-Natal Irrigation Area
Average yield (ton/ha) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Buffels							4.35	23						
Duzi	7.01	16	7.28	8	6.82	8	5.24	17	6.59	8	7.04	8	7.14	9
Koedoes	6.54	20	7.12	12			5.52	12					6.83	16
Krokodil	7.88	1	7.28	7	6.68	12	5.77	5	6.91	3	7.28	3	7.58	3
PAN 3400	6.70	19	7.19	10	7.07	4	5.33	14	6.57	9	6.98	10	6.94	15
PAN 3471	7.20	10	7.04	14	6.65	13	5.33	15	6.55	10	6.96	11	7.12	11
PAN3497	6.43	21	6.67	20	5.95	17	5.13	18	6.05	15	6.35	16	6.55	19
PAN 3515	7.04	13	6.97	15	7.23	2	5.73	7	6.74	6	7.08	7	7.00	13
PAN 3541	7.33	7												
PAN 3623	7.31	8	7.22	9	6.81	9	5.69	8	6.76	5	7.11	6	7.26	7
PAN 3644	7.41	5												
Renoster	7.24	9	7.33	4			6.18	1					7.28	6
Sabie	6.05	22	6.79	17	5.52	20	4.85	21	5.80	16	6.12	17	6.42	20
SST 806	6.82	18	6.76	18	6.81	10	5.57	9	6.49	11	6.80	12	6.79	18
SST 8125					6.76	11	4.88	20						
SST 8134							6.00	4						
SST 8135	7.59	3	7.63	2	7.21	3	6.13	2	7.14	1	7.47	1	7.61	2
SST 8154	7.43	4	7.30	6	7.35	1					7.36	2	7.37	5
SST 8155					5.83	19								
SST 8156	7.19	11	7.06	13									7.12	10
SST 835	6.83	17	6.75	19	6.56	14	5.25	16	6.35	14	6.71	15	6.79	17
SST 843	7.04	14	6.93	16	6.20	16	5.37	13	6.39	13	6.72	14	6.98	14
SST 866	7.10	12	7.31	5	5.89	18	5.54	11	6.46	12	6.77	13	7.20	8
SST 867							4.36	22						
SST 875	7.63	2	7.86	1	6.26	15	5.75	6	6.88	4	7.25	4	7.74	1
SST 877					6.85	7	5.06	19						
SST 884	7.39	6	7.37	3	6.90	5	6.01	3	6.92	2	7.22	5	7.38	4
SST 895	7.03	15	7.13	11	6.86	6	5.54	10	6.64	7	7.00	9	7.08	12
Mean	**7.10**		**7.15**		**6.61**		**5.42**		**6.58**		**6.95**		**7.11**	
LSD (0,05)	**0.23**		**0.20**		**0.35**		**0.19**		**0.12**		**0.15**		**0.15**	

KwaZulu-Natal Irrigation Area
Average hectolitre mass (kg/hl) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Buffels							80.61	18						
Duzi	80.89	20	82.45	15	79.35	12	81.23	16	80.98	15	80.90	14	81.67	17
Koedoes	81.42	19	83.14	6			82.02	10					82.28	13
Krokodil	81.43	18	82.11	16	79.66	8	81.83	11	81.26	12	81.07	12	81.77	16
PAN 3400	81.53	16	82.81	9	78.34	16	81.38	15	81.02	14	80.89	15	82.17	15
PAN 3471	82.75	4	83.36	3	80.74	2	82.44	4	82.32	3	82.28	3	83.06	3
PAN3497	82.61	5							82.61	1	82.61	1	82.61	9
PAN 3515	81.45	17	81.47	18	79.99	5	82.07	8	81.25	13	80.97	13	81.46	18
PAN 3541	82.58	6												
PAN 3623	81.92	14	83.40	2	80.03	4	81.78	12	81.78	7	81.78	6	82.66	8
PAN 3644	82.26	10												
Renoster	79.97	21	81.24	19			80.36	20					80.61	19
Sabie	79.71	22	81.48	17	78.45	15	80.30	21	79.99	16	79.88	17	80.60	20
SST 806	83.04	2	82.80	10	80.10	3	83.19	1	82.28	4	81.98	4	82.92	4
SST 8125					79.62	10	82.15	6						
SST 8134							80.65	17						
SST 8135	82.57	7	83.07	7	76.84	19	82.56	3	81.26	11	80.83	16	82.82	5
SST 8154	82.20	11	82.97	8	79.85	7					81.67	7	82.59	10
SST 8155					78.34	16								
SST 8156	83.07	1	83.18	5									83.13	1
SST 835	82.83	3	82.57	14	79.59	11	82.61	2	81.90	6	81.66	8	82.70	7
SST 843	82.12	12	84.12	1	80.91	1	82.40	5	82.39	2	82.38	2	83.12	2
SST 866	82.51	8	82.61	13	79.22	13	81.55	14	81.47	9	81.45	10	82.56	11
SST 867							80.38	19						
SST 875	82.02	13	82.78	11	79.65	9	81.62	13	81.52	8	81.48	9	82.40	12
SST 877					78.23	18	79.52	22						
SST 884	81.69	15	82.73	12	78.82	14	82.12	7	81.34	10	81.08	11	82.21	14
SST 895	82.32	9	83.31	4	79.96	6	82.03	9	81.91	5	81.86	5	82.82	6
Mean	**81.95**		**82.72**		**79.35**		**81.58**		**81.58**		**81.46**		**82.31**	
LSD$_t$(0,05)	**0.63**		**0.68**		**2.23**		**0.65**		**0.59**		**0.70**		**0.48**	

KwaZulu-Natal Irrigation Area
Average protein content (%) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Buffels							15.34	2						
Duzi	11.73	17	12.75	5	12.46	10	14.49	12	12.86	7	12.31	9	12.24	9
Koedoes	11.77	15	12.78	4			14.57	10					12.28	8
Krokodil	11.06	22	11.76	20	11.67	20	13.81	23	12.08	16	11.50	17	11.41	20
PAN 3400	11.88	12	12.27	13	12.80	5	14.34	15	12.82	9	12.32	8	12.08	13
PAN 3471	11.72	18	12.24	14	12.45	12	14.26	16	12.67	11	12.14	12	11.98	17
PAN3497	11.65	19	12.11	18	12.26	17	14.24	17	12.57	13	12.01	15	11.88	18
PAN 3515	11.96	10	12.14	17	11.95	19	13.91	21	12.49	14	12.02	14	12.05	14
PAN 3541	11.79	14												
PAN 3623	12.46	2	12.93	2	13.15	3	14.69	7	13.31	2	12.85	2	12.70	2
PAN 3644	11.76	16												
Renoster	11.52	21	12.48	8			14.20	19					12.00	16
Sabie	11.97	9	12.34	11	12.86	4	15.18	4	13.09	4	12.39	7	12.16	11
SST 806	12.28	4	12.62	6	12.30	16	14.59	9	12.95	5	12.40	6	12.45	4
SST 8125					12.39	14	14.54	11						
SST 8134							14.69	7						
SST 8135	12.00	8	12.32	12	12.56	7	14.49	12	12.84	8	12.29	10	12.16	10
SST 8154	12.18	7	12.87	3	12.66	6					12.57	4	12.53	3
SST 8155					12.07	18								
SST 8156	12.28	4	12.47	9									12.38	6
SST 835	12.23	6	12.44	10	12.55	8	14.22	18	12.86	6	12.41	5	12.34	7
SST 843	13.95	1	13.65	1	14.29	1	16.01	1	14.48	1	13.96	1	13.80	1
SST 866	11.62	20	11.99	19	12.41	13	13.86	22	12.47	15	12.01	15	11.81	19
SST 867							15.20	3						
SST 875	11.88	12	12.18	16	12.33	15	14.19	20	12.65	12	12.13	13	12.03	15
SST 877					12.52	9	14.87	6						
SST 884	11.93	11	12.24	14	12.46	10	14.44	14	12.77	10	12.21	11	12.09	12
SST 895	12.41	3	12.49	7	13.39	2	14.94	5	13.31	2	12.76	3	12.45	4
Mean	**12.00**		**12.45**		**12.58**		**14.57**		**12.89**		**12.37**		**12.24**	
LSD (0,05)	**0.41**		**0.45**		**0.60**		**0.44**		**0.24**		**0.28**		**0.31**	

KwaZulu-Natal Irrigation Area
Average falling number (s) of entries during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017	R	2016	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Buffels							304	16						
Duzi	344	17	339	11	331	14	303	17	329	12	338	12	342	12
Koedoes	355	10	340	9			318	1					348	10
Krokodil	313	21	298	19	290	20	297	21	299	16	300	17	306	19
PAN 3400	347	14	337	12	349	2	309	9	336	8	345	8	342	11
PAN 3471	341	19	340	10	335	11	318	2	334	9	339	10	341	13
PAN3497	344	18	333	15	330	15	308	12	329	13	336	15	338	16
PAN 3515	351	13	327	17	332	13	301	20	328	14	337	14	339	15
PAN 3541	364	3												
PAN 3623	332	20	327	18	320	19	313	7	323	15	327	16	330	18
PAN 3644	371	1												
Renoster	310	22	298	20			295	22					304	20
Sabie	346	15	335	14	333	12	317	4	333	11	338	13	340	14
SST 806	366	2	360	2	336	9	309	10	343	1	354	2	363	1
SST 8125					344	4	316	5						
SST 8134							306	15						
SST 8135	362	6	337	13	324	18	309	10	333	10	341	9	350	9
SST 8154	344	16	332	16	338	7					338	11	338	17
SST 8155					329	16								
SST 8156	354	11	354	3									354	6
SST 835	363	4	348	8	340	6	315	6	341	2	350	4	355	4
SST 843	359	8	349	5	349	1	308	12	341	4	353	3	354	5
SST 866	353	12	352	4	345	3	307	14	339	6	350	5	353	8
SST 867							301	19						
SST 875	359	9	349	7	327	17	310	8	336	7	345	7	354	6
SST 877					335	10	293	23						
SST 884	363	4	349	6	336	8	318	3	341	3	349	6	356	3
SST 895	361	7	360	1	340	5	303	18	341	5	354	1	361	2
Mean	**350**		**338**		**333**		**308**		**333**		**341**		**343**	
LSD (0,05)	**13.77**		**9.72**		**12.90**		**14.54**		**6.30**		**6.90**		**8.15**	

FERTILISATION GUIDELINES FOR WHEAT PRODUCTION

The cost of fertiliser is a substantial proportion of the total production cost of wheat and the optimisation of fertilising practices is therefore of the utmost importance.

The development of specifically adapted cultivars over the past few years has necessitated the planning of a fertilisation programme by the producer on an annual basis. As with cultivar choice, a fertilisation programme is planned on the basis of a specific yield potential or target yield. The following guidelines can be used as a reference to plan such a programme for a given situation.

Reliable soil analysis data is essential for planning an effective fertilisation programme. The regular sampling of lands to timeously identify problems, such as soil acidification, is absolutely essential.

Soil sampling for analysis

Soil is analysed to determine its ability to supply the necessary plant nutrients to the crop concerned. Soil analyses are related to potential nutrient uptake, supplementation of plant nutrients through fertilisation and the target yield. From plant nutrient research programmes that take these factors into account, guidelines that will be valid in a given situation, are laid down.

Therefore, to make the best possible use of these guidelines, it is essential that the soil samples that are interpreted are representative of the particular land. To achieve this, the following standard procedures are required when handling soil samples:

- Homogeneous units that are also practical for crop production purposes must be sampled. (Homogeneity is determined by previous crop performance, topography and the soil depth, colour and texture);
- A soil sample must represent a homogeneous unit of not more that 50 ha;
- Homogeneous units must be numbered clearly and separately;
- Problem/poor patches must be indicated and sampled separately;
- When taking the sample, all foreign matter (grass, twigs, loose stones) must be removed at the sampling point. In the case of very rocky soils an estimate must be made of the rock percentage per volume;
- Twenty to 40 samples must be taken at random over the entire area of each homogeneous unit of the land. Conspicuously poor patches, headlands, places where animals gather, et cetera, must be avoided;
- The recommended depth for sampling the topsoil is about 200 mm, in other words the 0-200 mm portion of the topsoil is sampled;
- Subsoil samples must be taken from the 200-600 mm layer of the profile for dryland cultivation, and at 200-600 and from 600-1200 mm for irrigation;

- If the land has been ploughed, random samples must be taken from the entire area. If the rows of the previous crop are still visible, the samples must be taken randomly between and in the rows;
- To compare results, sampling should be done at more or less the same time of the year every year, or during the same phase of the cultivation programme, but at least once every three years;
- The 20-40 samples from which the final sample is to be combined, must be collected in a clean bag, (farmers are warned against using salt bags, fertiliser bags or other contaminated containers). Clods must be crushed, foreign matter removed, and the soil must be mixed thoroughly. After spreading the soil in a thin layer, small scoops are taken evenly over the whole depth and area and placed in a clean plastic bag or carton. This final sample, representative of a homogeneous unit, must have a mass of 0.5-1.0 kg; and
- Additional information about the properties of the soil, climate, production and fertilisation history should also be furnished, since recommendations cannot be based on soil analysis alone.

Soil acidity

One of the major wheat production problems in the summer rainfall region is the increased acidification of soils, especially in the higher rainfall areas. The negative effect of acid soil lies in the high level of free aluminium ions, when compared to other cation levels, in the soil. As a result, high concentrations of toxic aluminium are taken up by the wheat plant.

Although germination and establishment are not influenced by high Al^{3+} -concentrations in the soil, aluminium toxicity symptoms occur in the early plant development stages (usually September when warmer temperatures promote active growth). When the root system of the young plant is exposed to high aluminium levels, severe drought and nutrient stress symptoms appear and plant mortality may eventually occur. The symptoms of aluminium toxicity are clearly visible on the roots. The root tips become thickened, the lateral roots brittle and a brown discoloration takes place. Inhibition of root growth limits the uptake of water and plant nutrients.

Guidelines

The pH (KCl) and soil texture is used to determine the lime requirements for wheat.

Soil analysis for lime requirement purposes is essential when the soil pH (KCl) is below 4.5, pH ($CaCl_2$) below 5.0 or pH (H_2O) below 5.5. Table 1 shows the lime requirement (ton per hectare) for different pH values and clay percentages.

Because the ratio of aluminium to other cations in the soil is essential to the reaction of the plant, it is important to emphasise that lime is recommended if the percentage acid saturation is above 8% and/or if the pH (KCl) is below 4.5.

Table 1. Lime requirements (ton/ha) for different acidity levels and clay content.

% Clay	Δ pH > 0.5 Δ SV > 32	Δ pH : 0.5-0.4 Δ SV : 32-25	Δ pH : 0.4-0.3 Δ SV : 25-15	Δ pH : 0.3-0.2 Δ SV : 15-10	Δ pH< 0,2-0,1 Δ SV <10
5-10	3.9	3.0	2.2	1.4	0.5
10-15	4.1	3.3	2.5	1.6	0.8
15-20	4.4	3.5	2.7	1.9	1.0
20-25	4.6	3.8	2.9	2.1	1.3
25-30	4.8	4.0	3.2	2.3	1.5
30-35	5.1	4.2	3.4	2.6	1.7

ΔpH - Change in pH(KCl)

ΔAS - Change in % acid saturation

*Lime requirement = ΔpH*8.324+0.0459*Clay-1.037*

If the lime requirement exceeds 4 ton/ha, lime must be applied over two cropping seasons and not all at once. The equation from Table 1 can also be used to calculate lime requirement, by inserting the desired change in pH and the clay content into the equation.

Lime requirement in Table 1 is based on a lime source with a CCE (Resin) of 75.3. If the lime source has a CCE (Resin) value higher or lower than 75.3 the following adaptations must be made for a soil, for example, with a lime requirement of 3.5 ton/ha.

Suppose a CCE (Resin) of 90%, then the actual lime requirement will be as follows:

75.3/90 = 0.84
3.5*0.84 = 2.93 ton lime/ha, thus ±3 ton/ha

Suppose a CCE (Resin) of 60%, then the actual lime requirement will be:

75.3/60 = 1.26
3.5*1.26 = 4.4 ton lime/ha thus ±4.5 ton/ha

Type of liming material

It is essential that the lime source (calcitic or dolomitic) be selected correctly. The type of lime to be used is determined by the Ca:Mg ratio and the Mg content of the soil. If the Ca:Mg ratio is higher than 10:1, dolomitic lime is recommended. When the Ca:Mg ratio is lower than 10:1 the choice of lime source is determined by the Mg content of the soil. If it is higher than 40 mg/kg (p.p.m.), calcitic lime is recommended, while dolomitic lime is used when the Mg content of the soil is lower than 40 mg/kg.

The application of lime

Liming material must comply to certain specifications of fineness and reactivity for the effective neutralising of acid soils. Dolomitic agricultural lime must contain more than 20% magnesium carbonate ($MgCO_3$) and calcitic agricultural lime more than 70% calcium carbonate ($CaCO_3$). Lime must have a fineness of less than 250 micron.

It is essential that lime be applied three to four months before planting. When dry soils are limed only a small change in the pH values will be obtained. Soil texture (which is the most important factor), nitrogen fertilisation and the quantity and quality of lime applied, will determine how often lime has to be re-applied. Acidification is more rapid in light textured soils than in the clay soils because of their differences in buffer capacity. Light textured soils have lower lime requirements to attain certain soil pH levels.

It is essential to remember that a good reaction will only be obtained when the lime is well mixed with the soil. The lime particles must come into close contact with the silt and clay particles to displace the hydrogen and aluminium ions. Lime has to be mixed into the soil with an offset or disc, and then ploughed in to a depth of 200 to 400 mm.

Cultivar choice as a remedy

In association with the liming programme, cultivars with good aluminium tolerance can also be used to limit yield losses caused by acid soils. Considerable variation in genetic (cultivar) tolerance to aluminium toxicity exists. Cultivars can be divided into three classes of aluminium tolerance (Table 2):

- Good tolerance
- Reasonable tolerance
- Poor tolerance

Table 2. Cultivars in different classes of aluminium tolerance

Tolerant	Moderate tolerant	Sensitive
Koonap	Matlabas	Elands
PAN 3118	PAN 3111	Gariep
PAN 3120	SST 316	PAN 3368
PAN 3161	SST 356	Senqu
PAN 3195	SST 317	
PAN 3198	SST 347	
PAN 3379	SST 374	
SST 387		

Based on the presence of the ALMT1 marker and seedling evaluation of cultivars.

