GUIDELINE

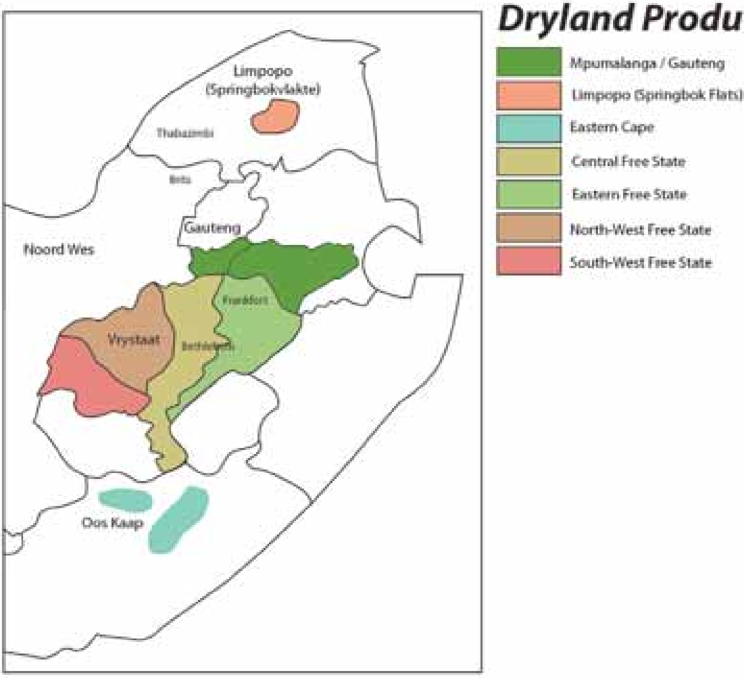
PRODUCTION OF SMALL GRAINS IN THE SUMMER RAINFALL AREA

ARC-Small Grain Institute

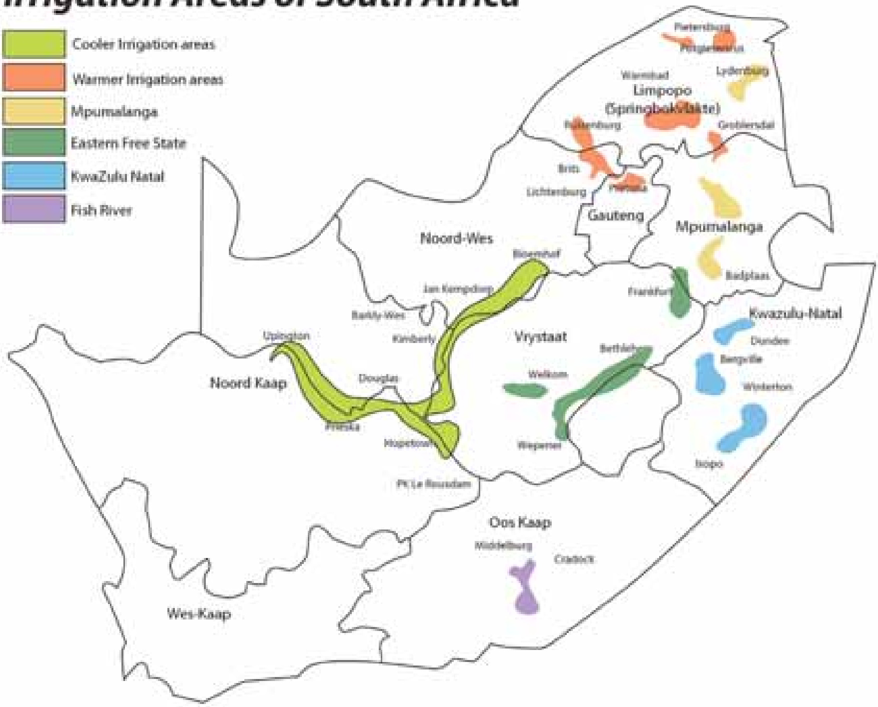
2014

ARC • LNR

Dryland Production Areas



Irrigation Areas of South Africa



GUIDELINES FOR THE PRODUCTION OF SMALL GRAINS

IN THE SUMMER RAINFALL REGION

2014

Compiled by:
ARC-Small Grain Institute
University of the Free State
SAB Maltings (Pty) Ltd

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FOREWORD

That the wheat and barley industries in South Africa are under significant pressure to become more competitive and profitable for the producers, is probably the understatement of the year. As a result, the hectares under wheat production reached an all-time low the previous season. Reasons behind this phenomenon are many fold, amongst others are that we do not realise the high intrinsic quality value of our wheat crop in monetary terms, that the cultivars at our disposal are lacking in competitive yields and that the varying climate also play a significant role.

Then came the 2012/2013 harvesting season and on the back of a similar 2011/2012 season (excluding the Free State) proved beyond any doubt that our recommended dryland and irrigation wheat cultivars have the genetic potential to yield up to four tons and nine tons to the hectare respectively. For the first time in many years this was backed-up by a significantly higher and more competitive wheat price. As a result, the wheat production regained its competitiveness to some extend in the Western and Southern Cape, both the warmer and cooler irrigation areas as well as certain parts of the Eastern and North-Western Free State. Wheat production needs to increase this level of competitiveness even in relation to maize, soybeans and canola production. In addition we realised that the genetic potential to achieve this is available in the cultivars available to us, but then we need to use them wisely.

In achieving this, the 2014 **Guidelines for the Production of Small Grains by the Small Grain Institute** as proven by its many annual predecessors, is a most important decision-making database. The information, which is based on sound objective and scientifically proven replicated trials (2-4 years data) is representative of all major production areas and will assist you to make the correct cultivar choice for your 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 recommendations. 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 tons/ha, but in profit/ha. Only the latter will ensure our competitiveness.

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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** program;
- 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 requirements.

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).

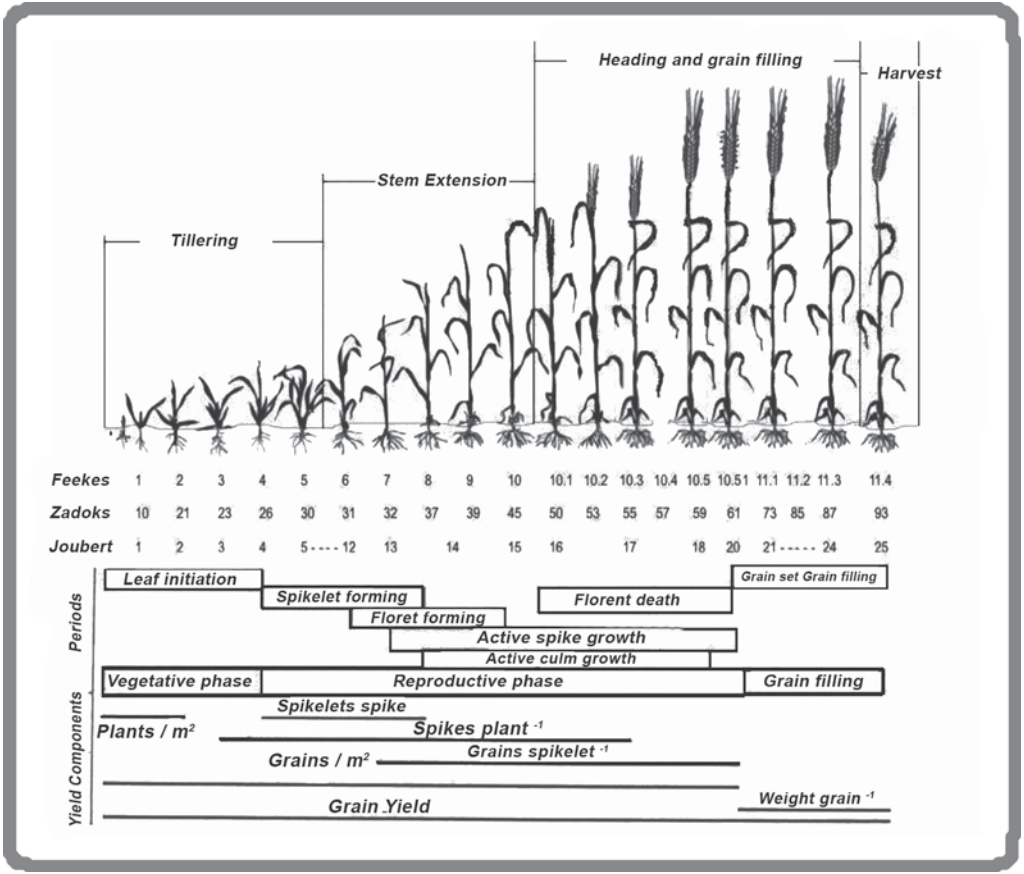
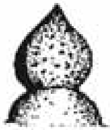


Figure 1. Growth and development stages of wheat during the growing season

**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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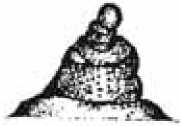

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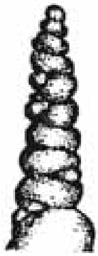

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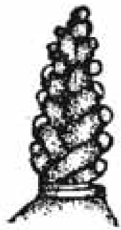

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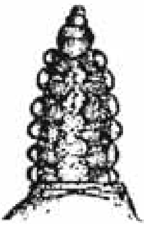

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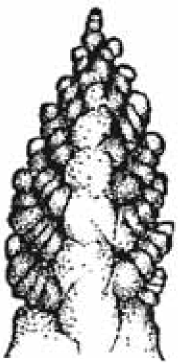