It is important to keep in mind that cultivar choice is not only made on the basis of aluminium tolerance. Grain yield and quality still remains one of the most important focus points of cultivar choice. Cultivar choice in terms of aluminium tolerance is only a short term solution with a certain amount of risk attached. Cultivar choice could effectively be used to overcome the acidity problem during the neutralisation period. Liming programmes will not only lower the production risk, but also sustain the soil for future generations.

High yields and the accompanying high volumes of crop residues returned to the soil can result in a large amount of undercomposed residue in the soil at planting. This scenario can result from the late soil cultivation and/or wet soil conditions during this time, leading to reduced N availability, depressing growth and yields and also decreasing grain quality. Where these scenarios are expected or encountered, adaptation to the fertiliser strategy must be made by increasing N fertiliser application at planting or adding N (15kg N/ha) and lime (0,5 ton/ha) during late cultivation to increase decomposition of residue. The removal of crop residue (baling, burning or grazing) also affect fertiliser planning due to removal of nutrients.

The advantages of effective crop rotation systems are obvious from the above discussion. Sufficient time for soil cultivation and residue management and decomposition are available in these systems. Compaction layers in soils that can negatively affect soil water availablility, root development and nutrients used by the crop can also be successfully managed.

Nitrogen fertilisation under dryland conditions

Table 3 gives nitrogen fertilisation guidelines on a regional basis for the different target yields. When using the guidelines, the following aspects must be kept in mind:

- All guidelines are valid for the cultivation of wheat after wheat, and all crop residues is timeously worked into the soil.
- All nitrogen fertiliser must have been applied at planting time and normally no nitrogen topdressing is recommended.
- High nitrogen applications with the seed could adversely affect germination and therefore the plant population. It is therefore recommended that not more than 20 kg N/ha be placed with the seed.
- Applications of more than 20 kg N/ha should be applied shortly before planting or be band placed away from the seed at planting. Because of stored soil water loss that usually accompanies tillage practices, it is preferable to band place higher N application at planting.
- The protein content of the grain can be increased by higher applications of nitrogen, and because of the changed grading regulations, the guidelines have been adapted to accommodate this.

- High yields and the accompanying high volumes of crop residues returned to the soil can result in a large amount of undercomposed residue in the soil at planting. This scenario can result from the late soil cultivation and/or wet soil conditions during this time, leading to reduced N availability, depressing growth and yields and also decreasing grain quality. Where these scenarios are expected or encountered, adaptation to the fertiliser strategy must be made by increasing N fertiliser application at planting or adding N (15kg N/ ha) and lime (0,5 ton/ha) during late cultivation to increase decomposition of residue. The removal of crop residue (baling, burning or grazing) also affects fertiliser planning due to removal of nutrients. The advantages of effective crop rotation systems are obvious from the above discussion. Sufficient time for soil cultivation and residue management and decomposition are available in these systems. Compaction layers in soils that can negatively affect soil water availablility, root development and nutrients used by the crop can also be successfully managed.

Table 3. Nitrogen fertilisation according to production area and target yield in the summer rainfall region

Production area	Target yield (ton/ha)	N fertilisation (kg N/ha)
Southern Free State	1.0 1.5 2.0	10 15 25
North-Western Free State	1.0 1.5 2.0 2.5 * 3.0 * >3.5 *	10 20 30 45 55 65+
Central Free State	1.0 1.5 >2.0	15 25 35+
Eastern Free State	1.0 1.5 2.0 2.5 >2.5	15 30 40 50 60+
North West Province	1.0 1.5 2.0	5 15 25
Mpumalanga	1.0 1.5 2.0 2.5	10 20 30 40

** Valid for the areas where a high water table and good moisture supply favour a higher target yield.*

Nitrogen fertilisation under irrigation

Nitrogen fertilisation guidelines for irrigated wheat are given in Table 4(a).

Table 4(a). Nitrogen fertilisation (kg N/ha) according to target yield under irrigation

Target yield (ton/ha)	Nitrogen (kg N/ha)
4 – 5	80 -130
5 – 6	130-160
6 - 7	160- 180
7 – 8	180-200
8+	200+

- The guidelines in Table 4(a) do not accommodate crop rotations with wheat following N-fixing crops. In these specific cases downward adaptations of N fertilisation guidelines can be made based on the residual N in the soil. Contact relevant experts in these cases, also in scenarios where large volumes of crop residues/manure are incorporated into the soil, necessitating adaptation in nitrogen management.
- Split applications of N under irrigation has been of interest for some time. It has been proved that effective N management during the growing season can result in high yields with acceptable grain protein percentages. Changes in growing conditions affecting yield potential, for instance cold winters resulting in increased tillering, can also be managed timeously. The principle of split application of N is to increase the efficiency of use by the plant by providing sufficient nutrients when needed for growth and yield development, and also to optimise grain quality.
- A general split application schedule at different yield potential levels for soils with a clay content of 15-25% is presented in Table 4(b). On the lower clay soils the amount of N applied at planting and at tillering can split into smaller applications according to the practical situation (irrigation equipment), for the prevention of N losses from the soil profile. On the higher clay soils (>25% clay) the guidelines in Table 4(b) can be used. It is important to concentrate the application and availability of N around the important growth stages for yield and grain quality (protein content) development. Linked to this is the importance of effective irrigation management on the effectivity of N use and split applications of applied N.

- During the development stages such as tillering to flagleaf stage, N management combined with yield potential should be evaluated. Effective N management during the season can fix the yield potential of the crop, but also ensure acceptable protein content of the grain. Research have shown that increased and split N applications can increase the protein content of the grain, even in scenarios where N is the limiting factor.
- The application of N during the flagleaf to anthesis growth stages of development can ensure that sufficient N is available during grain development to increase grain protein. Depending on the yield potential, between 0 and 60 kg N/ha must be applied during this time to increase grain protein above 11%.
- Nitrogen and water management is important in irrigation farming. Adequate water is needed to prevent water stresses, but also to aid nutrient uptake. Withdrawal of irrigation at maturity must only be done when the stem below the ear has completely discoloured. During this late stage of grain filling, nutrients are being transported to the grain and water stresses can impact on grain growth and result in a low hectolitre mass.

Table 4(b). Split application of N during the growing season at different levels of yield potential

Yield (ton/ha)	Nitrogen split application (kg N/ha)		
	Plant to tillering	Tillering to stem elongation	Flag leaf to anthesis
4-5	80-100	30	0
5-6	100	30	30
6-7	100-130	30	30
7-8	130-160	30	30
>8	160	30-60	30-60

Phosphorus fertilisation

The phosphorus fertilisation guidelines are given in Tables 6 and 7 in terms of Bray 1 analysis method (mass) for soil phosphorus.

Certain advisors, however, make recommendations in terms of other phosphorus analysis methods and it is therefore necessary to compare the different methods. Although the different methods do not maintain constant ratios to one another on clay soils (such as the black turf soils) and strong acid or alkaline conditions, Table 5 gives approximated ratios that will be valid for most soils.

Table 5. Approximate ratios (mg P/kg) determined according to different analyses methods

Ambic 1	Bray 1	Bray 2	Citric acid (1:20)	Olsen
6	6	9	10	4
8	10	13	15	6
11	14	18	20	8
13	17	22	25	10
16	20	26	30	12
20	24	31	35	14
23	28	36	40	16
26	31	40	45	18
30	34	45	50	20

When interpreting the phosphorus fertilisation guidelines, the following must be kept in mind:

- When referring to phosphorus fertilisation, citric acid soluble or water soluble phosphorus sources are intended.
- Economic principles were applied when guidelines were calculated and the quantity of phosphorus fertiliser indicates the quantity where maximum gross profit is obtained.
- The guidelines make provision for a gradual build-up of soil phosphorus status at low levels of soil phosphorus, if crop residue is not removed from the field. A gradual rather than sudden build-up is preferred with banding of fertiliser at planting.
- The higher phosphorus quantities in the guidelines refer to the lower analysis figure, and vice versa. For analysis values between these extremes, the correct phosphorus fertilisation must be deduced within the given quantities.
- Under acidic soil conditions, plant response to applied fertiliser at high soil P levels can occur, due to the relative lower availability of soil P.

Phosphorus fertilisation under dryland conditions

The phosphorus fertilisation guidelines for dryland conditions, according to target yield and soil phosphorus status, are given in Table 6.

Table 6. Phosphorus fertilisation (kg P/ha) for dryland area according to target yield and soil status according to the Bray 1 analysis method

Target yield (ton/ha)	Soil phosphorus status (mg/kg)			
	<5*	5-18	19-30	>30
1.0	6	5	4	4
1.5	9	8	6	5
2.0	12	12	8	7
2.5+	18	15	12	10

** Minimum quantity that should be applied at the low phosphorous level.*

Phosphorus fertilisation under irrigation

The phosphorus fertilisation guidelines for irrigated wheat are given in Table 7 in terms of the target yield and soil phosphorus status (Bray 1).

Table 7. Phosphorus fertilisation (kg P/ha) for the irrigation area target yield and soil status according to the Bray 1 analysis method

Target yield (ton/ha)	Soil phosphorus status (mg/kg)			
	<5*	5-18	19-30	>30
4-5	36	28	18	12
5-6	44	34	22	15
6-7	52	40	26	18
7+	>56	>42	>28	21

Potassium fertilisation

Potassium deficiencies are rarely observed in the wheat production areas, as South African soils are relatively rich in potassium. Increased wheat yields due to potassium fertilisation are, therefore, seldomly recorded. Potassium deficiencies may occur under the following conditions:

- Highly leached sandy soils with low levels of soil potassium
- Cold and/or wet and/or very dry soil conditions
- Very high magnesium and/or calcium content of soils.

Soil potassium levels determined according to the Ambic 1 and ammonium acetate methods of analysis are overall similar. Therefore, reference will only be made to soil potassium levels in the tables.

Potassium fertilisation under dryland conditions

The soil potassium analysis value, the soil texture (clay percentage) and the target yield are used in the recommendations in Table 8 to determine whether potassium fertilisation should be applied or not.

Potassium can be bandplaced with nitrogen and phosphate as a compound fertiliser. If the potassium requirement is too high to be bandplaced, the potassium must be broadcast and incorporated into the soil before planting. Research results, however, have shown bandplacing to be the most effective method of application.

Table 8. Guidelines for potassium fertilisation (kg K/ha) under dryland conditions according to soil texture, soil potassium levels and target yield

Target yield (ton/ha)	Soil potassium status (mg/kg)			
	<60	61-80	81-120*	>120
1-2	20	15	15	0
2-3	30	20	20	0
3+	40	25	25	0

** Soil with >35% clay (Soil with <35% clay content, no potassium recommended, but potassium applications may be done for maintenance of soil K values.)*

Potassium fertilisation under irrigation conditions

Potassium fertilisation guidelines for wheat under irrigation, according to soil potassium levels and target yield, are given in Table 9. Potassium can be broadcast and incorporated into the soil before planting as a compound with nitrogen and phosphate.

Table 9. Guidelines for potassium fertilisation (kg K/ha) under irrigation, ions according to soil texture, soil potassium levels and target yield

Target yield (ton/ha)	Soil potassium status (mg/kg)			
	<60	61-80	81-120*	>120
4-5	50	25	25	0
5-6	60	30	30	0
6-7	70	35	35	0
7+	80	40	40	0

** Soil with >35% clay (Soil with <35% clay content, no potassium recommended, but potassium applications may be done for maintenance of soil K values.)*

Micro nutrients

Although micro nutrients are needed in small amounts by plants, their importance in providing a healthy and strong growing plant cannot be overlooked. Each micro nutrient plays an important role in the physiology of plants. Iron, manganese, zinc, copper and boron are essential for normal development and growth of wheat. If one or more of the micro nutrients become deficient, visual deficiency symptoms will appear on the leaves. Deficiency must be corrected early in the growing season to prevent further yield losses.

At this stage micro nutrients are not generally recommended under dryland practices, because of the risk involved to recover the additional input costs. Under specific conditions, where micro nutrients are the yield limiting factor, plant analysis (Table 10) can be used to determine which nutrient is causing the problem.

Correction of marginal deficiencies can be solved by early micro nutrient applications between the tillering and flag leaf stages. If the deficiencies are more severe, a second micro nutrient application should follow at flag leaf stage.

Plant analysis values

Table 10. Plant analysis values of wheat at flag leaf stage

Elements	Low (deficient)	Marginal	High (sufficient)
N %	< 3.4	3.7-4.2	> 4.2
P %	< 0.2	0.2-0.5	> 0.5
K %	< 1.3	1.5	> 1.6
S %	< 0.15	0.15	> 0.4
Ca %	< 0.15	0.2	> 0.2
Mg %	< 0.1	0.15	0.15 – 0.3
Cu (mg/kg)	< 5	5-10	10
Zn (mg/kg)	< 20	20-70	> 70
Mn (mg/kg)	< 30	35-100	> 100
Fe (mg/kg)	< 25	50-180	> 180
Mo (mg/kg)	< 0.05	0.05-01	> 0.1
B (mg/kg)	<6	6-10	10

WEED CONTROL IN WHEAT

Weed control in any small grain production system can be very daunting, especially with the development of herbicide resistant weeds. The occurrence of weed in wheat has been documented to decrease the wheat yield with up to 33%. Throughout the past seasons, it has become clear that many post-emergence herbicides don't control grassweeds anymore. Many producers had to move to an integrated weed management system (IWM) and now focus more on pre-emergence herbicide control strategies.

Before any control strategies can be implemented, it is very important to identify the weed you want to control correctly. This is important, because different weeds will be killed by different herbicides and at different dosages. By using the incorrect herbicide and/or dosage, selection will favour the herbicide resistant weeds.

Some of the most troublesome or widespread weeds in the summer rainfall region will be discussed. The registered herbicide lists were compiled from the book: "A Guide for the Chemical Control of Weeds in South Africa".

It is a CropLife/AVCASA South Africa Compendium and was compiled by Kathy van Zyl (http://www.efekto.co.za/wp-content/uploads/mixing_labels/Herbicide%20 guide.pdf).

Fallopia convolvulus (Wild Buckwheat)

Figure 1. Wild buckwheat seedling

Figure 2. Wild buckwheat in an oats field

Wild buckwheat is a slender, twining annual plant with a deep taproot system. The stems are round and hairless with scabby stripes, while the leaves are simple and alternately arranged. The leaves are also triangular with a pointed apex and a heart-shaped base. The leaves are hairless and scabby and grow up to 5.5 cm long and 4.5 cm wide. The flowers of wild buckwheat are small, green or white of colour and are arranged in bundles on the axillary axes. The seeds are black, sharp triangular nutlets. They are hairless, shiny and are usually covered with a persistent, brown perianth segment. The seeds can be 3 mm long and 2.5 mm wide. (Fig.1)

Wild buckwheat is widespread in southern Africa and can be a severe competitor with crops. This weed can climb up against other crops and compete with the crop to such an extent that the crop may die. It is an especially troublesome weed in the Eastern Free State. (Fig.2)

This weed can be relatively tolerant to some herbicides, especially hormone-type herbicides. Several herbicides are registered for use on this weed (Table 1). As with all herbicides, please follow the instructions and dosage recommendations on the label.

Table 1: Broadleaved herbicides registered for the control of wild buckwheat in wheat

Active Ingredient	Formulation	Time of application
2,4-D	480 g/ℓ	Apply at growth stage 7-13 of the wheat
	500 g/ℓ	ONLY in the summer rainfall areas (not KZN). Apply at growth stage 7-13 of the wheat
aminopyralid	240 g/ℓ	Weed before leaf stage 4
bromoxynil	225 g/ℓ	Weeds must be fully germinated, but not older than 6 leaf stage
	400 g/ℓ	Apply when crop is between 3-leaf stage and the end of the stooling stage
	450 g/ℓ	Weeds must be fully germinated, but not older than 6 leaf stage
	500 g/ℓ	Wheat seedlings should be between the 3-leaf and end of booting stage
chlorsulfuron	750 g/kg	Wheat in 2-5 leaf stage
chlorsulfuron/metsulfuron-methyl	375/300 g/kg	Weed in leaf stage 3-4
chlorsulfuron/metsulfuron-methyl/tribenuron-methyl	119/79/222 g/kg	Eastern Cape. Wheat must be in 4-6 leaf stage
dicamba	700 g/kg	Only to be used in a tank mix with Enhancer (10-12 g) + Reaper (10 g) + adjuvant
MCPA	400 g/ℓ	Apply at growth stage 7-13 of the wheat
	700 g/kg	In dry land, Apply at growth stage 7-13 of the wheat
metsulfuron-methyl/ thifensulfuron-methyl	68/680 g/kg	Apply before 4-5 leaf stage of the weed
prosulfuron	750 g/kg	Apply before 4-5 leaf stage of the weed
thifensulfuron-methyl	750 g/kg	Eastern Cape. Only in tank mix with Enhancer + adjuvant, wheat must be 2-5 leaf stage, but not later than 4 weeks after weed emergence
tribenuron-methyl	750 g/kg	Irrigated wheat, when wheat is in 3-5 leaf stage

Chenopodium album (White goosefoot, fat hen, wild spinach)

Figure 3. Young *Chenopodium* plant

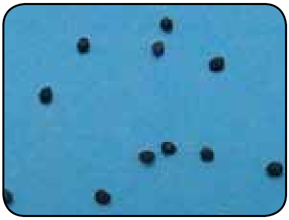


Figure 4. *Chenopodium* seeds

Chenopodium is an annual, multi-branched, erect herb that can grow as tall as 1.5 m. This weed has a sturdy taproot and the stems are ribbed, green-yellowish, often reddish striped and hairless. The leaves are simple, alternately arranged and vary from lancet-shaped to egg-shaped. The leaf margins can be entirely or irregularly toothed and are dark green at the top and floury white below. Seedlings can appear woolly due to the white colouring of the young leaves. Leaves can be 5 cm long and 3 cm wide. The flowers of *Chenopodium* are green and the seeds are black and shiny. (Fig.3)

Chenopodium is widespread in South Africa, is frost tolerant and occurs regularly in winter crops. This weed is commonly referred to as 'morog', but this weed must not be confused with *Amaranthus* species which are also edible. *Chenopodium* can be controlled through shallow cultivation at the seedling stage. (Fig.4)

The most effective way to control this weed is by using herbicides. Several herbicides are registered for use on this weed (Table 2). Follow the instructions and dosage recommendations on the label. Be aware that green goosefoot is also a *Chenopodium* spp. *(C. carinatum)* and while most of the herbicides listed in Table 2 will control green goosefoot, it is still necessary to make sure which *Chenopodium* spp. is indicated on the herbicide label.

Table 2: Broadleaved herbicides registered for the control of white goosefoot in wheat

Active Ingredient	Formulation	Time of application
2,4-D	480 g/l	Apply at growth stage 7-13 of the wheat
	500 g/l	ONLY in the summer rainfall areas (not KZN). Apply at growth stage 7-13 of the wheat
2,4-DB	400 g/ℓ	Undersowed lucerne in grain crops, wheat must be between leaf stage 5 and full tillering, READ THE LABEL
aminopyralid	240 g/ℓ	Weed before leaf stage 4
bendioxide	480 g/l	Apply on young, actively growing weeds
bromoxynil	225 g/l	Weeds must be fully germinated, but not older than 6 leaf stage
	400 g/l	Apply when crop is between 3-leaf stage and the end of the stooling stage
	450 g/l	Weeds must be fully germinated, but not older than 6 leaf stage
	500 g/l	Wheat seedlings should be between the 3-leaf and end of booting stage
carfentrazone-ethyl/ metsulfuron-methyl	400/100 g/kg	Eastern Cape. Wheat must be in 3-5 leaf stage
chlorsulfuron	750 g/kg	Wheat in 2-5 leaf stage
chlorsulfuron/ metsulfuron-methyl	375/300 g/kg	Weed in leaf stage 3-4
chlorsulfuron/ metsulfuron-methyl/ tribenuron-methyl	119/79/222 g/kg	Eastern Cape. Wheat must be in 4-6 leaf stage
dicamba	700 g/kg	Only to be used in a tank mix with Enhancer (10-12 g) + Reaper (10 g) + adjuvant
fluroxypyr/triclopyr	240/120 g/ℓ	Weed in leaf stage 2-10
MCPA	400 g/l	Apply at growth stage 7-13 of the wheat
	700 g/kg	In dry land, Apply at growth stage 7-13 of the wheat
metsulfuron-methyl/ thifensulfuron-methyl	68/680 g/kg	Apply before 4-5 leaf stage of the weed
metsulfuron-methyl/ tribenuron-methyl	120/600 g/kg	Only in tank mixture with 2,4-D Ester or Voloxynil B 225 EC
prosulfuron	750 g/kg	Apply before 4-5 leaf stage of the weed
thifensulfuron-methyl	750 g/kg	Eastern Cape. Only in tank mix with Enhancer + adjuvant, wheat must be 2-5 leaf stage, but not later than 4 weeks after weed emergence
triasulfuron	750 g/kg	Eastern Cape, apply at planting
tribenuron-methyl	750 g/kg	Irrigated wheat, when wheat is in 3-5 leaf stage
trifluralin	480 g/l	Use only in planted fields, dosage depends on weed species

Avena fatua (Common wild oats)

Figure 5. *Avena* plant

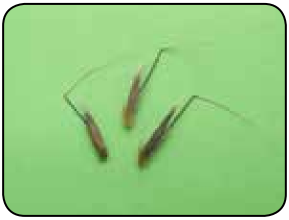


Figure 6. *Avena* spikelets

Wild oats is an annual (annual = goes through whole life cycle within a year) grass, which can be between 60-90 cm tall. The stems are solitary or often tufted. The culms are erect and hairless and has two to five nodes. The leaf sheaths are also hairless and can grow as long as 20 cm. The leaves, which are also hairless, are linear and have sharp apices and can grow up to 24 cm long and 8 mm wide. The ligule is membranous and can be up to 6 mm long. The inflorescence of wild oats is open, loose panicles that can be grow up to 40 cm long. The spikelets are oblong, narrow, gaping and contain two to three florets. Each lemma has a bent and tisted awn, with a darkly coloured underside. The seeds look like typical oat seeds. The seed can be 9 mm long and 2 mm wide. (Fig.5)

Wild oats is a severe competitor and commonly occur in the Southern Cape Province and the grain producing areas of the Free State, especially in monoculture wheat production. The seed of wild oats usually get distributed through contaminated wheat seed and contaminated machinery. (Fig.6)

Post-emergence herbicides are applied after the weed and/or crop has emerged from the soil. Several herbicides are registered for the control of wild oats in wheat (Table 3). Please follow the specific instructions and dosage recommendations on the chosen products label. Alway consult the label before spraying any herbicide.

Table 3: Grass weed herbicides registered for the control of wild oats in wheat

Active Ingredient	Formulation	Time of application
clodinafop-propargyl	240 g/ℓ	Apply when the weeds are in the 2-4 leaf stage. Dosage depends on the weed species and method of application
diclofop-methyl	378 g/ℓ	ONLY use in irrigated wheat. Apply before the crop reaches the 5 leaf stage
fenoxaprop-P-ethyl	120 g/ℓ	Apply when weeds are in the 3-5 leaf stage. Dosage depends on weed species, growth stage and method of application
flucarbazone-sodium	700 g/kg	Wheat in leaf stage 3-5
pinoxaden	45 g/ℓ	Dosage depends on the grass species
pyroxsulam	45 g/ℓ	Apply post-emergence between the 2-3 leaf stage of the wheat untill the 2 node stage when the weeds are in the seedling stage
tralkoxydim	100 g/ℓ	Post-emergence in irrigated wheat. Apply when the weeds are in the 2-4 leaf stage
Triallate	480 g/ℓ	Eastern Cape, Pre-emergence, apply to well prepared seedbed just before planting and incorporate with an airseed planter within 4 hours
triasulfuron	750 g/kg	Apply at planting

Herbicide resistance in this weed has been documented and poor control has been reported from all over South Africa. Producers and chemical advisors must always take herbicide resistance into account when making herbicide recommendations. Never use products to which resistance has been noted on specific fields/farms. Always make use of a reliable chemical advisor before buying and/or using any chemicals and follow the label recommendations strictly.

Amaranthus hybridus (Common pigweed, Cape pigweed, redshank)

Figure 7. Common pigweed plant

Figure 8. Common pigweed seed

Common pigweed is an erect, multi-branched, hairless, annual herbaceous plant. It can grow up to 90 cm long, but much higher in suptropical conditions. The stems are green to brown and sometimes it is redly tinged and strongly ribbed. The leaves ae simple, alternately arranged and broad lancet shaped. It can be up to 6 cm long and 3 cm wide. The margins of the leaves can be entire and the veins are more distinct on the lower surface of the leaf. Leaf stalks can sometimes be as long as 5 cm. Flowers are borne in dense terminal and axillary spikes and are unisexual, with male flowers at the top of the spike and the more numerous female flowers at the bottom. The flowers are straw-coloured. Fruits of common pigweed are small bladder-like fruits, that are dehisced by lids. The seeds are small, shiny, dark brown to black and lens-shaped. (Fig.7 & 8)

Common pigweed is one of the most abundant and widely distributed broadleaved weeds of cultivated fields in southern Africa. Common pigweed is easy to control with shallow cultivation when the weed is still in the seedling stage. Various pre- and post-emergence broadleaf herbicides can be used to control common pigweed effectively (Table 4).

Table 4: Broadleaved herbicides registered for the control of common pigweed in wheat

Active ingredient	Formulation	Time of application
2,4-D	480 g/l	Apply at growth stage 7-13 of the wheat
2,4-DB	400 g/ℓ	Undersowed lucerne in grain crops, wheat must be between leaf stage 5 and full tillering, READ THE LABEL
2,4-D/dicamba	240/80 g/l	Apply at growth stage 7-13 of the wheat
bendioxide	480 g/l	Apply on young, actively growing weeds
bromoxynil	225 g/l	Weeds must be fully germinated, but not older than 6 leaf stage. Wheat seedlings should be between the 3-leaf and end of booting stage
	400 g/l	
	450 g/l	
	500 g/l	
chlorsulfuron/metsulfuron-methyl	375/300 g/kg	Weed in leaf stage 3-4
dicamba	700 g/kg	Only to be used in a tank mix with Enhancer (10-12 g) + Reaper (10 g) + adjuvant
halosulfuron	750 g/kg	In mixtures (See label)
fluroxypyr/triclopyr	240/120 g/ℓ	Weed in leaf stage 2-8
MCPA	400 g/l	Apply at growth stage 7-13 of the wheat
	700 g/kg	
trifluralin	480 g/l	Before planting

Many thanks go to:

- *Dr Elbé Hugo (Syngenta) for assistance with compiling some of the weed information.*
- *Clive Bromilow (Problem Plants and Alien Weeds of South Africa) and*
- *Chris Botha (Common Weeds of Crops and Gardens in Southern Africa) for using their books as references on necessary information regarding the abovementioned weeds.*

Thank you to Dr Mike Ferreira for some of the photo's used.

INSECT CONTROL

During a season a number of different insect pests can occur on wheat plants and not all these pests are equally injurious. Therefore the decision to control should be made individually for each pest using the guidelines provided and the particular control measure should be chosen to give the best result in both economic and environmental terms. The correct identification of pests is of utmost importance to ensure that the appropriate control measure is followed. A Field Guide for the Identification of Insects in Wheat is available from ARC-Small Grain at a cost of R50 (+ R20 postage). This full colour guide contains a short description and photograph of each insect and includes both pests and beneficial insects. A pamphlet containing information on the registered insecticides is also included. It is helpful to make use of a magnifying glass when identifying wheat insects, as most of them are quite small. Dr. Goddy Prinsloo, Dr. Justin Hatting, Dr. Vicki Tolmay and Dr. Astrid Jankielsohn can be contacted for more information. Guidelines for the control of insect pests are discussed below.

Aphids

Five aphid species are commonly found on wheat in the summer rainfall production areas in South Africa. The Russian wheat aphid *(Diuraphis noxia)* is the most important with outbreaks occurring annually, while the other aphids namely greenbug *(Schizaphis graminum)*, bird-cherry oat aphid *(Rhopalosiphum padi)*, brown ear aphid, also called English grain aphid *(Sitobion avenae)* and the rose grain aphid *(Metopolophium dirhodum)* occur sporadically. Generally Russian wheat aphid and greenbug occur in dryer, low potential circumstances while bird-cherry oat aphid, brown ear aphid and rose grain aphid occur in wetter, high potential environments.

Russian wheat aphid

Russian wheat aphid (RWA) is a small (<2.0 mm), spindle shaped, pale yellow-green to grey-green aphid with extremely short antennae and a "double tail"(Figure 1).


Figure 1. Russian wheat aphid

Until 2005, only one biotype of the aphid was prevalent in the Free State Province, namely RWASA1. However a more damaging Russian wheat aphid biotype was recorded during the 2005 season and cultivars resistant to the original RWASA1 (listed in Table 1) were severely damaged by this Russian wheat aphid biotype, RWASA2. Another new biotype RWASA3 was recorded in 2009. Since 2009 RWASA2 and RWASA3 were present every year in wheat production areas in South Africa, but predominantly in the Eastern Free State. During 2016 RWASA4 was the predominant biotype in the Free State (21.2%), followed by RWASA3 (16.5%) and these two biotypes were limited to the Eastern Free State (Fig. 2). RWASA1 (9.4%) occurred in the Western Free State and Northern Cape (Fig. 2).

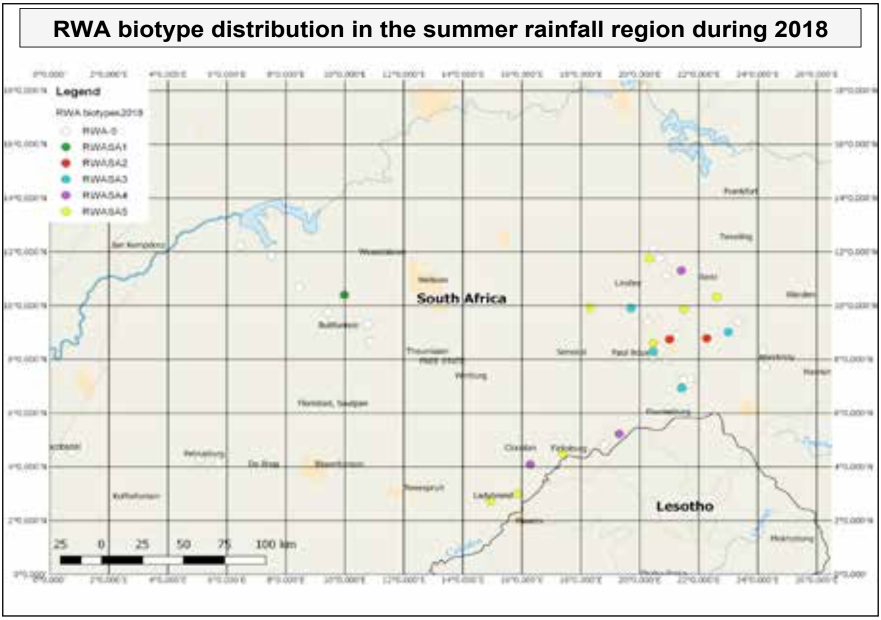


Figure 2. Distribution of Russian wheat aphid biotypes in the Summer rainfall area in South Africa during in 2018

Table 1. Russian wheat aphid resistance or susceptibility of wheat cultivars that are recommended for cultivation under dryland conditions in the summer rainfall region

Cultivar	RWASA1	RWASA2	RWASA3	RWASA4
Elands PBR	R	S	S	S
Gariep	R	S	S	S
Koonap PBR	R	S	S	S
Matlabas PBR	R	S	S	S
PAN3111 (PBR)	S	S	S	S
PAN3118 (PBR)	S	S	S	S
PAN3120 (PBR)	S	S	S	S
PAN 3161 (PBR)	HR	R	R	MR
PAN 3195 (PBR)	MR	S	R	S
PAN 3198 (PBR)	S	S	S	S
PAN 3368 (PBR)	R	R	R	R
PAN 3379 (PBR)	R	MR	R	MR
Senqu (PBR)	R	S	S	S
SST 3149 (PBR)	R	S	S	S
SST 316 (PBR)	R	R	MR	S
SST 317 (PBR)	R	R	MR	S
SST 347 (PBR)	MR	S	MR	S
SST 356 (PBR)	MR	S	S	S
SST 374 (PBR)	R	R	R	R
SST 387 (PBR)	MR	S	S	S

R= Resistant *MR= Moderately resistant* *S= Susceptible*

Resistance against RWASA1 and RWASA4 was tested in glasshouse only
Resistance against RWASA2 and RWASA3 was tested in both glasshouse and field

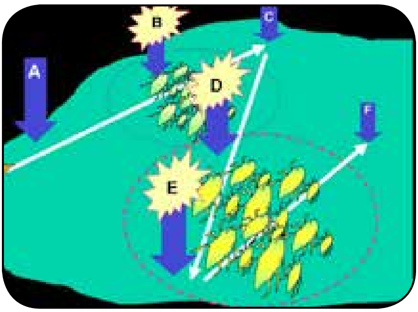
Host plant resistance has been the best control option for RWA since the release of the first RWA-resistant cultivar (Tugela-DN) in 1992 and it is recommended to still plant cultivars with resistance to RWASA1. It is not possible to visually distinguish between the biotypes, however damage symptoms can easily be recognised. Young plants showing a susceptible reaction become stunted and the leaves roll tightly closed. On more mature plants susceptible symptoms include longitudinal, white or pale yellow stripes, which can turn purple when cold conditions prevail, tightly rolled leaves and trapped heads. In contrast, only small white or yellow splotches and spots occur on the leaves of plants showing resistance and the leaves do not roll tightly closed as in the case of susceptible plants. Producers should monitor fields regularly and be aware that it may be necessary to apply insecticides if aphid populations increase.

Wheat is most prone to damage by Russian wheat aphid during the period between the emergence of the flag leaf (GS 14*) and the ear (GS 18*). Chemical treatment at GS 12* will ensure that the upper two leaves are protected from aphid infestation and this will reduce yield loss. Spraying before GS 12* is recommended only in cases of severe infestation > 30%, which may occur on wheat planted during spring in the Eastern Free State or under very dry conditions in the Western Free State. Re-infestation of this wheat may occur during the susceptible period necessitating an additional spray, though some damage may have already occurred with spraying after GS 12*. Infestation levels at various yield potentials, which necessitate spraying, are presented in Table 2. Seed treatments and soil systemic insecticides are available for control of aphid populations and control for up to 100 days after planting is possible.

(*Growth stages by Joubert pg 11)

Table 2. The minimum infestation levels that necessitate spraying against Russian wheat aphid at various yield potentials

Yield potential (ton/ha)	Minimum % aphid infestation per field at GS 12 (Joubert growth stages)
2.0 – 2.5	7
1.5 – 2.0	10
1.0 – 1.5	14



Determining the percentage aphid infestation in a field

By determining the percentage infestation in a field a farmer will be able to decide whether aphids should be controlled by chemical means. If the percentage infestation in a field is equal or higher than the recommendation for that specific field, the eventual yield will, due to Russian wheat aphid damage, not reach the optimum yield potential. Steps for determining the percentage infestation in a field are as follows:

Decide beforehand how many steps will be used as the standard and which foot will be the marker foot.

- Walk into the field for a short distance and then start to count off the number of steps that was decided on. On the specific number of steps the plant closest to the front of the marker foot is inspected for aphids. Plants are then ticked as either with “aphids present” or “aphids absent”.
- This procedure is now repeated throughout the field ten times or more. The scouting route must represent the whole field as aphid infestations usually occur in patches.

- The largest number of repetitions as possible should be scouted as this will increase the accuracy of the percentage infestation.
- Example: Three infested plants out of a total of six repetitions will result in an infestation percentage of 50% (3 divided by 6 x 100).

Other aphids

The oat aphid, English grain aphid and rose-grain aphid are sporadic pests in the summer rainfall area. These aphids prefer thick plant densities with damp conditions like in irrigated fields, but will also be present in wet years in dryland fields.

Figure 3. Oat aphid

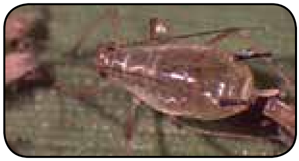


Figure 4. English grain aphid

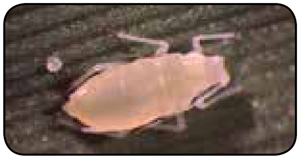


Figure 5. Rose grain aphid

The oat aphid has a dark green pear shaped body with a red coloured area between the siphunculi on the rear end of the aphid (Fig.3). A green and brown form of the English grain aphid (Fig.4) can be found. Long black siphunculi on the rear end is the most outstanding characteristic of this aphid. The rose-grain aphid is pale yellow-green in colour with a dark green longitudinal stripe on the back (Fig.5).

The siphunculi of this aphid are the same colour as the body.

These aphids are less harmful than RWA and all three of them can occur simultaneously. Plants are normally infested by these aphids at flag leaf stage, but oat aphids could occur at seedling stage. These three aphid species are also known for their potential to transfer plant viruses such as Barley Yellow dwarf virus (BYDV). This virus can cause yield reductions between 30 and 50% depending on the time of transmission. Because BYDV occurs only in the phloem of the plant, it can only be transmitted through the aphid's saliva during feeding. Population increase occurs after flag leaf stage.