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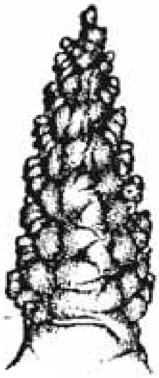

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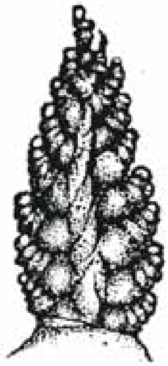

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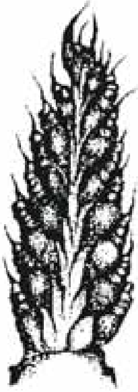
Growth stages (continued)



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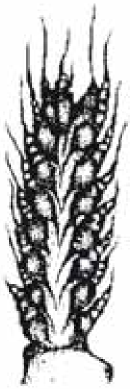

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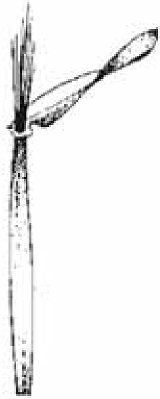

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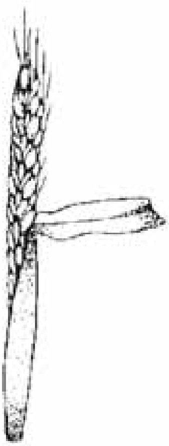

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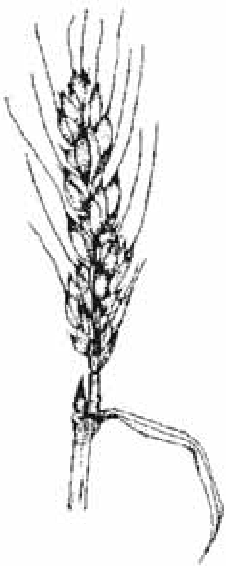

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Growth Stages (continued)

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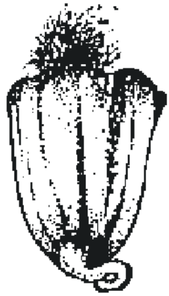

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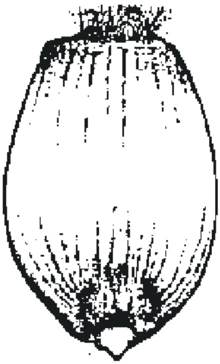

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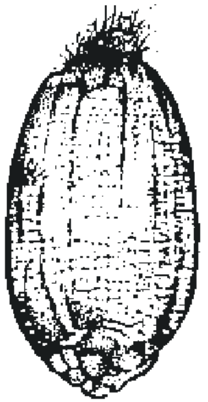

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Growth stages (photos by Robbie Lindeque)

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Growth stages (continues)

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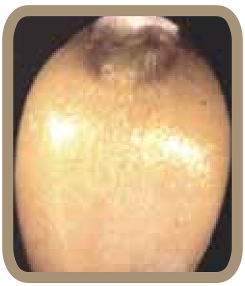

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Factors influencing yield components

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	Grains per ear and single grain mass

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

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 abovementioned 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 program 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.

The Chamber of Milling preferred list

The National Chamber of Milling annually publishes a list of cultivars that are acceptable for commercial purposes, and this list must be considered in cultivar choice. The Chamber of Milling does, however, point out that individual miller's choices are not restricted to the list. The list of preferred cultivars is divided into three categories: cultivars for dry land production in the north, cultivars for the southern production area and the irrigation cultivars.

Table 2. Miller's preference list of preferred bread wheat

Northern dryland production areas

Miller's preference		
SST 3137	Kouga	SST 1327
SST 316	PAN 3111	PAN 3364
Selati	SST 356	SST 972
Senqu	SST 954	SST 964
Hartbees	PAN 3144	SST 367
Koonap	SST 935	SST 363
PAN 3198	SST 347	PAN 3349
PAN 3195	Matlabas	SST 936
SST 398	Nossob	SST 966
SST 374	PAN 3120	Belinda
SST 387	PAN 3122	Betta DN
PAN 3172	SST 322	Carina
PAN 3379	SST 334	Carol
PAN 3161	PAN 3118	Gariep
PAN 3368	Tarka	Hugenoot
SST 963	Komati	Limpopo
SST 366	SST 399	SST 107
SST 308	Elands	SST 124
SST 319	PAN 3377	SST 333
PAN 3355	SST 983	SST 317
SST 946	Caledon	

Northern irrigation areas

Miller's preference		
PAN 3623	SST 8134	SST 8135
PAN 3515	SST 8126	SST 8136
Timbavati	SST 815	SST 8125
Tamboti	SST 816	PAN 3400
SST 805	SST 877	SST 802
Uhmlazi	SST 875	Steenbras
PAN 3497	Buffels	SST 885
PAN 3489	SST 867	SST 886
SST 895	PAN 3434	SST 876
SST 896	Duzi	Inia
Sabie	Krokodil	Kariega
Afgri 75-3	SST 835	Marico
SST 884	CRN 826	SST 822
PAN 3471	Olifants	SST 825
PAN 3478	Baviaans	SST 802

RECOMMENDATION AND SUMMARY OF RESULTS – 2013

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 Institute. The results are evaluated and the guidelines for cultivar choice revised annually by a committee consisting of officials from the ARC- Small Grain Institute, various Departments of Agriculture, Sensako, 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 afore-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 2012 are summarised below.

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 that are 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	**	***	#	***
Gariep	Low to high	Medium	**	**	*	***
Koonap (PBR)	Medium to high	Medium	***	*	***	***
Matlabas (PBR)	Medium to high	Long	***	***	**	**
Senqu (PBR)	Medium to high	Medium	***	***	*	**
PAN 3118 (PBR)	Low to high	Long	**	**	***	***
PAN 3120 (PBR)	Medium to high	Long	***	***	***	***
PAN 3161 (PBR)	Low to high	Long	***	#	***	**
PAN 3195 (PBR)	Medium to high	Long	***	#	***	**
PAN 3368 (PBR)	Medium to high	Medium	***	***	#	***
PAN 3379 (PBR)	Medium to high	Short	***	**	***	***
SST 316 (PBR)	Medium to high	Medium	***	**	?	**
SST 317 (PBR)	Medium to high	Long	***	***	?	***
SST 347 (PBR)	Medium to high	Long	***	***	?	***
SST 356 (PBR)	Medium to high	Medium	***	**	?	**
SST 374 (PBR)	Medium	Short to Medium	**	**	?	**
SST 387 (PBR)	Medium to high	Long	***	**	?	**

** Moderate ** Good ***Excellent # Poor R Resistant` S Susceptible ? Unknown*

PBR Cultivars protected by Plant Breeders' Rights

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

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

S = Susceptible MS = Moderately susceptible R = Resistant

MR = Moderately resistant ? = unknown

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 that are recommended for cultivation under dryland conditions in the summer rainfall region.

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

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:

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)					■	■	■	■	■	■							15-20
Gariep					■	■	■	■	■	■	■	■					15-20
Koonap (PBR)					■	■	■	■	■	■							15-30
Matlabas (PBR)					■	■	■	■	■	■	■						15-30
Senqu (PBR)					■	■	■	■	■	■	■	■					15-30
PAN 3118 (PBR)				■	■	■	■										15-20
PAN 3120 (PBR)			■	■	■	■											15-20
PAN 3161 (PBR)					■	■	■	■									20-25
PAN 3195 (PBR)				■	■	■	■										15-20
PAN 3368 (PBR)					■	■	■	■	■	■							20-30
PAN 3379 (PBR)							■	■	■	■	■	■					20-25
SST316 (PBR)					■	■	■	■	■	■	■	■					20-30
SST317 (PBR)				■	■	■	■	■	■	■							20-25
SST 347 (PBR)			■	■	■	■	■	■	■	■							20-25
SST 356 (PBR)					■	■	■	■	■	■	■	■					20-30
SST 374 (PBR)					■	■	■	■	■	■							30-40
SST 387 (PBR)				■	■	■	■	■	■	■							20-25

All the abovementioned cultivars qualify for all the grades of the bread class.

PBR Cultivars protected by Plant Breeders' Rights
Producers are solely responsible for the marketing of grain of cultivars planted by them. See Bakers and Millers annual press release regarding cultivar requirements and consult with local co-operative and marketing agents prior to planting.

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)						■	■	■	■	■	■	■					20-30
Gariep						■	■	■	■	■							20-30
Koonap (PBR)						■	■	■	■	■	■	■					20-30
Matlabas (PBR)			■	■	■	■	■	■	■	■	■						20-30
Senqu (PBR)						■	■	■	■	■							20-30
PAN 3118 (PBR)				■	■	■	■	■									15-20
PAN 3120 (PBR)			■	■	■	■											15-20
PAN 3161 (PBR)					■	■	■	■	■								20-25
PAN 3195 (PBR)				■	■	■	■	■									15-20
PAN 3368 (PBR)						■	■	■	■	■	■	■					20-30
PAN 3379 (PBR)							■	■	■	■	■	■					20-30
SST316 (PBR)					■	■	■	■	■	■	■						20-30
SST317 (PBR)				■	■	■	■	■									20-25
SST 347 (PBR)			■	■	■	■	■	■									20-25
SST 356 (PBR)					■	■	■	■	■	■	■						20-30
SST 374 (PBR)					■	■	■	■	■								30-40
SST 387 (PBR)				■	■	■	■	■									20-25

All the abovementioned cultivars qualify for all the grades of the bread class.

PBR Cultivars protected by Plant Breeders' Rights
Producers are solely responsible for the marketing of grain of cultivars planted by them. See Bakers and Millers annual press release regarding cultivar requirements and consult with local co-operative and marketing agents prior to planting.

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)								■	■	■	■						15-20
Gariep							■	■	■	■	■	■	■	■			15–30
Koonap (PBR)								■	■	■	■						15-30
Matlabas (PBR)					■	■	■	■	■	■	■						15-30
Senqu (PBR)							■	■	■	■	■	■	■	■			15-30
PAN 3118 (PBR)					■	■	■	■	■								15-20
PAN 3120 (PBR)				■	■	■	■	■									15-20
PAN 3161 (PBR)					■	■	■	■	■	■							20-25
PAN 3195 (PBR)					■	■	■	■	■								15-20
PAN 3368 (PBR)								■	■	■	■	■					25-30
PAN 3379 (PBR)							■	■	■	■	■	■	■				25-40
SST316 (PBR)								■	■	■	■	■	■	■			20-30
SST317 (PBR)					■	■	■	■	■	■	■	■					20-25
SST 347 (PBR)				■	■	■	■	■	■	■	■	■					20-25
SST 356 (PBR)								■	■	■	■	■	■	■			20-30
SST 374 (PBR)							■	■	■	■	■	■	■				30-40
SST 387 (PBR)					■	■	■	■	■	■	■	■					20-25

All the abovementioned cultivars qualify for all the grades of the bread class.

PBR Cultivars protected by Plant Breeders' Rights
Producers are solely responsible for the marketing of grain of cultivars planted by them. See Bakers and Millers annual press release regarding cultivar requirements and consult with local co-operative and marketing agents prior to planting.

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)					■	■	■	■	■	■	■						15-30
Gariep					■	■	■	■	■	■	■						15-30
Koonap (PBR)					■	■	■	■	■	■	■						15-30
Matlabas (PBR)		■	■	■	■	■	■	■									15-30
Senqu (PBR)					■	■	■	■	■	■	■						15-30
PAN 3118 (PBR)					■	■	■	■									15-30
PAN 3120 (PBR)					■	■	■	■									15-30
PAN 3161 (PBR)					■	■	■	■	■	■							20-25
PAN 3195 (PBR)					■	■	■	■	■								20-25
PAN 3368(PBR)							■	■	■	■	■	■	■				25-40
PAN 3379(PBR)							■	■	■	■	■	■	■				25-40
SST316 (PBR)					■	■	■	■	■	■	■	■					20-30
SST317 (PBR)				■	■	■	■	■	■								20-25
SST 347(PBR)			■	■	■	■	■	■	■								20-25
SST 356(PBR)					■	■	■	■	■	■	■	■					20-30
SST 374(PBR)					■	■	■	■	■	■	■	■	■	■			30-40
SST 387(PBR)				■	■	■	■	■	■								20-25

All the abovementioned cultivars qualify for all the grades of the bread class.

PBR Cultivars protected by Plant Breeders' Rights
Producers are solely responsible for the marketing of grain of cultivars planted by them. See Bakers and Millers annual press release regarding cultivar requirements and consult with local co-operative and marketing agents prior to planting.

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)					■	■	■	■	■	■	■		20-30
Gariep					■	■	■	■	■	■	■		20-30
Koonap (PBR)					■	■	■	■	■	■	■		20-30
PAN 3118(PBR)					■	■	■	■					20-30
PAN 3161(PBR)					■	■	■	■	■				20-30
PAN 3195 (PBR)					■	■	■	■					20-30
PAN 3368(PBR)							■	■	■	■	■		25-40
PAN 3379(PBR)							■	■	■	■	■		25-40
SST316 (PBR)					■	■	■	■	■	■	■		20-30
SST317 (PBR)					■	■	■	■	■				20-30
SST 347(PBR)					■	■	■	■	■				20-30
SST 356(PBR)					■	■	■	■	■	■	■		20-30
SST 374(PBR)						■	■	■	■	■	■	■	30-40
SST 387(PBR)					■	■	■	■	■				20-30

All the abovementioned cultivars qualify for all the grades of the bread class.

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SUMMARY OF RESULTS OBTAINED DURING 2013

The results obtained in the cultivar evaluation programme in the summer rainfall area over the last seasons (2010 to 2013) 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.

Average yield (ton/ha) of entries for the South Western Free State area (early planting date) during the full or partial period from 2010 – 2012

Cultivar	2013	R	2012	R	2011	R	2010	R	3 year average 2010-2012	R	2 year average 2011-2012	R
Betta-DN							1.64	12				
Caledon					1.97	11	1.68	10				
Elands	---	---	1.72	11	1.98	10	1.68	11	1.79	9	1.85	8
Gariep	---	---	1.93	2	1.96	12	1.60	14	1.83	6	1.95	5
Komati							1.70	8				
Koonap	---	---	1.73	9	1.62	17					1.67	
Limpopo							1.53	16				
Matlabas	---	---	2.05	1	2.03	8	1.77	6	1.95	3	2.04	1
PAN 3111	---	---										
PAN 3118	---	---	1.80	6	2.20	2	1.88	2	1.96	2	2.00	2
PAN 3120	---	---	1.60	14	2.37	1	1.92	1	1.96	1	1.99	3
PAN 3144					1.71	15	1.59	15				
PAN 3161	---	---	1.55	15	1.99	9	1.79	5	1.78	10	1.77	11
PAN 3195	---	---	1.64	13								
PAN 3198	---	---										
PAN 3355					2.11	4	1.63	13				
PAN 3368	---	---	1.75	7	2.04	7	1.69	9	1.83	7	1.90	7
PAN 3379	---	---	1.89	4	2.07	6	1.84	3	1.93	4	1.98	4
Senqu	---	---	1.72	10	1.71	14					1.72	12
SST 316	---	---	1.80	5								
SST 317	---	---	1.92	3								
SST 347	---	---	1.45	17	2.19	3	1.83	4	1.82	8	1.82	9
SST 356	---	---	1.69	12	1.95	13					1.82	10
SST 387	---	---	1.75	8	2.10	5	1.73	7	1.86		1.93	6
SST 398	---	---	1.51	16	1.67	16					1.59	
Average	**---**	**---**	**1.73**		**1.98**		**1.72**		**1.87**		**1.86**	
LSD_t(0,05)	**---**	**---**	**0.22**		**0.22**		**0.24**		**0.14**		**0.16**	

** Due to severe drought conditions no trials were planted in the South Western Free State in 2013*

Average hectolitre mass (kg/hl) of entries for the South Western Free State area (early planting date) during the full or partial period from 2010 – 2012

Cultivar	2013	R	2012	R	2011	R	2010	R	3 year average 2010-2012	R	2 year average 2011-2012	R
Betta-DN							77.40	10				
Caledon					78.58	12	77.50	7				
Elands	---	---	80.95	8	80.62	3	77.30	11	79.62	5	80.79	4
Gariep	---	---	80.21	13	79.35	8	77.10	12	78.89	6	79.78	7
Komati							76.90	13				
Koonap	---	---	80.68	10	80.07	5					80.37	
Limpopo							76.40	14				
Matlabas	---	---	80.56	11	75.82	16	77.60	6	77.99	10	78.19	14
PAN 3111	---	---										
PAN 3118	---	---	82.30	3	79.77	7	78.30	4	80.12	2	81.04	3
PAN 3120	---	---	83.05	1	80.38	4	79.40	1	80.94	1	81.72	1
PAN 3144					78.71	11	76.20	16				
PAN 3161	---	---	81.11	7	77.59	15	77.50	7	78.73	7	79.35	10
PAN 3195	---	---	81.30	5								
PAN 3198	---	---										
PAN 3355					80.65	2	77.90	5				
PAN 3368	---	---	79.40	15	79.87	6	76.40	14	78.56	9	79.64	8
PAN 3379	---	---	80.54	12	81.93	1	77.50	7	79.99	3	81.23	2
Senqu	---	---	79.90	14	79.27	9					79.59	9
SST 316	---	---	78.84	17								
SST 317	---	---	81.20	6								
SST 347	---	---	82.36	2	78.23	12	78.90	2	79.83	4	80.30	6
SST 356	---	---	79.09	16	77.96	13					78.52	12
SST 387	---	---	82.10	4	75.24	17	78.60	3	78.65		78.67	11
SST 398	---	---	80.95	8	75.70	16					78.33	
Average	**---**	**---**	**80.86**		**78.81**		**77.56**		**79.33**		**79.82**	
LSD_t(0,05)	**---**	**---**	**0.73**		**0.50**		**0.96**		**0.42**		**0.42**	

** Due to severe drought conditions no trials were planted in the South Western Free State in 2013*

Average protein content (%) of entries for the South Western Free State area (early planting date) during the full or partial period from 2010 – 2012