Oat aphids prefer to feed on stems of plants, while the English grain aphid, migrates into the head for feeding. Rose grain aphids occur on the underside of the upper leaves and produce large quantities of honeydew, which makes the plants sticky and shiny when large populations are present.

When concerned about normal aphid feeding damage, chemical control can be applied between flag leaf appearance (GS14) and full ear emergence (GS17) when 20 to 30% of tillers are infested with 5-10 aphids per tiller. However, when you are aware of the presence of BYDV in your area, preventative spraying may be conducted at an early stage to prevent virus transmission by aphids arriving early. ARC-Small Grain is currently monitoring migrating aphid numbers using 12m high suction traps in some of the irrigation areas. Data are presented on a weekly basis on the ARC-Small Grain website to inform farmers about the status of aphid numbers present at critical times.

Follow the link http://www.arc.agric.za/arc-sgi/Pages/2017-Aphid-numbers.aspx.

Be sure that chemical control is applied correctly when necessary, read the label and do the application accordingly. Be careful to ensure application of the correct dosage, a wrong dosage could necessitate another application which has financial implications and increases the risk of resistance development in aphids. Unnecessary applications should be reduced to a minimum, because they also kill the natural enemies, which are important in the control of aphids. When the environment around the fields progress in ecological balance, an increase in natural enemies occurs, which will control the aphids and reduce the control costs.

Other insect pests

Except for aphids, brown wheat mite *(Petrobia latens)*, false wireworm *(Somaticus spp., Gonocephalum sp.)*, bollworm *(Helicoverpa armigera)*, black maize beetle *(Heteronychus arator)* and leafhoppers are considered sporadic, secondary pests of small grains in the summer rainfall region. False army worm and leaf miners are becoming sporadic pests of irrigated wheat.

Brown wheat mite

These mites are small, dark brown with a slightly oval body; the first pair of forelegs being notably longer than the others. Scouting should be conducted between 9 and 11 in the morning, because they hide beneath soil clots during warm and windy periods of the day. White dormant eggs are laid in the soil, which will hatch after light rain in July/August. After hatching, dry conditions will promote population increases with affected plants showing white speckled leaves due to sap-feeding activity. Under severe infestations, leaves may turn yellow or bronze resulting in yellow or brown patches appearing in the field. Chemical control can be considered under such conditions. On the other hand, brown wheat mite damage is more pronounced when plants are under stress and these conditions are generally inhibitive for the uptake and trans-location of systemic insecticides. Producers should also take note that rain showers of 12 mm or more can effectively reduce mite populations, thereby negating the need for chemical intervention.

False wireworm

The false wireworm belongs to the family Tenebrionidae and is the larval stage of dark-colored beetles, about 5 to 10 mm long. The larva is the most damaging stage feeding on seed, roots and seedling stems at or just below the soil surface. Adult beetles may damage emerging seedlings. The larvae can grow to 20 mm in length and are smooth, hard-bodied and golden-brown to dark brown with pointed, upturned tails. Rotten plant material in the soil may serve as a food source for the beetles and when present during planting time, farmers should use seed treatments to prevent damage.

Bollworm

The adult moths are light brown to grey with a wingspan of about 20 mm. The moths fly at dawn and dusk laying their eggs directly on the plant. Young larvae of early season generations initially feed on the chlorophyll of leaves, later migrating into the ear to feed on the developing kernels. Moths of later generations deposit their eggs directly on the ear. Final instar larvae can vary from bright green to brown and have a characteristic lateral white stripe on either side. The larva can reach up to 40 mm in length and can cause considerable damage, especially in terms of quality loss and subsequent downgrading of the consignment. The presence of bollworm is generally noticed only once the larvae have reached the mid-instar stage inside the awns. Producers should scout their fields in order to detect the younger larvae, as the older, more mature larvae, are generally less susceptible to insecticides and obviously cause more damage compared to small larvae. Under dryland conditions, chemical intervention can be considered when 3-4 larvae per meter row are present. A slightly higher threshold of 6-7 larvae per meter is applicable under irrigated conditions with higher seeding density. However, producers should take care in applying the correct dose of registered insecticide under weather conditions conducive to insect control.

Black maize beetle

The adult beetle is black, about 12-15 mm in length and capable of extended flight. Females lay about 7-10 eggs in the soil and the larvae develop through three instars followed by a pupal stage. The beetles are the most damaging stage while their larvae survive mostly on organic material in the soil. Adults chew at the base of the seedling stem resulting in reduced stand. Given the migrating nature of the adult stage, seed treatments are registered as pre-plant approach toward control of adult beetles.

Leafhoppers and maize streak virus

The leafhopper, *Cicadulina mbila,* is recognized as a pest on wheat, since they can transmit maize streak virus from infected maize and grasses. Leafhoppers can easily migrate from maize fields to adjacent early seeded wheat fields. Young infected wheat plants have a stunted appearance with curled leaves showing thin white longitudinal stripes. No chemicals are registered for the control of leafhoppers on wheat. Infestation can be prevented by later planting dates in areas away from maize fields.

Leafminer

A small black leaf miner fly, *Agromyza ocularis* (Fig.6), infests the wheat and barley crop under irrigation in the Northern Cape, North West and the Western Free State. They have spread during the past two years to the dryland production areas of the Western Cape, where a single early cycle is occurring, mainly on barley. They do not occur in large numbers later in the growing season. At the early stage of infestation, they mine only in the first leaves and then pupate in the soil causing no noticeable damage to the crop. They have also spread to the irrigation areas in the North West and some dryland wheat in the Western Free State. Their occurrence in these areas is at a low level and spraying is not needed. The female drills holes in leaves with her ovipositor and eggs are laid in some, while the rest of the holes (oozing plant sap) are used for feeding. Larvae hatch and feed inside the leaf while they burrow through it, leaving only the two epithelial cell layers as a safe environment for survival. The mined part of a leaf is dead and turns brown with time (Fig.7) and can't be revived by spraying insecticides. The fully grown larvae escape from the leaf and pupate in the soil (Fig.8). The adult flies hatch from the pupae at a later stage. Although the damage to the plants is noticeable, no significant damage could be measured during field trials and therefore spraying should only be considered in very severe cases. The amount of yield loss caused by this insect is still uncertain.

Figure 6. Adult leaf miner fly

Figure 7. Mined portion of the wheat leafs which turned brown

Figure 8. Leaf miner pupae

False armyworm

False armyworm *Leucania loreyi* is present as a sporadic pest in wheat and barley fields of the Northern Cape, North West and the Western Free State. During grain filling, high larval numbers can consume most leaves of the wheat crop while the beard of some ears may be damaged. Extensive damage could occur on barley when heads are cut-off during feeding by these larvae. Crop damage normally occurs in the last days before the grain is harvested. Both larvae and moths are active during night and not very visible during day. Larvae pupate in the soil. This sporadic pest occurs also in irrigated maize. No insecticide is registered against this pest on wheat or barley. (Fig.9)

Figure 9. False armyworm larve

DISEASES OF SMALL GRAINS

Diseases of small grains affect small grain production by reducing yield and impairing quality. To maximise profits, producers need to understand the influences that diseases have on crop potential. The purpose of this section is to assist with the identification of small grain diseases most commonly found in the summer rainfall areas of small grain production. The information contained here is intended to increase the producer's knowledge of small grain diseases and so indirectly assist with the control of the plant diseases that they may encounter.

A single fungal pathogen may attack a range of small grains, while other small grain pathogens may be confined only to infecting a specific host. Additionally, cultivars may vary in their susceptibility to different diseases. In this section, the most important diseases of small grains in the summer rainfall area are discussed. After the scientific name of a certain disease, the hosts that are attacked by the specific disease are listed. Advice is given on means of control. In the case of chemical control, the active ingredients registered in South Africa against the disease are listed in Tables 5 to 7.

Leaf and Stem diseases

Rusts

All three types of rusts (stem rust, stripe rust and leaf rust) (Fig. 3 - 9) can be effectively controlled using resistant cultivars. However, fungi that cause wheat rusts are variable consisting of several strains (races) which differ in their virulence to different wheat cultivars. New virulent races emerge mostly through mutation of local races and/or through introduction from other countries. Such new races can overcome resistance in existing cultivars thereby making them susceptible to rusts. There is sufficient evidence in South Africa and other countries which indicates that new rust races may result in epidemics and significant yield losses. The complex biology of rusts causes their frequency and distribution to vary from season to season and between different wheat growing regions (Fig 1 and 2). For instance, Fig 1 shows that TTKSF is the most widely found stem rust race in South Africa, being observed in all the major wheat growing regions. In contrast, race TTKSP is found only in the Western Cape and race, PTKST and only in the Free State and KwaZulu-Natal.

Similar to stem rust, differential distribution of leaf rust races has been observed in South Africa (Fig 2). For example, race CBMS has been detected only in the Western Cape and Eastern Cape but race MCDS has been found in the Free State, Eastern Cape and KwaZulu-Natal.

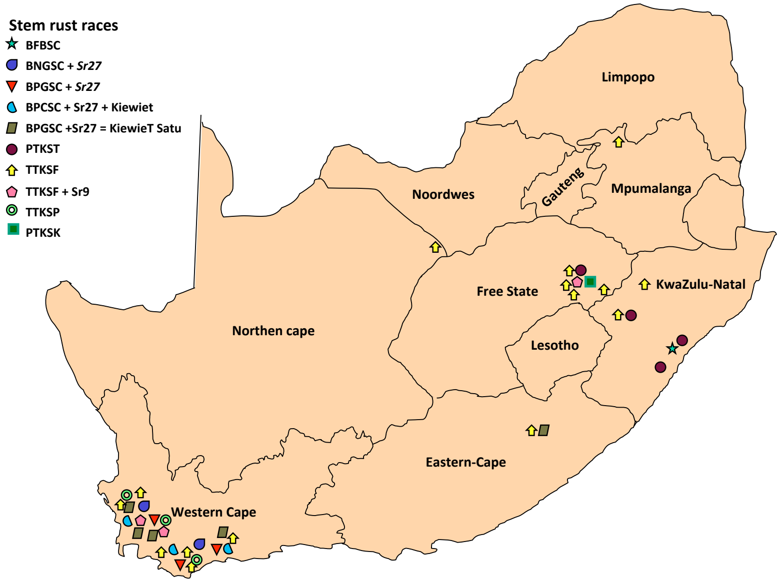


Figure 1. The distribution of common stem rust races in the major wheat growing areas of South Africa

Stripe rust was detected for the first time in South Africa in 1996. It gradually spread to the remaining wheat growing areas and presently, it has become a major production constraint in the cool weather wheat growing areas such as the Eastern Free State. Like stem and leaf rust, stripe rust has also evolved into different races. To date, four races of stripe rust (6E16A-, 6E22A-, 6E22A+ and 7E22A-) have been recorded in South Africa. The most frequently and widely found stripe rust race in recent years is 6E22A+.

Collaborative studies between ARC-Small Grain and the University of the Free State indicate that some of the stem and leaf rust races recently detected in South Africa were most probably exotic introductions rather than local adaptations. One or more of these new races were detected also in Southern African countries like Zimbabwe, Zambia, Mozambique and Malawi, indicating that they were probably introduced into South Africa from neighboring countries through wind-borne rust spores and/or via other mechanisms.

As mutations and migration of new rust races cannot be stopped, the rust monitoring programme at ARC-Small Grain has been regularly conducting rust surveys to mitigate the negative impacts of constantly evolving rust fungi. From such surveys, the frequency of races and their distribution in the major wheat growing areas have been determined (Fig 1 and 2). This has also helped in the early detection and control of new rust races, which might pose a threat to commercial wheat cultivars.

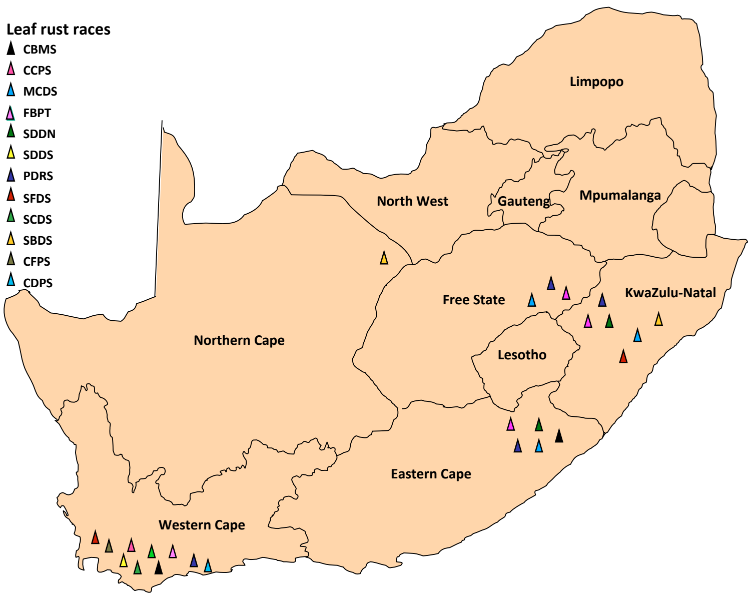


Figure 2. The distribution of common leaf rust races in the major wheat growing areas of South Africa

In addition, new races detected through surveys allowed identification of effective resistance genes that could be used in breeding and deployment of new resistant cultivars.

Rust pathogens will continue to evolve and form new races that may result in economic losses. Therefore, rust monitoring will be ongoing at ARC-Small Grain to ensure timeous detection and control of new races and to generate information that will enable sustainable breeding and availability of resistant cultivars. It is also important for wheat producers to regularly monitor their wheat fields for signs of rust diseases. Severe rust infections on cultivars that are supposed to be resistant could be due to the emergence of new races. When unusually high rust levels are observed on previously resistant cultivars, infected leaf and stem samples should be sent to ARC-Small Grain, Bethlehem, for race identification.

Symptoms of small grain diseases (photos by Dr Ida Paul)

Fig.3 Uredinia of stem rust on a wheat ear

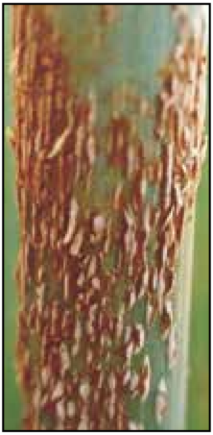


Fig.4 Uredinia of stem rust on an oat stem

Fig.5 Urediniaspores and teliospores of stem rust on a wheat stem

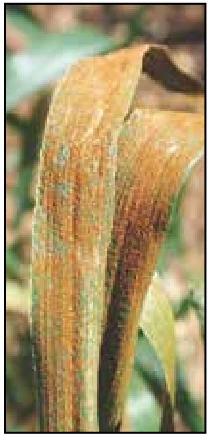


Fig.6 Uredinia of leaf rust on wheat leaves

Fig.7 Uredinia of stripe rust on a wheat leaf

Fig.8 Uredinia of stripe rust on wheat spikelets

Fig.9 Stripe rust infection in the field causes a yellow discolouration of the ears

Fig.10 Cottony white growth of powdery mildew on a barley leaf

Simptoms of small grain diseases

Fig.11 Cottony white growth of powdery mildew on the ear of wheat

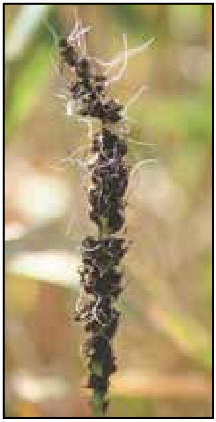


Fig.12 Wheat ear infected with loose smut

Fig.13 Oats ear infected with loose smut

Fig.14 Blackened crowns of wheat with take-all infection

Mildew

Powdery mildew

Erysiphe [Blumeria] graminis f. sp. *tritici* - wheat
Erysiphe [Blumeria] graminis f. sp. *hordei* - barley
Erysiphe [Blumeria] graminis f. sp. *avenae* - oats
Erysiphe [Blumeria] graminis f. sp. *secalis* - rye

Powdery mildew (Fig. 10 and 11) is a very common disease of cereals worldwide. Symptoms are most often seen on leaves and include fluffy white mycelium that become grey as they age. These pustules can be scraped off the surface or the leaf, as the infection on the leaf surface is very superficial. Later in the season, black dots may be found embedded in the white mycelium. These dots are the fruiting bodies of the fungus. The fungus survives non-crop seasons as dormant mycelium on host debris or in volunteer crops. Later spores called conidia, which are mainly produced on volunteer plants, serve as a source of inoculum. The disease is more prevalent in densely planted fields that are over-fertilized. In the United Kingdom, up to 25% loss in yield has been recorded; however yield losses in South Africa have not been measured. Small grain producers should take note that powdery mildew can cause losses if not controlled. The foliar application of fungicides is a reliable method of controlling the disease and it is widely practiced.

Virus diseases

Maize streak

Maize streak virus (MSV) - wheat, barley, oats

The Maize Streak Virus (MSV) causes a disease in maize, but a certain strain of the disease also infects sugarcane, millet, oats, barley, wheat and some wild grasses. The causal organism belongs to the Gemini virus group. In wheat, infection by this virus causes wheat streak or wheat stunt. Symptoms include fine, linear, chlorotic leaf streaks, shortened tillers, leaves and spikes and excessive tillering. Plants may also have leaves with bent and curled tips. Symptoms of the disease can easily be confused with streaks caused by the Russian wheat aphid. The disease is transmitted by leafhoppers from infected maize to healthy wheat. Warmer temperatures support higher populations of the leafhoppers, which can translate into higher infection rates. Maize streak is known to occur in the wheat production areas of the Limpopo Province, KwaZulu-Natal and the Vaalharts-region. The disease can be avoided by planting in areas where affected maize and grasses have been removed. However, planting resistant cultivars remains the best option for controlling the disease. Yet, no such cultivars are currently commercially available in South Africa. As the leafhoppers are vectors of the disease, controlling the leafhopper populations will also assist in reducing infection levels.

Ear and grain diseases

Fusarium head blight *(Gert van Coller, Dept. of Agriculture, Elsenburg) Fusarium graminearum* (previously known as F. *graminearum* Group 2)

- wheat, barley, triticale, oats

Fusarium head blight is one of the most important diseases of wheat, barley and triticale in most grain producing regions of the country. It is especially important in regions where small grains are produced under irrigation. Infection of florets takes place as result of spore release and high humidity during flowering. The disease is characterised by the discolouration of infected florets about 2-3 weeks after flowering. The florets become light-coloured and appear blighted. Under high disease pressure the whole wheat head may become infected. The symptoms become less visible as the heads ripen. Infected kernels become shrivelled and contain much less starch and proteins than uninfected kernels. Fusarium head blight can be distinguished from take-all (which also occurs under irrigation) where the entire tiller and head dies and whitens, as opposed to Fusarium head blight where the tiller still remains green and bands of blighted florets form on the wheat heads. The fungus survives primarily on crop residues; therefore retention of stubble is needed for the fungus to survive. It is important to note that the fungus can also infect maize, and production systems where barley and wheat are produced in rotation with maize can lead to higher disease pressure in subsequent years. Chemical applications with fungicides can help to manage the disease; however, there are currently no fungicides registered against Fusarium head blight in South

Africa. Research to evaluate different fungicides as well as methods of application is underway. Resistant cultivars are currently not available in South Africa.