Cultivar	2013	R	2012	R	2011	R	2010	R	3 year average 2010-2012	R	2 year average 2011-2012	R
Betta-DN							12.83	1				
Caledon					11.98	2	12.36	6				
Elands	---	---	15.20	5	11.50	7	12.26	7	12.99	2	13.35	3
Gariep	---	---	14.34	15	11.14	12	12.10	11	12.53	8	12.74	12
Komati							12.23	9				
Koonap	---	---	15.24	3	12.30	1					13.77	
Limpopo							12.40	5				
Matlabas	---	---	14.70	13	11.56	6	12.51	4	12.92	4	13.13	9
PAN 3111	---	---										
PAN 3118	---	---	15.41	2	11.16	11	12.21	10	12.93	3	13.29	4
PAN 3120	---	---	15.46	1	11.35	9	12.54	3	13.12	1	13.41	2
PAN 3144					11.81	3	12.71	2				
PAN 3161	---	---	14.28	16	11.02	14	11.93	15	12.41	9	12.65	13
PAN 3195	---	---	14.24	17								
PAN 3198	---	---										
PAN 3355					10.71	16	11.86	16				
PAN 3368	---	---	14.74	12	11.40	8	12.10	11	12.75	6	13.07	10
PAN 3379	---	---	14.50	14	10.16	17	11.98	14	12.21	10	12.33	14
Senqu	---	---	14.77	9	11.65	4					13.21	5
SST 316	---	---	15.16	6								
SST 317	---	---	15.04	8								
SST 347	---	---	15.21	4	11.07	13	12.26	7	12.85	5	13.14	8
SST 356	---	---	15.07	7	11.25	10					13.16	7
SST 387	---	---	14.77	11	11.01	15	12.09	13	12.62		12.89	11
SST 398	---	---	14.77	10	11.64	5					13.21	
Average	**---**	**---**	**14.88**		**11.34**		**12.27**		**12.73**		**13.10**	
LSD_t(0,05)	**---**	**---**	**0.55**		**0.57**		**0.93**		**0.36**		**0.42**	

** Due to severe drought conditions no trials were planted in the South Western Free State in 2013*

Average falling number (s) of entries for the South Western Free State (early planting date) during the full or partial period from 2010 – 2012

Cultivar	2013	R	2012	R	2011	R	2010	R	3 year average 2010-2012	R	2 year average 2011-2012	R
Betta-DN							293	4				
Caledon					288	12	296	3				
Elands	---	---	372	6	285	13	288	6	315	3	328	8
Gariep	---	---	367	8	291	11	248	14	302	7	329	7
Komati							302	1				
Koonap	---	---	383	4	293	10					338	
Limpopo							265	11				
Matlabas	---	---	347	14	299	9	285	8	310	5	323	10
PAN 3111	---	---										
PAN 3118	---	---	347	14	305	8	248	13	300	8	326	9
PAN 3120	---	---	355	11	307	6	277	9	313	4	331	5
PAN 3144					321	3	276	10				
PAN 3161	---	---	401	2	321	4	302	2	341	1	361	1
PAN 3195	---	---	403	1								
PAN 3198	---	---										
PAN 3355					328	2	286	7				
PAN 3368	---	---	332	17	283	14	252	12	289	9	308	13
PAN 3379	---	---	387	3	335	1	247	15	323	2	361	2
Senqu	---	---	380	5	307	5					343	3
SST 316	---	---	372	7								
SST 317	---	---	340	16								
SST 347	---	---	362	9	259	16	290	5	304	6	311	12
SST 356	---	---	351	12	306	7					329	6
SST 387	---	---	349	13	238	17	239	16	275		293	14
SST 398	---	---	360	10	268	15					314	
Average	**---**	**---**	**365**		**296**		**275**		**307**		**328**	
LSD_t(0,05)	**---**	**---**	**21.58**		**34.59**		**32.81**		**19.45**		**22.71**	

** Due to severe drought conditions no trials were planted in the South Western Free State in 2013*

Average yield (ton/ha) of entries for the South Western Free State area (late planting date) during the full or partial period from 2010 – 2012

Cultivar	2013	R	2012	R	2011	R	2010	R	3 year average 2010-2012	R	2 year average 2011-2012	R
Betta-DN							0.98	16				
Caledon					1.42	11	1.25	10				
Elands	---	---	1.84	11	1.52	5	1.37	2	1.57	6	1.68	7
Gariep	---	---	1.73	14	1.62	2	1.29	8	1.55	8	1.68	7
Komati							1.20	13				
Koonap	---	---	1.66	16	1.43	10					1.54	11
Limpopo							1.20	12				
Matlabas	---	---	2.03	4	1.48	8	1.35	4	1.62	4	1.75	4
PAN 3111	---	---										
PAN 3118	---	---	2.00	7	1.48	7	1.54	1	1.67	1	1.74	5
PAN 3144					1.38	15	1.05	15				
PAN 3161	---	---	2.01	6	1.58	3	1.37	3	1.65	2	1.80	1
PAN 3195	---	---	2.02	5								
PAN 3198	---	---										
PAN 3355					1.46	9	1.32	5				
PAN 3368	---	---	1.65	17	1.42	12	1.18	14	1.41	9	1.53	12
PAN 3379	---	---	1.87	10	1.66	1	1.30	6	1.61	5	1.77	3
Senqu	---	---	1.75	13	1.49	6					1.62	10
SST 316	---	---										
SST 317	---	---	1.97	8								
SST 347	---	---	2.11	1								
SST 356	---	---	1.93	9	1.39	14					1.66	9
SST 374	---	---	1.80	12	1.22	17	1.22	11	1.41	10	1.51	14
SST 387	---	---	2.05	3	1.53	4	1.30	7	1.63	3	1.79	2
SST 398	---	---	2.05	2	1.40	13	1.26	9	1.57	7	1.73	6
Average	**---**	**---**	1.71	15	1.34	16					1.52	13
LSD_t(0,05)	**---**	**---**	**1.89**		**1.46**		**1.26**		**1.57**		**1.66**	
LSD_t(0,05)			**0.19**		**0.13**		**0.17**		**0.10**		**0.11**	

** Due to severe drought conditions no trials were planted in the South Western Free State in 2013*

Average hectolitre mass (kg/hl) of entries for the South Western Free State area (late planting date) during the full or partial period from 2010 – 2012

Cultivar	2013	R	2012	R	2011	R	2010	R	3 year average 2010-2012	R	2 year average 2011-2012	R
Betta-DN							78.50	9				
Caledon					76.99	7	78.90	6				
Elands	---	---	80.17	4	77.96	3	79.60	4	79.24	3	79.07	3
Gariep	---	---	80.70	2	77.26	6	79.80	3	79.25	2	78.98	4
Komati							78.20	10				
Koonap	---	---	80.23	3	78.53	2					79.38	2
Limpopo							78.70	7				
Matlabas	---	---	77.03	16	75.78	14	73.90	16	75.57	10	76.41	11
PAN 3111	---	---										
PAN 3118	---	---	79.47	6	77.35	5	79.90	1	78.91	4	78.41	5
PAN 3144					76.17	11	77.60	12				
PAN 3161	---	---	78.83	8	75.97	13	78.70	7	77.83	5	77.40	9
PAN 3195	---	---	78.33	10								
PAN 3198	---	---										
PAN 3355					77.88	4	79.10	5				
PAN 3368	---	---	78.92	7	76.14	12	78.10	11	77.72	6	77.53	7
PAN 3379	---	---	80.89	1	79.03	1	79.90	1	79.94	1	79.96	1
Senqu	---	---	79.55	5	76.64	8					78.10	6
SST 316	---	---	77.43	15								
SST 317	---	---	77.90	11								
SST 347	---	---	77.81	14	76.49	9					77.15	10
SST 356	---	---	76.62	17	74.17	17	76.80	15	75.86	9	75.40	14
SST 374	---	---	78.66	9	76.28	10	77.20	13	77.38	7	77.47	8
SST 387	---	---	77.90	11	74.23	16	77.20	13	76.44	8	76.07	13
SST 398	---	---	77.89	13	74.73	15					76.31	12
Average	**---**	**---**	**78.73**		**76.56**		**78.26**		**77.82**		**77.69**	
LSD$_t$(0,05)	**---**	**---**	**0.76**		**0.60**		**0.62**		**0.44**		**0.49**	

** Due to severe drought conditions no trials were planted in the South Western Free State in 2013*

Average protein content (%) of entries for the South Western Free State area (late planting date) during the full or partial period from 2010 – 2012

Cultivar	2013	R	2012	R	2011	R	2010	R	3 year average 2010-2012	R	2 year average 2011-2012	R
Betta-DN							15.21	1				
Caledon					12.88	3	14.77	6				
Elands	---	---	13.96	13	12.20	12	14.22	9	13.46	6	13.08	11
Gariep	---	---	14.51	6	12.21	11	14.53	7	13.75	5	13.36	7
Komati							15.11	2				
Koonap	---	---	14.45	8	13.09	1					13.77	3
Limpopo							14.02	12				
Matlabas	---	---	14.49	7	12.65	7	14.98	3	14.04	2	13.57	5
PAN 3111	---	---										
PAN 3118	---	---	14.86	1	12.46	8	14.42	8	13.91	3	13.66	4
PAN 3144					12.80	5	14.88	5				
PAN 3161	---	---	13.91	14	12.24	10	14.06	11	13.40	8	13.08	12
PAN 3195	---	---	13.66	16								
PAN 3198	---	---										
PAN 3355					12.13	14	14.01	13				
PAN 3368	---	---	14.86	1	12.78	6	14.94	4	14.19	1	13.82	1
PAN 3379	---	---	13.82	15	11.39	17	13.72	15	12.98	9	12.61	13
Senqu	---	---	14.52	5	12.11	15					13.32	8
SST 316	---	---	14.05	11								
SST 317	---	---	14.70	4								
SST 347	---	---	14.03	12	12.46	8					13.25	9
SST 356	---	---	14.22	9	12.92	2	14.12	10	13.75	4	13.57	5
SST 374	---	---	13.40	17	11.54	16	13.51	16	12.82	10	12.47	14
SST 387	---	---	14.09	10	12.17	13	14.00	14	13.42	7	13.13	10
SST 398	---	---	14.76	3	12.82	4					13.79	2
Average	**---**	**---**	**14.25**		**12.40**		**14.41**		**13.57**		**13.32**	
LSD_t(0,05)	**---**	**---**	**0.48**		**0.49**		**0.63**		**0.30**		**0.34**	

** Due to severe drought conditions no trials were planted in the South Western Free State in 2013*

Average falling number (s) of entries for the South Western Free State area (late planting date) during the full or partial period from 2010 – 2012

Cultivar	2013	R	2012	R	2011	R	2010	R	3 year average 2010-2012	R	2 year average 2011-2012	R
Betta-DN							279	2				
Caledon					320	5	273	5				
Elands	---	---	344	2	304	8	271	7	307	1	324	2
Gariep	---	---	282	14	302	9	272	6	285	5	292	11
Komati							276	3				
Koonap	---	---	318	7	305	7					312	5
Limpopo							271	8				
Matlabas	---	---	329	3	289	13	228	16	282	7	309	6
PAN 3111	---	---										
PAN 3118	---	---	300	10	301	10	274	4	291	4	300	9
PAN 3144					321	4	298	1				
PAN 3161	---	---	319	5	318	6	266	11	301	2	319	3
PAN 3195	---	---	273	15								
PAN 3198	---	---										
PAN 3355					345	1	268	9				
PAN 3368	---	---	288	13	275	16	255	13	273	9	281	13
PAN 3379	---	---	297	11	331	2	258	12	295	3	314	4
Senqu	---	---	346	1	329	3					337	1
SST 316	---	---	291	12								
SST 317	---	---	319	6								
SST 347	---	---	311	8	282	15					297	10
SST 356	---	---	309	9	300	12	247	14	285	6	304	8
SST 374	---	---	269	16	300	11	267	10	279	8	285	12
SST 387	---	---	256	17	274	17	243	15	258	10	265	14
SST 398	---	---	322	4	287	14					305	7
Average	**---**	**---**	**304**		**305**		**265**		**286**		**303**	
LSD_t(0,05)	**---**	**---**	**19.08**		**26.34**		**43.73**		**16.17**		**15.89**	

** Due to severe drought conditions no trials were planted in the South Western Free State in 2013*

Average yield (ton/ha) of entries for the North Western Free State area (early planting date) during the full or partial period from 2010 – 2013

Cultivar	2013	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Betta–DN							1.72	16						
Caledon					3.98	14	1.82	14						
Elands	2.67	18	4.14	14	4.13	11	2.08	10	3.25	10	3.65	11	3.40	15
Gariep	3.16	12	4.55	11	4.45	6	1.80	15	3.49	8	4.05	8	3.86	11
Komati							2.12	8						
Koonap	3.22	10	3.55	17	3.47	17					3.41	14	3.39	16
Limpopo							1.55	17						
Matlabas	4.22	2	4.69	9	4.41	7	2.57	5	3.97	4	4.44	4	4.46	5
PAN 3111	3.95	5												
PAN 3118	4.20	3	4.94	5	4.32	8	2.57	3	4.01	3	4.49	3	4.57	3
PAN 3120	4.33	1	5.17	4	4.75	3	2.64	1	4.22	1	4.75	1	4.75	1
PAN 3144					3.88	15	2.08	10						
PAN 3161	3.56	7	4.85	6	4.68	4	2.55	6	3.91	5	4.36	5	4.20	7
PAN 3195	3.18	11	5.44	1									4.31	6
PAN 3198	2.83	16												
PAN 3355					4.47	5	2.00	12						
PAN 3368	2.81	17	3.76	16	4.15	10	1.92	13	3.16	11	3.58	12	3.29	17
PAN 3379	3.26	9	4.60	10	5.13	1	2.44	7	3.86	6	4.33	6	3.93	9
Senqu	2.87	15	4.14	13	4.01	13					3.67	10	3.51	14
SST 316	2.99	13	4.76	7									3.87	10
SST 317	4.00	4	5.26	3									4.63	2
SST 347	3.49	8	4.76	7	4.31	9	2.57	3	3.78	7	4.18	7	4.12	8
SST 356	2.60	19	4.42	12	4.07	12	2.11	9	3.30	9	3.70	9	3.51	12
SST 387	3.70	6	5.32	2	4.96	2	2.63	2	4.15	2	4.66	2	4.51	4
SST 398	2.97	14	4.06	15	3.57	16					3.53	13	3.51	13
Average	**3.37**		**4.61**		**4.28**		**2.19**		**3.74**		**4.06**		**3.99**	
LSD_t(0.05)	**0.42**		**0.39**		**0.43**		**0.29**		**0.20**		**0.24**		**0.29**	

Average hectolitre mass (kg/hl) of entries for the North Western Free State area (early planting date) during the full or partial period from 2010 – 2013

Cultivar	2013	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Betta–DN							78.00	10						
Caledon					78.29	12	77.97	11						
Elands	76.58	14	77.03	2	79.59	4	78.52	7	77.93	6	77.73	7	76.81	9
Gariep	77.69	11	77.00	3	80.07	2	78.58	6	78.34	5	78.25	5	77.35	7
Komati							77.43	15						
Koonap	79.05	6	76.23	6	79.24	5					78.17	6	77.64	4
Limpopo							77.79	13						
Matlabas	78.93	7	75.09	10	78.64	10	78.77	5	77.86	7	77.55	8	77.01	8
PAN 3111	79.78	4												
PAN 3118	79.58	5	76.08	7	79.13	7	78.87	4	78.42	4	78.26	4	77.83	3
PAN 3120	81.36	1	76.91	4	80.71	1	80.36	2	79.83	1	79.66	1	79.13	1
PAN 3144					77.99	13	77.75	14						
PAN 3161	76.62	13	74.98	11	78.40	11	77.83	12	76.96	9	76.67	11	75.80	14
PAN 3195	75.76	17	74.89	13									75.32	15
PAN 3198	77.72	10												
PAN 3355					78.98	8	78.12	8						
PAN 3368	76.52	16	75.32	9	77.83	14	76.82	16	76.62	10	76.56	12	75.92	13
PAN 3379	78.64	8	76.44	5	79.95	3	79.17	3	78.55	3	78.34	3	77.54	6
Senqu	76.54	15	75.92	8	78.75	9					77.07	9	76.23	11
SST 316	74.86	19	74.58	16									74.72	16
SST 317	78.49	9	74.67	15									76.58	10
SST 347	80.39	2	77.40	1	79.23	6	80.42	1	79.36	2	79.01	2	78.89	2
SST 356	75.00	18	74.26	17	76.84	16	76.09	17	75.55	11	75.37	14	74.63	17
SST 387	80.23	3	74.97	12	75.04	17	78.05	9	77.07	8	76.75	10	77.60	5
SST 398	77.40	12	74.89	13	77.00	15					76.43	13	76.14	12
Average	**77.95**		**75.69**		**78.57**		**78.27**		**77.86**		**77.56**		**76.77**	
LSD_t(0.05)	**1.03**		**0.56**		**1.30**		**0.66**		**0.52**		**0.64**		**0.55**	

Average protein content (%) of entries for the North Western Free State area (early planting date) during the full or partial period from 2010 – 2013

Cultivar	2013	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Betta–DN							12.67	1						
Caledon					12.49	9	12.19	5						
Elands	14.27	6	12.60	4	12.51	7	11.61	10	12.75	3	13.13	5	13.44	5
Gariep	14.12	9	11.65	12	12.13	15	11.16	13	12.26	7	12.63	9	12.88	10
Komati							12.14	7						
Koonap	14.69	2	13.41	1	12.89	1					13.66	1	14.05	1
Limpopo							12.22	4						
Matlabas	14.75	1	12.36	6	12.39	11	12.19	5	12.92	2	13.17	4	13.55	4
PAN 3111	13.36	18												
PAN 3118	13.70	14	11.48	15	12.60	4	11.95	9	12.43	6	12.59	11	12.59	15
PAN 3120	14.06	10	11.93	9	12.36	12	12.42	2	12.69	5	12.78	8	13.00	9
PAN 3144					12.48	10	12.42	2						
PAN 3161	13.52	17	12.15	8	12.14	14	11.11	16	12.23	8	12.60	10	12.83	11
PAN 3195	13.72	13	10.99	16									12.35	16
PAN 3198	13.92	11												
PAN 3355					11.96	17	11.16	13						
PAN 3368	14.30	5	13.21	2	12.81	2	11.98	8	13.07	1	13.44	2	13.75	2
PAN 3379	13.53	16	11.91	10	11.98	16	10.34	17	11.94	10	12.47	13	12.72	12
Senqu	14.14	8	12.40	5	12.53	6					13.02	7	13.27	7
SST 316	14.46	4	11.83	11									13.15	8
SST 317	13.61	15	11.61	13									12.61	14
SST 347	13.76	12	11.56	14	12.27	13	11.16	13	12.19	9	12.53	12	12.66	13
SST 356	14.65	3	12.20	7	12.51	7	11.59	11	12.74	4	13.12	6	13.42	6
SST 387	13.25	19	10.57	17	12.54	5	11.26	12	11.91	11	12.12	14	11.91	17
SST 398	14.17	7	13.02	3	12.73	3					13.31	3	13.60	3
Average	**14.00**		**12.05**		**12.43**		**11.74**		**12.47**		**12.90**		**13.05**	
LSD_t(0.05)	**0.91**		**0.59**		**0.65**		**0.94**		**0.39**		**0.42**		**0.51**	

Average falling number (s) of entries for the North Western Free State area (early planting date) during the full or partial period from 2010 – 2013