Bunts and smuts

Smuts and bunts infect small grain cereals and several species of grass. These fungi produce masses of black spores that partially or completely replace the heads, spikelets and kernels. In South Africa, these diseases are controlled by the routine application of seed treatments by seed distributing companies. Farmers who retain seed to plant must use seed dressings against bunts and smuts. Failure to treat seed, in order to save on input costs, leads to the increased incidence of these diseases.

Loose smut

Ustilago tritici - wheat

Ustilago nuda - barley

Ustilago avenae - oats

Loose smut (Fig. 12 and 13) is a common small grain disease that occurs widely in areas where wheat, oats and barley are grown. Symptoms are not apparent until ear emergence. Infected ears emerge earlier, have a darker colour and are slightly longer than those of healthy plants. Infected spikelets are transformed into powdery masses of dark brown teliospores. Within a few days, the spores are blown away and only the rachis remains. When a spore lands on a flower of a small grain plant in the surrounding area, it germinates and infects the reproductive tissue of the grain so that the embryos of developing seeds are also infected. The fungus then survives as dormant hyphae in infected seed. After seed germination, the fungus forms a systemic infection in the plant and later, as the plant approaches heading, the fungus penetrates the head tissues and converts it to a brown powdery mass of teliospores. Yield losses are roughly equal to the percentage of infected ears. In contrast to stinking smut (*Tilletia* spp.), the quality of the harvested grain is not affected. This disease is effectively managed by the application of seed treatments (Table 7), although some seed treatments may impede seed germination. The use of high quality, disease free seed is also an effective way of controlling the disease, as the only source of inoculum is infected seed.

Covered smut

Ustilago hordei - barley, oats, rye

Covered smut is a common disease of mainly oats and barley, but it also infects rye and other wild grasses. Symptoms are not obvious until after ear emergence. Smutted heads emerge later than healthy heads and may become trapped in the flag leaf sheath and fail to emerge. With severe infections plants become dwarfed. Parts of the infected ear or the whole ear are transformed into powdery masses of dark brown teliospores, which are covered by a persistent membrane from where they are released at harvest, when this membrane is disrupted. The covered smut fungus survives in soil and on the surface of seed. The fungus infects the germinating seed through the coleoptile. After seed germination, the fungus forms a systemic infection in the plant and later, as the plant approaches heading, the fungus penetrates the head tissue and converts it to the brown powdery masses of teliospores. The dark powder from the teliospores discolours grain and affects grain quality and marketability. Covered smut is of economical importance in areas where seed treatments are not routinely used. Several seed treatments are registered for the control of covered smut in South Africa (Table 7).

Karnal Bunt

Tilletia indica - wheat, triticale

Historically, Karnal bunt did not occur in South Africa, it was identified for the first time in December 2000 from the Douglas irrigation area. Currently, several measures are in place to limit the spread of this disease throughout the country. These measures include testing of registered seed units and commercial grains for the presence of teliospores and quarantine regulations on the transport and entry of grains to mills and other delivery points. Since Karnal bunt is regarded as a quarantine disease according to South African regulations, all occurrences of this disease should be reported to the National Department of Agriculture (NDA). It is also important to implement phytosanitary measures in quarantine areas to prevent movement of the pathogen out of the infested area.

Karnal bunt infected kernels appear blackened, eroded and emit a foul 'fishy' odour. In infected spikes, the glumes may also appear flared and expose bunted kernels. Spikes of infected plants are generally reduced in length and in number of spikelets. However, only a few florets per spike might be affected and it may be difficult to identify the disease in the field, as the whole ear does not necessarily become infested. Microscopic examination of the seed to detect the presence of the teliospores is a more reliable method of identification.

The primary inoculum source is soil or seed contaminated with teliospores. These teliospores germinate and generate another kind of spore, known as basidiospores. One teliospore can produce up to 200 basidiospores that germinate and infect the head tissue of the plant. The infection is localised and not systemic as with loose smut and covered smut. Individual fungal cells within the kernel are converted to teliospores and parts of, or the whole of the diseased kernel is completely displaced by masses of teliospores as the kernel matures. Karnal bunt is of economical importance mainly due to the reduction in flour quality of grain infected with the disease. The flour will have a disagreeable odour and depending on the percentage infection, be darkened by the teliospores. This disease does not lead to yield losses as such. Karnal bunt is difficult to control. A first measure of protecting plants is preventing the entry of the pathogen to a certain area. Therefore, it is of utmost importance to adhere to quarantine regulations and to plant seed that has been certified to be disease free. Some fungicides applied at ear emergence may reduce the incidence of the disease but it is unlikely that they will prevent infection.

Stem base and root diseases

Fusarium crown rot *(Dr Sandra Lamprecht, ARC Plant Protection)*

Fusarium pseudograminearum (previously known as F. graminearum Group 1)

– wheat, barley, triticale

Fusarium crown rot is one of the most important soilborne diseases of wheat, barley and triticale in the Western Cape, but it is also present in other small grain producing areas in the country. The disease is especially important in areas where wheat is cultivated under dryland conditions. Oats are susceptible, but is a symptomless host. The disease is characterized by the honey-brown discolouration of the lower parts of the tillers and necrosis of the crown tissue and subcrown internodes. A pink discolouration can sometimes be observed under the lower leaf sheaths. The most characteristic symptom is, however, the formation of white heads, but this depends on water stress during grain fill. The disease can be confused with take-all which also causes white heads. The fungus requires moisture for infection, but subsequent disease development is favoured by moisture stress. The fungus survives primarily on crop residues between host crops and the retention of stubble therefore favours its survival, especially where small grain crops are grown in monoculture. The disease is therefore favoured by conservation tillage which is increasingly adopted by small grain farmers. Fusarium crown rot can be reduced with an integrated disease management strategy which include practices such as crop rotation with non-host crops (broadleaf crops such as canola, lupin, medic, lucerne etc.), control of grass weeds (most grass weeds are hosts), alleviation of zinc deficiency and reduction of moisture stress by practices that conserve soil moisture such as conservation tillage. Research conducted in the Western Cape showed that rotation systems where wheat was planted after three years of broadleaf crops had the lowest incidence of this disease. Resistant cultivars are not available, but tolerant cultivars with partial resistance have been identified in other countries such as Australia. South African wheat and barley cultivars will be evaluated for resistance/tolerance in the near future.

Take-all

Gaeumannomyces graminis var. graminis – wheat, barley, rye, triticale
Gaeumannomyces graminis var. tritici – wheat, barley, rye
Gaeumannomyces graminis var. avenae – oats

Take-all (Fig. 14) occurs widely throughout the small grain producing areas in South Africa. This disease affects the roots, crowns and basal stems of small grains, wheat in particular, and wild grasses. It is an important disease in areas where wheat is cultured intensively, the soil pH is neutral or alkaline, moisture is abundant and soils are deficient in manganese and/or nitrogen. Mildly infected plants appear to have no symptoms of the disease, while more severely infected plants ripen prematurely and are stunted. Take-all symptoms are more apparent during heading, as infected plants are uneven in height, die prematurely and whole plants discolour to the colour of ripe plants. A typical take-all infestation is characterised by the appearance of patches of white heads amongst areas with healthy green plants before ripening. The heads that ripen prematurely tend to be sterile or contain shriveled grain. Diseased plants pull up easily. Roots appear blackened and brittle and lower stems may take on a black colour, which is indicative of the disease. The pathogen persists in infected host residues from where the ascospores can act as sources of inoculum. Roots growing near infected residues become infected and early infections may progress to the crown. The disease is favoured by poorly drained soils, high seedling densities and high organic matter content in the soil. As the pathogen is favoured by wet conditions, the disease is more prominent in wet years or in irrigated fields. If conditions become dry, the pathogen becomes less active. The best way to control take-all is by crop rotation. A one-year break from barley or wheat can be sufficient to control the disease. Volunteer plants, grassy weeds and crop residues, that may harbour the pathogen, should be destroyed. Take-all can also be controlled to a certain extent by ensuring that the wheat plants have sufficient nutrients to promote healthy root growth. A newly registered seed treatment Galmano Plus® can be applied to support root health and help control take-all.

Wheat disease updates

Wheat blast: an emerging threat to global wheat production

A fungal disease named wheat blast was reported for the first time on wheat in 1985 in Brazil. Under conducive moist and warm weather conditions, this disease can cause more than 70% yield loss on susceptible cultivars. Wheat blast can infect leaves and heads of wheat. On wheat heads, infection starts as brown to black spots and gradually the entire spike, above the infection points, will dry and become straw-coloured (Fig. 15). Depending on the severity of the disease, infected heads may completely fail to produce any grain or may produce poor quality, shrivelled grains. Although blast symptoms resemble that of Fusarium head blight (FHB), the former lacks the characteristic pinkish discolorations which develop on wheat ears infected by FHB. On leaves, blast symptoms appear as different sizes of round to elliptical spots with gray centres and reddish brown margins (Fig.16).

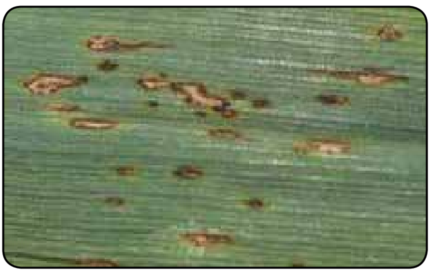


Figure 3. Blast signs on wheat heads (Source: compendium of wheat diseases and pests, 2010)

Figure 4. Sign of blast on a wheat leaf collected in Bangladesh (Source: http://phys.org/ news/2016-04- scientists-issue-rallying-wheat-blast.html)

The wheat blast fungus produces spores which can be dispersed over long distances in air currents. The disease is also seed-borne and can spread through infected seeds. A few years after the first epidemic in Brazil in 1985, wheat blast has spread to other South American countries including Bolivia (in 1996), Paraguay (2002) and Argentina (2007). However, it had not been reported outside of South America untilFebruary 2016 when a severe epidemic of this disease was observed for the first timein Bangladesh (Asia), affecting over 15 000 hectares of wheat and resulting in about90% yield losses in certain fields (www.cimmyt.org/wheat-blast/), threatening thelivelihood of hundreds of millions of people in South Asia who consume over 100 million tons of wheat, annually. It is therefore highly likely that wheat blast could also spread to other regions including Africa.

In South Africa, stripe rust of wheat was detected for the first time in 1996. In addition, some of the new races of leaf and stem rust, which were identified in recent years, were believed to be introductions into South Africa from other countries. This evidence underscores the vulnerability of the South African wheat industry to diseases of exotic origin and points to the possibility that sooner or later, wheat blast could make its way to South Africa.

A few blast-tolerant cultivars have been identified in South America. To a limited extent, fungicides can also provide protection from this disease. As a proactive measure, it is important to source and import resistant material for use in breeding programmes in South Africa. In addition, a well-organised disease surveillance programme should assist in the early detection of wheat blast as this would enable preparation and application of control measures, reducing the risk of the disease developing at epidemic level. The ongoing rust surveillance programme at ARC-SGI is closely monitoring major wheat growing regions for possible occurrence of this disease. It is also essential that wheat producers and institutions working on wheat inspect commercial wheat fields and experimental plots for blast symptoms. When wheat blast is suspected, samples can be sent to ARC-Small Grain, Bethlehem for diagnosis.

Control of Fungal Diseases

Genetic control of fungal diseases

Breeding for resistance is an economically important and environmentally friendly way of controlling fungal diseases of small grains. The objective of breeding programmes being the incorporation of resistance genes into well adapted cultivars. The susceptibility or resistance of some wheat cultivars to certain diseases are indicated in Tables 1 and 3. The risk of occurrence of certain diseases occurring in a given area are indicated in Tables 2 and 4. However, no one cultivar can be resistant to all the fungal diseases that might attack it. Therefore, fungicide application remains of importance in the sustainable production of small grains in South Africa.

Table 1. Disease resistance or susceptibility of wheat cultivars recommended for cultivation under dryland conditions in the summer rainfall region.

Cultivar	Stem rust	Leaf rust	Stripe rust
Elands (PBR)	MR	S	MS
Gariep	R	S	S
Koonap (PBR)	R	S	R
Matlabas (PBR)	S	S	S
PAN 3111 (PBR)	R	S	MR
PAN 3118 (PBR)	R	S	S
PAN 3120 (PBR)	R	MS	MS
PAN 3161 (PBR)	R	MS	MR
PAN 3195 (PBR)	R	S	MR
PAN 3198 (PBR)	R	R	MR
PAN 3368 (PBR)	MR	MS	MR
PAN 3379 (PBR)	MS	MS	MS
Senqu (PBR)	R	MS	R
SST 3149 (PBR)	MR	R	R
SST 316 (PBR)	MR	S	R
SST 317 (PBR)	MR	S	R
SST 347 (PBR)	MR	MS	MS
SST 356 (PBR)	MS	S	R
SST 374 (PBR)	MS	S	MS
SST 387 (PBR)	R	S	R

S = Susceptible *MS = Moderately susceptible* *R = Resistant*

MR = Moderately resistant

PBR: Cultivars protected by Plant Breeders' Rights

Variation in rust races may affect cultivars differently. Reactions given here are based on existing data for the most virulent rust races occurring in South Africa. Distribution of races may vary between production regions.

Table 2. The risk of occurrence of rust diseases under dryland conditions of the summer rainfall regions

Production Region	Stem rust	Leaf rust	Stripe rust
Western Free State	LR	LR	LR
Central Free State	LR	LR	LR
Eastern Free State	LR	LR	HR
Mpumalanga	LR	LR	LR
Gauteng	LR	LR	LR
Limpopo	LR	LR	LR
Northern Cape	LR	LR	LR

LR = low risk *HR = high risk*

Table 3. Disease resistance or susceptibility of wheat cultivars recommended for cultivation under irrigation.

Cultivar	Stem Rust	Leaf Rust	Stripe Rust
Baviaans (PBR)	S	MS	R
Duzi (PBR)	S	S	R
Kariega	S	MS	R
Koedoes (PBR)	MS	S	S
Krokodil (PBR)	MS	S	S
PAN 3400 (PBR)	MS	S	R
PAN 3471 (PBR)	S	MS	R
PAN 3497 (PBR)	S	S	R
PAN 3515 (PBR)	MS	R	R
PAN 3623 (PBR)	S	S	R
Renoster (PBR)	S	S	MS
Sabie (PBR)	S	MS	R
SST 806 (PBR)	S	MS	R
SST 8135 (PBR)	MS	MS	R
SST 8154 (PBR)	MS	S	R
SST 8156 (PBR)	MS	MS	R
SST 822 (PBR)	MS	MS	R
SST 835 (PBR)	MS	MS	MR
SST 843 (PBR)	MS	MS	R
SST 866 (PBR)	S	MS	R/MS
SST 867 (PBR)	S	MS	MR
SST 875 (PBR)	S	MS	R
SST 876 (PBR)	S	MS	MR
SST 877 (PBR)	S	MS	R/MS
SST 884 (PBR)	MR	S	R
SST 895 (PBR)	MS	MS	R

S=Susceptible *MS= Moderately susceptible* *R=Resistant* *MR=Moderately resistant*

/ = mixed for rust reaction

PBR: Cultivars protected by Plant Breeders' Rights

Variation in rust races may affect cultivars differently. Reactions given here are based on existing data for the most virulent rust races occurring in South Africa. Distribution of races may vary between production regions.

Table 4. The risk of wheat diseases in cultivation areas under irrigation in the summer rainfall region

Production Region	Stem rust	Leaf rust	Stripe rust	Head blight
Cooler Central area [a]	LR	LR	HR	HR
Warmer Northern area [b]	LR	HR	LR	HR
KwaZulu-Natal	LR	HR	HR	HR
Fish River	HR	HR	HR	HR

LR = low risk *HR = high risk*

a: *Irrigation areas include areas around Vaalharts, Sandvet, the Riet River and the Orange River*

b: *Irrigation areas include areas in the Magaliesburg area, in Mpumalanga and Limpopo provinces and in the Lowveld*

Chemical control of fungal diseases

Fungicides are routinely used for control of foliar ear, grain and stem diseases. In South Africa various active ingredients are registered for the control of fungal diseases on small grains (Tables 5 and 6). Several active ingredients are registered for the control of seed and/or soil borne diseases (Table 7).

In order to be successful with the use of fungicides for disease control, the following aspects must be taken into account:

- In order to choose the appropriate fungicide the disease and causal organism of the disease should be identified correctly.
- The efficacy of fungicides differs and a fungicide registered against the observed disease should be chosen.
- The susceptibility of the particular cultivar to the disease should be considered.
- In most cases resistant cultivars will not need fungicide protection, unless new races of the pathogen develop.
- Timing of application is critical. One application at the correct timing can give more protection to the plants than three badly timed spray applications.
- Protection of the flag leaf is important, as this leaf greatly contributes to the productivity of the plant.
- Some fungicides require intervals before harvest or consumption of produce and should also be considered.
- Use the correct amount of water so as to ensure adequate coverage.

Table 5. Active ingredient/s of fungicides registered for the control of selected diseases of wheat

Active ingredient/s	Wheat disease				
	Stem rust	Leaf rust	Stripe rust	Powdery mildew	Take-all
Carbendazim/Epoxiconazole			x		
Carbendazim/Flusilazole		x	x	x	
Carbendazim/Propiconazole		x	x	x	
Carbendazim/Cyproconazole		x	x	x	
Carbendazim/Tebuconazole		x	x	x	
Carbendazim/Triadimefon		x		x	
Epoxiconazole		x			
Flusilazole			x		
Fluquinconazole/Prochloraz		x			x
Propiconazole	x	x	x	x	
Propiconazole/Cyproconazole	x	x	x	x	
Prothioconazole/Tebuconazole		x		x	
Tebuconazole	x	x	x	x	

**The booklet can be obtained from http://www.croplife.co.za/docs/Fungicides.pdf and the webpage of the National Department of Agriculture http://www.nda.agric.za/act36/AR/AR%20Lists.htm. Please note that although some formulations of fungicide are registered against a wide range of diseases, some formulations may only be effective for the control of one disease. Always be sure to consult the label for exact specifications.*

Table 6. Active ingredient/s of available fungicides registered for the control of selected diseases of barley*

Active ingredient/s	Barley disease	
	Leaf rust	Powdery mildew
Carbendazim/Flusilazole	x	x
Carbendazim/Propiconazole	x	x
Carbendazim/Tebuconazole	x	x
Carbendazim/Triadimefon	x	x
Cyproconazole/Propiconazole	x	x
Flusilazole	x	x
Picoxystrobin + Carbendazim/ Flusilazole (tank mixture)	x	x
Propiconazole	x	x
Prothioconazole/Tebuconazole	x	x
Tebuconazole	x	x

**The booklet can be obtained from http://www.croplife.co.za/docs/Fungicides.pdf and the webpage of the National Department of Agriculture http://www.nda.agric.za/act36/AR/AR%20Lists.htm. Please note that although some formulations of fungicide are registered against a wide range of diseases, some formulations may only be effective for the control of one disease. Always be sure to consult the label for exact specifications.*

Table 7. Active ingredient/s of fungicides registered for the control of selected seed borne diseases of small grains*

Active ingredient/s	Seed borne disease				
	Loose smut wheat	Loose smut barley	Loose smut oats	Covered smut barley	Covered smut oats
Benomyl	x				
Carboxin/Thiram	x	x		x	
Difenoconazole	x				
Mancozeb				x	x
Prothioconazole	x	x		x	
Tebuconazole	x	x		x	
Thiram			x	x	x
Triticonazole	x	x		x	

**The booklet can be obtained from http://www.croplife.co.za/docs/Fungicides.pdf and the webpage of the National Department of Agriculture http://www.nda.agric.za/act36/AR/AR%20Lists.htm. Please note that although some formulations of fungicide are registered against a wide range of diseases, some formulations may only be effective for the control of one disease. Always be sure to consult the label for exact specifications.*

GUIDELINES FOR THE PRODUCTION OF MALTING BARLEY UNDER IRRIGATION 2018

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The effect of different production factors, of which cultivar choice, planting date, planting density, nitrogen fertilisation and irrigation are the most important, are reflected in the yield and the malt quality of the crop. The research programs running in the irrigation areas since 1991 are, therefore aimed at identifying the most suitable cultivar with the optimum date and planting density and a nitrogen fertilisation application level that will ensure an economical, optimum yield and grain conforming to quality specifications.

From the results obtained from the research programme, as well as experience from some commercial plantings in this area in the past, the following recommendations can serve as guidelines for the production of malting barley.

Plant Breeders' Rights (Act 15 of 1976)

The act renders legal protection to the breeders and owners of cultivars. The awarding of rights stipulates that cultivars must be new, distinguishable, uniform and stable, and protection is granted for a period of 20 years. The rights of the owner/ breeder entail that no party may multiply propagating material (seed), process it for planting, sell it, import it, export it or keep it in stock without the necessary authorization or license of the holders of the rights. The act makes provision for the court to grant compensation of R10 000.00 to the holder of Plant Breeder's Rights in cases of breaching of rights.

Seed certification and Table 8, as described in the Plant Improvement Act

The main aim of certification of seed is to maintain cultivars. Seed laws and regulations prescribe the minimum physical requirements, while certification of seed strives to achieve high standards of genetic purity and other quality requirements. Seed certification is a voluntary action that is administered by SANSOR on behalf of the Minister of Agriculture. However, if a cultivar is listed in Table 8, it is subject to compulsory certification. Hereby cultivar purity as well as good seed quality is guaranteed, and renders protection and peace of mind to the buyer (farmer), as well as an improved control system for acting on complaints and claims. The costs involved are surely a minimal price to pay for the peace of mind of both the buyer and seller of certified seed.

Soil Preparation

Soil preparation for the production of barley is the same as for wheat. It must, however, be emphasised that a weed free, fine and very even seedbed is prepared. An uneven seedbed causes uneven development of the crop and in the end also uneven ripening and quality.

Cultivars

The barley cultivars Cristalia and Overture are at this point in time the only recommended cultivars for commercial production of malting barley under irrigation. The ratio of production between these two cultivars is revised on an annual basis.

The malting characteristics of these cultivars differ and for this reason the mixing of these cultivars must be prohibited at all costs. It is thus imperative that the different cultivars are transported, handled and stored separately.

Seed of both cultivars will be available at the local co-operative and only at the depots as communicated prior to the planting season. These cultivars are only allowed to be delivered at the depots as stipulated in the contract or as communicated beforehand. The seed will be treated with a fungicide as well as an insecticide. This is for the prevention of powdery mildew during the development stages (approximately 10 weeks) of the seedlings and also to prevent covered smut and loose smut, while the insecticide will protect the seed against insect damage for a limited period before it is planted.

Agronomic characteristics

Cultivar choice is economically a very important decision the producer has to make, as it is one of the easiest ways to achieve higher and more stable income with the least risk. Factors that determine cultivar choice are thus fundamental to this decision. Only the most important factors are discussed briefly and for this reason Table 1, which characterises cultivars in terms of agronomic and quality characteristics, is included.

Growth period

Growth period refers to the average number of days that it takes from emergence to physiological maturity. For this reason cultivars must be planted that are adapted to the climatic conditions, such as growing season, rainfall pattern and temperature of the area.

Straw strength

Straw strength is the ability of a cultivar to remain standing (no lodging) under extreme conditions and is largely determined by straw length and thickness. The lodging of barley often results in considerable yield and grain quality losses, which can largely be attributed to the resulting decrease in kernel plumpness. It is largely a problem where critical yield potential conditions have been exceeded, but bad irrigation practices with a strong wind and excessive nitrogen fertilisation and/or seeding density can also play a role.

Peduncle strength

This characteristic refers to the strength of the straw between the flag leaf and the head/ear, and thus to the susceptibility of the cultivar to wind damage (Table 1). The greatest risk of the latter is just prior to harvesting.

Kernel plumpness

The percentage plump kernels largely determine the grade of the grain. This characteristic is strongly cultivar related (Table 1). Under conditions where soil water deficits, water logging and heat stress occur during the grain filling period or where lodging occurs, considerable losses could occur with the downgrading of the crop due to a low kernel plumpness percentage.

Table 1. Agronomic and quality characteristics of barley cultivars

Cultivars	Growth period	Straw length	Straw strength	Peduncle strength	Kernel Plumpness (%)
Cristalia	ME	M	GMG	GGM	G
Overture	M	M	G	M	G

Growth period:	*ME = Medium Early*	*M = Medium*
Straw length:	*M = Medium*	
Straw strength:	*G = Good*	*M = Medium*
Peduncle strength:	*G = Good*	
Kernel Plumpness (%)	*G = Good*	

Planting practices

The planting equipment used for the planting of wheat is also suitable for the planting of barley. It is very important that barley is not planted too deep, because this can be detrimental to emergence of the seedlings and also tillering.

The optimum planting date for the different irrigation areas are as follows:

Region	May	June				July		
	4	1	2	3	4	1	2	3
Vaalharts/Taung								
Riet River/Douglas								
Luckhoft/Hopetown								
Barkley West								
Northern Irrigation Areas								

Northern irrigation areas: Brits, Atlanta, Beestekraal, Koedoeskop, Thabazimbi and Skuisdrift)

These are only optimum planting dates and do not mean that in certain micro-climates in the mentioned areas, a later or an earlier planting date will not be successful.

The planting density can vary from 60 kg/ha to 90kg/ha depending on the status of the seedbed, the planting date, irrigation method and the planter used. The average recommended planting density is 70 kg/ha, if the seed have 100% germination capacity and a thousand kernel mass of approximately 40 grams. Aim to establish 130 to 140 plants/m² at harvesting. Due to this reason, 60 to 80 kg seed per hectare ought to be sufficient under center pivot conditions where seedbed preparation is optimum, it is important to note that seedbed preparation plays a vital role where lower planting densities are used. It can be considered to increase the planting density of Cristalia in order to insure the optimum plant population (70 – 90 kg/ha). It is important to note that seedbed preparation plays a critical role where lower planting densities is used. Under flood irrigation, conditions the planting density should be adjusted upwards (10%). The producer must be aware of the fact that the thousand kernel mass and the germination capacity of the seed can vary from year to year and that he must adjust his seeding density accordingly.

The following table indicates the planting density in kg/ha at the different 1000 kernel masses of the seed in order to realise the desired number of plants/m² at harvesting, with an expected survival of 80%.

Planting density in kg/ha												80		% Germination		
1000 Kernel Weight (g) of Seed	Target number of plants/m^2 at harvesting															
	100	**110**	**120**	**130**	**140**	**150**	**160**	**170**	**180**	**190**	**200**	**210**	**220**	**230**	**240**	**250**
35	44	48	53	57	61	66	70	74	79	83	88	92	96	101	105	109
36	45	50	54	59	63	68	72	77	81	86	90	95	99	104	108	113
37	46	51	56	60	65	69	74	79	83	88	93	97	102	106	111	116
38	48	52	57	62	67	71	76	81	86	90	95	100	105	109	114	119
39	49	54	59	63	68	73	78	83	88	93	98	102	107	112	117	122
40	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125
41	51	56	62	67	72	77	82	87	92	97	103	108	113	118	123	128
42	53	58	63	68	74	79	84	89	95	100	105	110	116	121	126	131
43	54	59	65	70	75	81	86	91	97	102	108	113	118	124	129	134
44	55	61	66	72	77	83	88	94	99	105	110	116	121	127	132	138
45	56	62	68	73	79	84	90	96	101	107	113	118	124	129	135	141
46	58	63	69	75	81	86	92	98	104	109	115	121	127	132	138	144
47	59	65	71	76	82	88	94	100	106	112	118	123	129	135	141	147

The data of the previous five seasons are shown in the following three tables.

Table 2. Average yield (ton/ha) of barley cultivars in the Northern irrigation regions for the period 2014 – 2018 (Beestekraal, Koedoeskop, Skuinsdrift)

Cultivar	2014	2015	2016	2017	2018	Average
Overture	8.62	6.54	8.33	7.01	7.73	7.65
Cristalia	7.88	6.70	7.83	5.83	6.56	6.96
Average	**8.25**	**6.62**	**8.08**	**6.42**	**7.15**	**7.30**

Table 3. Average yield (ton/ha) of barley cultivars in the Central irrigation regions for the period 2014 – 2018 (Taung, Hartswater, Jan Kempdorp)

Cultivar	2014	2015	2016	2017	2018	Average
Overture	9.79	5.91	10.25	8.82	9.03	8.76
Cristalia	8.81	5.79	9.21	8.60	9.31	8.34
Average	**9.30**	**5.85**	**9.73**	**8.71**	**9.17**	**8.55**

Table 4. Average yield (ton/ha) of barley cultivars in the Southern irrigation regions for the period 2014 – 2018 (Rietrivier, Douglas-East, Douglas-West, Luckhoff)

Cultivar	2014	2015	2016	2017	2018	Average
Overture	8.24	7.77	6.97	10.17	10.41	8.71
Cristalia	7.70	7.23	6.34	8.65	10.18	8.02
Average	**7.97**	**7.50**	**6.66**	**9.41**	**10.30**	**8.37**

Table 5. Average kernel plumpness (%) of barley cultivars in the Northern irrigation regions for the period 2014 – 2018 (Beestekraal, Koedoeskop, Skuinsdrift)

Cultivar	2014	2015	2016	2017	2018	Average
Overture	96.40	90.00	95.70	96.88	97.63	95.32
Cristalia	93.20	91.40	97.30	95.79	94.30	94.40
Average	**94.80**	**90.70**	**96.50**	**96.33**	**95.97**	**94.86**

Table 6. Average kernel plumpness (%) of barley cultivars in the Central irrigation regions for the period 2014 – 2018 (Taung, Hartswater, Jan Kempdorp)

Cultivar	2014	2015	2016	2017	2018	Average
Overture	97.30	87.20	97.20	94.76	92.97	93.89
Cristalia	97.10	83.30	94.80	96.63	93.13	92.99
Average	**97.20**	**85.25**	**96.00**	**95.70**	**93.05**	**93.44**

Table 7. Average kernel plumpness (%) of barley cultivars in the Southern irrigation regions for the period 2014 – 2018 (Rietrivier, Douglas-East, Douglas-West, Luckhoff)

Cultivar	2014	2015	2016	2017	2018	Average
Overture	98.40	91.80	95.10	98.20	92.88	95.28
Cristalia	97.70	93.30	95.70	97.34	91.83	95.17
Average	**98.05**	**92.55**	**95.40**	**97.77**	**92.35**	**95.22**

Table 8. Average kernel nitrogen (%) of barley cultivars in the Northern irrigation regions for the period 2014 – 2018 (Beestekraal, Koedoeskop, Skuinsdrift)

Cultivar	2014	2015	2016	2017	2018	Average
Overture	1.66	2.28	1.71	1.77	1.88	1.86
Cristalia	1.77	2.23	1.72	2.04	2.00	1.95
Average	**1.72**	**2.26**	**1.72**	**1.90**	**1.94**	**1.91**

Table 9. Average kernel nitrogen (%) of barley cultivars in the Central irrigation regions for the period 2014 – 2018 (Taung, Hartswater, Jan Kempdorp)

Cultivar	2014	2015	2016	2017	2018	Average
Overture	1.77	2.10	1.75	1.83	1.92	1.87
Cristalia	1.93	2.02	1.83	1.86	2.06	1.94
Average	**1.85**	**2.06**	**1.79**	**1.85**	**1.99**	**1.91**

Table 10. Average kernel nitrogen (%) of barley cultivars in the Southern irrigation regions for the period 2014 – 2018 (Rietrivier, Douglas-East, Douglas-West, Luckhoff)

Cultivar	2014	2015	2016	2017	2018	Average
Overture	1.89	1.93	2.02	1.69	1.91	1.89
Cristalia	1.98	2.03	2.15	1.76	1.98	1.98
Average	**1.94**	**1.98**	**2.09**	**1.72**	**1.94**	**1.93**

FERTILISATION

Soil acidity requirements

The management of an effective fertilisation programme entails soil analyses just prior to the season. As is the case with all crops, a fertilisation programme can only be successful if the crop's minimum acidity requirements are met. For barley this has been established at a pH of 5.5 (KCl medium) and the target for lime application to the soil should, therefore, be to create a pH of 5.5 to 6.0. The pH of the soil can rather be higher than 6.0 than lower than 5.5. Yield losses could be severe at lower pH values, but could also occur if the pH is injudiciously raised by more than one pH unit. Unnecessary increases in pH could lead to zinc and manganese deficiencies, something to which barley is very sensitive.

Phosphorus

It is generally accepted that the phosphorus requirement of barley is higher than that of wheat, and that soil analyses are essential for estimating the fertilisation requirement. The objective should be to reach 30 mg/kg citric acid soluble phosphorus, or 20 mg/kg Bray 1 soluble phosphorus in the soil. To achieve this, 4 kg P/ha can be applied for each 1 mg/kg that the analyses is below 30 mg/kg (citric acid), or 6 kg P/ha for each 1 mg/kg that the analysis is below 20 mg/kg (Bray 1). For analyses higher than the above, 12 to 15 kg P/ha is applied, which is adequate to maintain soil fertility.

Potassium

Potassium deficiencies are possible in the lighter textured soils in the irrigation areas and where deficiencies do occur, the following guidelines apply:

Table 11. Potassium fertilisation according to soil analysis

Citric acid soluble or ammonium acetate soluble Potassium (mg/kg)	**Potassium fertiliser (kg K/ha)**
20 - 30	40 - 30
30 - 50	30 - 15
50 - 70	15 - 0
Bo 70	0

In soil analyses below 50 mg/kg an extra 15 kg k/ha can be applied for each ton of hay baled or removed. Experience has shown that a split application of potassium (with planting and at 8 weeks after planting) can decrease the risk of lodging.

Nitrogen

Nitrogen fertilisation can be applied at different growth stages during the development of the barley plant. Under dry land conditions, rainfall is regarded as the most important factor for determining the nitrogen requirements of barley. Under irrigation this is, however, not such a decisive factor and the production system and soil type play a more important role. The first nitrogen is applied just prior to or during the planting process. Top dressing of nitrogen is, according to trial results, beneficial to higher yields and more so for overhead irrigation than flood irrigation. Split applications of nitrogen fertiliser are also more beneficial on lighter sandy soils than on heavier clay soils.

With the increase in yield over the last couple of years, mainly due to genetic improvement, improved production practices and optimum irrigation scheduling, it appears that a total nitrogen application of 140 kg/ha, depending on the soil texture and rotation system seems to be sufficient for optimum yield and quality.

On a cotton rotation system, and where a lot of maize harvest rests are present just prior to planting, the nitrogen application rate can be higher (approximately 20 - 30 kg N/ha more, depending on the soil texture) and must be applied as a split application to overcome the nitrogen negative period. On very sandy soils, where leaching of nitrogen is a major problem, an additional 20 kg N/ha is recommended. Although it is not recommended to plant barley directly after lucerne, this practice is widely used. It is important to note that under this condition, N fertilisation needs to be decreased to 100 – 120 kg/ha and preferably all applied with planting. Split application of nitrogen fertilisation is more important under overhead irrigation (specifically centre pivot) and sandy soils than under flood irrigation and heavy clay soils. A split of two thirds of the total nitrogen with planting and the rest 6 weeks after emergence, seems to give the best results. On very sandy soils where leaching is a problem and a history of low nitrogen content in the grain is experienced, the topdressing can be applied at a later stage, but not later than the soft dough stage. Experience in the practice has shown that barley tends to dislike a small application of nitrogen with planting, followed by the bulk of the nitrogen in a couple of topdressings. The yield potential of barley is mainly determined during the first six weeks after emergence, up to the appearance of the first node. Limestone ammonium nitrate (LAN) appeared to be the best source of nitrogen for topdressing and where nitrogen topdressing is applied through the irrigation system, an ammonium nitrate based fertiliser is recommended. It is also recommended that some part of the nitrogen that is applied at planting, is ammonium nitrate based. Additional nitrogen topdressing after exceptionally heavy rains could be economically beneficial as late as the soft dough stage. On the sandy, high potential soils of the Douglas area, additional topdressing of 20 kg of nitrogen per hectare can be considered.

POST SEEDING PRACTICES

Weed control

Together with fertilisation, the control of weeds can be seen as most important. Barley is very sensitive to competition of weeds and even more so in the early developmental stages of the plants. Early control measures will, therefore, enhance the yield potential of barley and must preferably be done as soon as possible after most weeds have germinated and infestation is high enough to justify control measures. The same guidelines as for weed control in wheat apply for barley. Weeds must be correctly identified (broadleaf and grass weeds), because different herbicides are used for the control of broadleaf and grass weeds. The only herbicides for the control of grass weeds in barley are Hoelon/Ravenger, Axial and Grasp. Under no circumstances must herbicides like Topic and Puma be sprayed on barley. The correct amount of herbicide, as recommended on the label, must be applied, because too high dosages can be detrimental to the barley plant and too low dosages will be ineffective. Only herbicides registered specifically on barley, according to the label, are allowed to be used.