Cultivar	2013	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Betta–DN							296	8						
Caledon					332	6	296	7						
Elands	274	14	283	3	324	10	294	9	294	2	294	3	279	3
Gariep	258	18	214	13	318	12	269	13	265	9	263	13	236	15
Komati							302	5						
Koonap	298	2	233	10	334	4					288	5	266	8
Limpopo							286	11						
Matlabas	294	6	255	5	324	11	299	6	293	4	291	4	274	6
PAN 3111	294	5												
PAN 3118	283	11	214	12	329	7	252	15	270	8	276	9	249	12
PAN 3120	276	12	238	8	312	15	229	16	264	10	276	9	257	9
PAN 3144					341	2	309	3						
PAN 3161	272	15	236	9	346	1	326	1	295	1	285	8	254	11
PAN 3195	262	17	104	17									183	17
PAN 3198	298	3												
PAN 3355					336	3	279	12						
PAN 3368	275	13	279	4	309	16	309	2	293	3	288	7	277	4
PAN 3379	288	9	204	15	333	5	288	10	278	7	275	11	246	13
Senqu	292	8	298	1	329	8					306	1	295	1
SST 316	284	10	227	11									256	10
SST 317	294	7	242	7									268	7
SST 347	296	4	254	6	315	14	256	14	280	5	288	6	275	5
SST 356	271	16	214	14	328	9	307	4	280	6	271	12	242	14
SST 387	221	19	157	16	299	17	209	17	222	11	226	14	189	16
SST 398	299	1	286	2	315	13					300	2	292	2
Average	**280**		**232**		**325**		**283**		**276**		**280**		**255**	
LSD_t(0.05)	**22.83**		**27.43**		**23.92**		**25.85**		**13.45**		**15.40**		**18.88**	

Average yield (ton/ha) of entries for the North Western Free State area (late planting date) during the full or partial period from 2010 – 2013

Cultivar	* 2013	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Betta–DN							1.72	17						
Caledon					3.91	8	1.97	8						
Elands	3.75	18	3.74	16	3.59	15	1.90	13	3.24	11	3.69	14	3.74	17
Gariep	4.37	13	4.38	9	3.90	10	1.97	9	3.66	7	4.22	7	4.37	10
Komati							1.79	15						
Koonap	4.72	11	3.17	17	3.48	16					3.79	12	3.95	15
Limpopo							1.80	14						
Matlabas	5.54	5	4.40	8	3.77	11	2.35	3	4.01	5	4.57	5	4.97	6
PAN 3111	5.44	7												
PAN 3118	5.99	1	4.84	2	4.08	5	2.39	2	4.33	1	4.97	1	5.42	1
PAN 3144					3.46	17	1.94	11						
PAN 3161	5.60	3	4.74	4	4.19	3	2.30	4	4.21	2	4.84	2	5.17	3
PAN 3195	5.70	2	4.97	1									5.33	2
PAN 3198	4.26	16												
PAN 3355					4.24	2	1.77	16						
PAN 3368	4.18	17	3.74	15	3.96	7	1.90	12	3.45	10	3.96	11	3.96	14
PAN 3379	5.46	6	4.53	6	4.32	1	2.19	6	4.13	3	4.77	3	4.99	5
Senqu	4.27	15	4.02	12	4.19	4					4.16	8	4.15	13
SST 316	4.84	10	4.52	7									4.68	8
SST 317	5.58	4	4.53	5									5.05	4
SST 347	5.04	8	4.31	10	3.73	13	2.20	5	3.82	6	4.36	6	4.67	9
SST 356	4.57	12	3.83	14	3.77	12	1.96	10	3.53	9	4.06	10	4.20	12
SST 374	4.28	14	4.20	11	3.91	8	2.02	7	3.60	8	4.13	9	4.24	11
SST 387	4.91	9	4.84	2	4.07	6	2.54	1	4.09	4	4.61	4	4.87	7
SST 398	3.68	19	3.90	13	3.65	14					3.74	13	3.79	16
Average	**4.85**		**4.28**		**3.89**		**2.04**		**3.82**		**4.28**		**4.56**	
LSD_t (0.05)	**0.77**		**0.36**		**0.43**		**0.25**		**0.20**		**0.26**		**0.34**	

Average hectolitre mass (kg/hl) of entries for the North Western Free State area (late planting date) during the full or partial period from 2010 – 2013

Cultivar	* 2013	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Betta–DN							79.56	3						
Caledon					78.31	10	79.29	5						
Elands	78.78	8	76.82	4	79.33	4	79.41	4	78.59	5	78.31	6	77.80	6
Gariep	80.09	1	77.73	2	79.19	7	79.74	1	79.19	1	79.00	2	78.91	1
Komati							79.05	8						
Koonap	79.66	4	76.49	5	79.58	3					78.58	3	78.08	5
Limpopo							78.32	12						
Matlabas	77.69	17	75.71	8	77.54	13	77.32	16	77.07	9	76.98	11	76.70	11
PAN 3111	78.11	13												
PAN 3118	80.03	2	76.35	6	79.23	5	79.67	2	78.82	3	78.54	4	78.19	3
PAN 3144					77.75	12	78.19	13						
PAN 3161	78.93	7	75.01	11	78.26	11	79.21	6	77.85	6	77.40	8	76.97	9
PAN 3195	78.29	11	74.31	15									76.30	14
PAN 3198	78.57	9												
PAN 3355					79.92	2	78.65	10						
PAN 3368	77.88	15	75.52	9	78.72	9	77.95	14	77.52	7	77.37	9	76.70	11
PAN 3379	79.95	3	77.26	3	80.57	1	78.53	11	79.08	2	79.26	1	78.61	2
Senqu	78.15	12	76.14	7	79.00	8					77.76	7	77.15	8
SST 316	78.06	14	74.70	13									76.38	13
SST 317	79.46	5	74.93	12									77.20	7
SST 347	78.49	10	77.81	1	79.22	6	79.14	7	78.67	4	78.51	5	78.15	4
SST 356	77.80	16	73.90	17	76.48	15	76.86	17	76.26	11	76.06	12	75.85	15
SST 374	78.95	6	74.67	14	77.52	14	77.55	15	77.17	8	77.05	10	76.81	10
SST 387	77.22	18	74.02	16	75.49	17	78.76	9	76.37	10	75.58	14	75.62	17
SST 398	76.14	19	75.38	10	76.48	15					76.00	13	75.76	16
Average	**78.54**		**75.69**		**78.39**		**78.66**		**77.87**		**77.60**		**77.13**	
LSD_t(0.05)	**1.94**		**0.50**		**1.10**		**0.45**		**0.48**		**0.62**		**0.74**	

Average protein content (%) of entries for the North Western Free State area (late planting date) during the full or partial period from 2010 – 2013

Cultivar	* 2013	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Betta–DN							13.42	5						
Caledon					11.56	5	13.54	3						
Elands	15.05	7	12.89	6	11.48	6	13.33	7	13.19	3	13.14	6	13.97	6
Gariep	14.46	11	12.62	8	11.07	11	12.83	10	12.74	5	12.72	8	13.54	8
Komati							13.36	6						
Koonap	15.17	4	13.76	2	11.79	1					13.57	1	14.46	3
Limpopo							12.94	8						
Matlabas	15.71	1	13.36	3	11.60	4	13.87	1	13.64	1	13.56	2	14.54	2
PAN 3111	13.82	15												
PAN 3118	14.47	10	12.05	14	11.17	10	12.75	11	12.61	7	12.56	11	13.26	11
PAN 3144					11.75	2	13.59	2						
PAN 3161	14.82	9	12.16	13	10.80	15	12.64	13	12.61	8	12.59	10	13.49	10
PAN 3195	13.89	14	11.21	16									12.55	16
PAN 3198	15.13	6												
PAN 3355					10.95	13	12.61	14						
PAN 3368	15.28	3	13.88	1	11.20	7	13.53	4	13.47	2	13.45	4	14.58	1
PAN 3379	13.46	17	12.04	15	10.38	17	11.95	17	11.96	10	11.96	13	12.75	14
Senqu	15.16	5	13.27	4	11.04	12					13.16	5	14.21	5
SST 316	13.03	18	12.18	12									12.60	15
SST 317	14.13	13	12.28	11									13.21	12
SST 347	14.97	8	12.37	10	11.19	9	12.54	15	12.77	4	12.84	7	13.67	7
SST 356	14.33	12	12.72	7	10.87	14	12.84	9	12.69	6	12.64	9	13.52	9
SST 374	13.47	16	12.44	9	11.20	7	12.74	12	12.46	9	12.37	12	12.96	13
SST 387	12.99	19	11.13	17	10.51	16	12.43	16	11.76	11	11.54	14	12.06	17
SST 398	15.52	2	13.22	5	11.62	3					13.45	3	14.37	4
Average	**14.46**		**12.56**		**11.19**		**12.99**		**12.72**		**12.83**		**13.51**	
LSD_t(0.05)	**1.07**		**0.70**		**0.86**		**0.50**		**0.36**		**0.48**		**0.60**	

Average falling number (s) of entries for the North Western Free State area (late planting date) during the full or partial period from 2010 – 2013