Insect control

Barley is a natural host plant for the well-known Russian wheat aphid and some other plant aphids. For early infestation by aphids, an insecticide can be applied with the herbicide. For a late infestation an insecticide has to be applied on its own. The same guidelines apply as for wheat. Barley is, as wheat, susceptible to bollworm damage and the same guidelines for bollworm control apply as for wheat.

During the 2010 season the false armyworm caused huge damage to plantings, especially in the Vaalharts area. It was, however noticed throughout the entire production area and producers must be on the lookout for this insect. In Australia this is a sporadic plague and not necessary a year to year phenomenon. The Small Grain Institute is currently hard at work to determine a control strategy for this plague. Although no insecticide is specifically registered for the control of false armyworm, the general feeling is that insecticides used for the control of bollworm can also be successful for the control of false armyworm. The Small Grain Institute also undertook to put out pheromone traps to monitor moth flights of the false armyworm. By doing this agriculturalists can notify producers in advance of a possible infestation.

Growth regulation

Although the current cultivars are more resistant to lodging than the older generation cultivars, it is also prone to lodging under very high potential conditions and more so under overhead systems. This problem can be minimised if the crop is not over-irrigated during the early stages of plant development. If the producer is of the opinion that his barley is too lush during the early growth stages and feel that lodging may become a problem, he can stress his crop by applying less water for the period 8 to 12 weeks after emergence. At this specific stage, water stress will have the least negative effect on yield.

Lower planting densities (<140 plants/m²) can also play a significant role in the decrease of lodging given that the seedbed preparation is optimal. Higher seeding densities (>140 plants/m²) leads to longer plants with weak straw, which is caused by excessive competition for air and light.

Lodging can also be limited by applying a growth regulator, but presently no growth regulator is registered on barley in South Africa. Trials that were executed for registration purposes showed that these growth regulators did more harm than good.

The only way therefore, to minimise lodging is not to:

- apply too much nitrogen fertiliser,
- use a too high planting rate,
- over irrigate during the early growing stages of the crop,
- apply too heavy irrigation during the ripening stage of the barley and
- apply irrigation when strong winds prevail.

Fungal control

Fungal diseases do not seem to be a problem in barley under the dry and hot conditions in the irrigation areas. If any diseases do appear on the barley, a representative of SAB Maltings must be informed immediately for the necessary recommendations.

Fungal contamination of the barley grain in this area is, however, common. Some of these fungi can produce toxic substances (DON) that can be detrimental to humans and livestock. It is thus essential that the crop must be harvested as soon as it is ready, in order to minimise the risk of ripe barley being exposed to rain during harvesting.

Irrigation

Irrigation scheduling must be according to evaporation and needs, as per growth stage. This information is available from your SAB Maltings representative. It is,however, very important that irrigation is not stopped too early and the last irrigation must be applied when the total plant is almost discoloured. This is to ensure an even ripening and to produce grain with a high percentage kernel plumpness and acceptable nitrogen content. As mentioned, skilful irrigation practices can minimise lodging and optimise yield and quality (refer to section under growth regulation).

HARVESTING

In the traditional barley producing area, barley is swathed and windrowed before it is threshed. This is mainly done to reduce the risk of damage by strong winds. Barley ears bend downwards when they mature and are prone to be blown off by strong winds and this can cause huge yield losses. The producers in the irrigation areas, however, are not equipped for this practice. That is why it is crucial that the barley must be harvested as soon as it reaches a moisture content of 13% in order to minimise the risk of ripe barley being exposed to possible damage by wind and hail for prolonged periods. Barley can be harvested with the same equipment as wheat with minor adjustments to the drum speed, concave setting and wind. Since the contracts are for the supply of malting barley, it is essential that skinning of the grain be avoided during harvesting. Skinning impairs germination and introduces problems during malting. Thus the combine harvester operation should not be as aggressive as for wheat and care should be taken to avoid an excessively fast drum speed and/or an excessively tight concave setting.

The barley must be harvested in bulk (except where other arrangements have been made) and delivered at the depot as stipulated on the contract or as communicated during the growing season, where it will be sampled, classified and graded. The producer then gets paid according to quantity and quality. Producers will get paid for quality on a sliding scale system as stipulated in the contract.

QUALITY

As from the 2018 season the sliding scale and the consequent payment for quality of barley is as adjusted. A variable quality premium will be paid for a kernel nitrogen content of between 1.61% and 1.90% as well as for screenings of 2.4% and lower. It is important that producers must verify these changes with their nearest SAB agriculturalist, grain dealer or member of the Barley Industry Committee.

Maltsters require barley that malts homogenous and modifies quickly, requires no or little cleaning and that will deliver malt of an acceptable and consistent quality to brewers. For this reason maltsters set certain quality standards for malting barley to ensure that the end product is produced in the most economical way possible.

Nine characteristics, viz. cultivar purity, germination, nitrogen content, kernel plumpness, screenings, foreign matter, mechanical damage, fungal infestation and moisture content are of critical importance in grading and are discussed briefly.

Germination/cultivar purity

Malting barley differs from most cereals as it has to grow again during processing. Germination refers to the percentage barley kernels that are viable within a specified time. It is the most important characteristic of malting barley and must be higher than 98% after the breaking of the dormancy period. Different cultivars have different dormancy periods (rest periods) and therefore, it is important that cultivars are not mixed, but stored separately.

The viability or germination energy of barley can be affected by rain prior to harvesting. If barley is subjected to rain when ripe, biochemical processes in the kernel are initiated that precede germination. The result is uneven or poor germination of the barley during the malting process and produces a poor end product.

Nitrogen content

Barley with extensively high (>2.00) or low nitrogen content (<1.50%) cannot produce malt of the required quality for brewing purposes and will be downgraded to feed grade. The price for barley is based on a base price onto which a premium is added for certain nitrogen levels in the grain (1.61% - 1.90%)

Nitrogen content of barley is a characteristic that is genetically, as well as environmentally, influenced. Certain cultivars produce lower nitrogen content despite higher nitrogen fertilisation. Such a characteristic of a cultivar would be beneficial as it is not only high nitrogen fertilisation that increases the nitrogen levels in the grain, but also uncontrollable factors such as drought and heat stress during the grain filling period and the nitrogen supply capacity of the soil. The producer must at all times also consider the nitrogen supply capability of his soils. Soil tillage and the preceding crop are some of the important factors to keep in mind.

Kernel plumpness

Kernel plumpness is important for homogeneous malting. Thin kernels absorb water faster than plump kernels. Thin kernels also have a relatively higher percentage husk, which gives beer an astringent taste. Therefore, uniform plumpness will result in better malting quality. Barley qualify as malting barley when the kernel plumpness is from 70% upwards, as measured with a 2.5mm sieve. As in the case of nitrogen content, the cut-off point must be confirmed with the grain handlers.

It is also important to note that plump kernels produce malt with a higher extract, which is an important aspect in the brewing process. A low kernel plumpness percentage is the result of unfavorable conditions during the grain filling period, as late ears ripen too fast or if the initial yield potential exceeds the capacity of the environment at the grain-filling stage. Certain cultivars however, also tend to constantly have a lower kernel plumpness and for this reason breeders specifically select for lines with high kernel plumpness. The kernel plumpness of all the present barley cultivars can be described as good to very good.

Screening, foreign matter and mechanical damage

Screenings is material that is so small that it falls through a 2.2 mm sieve and needs to be less than 5%. This material generally consists of shriveled kernels, broken kernels, small weed seeds, glumae, awns, dead insects and dust. Thin kernels can be ascribed to factors noted, while broken kernels, glumae, awns and dust generally reflect on harvester adjustments. For this reason it is imperative that the producer adjusts his harvester correctly to ensure good quality.

Dead weevils in the screenings are usually an indication of a possible infestation and this would require further investigation. The presence of weevils can lead to downgrading of the crop due to the live insects on the one hand or the presence of insect damaged kernels on the other hand.

The cut-off point for foreign matter is 2%, a feed grade price is applicable for barley with a foreign matter content >2%.

Mechanical damage by harvesters decreases the percentage of usable barley kernels. When embryos are damaged or, husk over the embryo is removed, the kernels cause problems in the malting process. A too high percentage of endosperm exposed kernels results in several processing problems in the malting process (fungal growth, foam in steep tanks etc.).

Fungal infection

Malting barley infected with fungi is not considered fit for human consumption and is downgraded to under grade. Some fungi produce mycotoxins (DON) when under stress. Fungal infection usually takes place when grain, that is ready for harvesting, is subjected to continual moist conditions or when barley with too high moisture content is harvested and stored on the farm under unfavorable conditions. Barley cultivars have no genetic resistance to these fungi that occur on the grain.

Moisture Content

Malting barley that is delivered and stored with too high a moisture content can lead to fungal development and also a decrease in germination capacity. Due to this reason no malting barley with a moisture content of higher than 13% will be accepted.

BARLEY PASSPORT

As from the 2005 season a system was implemented by which the producer is obliged to submit a passport before he can deliver his first load of barley. This barley passport entails a schedule that has to be completed by the producer in co- operation with his chemical agent and must clearly stipulate which chemicals have been applied on the barley as well as when it was applied, how it was applied and the dosage used. It is therefore of the utmost importance that the passport has to be fully completed and handed in at the delivery depot before any grain will be accepted.

Lastly it is also important to note that no grain will be accepted that was treated with an unregistered chemical, unregistered dosage or unregistered application method. For more information, the local SAB representative can be contacted Germination/cultivar purity

SUMMARY

The production of barley of good quality with an optimum yield, starts and ends at the producer and the following points are of the utmost importance:

- pH of the soil must be higher than 5.5 (KCl) and preferably between 5.5 and 6.0 (KCl).
- Phosphate status of the soil must be sufficient (30 mg/kg citric acid soluble P) or of such a nature that it can be rectified with a one-time application.
- Planting date is of the utmost importance and barley must be planted during the optimum recommended planting date for the specific area.
- Planting density may vary between 60 and 90 kg/ha, depending on the status of the seedbed, irrigation method and the planting equipment that is used. Germination capacity and thousand kernel mass must also be taken into account.

- A total average nitrogen fertilisation of 170 kg/ha (depending on the soil type and rotation system) is optimal in terms of yield and quality. Directly after Lucerne the N fertilisation needs to be decreased to 125 kg/ha and preferably all needs to be applied with planting.
- Split application of nitrogen fertilisation is more important under overhead irrigation (specifically center pivot) than under flood irrigation and on lighter sandy soils. A split of 60% of the total nitrogen with planting, another 20% at 4-6 weeks after emergence and the last 20% between flag leaf and 100% heading seems to give the best results.
- Optimum planting, fertilisation and irrigation practices should be applied to minimize the problem of lodging. Syngenta Moddus plant growth regulator is now registered for the use on barley in order to reduce lodging.
- Irrigation scheduling must be according to evaporation and needs as per growth stage. Irrigation must not be withdrawn too early and the last irrigation must be applied when the crop is almost completely discolored.
- Harvesting must commence as soon as the crop is ready for threshing (13% moisture content) in order to minimize possible damage by wind and hail, as well as weather damage of grain (fungal contamination).
- The combine harvester operation should not be as aggressive as for wheat in order to avoid skinning.
- Only use registered chemicals, at the registered dosage and according to the registered application method.

Barley can compete very well with wheat in irrigation areas with regard to quality and yield, if above-mentioned criteria are adhered to and climatic conditions do not differ significantly from the long-term average.

For any further information, you can contact one of the following SAB agricultural advisors:

Burrie Erasmus (Hartswater)	*082 921 7967*
Johannes Kokome (Taung)	*082 921 7981*
Hennie Cloete (Douglas)	*083 795 8587*

OATS PRODUCTION IN THE SUMMER RAINFALL REGION

Oats has been cultivated in the past mainly for grazing purposes and hay production. Grain production of oats makes a limited contribution to the developing breakfast cereal market, with the majority of grain produced ending up in the animal feed market. Human consumption of oats is currently the only organized market, with competitive grain prices being paid for a product with suitable grain quality.

There are however other attributes of oats that are of importance. The introduction and expansion of no-till practices and reduced cultivation systems necessitates the use of suitable cover crops to achieve significant ground cover. Oats is suited to this scenario due to the wide planting spectrum, wide adaptability and high biomass production, and can be planted with available cultivation equipment. Furthermore, oats has a depressing effect on soil-borne diseases, like take-all, in these crop rotation systems.

Grazing, silage and hay production

Oat grain is widely used by horse owners and other producers in feed mixtures. Well fertilized oats produces high quality hay and grain with a high nutritional value. Oat grain that do not qualify for suitable grades due to low hectolitre mass values, is also utilized in the animal feed market.

Oats plays a significant part in a balanced grazing availability program, with several cultivars suited for this purpose. The wide adaptability, nutritional value and regrowth characteristics of oats create the situation of available grazing over a long period. Planting for this purpose can start in February and continue up to July. Contact experts for further information in this area.

For hay production under irrigation, the cultivars Maluti, Witteberg, Drakensberg and SWK001 can be planted from March to June at a seeding density of 40 - 50 kg seed/ha. Kompasberg, SSH 421, SSH 405 and SSH 491 can be planted from May to June at a seeding density of 70 - 100 kg seed/ha.

Grain production

The local consumption of oats for processing in the cereal market is approximately 40 000 - 50 000 ton. Due to the low quality of oats grain produced (mainly of a low hectolitre mass), a major part of this local grain production is not suited for commercial processing and the requirement of the market is filled via imports. Local cultivars have the potential to produce the required yield and quality oats.

Grain quality

The quality standards applied at present are directly related to the processing of the oats seed. To develop an understanding of these standards it is necessary to briefly note the most important processes through which oats goes during processing.

Firstly all impurities and foreign material such as chaff, stones, weed seeds, wheat and barley are removed. The groats or kernel is the economically valuable part of the grain, while the hulls have no commercial value. The hulls are removed by two rotating milling stones that are set fractionally closer to one another than the thickness of the grain, and literally rub off the hulls. It is thus understandable that the hulls of twin oats cannot be removed and that naked oats will be damaged in this process. After this process the oats undergoes specific processing for the purpose for which it is needed.

Hectolitre mass

Large and well filled groats/kernels are in big demand by the processors and hectolitre mass is an indication of this quality aspect. The minimum hectolitre mass depending on the grade is shown in Table 1.

Just as in the case of wheat and barley, hectolitre mass of oats is determined during the grain filling stage. Abnormal leaf senescence prior to or during flowering and grain filling due to malnutrition, diseases or stress, causes low hectolitre mass. The deficiencies must be corrected before the flag leaf stage to ensure a positive effect on hectolitre mass.

Table 1. Grading requirements for oats

Grade	Minimum hectolitre mass (kg/hl)
Grade 1	53
Grade 2	48
Feed Grade	38

Groats: hull relation

The oats kernel is enclosed by two hulls that are worthless to the industry. Plenty of groats and little hull are thus required and processors require no more than 30% hulls against 70% or more groats. This characteristic is generally also reflected in the hectolitre mass and is environmentally, as well as genetically determined. In shrivelled oat grain the hulls make out a greater percentage of the groats:hull relation and in this case is undesirable.

Seed size

During processing the oats grain is sieved into different class sizes. This process is done very accurately, as an important quality component of the end-product relies on the effectivity of the sieving process. The largest seeds are more desirable, while the smallest grains are generally worthless. Uniform seed size is thus ideal. As the largest seeds ripen first and tend to fall out first, it is important not to delay harvesting.

Twin oat grain often occur. This characteristic is cultivar specific but can also be the result of environmental conditions and the harvesting process. Twin oats are undesirable as they go through the sieving process as large seeds and are later separated as two small oat grains that later cannot be dehulled. The harvester must thus be set in such a way that a minimum of twin oat grains are harvested.

Naked oat grains are grain of which the hulls have been removed in the harvesting process and are totally undesirable as they are separated into the small and medium seed sizes in the sieving process and are then ground, not dehulled in the dehulling process. The adjustment of the harvester is thus critical and requires special and specific attention by the producer.

As with wheat, planting date, fertilisation, pest and weed control, timely harvesting and correct adjustment of the harvester is of critical importance to produce grain of high quality. Locally available oats cultivars do have the potential to produce suitable quality grain and this potential must be utilized.

General production practices for oats in the summer rainfall area are similar to that for wheat production.

Cultivation

Irrespective of the crop rotation system followed, the main aim is to accumulate the maximum amount of soil water, alleviate compacted soil layers and prepare a seedbed that will ensure good germination and seedling establishment. Planting activities of oats are similar to those of wheat with regard to planting depth and row widths used.

Seed treatments for oats

The standard seed treatments against seed-borne diseases must be applied in grain productions, while it is optional in grazing and hay productions.

Cultivar choice, planting spectrum and seeding density

The producer must decide on the end-market for the production, that being grain, grazing or feed (Table 2). Cultivars more suited for grazing and hay production have different characteristics, and a cultivar for grain production must be chosen in correspondence with the needs of the buyer and end-user of the product, but also fits into the production system of the farmer. Once this decision has been made, plant the chosen cultivar and optimise all production practices (Tables 3, 4 and 5). Use certified seed to ensure that the correct cultivar is planted according to the proposed end-user, and to ensure good germination and seedling establishment.

Table 2. Characteristics of oats cultivars

Cultivars	Grain yield	Hectolitre mass	Lodging resistance	Plant height (cm)	Crown rust resistance	Stem rust resistance	Main use
Simonsberg	High	Good	Good	85	MR	MR	Grain/ Grazing
Towerberg	Good	High	Good	85	MR	MR	Grain/ Grazing
Overberg	Good	Good	Good	80	MS	MR	Grain/ Grazing
Sederberg	Ave	Ave	Reasonable	90	MS	MS	Grain/ Grazing
Kompasberg	High	High	High	75	MR	MS	Grain/ Grazing
Heros	Ave	Ave	Reasonable	85	S	S	Grain
Witteberg	Good	Ave	Ave	100+	S	S	Grazing
Pallinup	High	High	Good	80	MS	MS	Grain
Potoroo	Good	High	Good	80	MR	MR	Grain
SSH 491	Ave	High	Good	90	MR	S	Grain/Hay
SSH 405	Ave	Good	Reasonable	85	S	S	Grain
SSH 421	Good	Ave	Ave	90+	-	-	Grazing
Drakensberg	High	Ave	Reasonable	100+	R	MS	Grazing/ Silage
Maluti	Ave	Ave	Ave	100+	MS	MS	Grazing
SSH 39W	Ave	Ave	Ave	100+	-	-	Grazing
SWK 001	Ave	Ave	Ave	100+	MR	MS	Grazing
Le Tucana	Higher yield and better cold tolerance than Drakensberg						Grazing

MS = Moderately Susceptible   *MR = Moderately Resistant*   *S = Susceptible*   *R = Resistant*   *? = Unknown*

Table 3. The planting spectrum of cultivars in the cooler irrigation areas

Cultivar	May				June				July			
	1	2	3	4	1	2	3	1	1	2	3	4
Kompasberg												
Sederberg												
Overberg												
Heros												
SSH 405												
SSH 491												
Pallinup												

Table 4. The planting spectrum of cultivars in the warmer irrigation areas

Cultivar	May				June			
	1	2	3	4	1	2	3	4
Kompasberg								
Sederberg								
Overberg								
Heros								
SSH 405								
SSH 491								
Pallinup								

Under irrigation target plant population (plants/m²) for the early planting is 175 - 200, for plantings in the middle of the spectrum 200 - 275 and for late plantings 275 - 350. Depending on the specific seed lot and thousand kernel mass the seeding density can range from 60 - 100 kg seed/ha.

Table 5. The planting spectrum of cultivars for dryland in the Eastern Highveld

Cultivar	May				June				July			
	1	2	3	4	1	2	3	1	1	2	3	4
Kompasberg												
Sederberg												
Overberg												
Heros												
SSH 405												
SSH 491												
Pallinup												

The seeding density for dryland plantings is 20-25 kg seed/ha. The planting spectrum is based on available data. Plantings outside this spectrum is at own risk after assessing the possible production risks.

Fertiliser requirement

Oats generally has similar soil requirements as wheat with regards to the macro and micro nutrients (Fe, Cu, Zn, Mn and Mo) that have major influence on production. Soil acidity levels of (pH 4.8 to 5.5 (KCl)) are regarded as being optimal. Oats is more acid tolerant (up to 15% acid saturation) than wheat, but less saline tolerant than wheat and barley.

Nitrogen management of the oats crop is determined by soil and nutrient management strategies including the previous crop, soil water availability, soil nitrogen availability, yield potential, risk of lodging, timing of nitrogen applications and nitrogen sources available for use.

For hay production under irrigation 100 kg N/ha is recommended, with additional 25 - 50 kg N/ha after each grazing and/or fodder harvest depending on level of production.

For grain production the general recommendation is 90 kg N/ha, 25 kg P/ha and 20 kg K/ha for a grain yield potential of 4.5 ton/ha. The general guideline is 20 kg N/ton grain for soils with a low organic carb content <3% and of high quality residue are available for utilisation, apply 30 kg N/ton grain yield potential. Phosphorus is important especially early in the growing season for establishment, while sufficiently available potassium can reduce lodging and ensure uniform ripening.

Under dryland conditions in the high rainfall regions, a general recommendation of 40 kg N/ha, 10 kg P/ha and 10 kg K/ha (optional) is used. A maximum of 20 kg N/ha or a total of 50 kg N+K/ha can be seed placed safely, and higher applications must be banded away from the seed. The phosphorus fertilizer recommendations (kg P/ha) at the yield potential levels and soil analysis value (mg/kg P-Bray 1), as well as the potassium fertilizer recommendations (kg K/ha) at the relevant yield potential levels and soil potassium analysis value (mg/kg K) currently used for dryland wheat production can also be applied for oats production. Keep in mind that the yield potential of oats is lower compared to that of wheat under both dryland and irrigated conditions. The same fertilizer recommendations can be used for grazing plantings, with the option of additional N applications after grazing events combined with rainfall occurrence.

Diseases and control

Oats is susceptible to crown and stem rust, and to “Barley yellow dwarf virus” which is spread by aphid infestations. It is economically viable to control diseases at yield potential levels above 4 ton/ha. Diseases generally lower the kernel weight and hectolitre mass, and discolour the grain, resulting in downgrading of the product resulting in a lower price per ton grain.

Irrigation requirements

Under movable irrigation systems and supplemental irrigation applications, the current recommendation is five irrigations during the growing season if production is started on a full soil profile. These irrigations are applied at 5-leaf, early stem elongation, flag leaf, flowering and during the grain filling stages. Under centre pivot irrigation systems, a similar irrigation management program as for wheat is used. Irrigation during the later growth stages tends to disrupt uniform ripening, thereby delaying harvesting. Similar to the other small grains, oats is susceptible to high temperatures and water stress during grain filling, and these necessitates well-timed and effective soil water management.

Harvesting, storage and marketing

Oats can be harvested at a grain moisture content below 20%, but can only be stored safely at a grain moisture below 12.5%. Shattering in the field can be a problem, and rain during harvesting can discolour kernels, resulting in downgrading of the crop. There are various options (including cleaning and sieving) to improve grain quality parameters, especially hectolitre mass, to attain better prices per ton of grain.

Problems in oats production

Grasses in oats production can be a huge problem as it cannot be chemically controlled, and these grasses and volunteer wheat must be controlled beforehand especially if take-all depression is one of the production objectives. Lodging of the crop causes yield losses and non-uniform ripening and hence difficulties in timely harvesting, and can result in reduced grain quality. Lodging can be managed by cultivar choice, seeding density and nutrient management. In particular, seeding density is a major factor with regard to the incidence of lodging. Because of the lower kernel weight of oats seed, lower seeding densities (kg seed/ha) are needed to achieve target plant populations. Cultivars also differ in tillering capacity that can influence seeding density for a yield target. Bird damage is also a limiting factor in some areas.

Oats field trial results

The yield and hectolitre mass results obtained in the field trials in the Northern Cape (Vaalharts and Riet River) and the Free State (Bethlehem, Harrismith and Clarens) over the past years of testing are given in the following tables.

Average yield (ton/ha) of oats cultivars under dryland conditions during the full or partial period from 2014 - 2017

Cultivar	2017**	R	2016*	R	*2015	R	*2014	R	4 year average 2014-2017	R	3 year average 2015-2017	R	2 year average 2016-2017	R
Dunnart	2.24	1	1.85	8									1.85	8
H 06/15					2.12	9	3.61	7						
H 07/04					2.80	5	2.94	9						
H 013/09	1.80	5	2.28	5									2.28	7
H 013/7	1.49	10	2.49	2									2.49	3
KKSH 301					1.71	11								
Kompasberg	1.87	3	1.48	11	3.19	3	3.66	6	2.55	4	2.78	4	2.33	5
Macnifico			1.43	13										
Mainda			3.22	1										
Majoris					2.78	6	5.03	1						
Mitika	1.57	8	1.46	12									1.46	11
Overberg			1.53	10	3.30	2	4.62	2						
Pallinup	1.51	9	1.59	9									1.59	9
Piketberg	1.70	7	2.31	4									2.31	6
Simonsberg	1.87	4	2.38	3	2.58	7	3.70	5	2.63	3	2.89	3	2.48	4
SSH 405	1.39	11	1.15	14									1.15	12
SSH 421	1.10	12	0.98	15	2.09	10					1.54	5	1.54	10
SSH 423					2.45	8	3.78	4						
SSH 491	1.72	6	1.94	7	3.47	1	3.85	3	2.75	1	3.09	1	2.70	1
Towerberg	1.95	2	2.22	6	3.17	4	3.50	8	2.71	2	2.96	2	2.69	2
Mean	**1.68**		**1.89**		**2.70**		**3.85**		**2.66**		**2.65**		**2.07**	
CV%	**9.44**		**12.47**		**6.80**		**5.00**							
LSD_t(0,05)	**0.24**		**0.35**		**0.27**		**0.28**		**0.16**		**0.18**		**0.21**	

Due to drought conditions no result are available for 2018

*** Bethlehem data**

**** Clarens data**

Average hectolitre mass (kg/hl) of oat cultivars under dryland conditions during the full or partial period from 2014 - 2017

Cultivar	2017*	R	2016*	R	*2015	R	*2014	R	4 year average 2014-2017	R	3 year average 2015-2017	R	2 year average 2016-2017	R
Dunnart	39.70	12	51.78	2									51.78	2
H 06/15					51.60	6	48.37	8						
H 07/04					50.73	8	48.75	7						
H 013/09	42.00	7	46.33	15									46.33	12
H 013/7	39.90	11	46.75	14									46.75	11
KKSH 301					52.49	2								
Kompasberg	41.30	8	51.73	3	50.98	7	48.97	5	48.25	2	50.56	3	51.36	4
Macnifico			47.98	11										
Mainda			51.5	5										
Marjoris					46.58	11	50.25	2						
Mitika	43.87	4	47.28	13									47.28	10
Overberg			51.25	6	51.80	4	50.02	3						
Pallinup	42.55	6	51.53	4									51.53	3
Piketberg	44.30	3	47.58	12									47.58	9
Simonsberg	40.90	9	48.15	10	51.90	3	49.05	4	47.50	3	49.70	4	50.03	7
SSH 405	46.35	1	49.15	8									49.15	8
SSH 421	42.75	5	50.88	7	50.63	9					50.76	2	50.76	5
SSH 423					48.73	10	47.85	9						
SSH 491	46.00	2	56.55	1	58.45	1	52.92	1	53.48	1	55.97	1	57.50	1
Towerberg	40.35	10	48.55	9	51.73	5	48.82	6	47.36	4	49.70	4	50.14	6
Mean	**42.50**		**49.80**		**51.42**		**49.44**		**49.15**		**51.34**		**50.01**	
CV%	**2.42**		**3.45**		**1.50**		**2.00**							
LSD Cultivar	**1.57**		**2.55**		**1.12**		**1.47**		**0.77**		**0.87**		**1.67**	

Due to drought conditions no result are available for 2018

*** Bethlehem data**

**** Clarens data**

Average yield (ton/ha) of oats cultivars under irrigation during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017 *	R	2016 *	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Dunnart	5.73	6	5.18	1	5.12	10					5.34	4	5.46	3
H13/09			3.85	11	5.79	6								
H13/7			4.13	9	6.17	3								
Kompasberg	6.06	3	4.71	5	6.98	1	3.85	2	5.40	1	5.92	1	5.39	4
Macnifico					4.61	13								
Mainda					5.91	5								
Mitika			4.94	3	5.50	9								
Overberg	4.89	10			5.61	8								
Pallinup	5.62	8	4.14	8	4.29	15					4.68	9	4.88	8
Piketberg	5.82	5	5.11	2	6.24	2					5.72	2	5.47	2
Simonsberg	5.67	7	4.79	4	4.30	14					4.92	7	5.23	5
SSH 405	6.26	2	3.90	10	4.99	11					5.05	6	5.08	7
SSH 421	5.08	9	3.19	12	5.93	4	2.33	5	4.13	4	4.73	8	4.14	9
SSH 423							4.00	1						
SSH 491	6.47	1	4.57	6	5.62	7	3.13	4	4.95	2	5.55	3	5.52	1
Towerberg	5.87	4	4.32	7	4.98	12	3.26	3	4.61	3	5.06	5	5.10	6
Mean	**5.75**		**4.40**		**5.47**		**3.31**		**4.77**		**5.22**		**5.14**	
LSD_t(0,05)	**0.24**		**0.60**		**0.60**		**0.26**		**0.32**		**0.30**		**0.35**	

*** Only Vaalharts data**

Average hectolitre mass (kg/hl) of oats cultivars under irrigation during the full or partial period from 2015 - 2018

Cultivar	2018	R	2017 *	R	2016 *	R	2015	R	4 year average 2015-2018	R	3 year average 2016-2018	R	2 year average 2017-2018	R
Dunnart	47.11	9	51.01	10	48.30	7					48.81	9	49.06	9
H13/09			53.66	5	49.50	4								
H13/7			50.99	11	46.95	13								
Kompasberg	46.16	10	52.76	8	49.65	3	50.09	4	49.67	4	49.52	7	49.46	8
Macnifico					45.30	14								
Mainda					50.70	1								
Mitika			55.74	2	49.35	5								
Overberg	48.54	8			47.80	9								
Pallinup	50.04	6	55.08	3	44.00	15					49.71	6	52.56	2
Piketberg	50.01	7	53.49	6	47.40	11					50.30	5	51.75	6
Simonsberg	52.03	1	52.48	9	48.25	8					50.92	3	52.26	4
SSH 405	51.35	2	49.79	12	47.30	12					49.48	8	50.57	7
SSH 421	51.01	4	53.80	4	47.65	10	51.45	3	50.98	3	50.82	4	52.41	3
SSH 423							48.60	5						
SSH 491	50.19	5	55.88	1	49.00	6	54.25	1	52.33	1	51.69	1	53.04	1
Towerberg	51.06	3	52.88	7	49.80	2	51.58	2	51.33	2	51.25	2	51.97	5
Mean	**49.75**		**53.13**		**48.06**		**51.19**		**51.08**		**50.28**		**51.45**	
LSD_t(0,05)	**2.86**		**1.88**		**3.09**		**1.71**		**1.18**		**1.33**		**1.38**	

*** Only Vaalharts data**

ARC-SMALL GRAIN SERVICES

The laboratories of ARC-Small Grain are well known for their fast, accurate and reliable services to you as producer.

Seed Testing Laboratory

The Seed Testing Laboratory is registered with the Department of Agriculture and ISTA (International Seed Testing Association)-rules are strictly applied to comply with international standards in determining the quality characteristics of seed. Tests include the following:

Germination tests and physical purity analysis package

The germination test is an indication of the percentage seed that will, under favourable conditions, produce normal seedlings. Together with the germination results, the percentage of seed from other crops and weeds are determined. This is also subject to requirements set by law. Each seedlot planted in the field must be tested so that the producer is assured that the seed planted has a germination percentage greater than 80%, which is the minimum for making wheat production a viable proposition.

Coleoptile length

Coleoptile length is the length of the sheath that enfolds the first leaf. The coleoptile provides the force that carries the leaf to the soil surface. To prevent emergence problems under dryland conditions, coleoptile length determinations are recommended. It is important to remember that planting depth is critical where cultivars with short coleoptile lengths are planted.

Seed analyses testing chemical treatments

A seed treatment can be tested for its effect on South African small grain cultivars and even its compatibility with other seed treatments. These services will be provided on contract basis only.

Contact person: Hesta Hatting

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Fax: (058) 307-3519

E-mail: hattingh@arc.agric.za

Wheat Quality Laboratory

The Wheat Quality Laboratory participates in two external quality control schemes. The Premier Foods Ring test samples are analysed monthly and the Southern African Grain Laboratory (SAGL)'s Ring test samples are analysed quarterly. The laboratory offers the following analyses on whole wheat kernels:

- Hectolitre mass / Test weight
- Kernel colour
- Flour yield potential

Analyses that can be performed on flour include:

- Flour colour
- Protein content
- Falling number
- Sodium Dodecyl Sulphate (SDS) sedimentation volume
- Wet gluten content
- Moisture content

Analyses indicative of dough properties and end-use quality include:

- Mixograph analyses
- Farinograph analyses
- Mixolab analyses
- Loaf volume

Contact person: Dr. Chrissie Miles

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Soil Analyses Laboratory

The Analyses Laboratory specialises in soil analyses and is an active member of the Agri-LASA control scheme.

Soil analyses

pH (KCl)

Ca, Mg, Na, K (Ammonium Acetate)

Phosphate (Bray 1)

% Acid Saturation

Other analyses:

Lime requirement Zinc (HCl)

% Total Carbon (TOC)

Clay % (Hydrometer Method)

Particle size

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Weed Resistant Allele Profiling Service (WRAPS)

This innovative herbicide resistance screening service is a new tool in the toolbox, offered to producers to assist with the effective management of herbicide resistant weeds. To date, various target-site resistance mutations have been identified on farmers' fields from the Western Cape, Eastern Cape and Northern Cape. Currently this service has been optimised for ryegrass samples.

For which herbicide groups can the samples be screened for?

Currently ryegrass biotypes can be screened for resistance to herbicides from the ACCase inhibitor (Group A) herbicides, ALS inhibitor (Group B) herbicides and the Group D (bipyridyliums) and Group G (glycine) herbicides. The target-site mutation markers used, can detect single group resistance or broad target-site resistance across multiple groups. All weedy grass species can be screened.

How to get your ryegrass tested for resistance?

Producers/chemical company representatives are welcome to send ryegrass seedlings/fresh bulk leaf material or seeds for testing to ARC-Small Grain, Bethlehem. The samples can be taken any time during the plant life cycle, preferably the younger the better. Please make sure that the bulk sample was taken from plants distributed over the entire field, so as to constitute a true representative sample of the field. Seedlings/leaf material must be kept moist, placed in a zip lock bag, labelled and preferably couriered overnight to ARC-Small Grain, Bethlehem, as this will assure that fresh seedlings/leaf material arrive for processing. This is critical to allow for the isolation of the required DNA quality for successful resistance identification. Seeds must be stored in brown paper bags to prevent microbial contamination. Please indicate the GPS-coordinates and name of the field/farm where the seedling/leaf material/seed samples were taken. Please prevent sending seedling samples with intact root systems and soil as this adds unnecessary weight to the parcel. An adequate number of seeds/seedlings must be submitted for the screening process to be conducted successfully.

A full detailed written report per field/farm with recommendations will be submitted electronically via e-mail and telephonically communicated to the producer/chemical company representative within five to seven working days after receiving the samples in good order.

Costs

Currently WRAPS is offered as a free service, but clients are expected to pay for the courier costs to get the samples to Bethlehem. This innovative project is currently jointly funded by the ARC, Winter Cereal Trust and the National Research Foundation.

In future, to make this service sustainable for the long term, an affordable flat rate per sample will be charged.

Note: This molecular genotyping service only detects the presence of the most common targetsite mutation induced herbicide resistances and other forms of resistance, such as metabolic or compartmentalised resistance requires additional testing.

For further information, please contact:

ARC-Small Grain: (058) 307 3400

Ms Hestia Nienaber (Weed Scientist) - deweth@arc.agric.za

Dr Scott Sydenham (Biotechnologist) - sydenhams@arc.agric.za

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For more information you are advised to contact the following specialists:

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Dr Tarakegn Terefe

Insect Control

Dr Goddy Prinsloo
Dr Vicki Tolmay
Dr Justin Hatting
Dr Astrid Jankielsohn

Weed Control

Hestia Nienaber

Plant Nutrition

Willem Kilian

Soil Tillage

Willem Kilian

Plant Breeding

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Lientjie Visser

Quality Analyses

Dr. Chrissie Miles

Seed Services

Hesta Hatting

Weed Resistance Allele Profiling Service

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