Cultivar	* 2013	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Betta–DN							291	13						
Caledon					282	8	323	3						
Elands	302	9	269	5	294	4	293	12	289	1	288	2	285	4
Gariep	295	13	219	11	252	13	306	5	268	6	255	10	257	11
Komati							301	7						
Koonap	324	2	270	4	314	1					303	1	297	1
Limpopo							308	4						
Matlabas	245	19	299	1	297	2	283	14	281	2	280	6	272	7
PAN 3111	278	16												
PAN 3118	296	12	192	14	259	12	248	15	249	10	249	13	244	14
PAN 3144					283	6	298	8						
PAN 3161	272	18	226	8	263	11	341	1	275	3	253	11	249	13
PAN 3195	321	3	123	17									222	16
PAN 3198	305	7												
PAN 3355					283	7	331	2						
PAN 3368	291	14	254	7	232	16	294	11	268	7	259	8	273	6
PAN 3379	327	1	217	12	247	14	297	9	272	4	263	7	272	8
Senqu	300	10	276	3	273	9					283	4	288	3
SST 316	302	8	216	13									259	10
SST 317	310	6	224	9									267	9
SST 347	299	11	256	6	292	5	233	16	270	5	282	5	277	5
SST 356	289	15	222	10	243	15	302	6	264	9	251	12	255	12
SST 374	313	5	160	15	294	3	297	10	266	8	256	9	237	15
SST 387	276	17	127	16	218	17	217	17	209	11	207	14	201	17
SST 398	315	4	276	2	268	10					286	3	296	2
Average	**298**		**225**		**270**		**292**		**265**		**265**		**262**	
LSD_t(0.05)	**49.58**		**25.34**		**40.71**		**28.15**		**17.69**		**21.43**		**21.81**	

Average yield (ton/ha) of entries for the Central Free State area (early planting date) during the full or partial period from 2010 – 2013

Cultivar	2013	R	2012	R	2011	R	2010 *	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Betta–DN							1.18	11						
Caledon					1.54	9	1.32	10						
Elands	1.57	18	2.19	16	1.58	6	1.38	9	1.68	9	1.78	9	1.88	13
Gariep	1.41	19	2.32	12	1.70	1	1.13	13	1.64	11	1.71	13	2.01	8
Komati							1.52	6						
Koonap	1.57	16	2.05	17	1.42	16					1.73	11	1.73	17
Limpopo							0.90	16						
Matlabas	2.07	4	2.51	5	1.70	2	2.09	2	2.09	2	2.10	1	2.10	4
PAN 3111	2.40	2												
PAN 3118	1.77	10	2.42	8	1.58	5	1.41	8	1.80	5	1.81	7	2.00	9
PAN 3120	2.01	7	2.44	7	1.55	8	2.13	1	2.03	3	2.04	3	2.00	10
PAN 3144					1.47	13	1.42	7						
PAN 3161	1.82	8	2.49	6	1.65	4	1.06	15	1.75	7	1.73	12	2.07	5
PAN 3195	2.07	5	2.62	2									2.62	1
PAN 3198	1.80	9												
PAN 3355					1.58	7	0.85	17						
PAN 3364														
PAN 3368	1.65	14	2.40	10	1.46	14	1.07	14	1.64	10	1.64	14	1.93	11
PAN 3379	1.57	17	2.41	9	1.66	3	1.13	12	1.69	8	1.73	10	2.04	7
Senqu	1.67	12	2.26	14	1.44	15					1.85	6	1.85	15
SST 316	1.67	13	2.52	4									2.52	2
SST 317	2.05	6	2.39	11									2.39	3
SST 347	2.41	1	2.66	1	1.48	12	2.08	3	2.16	1	2.07	2	2.07	6
SST 356	1.63	15	2.27	13	1.48	10	1.66	5	1.76	6	1.80	8	1.88	14
SST 387	1.70	11	2.20	15	1.48	10	1.90	4	1.82	4	1.86	5	1.84	16
SST 398	2.16	3	2.61	3	1.23	17					1.92	4	1.92	12
Average	**1.84**		**2.40**		**1.53**		**1.42**		**1.82**		**1.90**		**2.10**	
LSD_t (0.05)	**0.22**		**0.24**		**0.15**		**0.29**		**0.11**		**0.12**		**0.16**	

Average hectolitre mass (kg/hl) of entries for the Central Free State area (early planting date) during the full or partial period from 2010 – 2013

Cultivar	2013	R	2012	R	2011	R	2010 *	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Betta–DN							77.40	4						
Caledon					75.44	10	77.00	8						
Elands	78.46	6	78.67	5	76.06	7	77.20	6	77.60	5	77.73	5	78.57	4
Gariep	78.74	5	78.63	6	76.93	6	76.80	9	77.77	4	77.45	6	77.78	6
Komati							76.50	10						
Koonap	79.96	2	79.52	4	77.58	3					78.55	3	78.55	5
Limpopo							76.00	12						
Matlabas	78.16	9	78.26	7	75.77	9	77.30	5	77.37	7	77.11	8	77.02	9
PAN 3111	77.78	15												
PAN 3118	77.71	16	77.73	12	77.39	4	77.20	6	77.51	6	77.44	7	77.56	8
PAN 3120	78.76	4	80.38	1	78.66	1	79.20	1	79.25	2	79.41	1	79.52	1
PAN 3144					74.89	15	76.00	12						
PAN 3161	76.88	18	77.95	9	75.97	8	72.10	17	75.72	10	75.34	13	76.96	10
PAN 3195	77.76	15	76.48	14									76.48	12
PAN 3198	77.95	12												
PAN 3355					75.44	10	73.60	15						
PAN 3364														
PAN 3368	77.80	13	77.81	10	75.03	14	73.60	15	76.06	9	75.48	12	76.42	14
PAN 3379	79.16	3	79.94	3	77.39	4	76.10	11	78.15	3	77.81	4	78.67	3
Senqu	78.33	7	78.12	8	75.04	13					76.58	9	76.58	11
SST 316	77.08	17	75.59	15									75.59	15
SST 317	77.98	11	77.61	13									77.61	7
SST 347	80.99	1	80.08	2	77.79	2	79.20	1	79.51	1	79.02	2	78.94	2
SST 356	76.83	19	74.32	17	72.67	17	75.90	14	74.93	11	74.30	14	73.50	17
SST 387	78.21	8	74.66	16	74.24	16	78.00	3	76.28	8	75.63	11	74.45	16
SST 398	78.10	10	77.79	11	75.09	12					76.44	10	76.44	13
Average	**78.24**		**77.86**		**75.96**		**76.42**		**77.29**		**77.56**		**78.07**	
LSD_t(0.05)	**0.62**		**0.56**		**0.73**		**2.03**		**0.43**		**0.40**		**0.41**	

Average protein content (%) of entries for the Central Free State area (early planting date) during the full or partial period from 2010 – 2013

Cultivar	2013	R	2012	R	2011	R	2010 *	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Betta–DN							16.14	4						
Caledon					14.77	2	15.44	10						
Elands	14.95	4	14.35	9	14.34	10	15.29	12	14.73	5	14.55	8	14.65	4
Gariep	15.05	2	14.61	4	13.97	13	16.64	2	15.07	3	15.07	3	14.29	10
Komati							15.96	5						
Koonap	14.46	8	15.13	2	14.50	7					14.82	6	14.82	2
Limpopo							15.70	9						
Matlabas	13.90	10	14.99	3	14.36	9	15.39	11	14.66	6	14.91	5	14.68	3
PAN 3111	13.50	15												
PAN 3118	15.52	1	14.52	6	14.21	11	16.84	1	15.27	1	15.19	1	14.37	9
PAN 3120	14.26	9	15.35	1	14.72	3	14.79	16	14.78	4	14.95	4	15.04	1
PAN 3144					14.61	6	15.81	8						
PAN 3161	13.86	11	13.60	17	13.44	17	15.84	7	14.18	8	14.29	10	13.52	17
PAN 3195	13.70	12	13.66	16									13.66	16
PAN 3198	14.60	6												
PAN 3355					14.12	12	15.88	6						
PAN 3364														
PAN 3368	14.97	3	14.40	8	14.71	4	16.40	3	15.12	2	15.17	2	14.56	7
PAN 3379	14.56	7	13.80	14	13.74	14	15.18	13	14.32	7	14.24	12	13.77	14
Senqu	14.84	5	14.59	5	14.43	8					14.51	9	14.51	8
SST 316	13.36	15	14.21	11									14.21	12
SST 317	13.51	13	14.22	10									14.22	11
SST 347	12.91	19	13.74	15	13.60	16	14.81	15	13.76	11	14.05	14	13.67	15
SST 356	13.19	17	14.18	12	15.00	1	13.48	17	13.96	9	14.22	13	14.59	5
SST 387	13.02	18	14.03	13	13.68	15	15.04	14	13.94	10	14.25	11	13.86	13
SST 398	13.34	16	14.50	7	14.62	5					14.56	7	14.56	6
Average	**14.08**		**14.35**		**14.28**		**15.57**		**14.53**		**14.28**		**14.21**	
LSD_t(0.05)	**0.85**		**0.51**		**0.68**		**0.82**		**0.38**		**0.39**		**0.47**	

Average falling number (s) of entries for the Central Free State area (early planting date) during the full or partial period from 2010 – 2013

Cultivar	2013	R	2012	R	2011	R	2010 *	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Betta–DN							241	6						
Caledon					350	6	231	8						
Elands	260	3	342	5	364	1	257	3	306	1	322	5	301	15
Gariep	201	16	291	14	321	15	182	13	249	10	264	12	306	14
Komati							266	2						
Koonap	269	1	355	2	352	5					354	1	354	2
Limpopo							156	15						
Matlabas	235	9	331	10	364	2	281	1	303	2	325	4	347	4
PAN 3111	219	15												
PAN 3118	227	11	319	12	343	9	229	9	279	4	297	7	331	9
PAN 3120	244	5	307	13	327	14	235	7	278	5	289	8	317	12
PAN 3144					341	10	256	4						
PAN 3161	167	19	331	8	349	7	153	16	250	9	278	11	340	6
PAN 3195	187	17	260	16									260	17
PAN 3198	218	15												
PAN 3355					332	13	185	12						
PAN 3364														
PAN 3368	252	4	331	9	308	17	215	10	276	7	285	10	319	11
PAN 3379	243	6	322	11	334	11	209	11	277	6	288	9	328	10
Senqu	240	8	343	4	345	8					344	3	344	5
SST 316	221	13	339	6									339	7
SST 317	226	12	334	7									334	8
SST 347	243	7	281	15	334	12	169	14	257	8	261	13	308	13
SST 356	234	10	359	1	358	3	249	5	300	3	322	6	358	1
SST 387	169	18	223	17	313	16	88	17	198	11	208	14	268	16
SST 398	263	2	355	3	353	4					354	1	354	2
Average	**227**		**319**		**340**		**212**		**270**		**298**		**274**	
LSD_t(0.05)	**34.66**		**26.43**		**29.36**		**47.17**		**16.69**		**17.60**		**20.20**	

Average yield (ton/ha) of entries for the Central Free State area (late planting date) during the full or partial period from 2010 – 2013

Cultivar	2013	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Betta–DN							2.24	13						
Caledon					1.61	14	2.38	8						
Elands	2.54	5	2.31	5	1.81	4	2.38	9	2.26	3	2.22	3	2.43	4
Gariep	2.22	16	2.14	14	1.82	2	2.27	12	2.11	9	2.06	11	2.18	15
Komati							2.54	5						
Koonap	2.39	8	2.21	9	1.77	7					2.12	7	2.30	10
Limpopo							2.01	14						
PAN 3111	2.61	2												
PAN 3118	2.55	4	2.22	6	1.82	3	2.71	4	2.33	2	2.20	4	2.39	7
PAN 3144					1.66	13	2.27	11						
PAN 3161	2.26	12	2.53	2	1.90	1	2.86	1	2.39	1	2.23	2	2.39	6
PAN 3195	2.32	10	2.15	13									2.24	12
PAN 3198	1.87	18												
PAN 3355					1.70	8	1.95	15						
PAN 3368	2.49	6	2.18	12	1.61	14	2.32	10	2.15	8	2.09	8	2.34	9
PAN 3379	2.24	14	2.20	10	1.80	6	1.89	16	2.03	10	2.08	9	2.22	13
Senqu	2.23	15	2.01	16	1.69	9					1.98	13	2.12	17
SST 316	2.32	11	2.05	15									2.19	14
SST 317	2.57	3	2.22	6									2.39	5
SST 347	2.42	7	2.66	1	1.37	16	2.54	6	2.25	5	2.15	5	2.54	3
SST 356	2.37	9	2.20	10	1.66	12	2.81	2	2.26	4	2.08	10	2.28	11
SST 374	2.26	13	2.44	4	1.68	10	2.44	7	2.20	7	2.13	6	2.35	8
SST 387	2.10	17	2.22	6	1.81	5	2.72	3	2.21	6	2.04	12	2.16	16
SST 398	2.79	1	2.45	3	1.66	11					2.30	1	2.62	1
Average	**2.36**		**2.26**		**1.71**		**2.40**		**2.22**		**2.13**		**2.34**	
LSD_t (0.05)	**0.30**		**0.28**		**0.16**		**0.35**		**0.14**		**0.14**		**0.21**	

Average hectolitre mass (kg/hl) of entries for the Central Free State area (late planting date) during the full or partial period from 2010 – 2013

Cultivar	2013	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Betta–DN							80.20	2						
Caledon					75.02	10	79.00	8						
Elands	79.71	2	77.50	7	75.97	6	79.30	6	78.12	3	77.73	5	78.61	7
Gariep	78.99	7	76.20	12	76.04	5	78.90	9	77.53	5	77.08	7	77.59	10
Komati							79.50	4						
Koonap	80.69	1	79.10	3	77.36	2					79.05	1	79.89	2
Limpopo							78.00	12						
PAN 3111	77.79	11												
PAN 3118	78.94	8	79.40	2	77.14	3	79.80	3	78.82	2	78.49	3	79.17	3
PAN 3144					74.60	12	79.30	6						
PAN 3161	77.69	12	76.90	9	75.97	6	78.40	10	77.24	6	76.85	8	77.29	11
PAN 3195	76.81	16	75.50	13									76.16	13
PAN 3198	77.55	13												
PAN 3355					74.03	14	76.30	15						
PAN 3368	78.71	10	76.80	10	75.04	9	78.00	12	77.14	7	76.85	9	77.76	9
PAN 3379	79.09	6	78.40	5	76.23	4	78.10	11	77.95	4	77.91	4	78.74	5
Senqu	79.50	3	76.70	11	75.06	8					77.09	6	78.10	8
SST 316	76.43	17	74.60	15									75.51	15
SST 317	78.76	9	78.70	4									78.73	6
SST 347	79.41	5	81.50	1	74.85	11	81.60	1	79.34	1	78.59	2	80.46	1
SST 356	76.35	18	73.80	16	78.06	1	77.00	14	76.30	9	76.07	11	75.08	16
SST 374	76.86	15	77.10	8	72.08	16	76.10	16	75.54	10	75.35	13	76.98	12
SST 387	77.15	14	74.70	14	74.40	13	79.40	5	76.41	8	75.42	12	75.93	14
SST 398	79.50	3	78.40	5	72.36	15					76.75	10	78.95	4
Average	**78.33**		**77.21**		**75.26**		**78.68**		**77.44**		**77.17**		**77.81**	
LSD_t(0.05)	**0.84**		**0.83**		**0.86**		**0.46**		**0.49**		**0.51**		**0.59**	

Average protein content (%) of entries for the Central Free State (late planting date) during the full or partial period from 2010 – 2013

Cultivar	2013	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Betta–DN							15.13	6						
Caledon					15.96	4	15.44	2						
Elands	13.77	6	15.04	8	15.87	6	14.43	12	14.78	3	14.89	6	14.41	6
Gariep	13.59	7	14.79	11	15.19	14	14.98	9	14.64	4	14.52	8	14.19	9
Komati							15.18	4						
Koonap	14.09	1	15.11	7	16.27	1					15.16	2	14.60	2
Limpopo							15.25	3						
PAN 3111	12.57	17												
PAN 3118	14.04	2	16.04	1	16.15	2	14.65	10	15.22	1	15.41	1	15.04	1
PAN 3144					15.54	10	15.04	8						
PAN 3161	13.37	10	14.3	14	15.08	15	13.66	13	14.10	9	14.25	12	13.83	13
PAN 3195	13.06	12	14.77	12									13.91	10
PAN 3198	13.89	4												
PAN 3355					15.83	7	15.15	5						
PAN 3368	13.91	3	15.04	8	15.80	8	15.64	1	15.10	2	14.92	5	14.47	4
PAN 3379	13.28	11	14.16	16	14.83	16	15.11	7	14.35	7	14.09	13	13.72	15
Senqu	13.86	5	15.34	5	15.66	9					14.95	3	14.60	3
SST 316	13.04	13	15.51	3									14.27	8
SST 317	12.79	15	14.99	10									13.89	11
SST 347	12.65	16	14.47	13	16.06	3	13.61	14	14.20	8	14.39	9	13.56	16
SST 356	12.97	14	15.63	2	15.35	12	13.51	15	14.36	6	14.65	7	14.30	7
SST 374	13.38	9	14.27	15	15.41	11	14.65	11	14.43	5	14.35	10	13.82	14
SST 387	12.48	18	15.21	6	15.31	13	13.24	16	14.06	10	14.33	11	13.85	12
SST 398	13.48	8	15.46	4	15.88	5					14.94	4	14.47	5
Average	**13.35**		**15.01**		**15.64**		**14.67**		**14.52**		**14.68**		**14.18**	
LSD_t(0.05)	**0.71**		**0.67**		**0.84**		**0.89**		**0.43**		**0.46**		**0.49**	

Average falling number (s) of entries for the Central Free State (late planting date) during the full or partial period from 2010 – 2013

Cultivar	2013	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Betta–DN							246	10						
Caledon					310	13	269	5						
Elands	286	17	393	4	373	1	273	3	331	2	351	2	340	7
Gariep	265	18	319	14	311	12	242	11	284	9	298	13	292	15
Komati							260	8						
Koonap	311	2	400	1	359	3					357	1	355	1
Limpopo							218	14						
PAN 3111	325	1												
PAN 3118	302	6	370	8	301	14	269	4	311	5	324	10	336	8
PAN 3144					334	10	303	1						
PAN 3161	290	14	367	10	336	9	220	13	303	8	331	6	329	9
PAN 3195	310	3	316	15									313	14
PAN 3198	304	5												
PAN 3355					343	6	198	15						
PAN 3368	296	8	390	6	297	15	264	6	312	4	327	7	343	5
PAN 3379	306	4	399	2	344	5	297	2	336	1	350	3	352	2
Senqu	301	7	385	7	331	11					339	5	343	4
SST 316	296	9	390	5									343	6
SST 317	287	16	370	8									328	10
SST 347	290	15	350	11	342	7	238	12	305	7	327	8	320	12
SST 356	294	11	398	3	339	8	259	9	322	3	344	4	346	3
SST 374	291	13	338	13	349	4	261	7	310	6	326	9	314	13
SST 387	292	12	277	16	363	2	129	16	265	10	311	11	284	16
SST 398	295	10	345	12	275	16					305	12	320	11
Average	**297**		**363**		**332**		**247**		**308**		**330**		**329**	
LSD_t(0.05)	**12.89**		**41.25**		**39.41**		**52.65**		**19.80**		**21.77**		**21.65**	

Average yield (ton/ha) of entries for the Eastern Free State area (early planting date) during the full or partial period from 2010 – 2013

Cultivar	2013	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Betta–DN							2.19	14						
Caledon					2.26	12	2.53	8						
Elands	2.24	16	4.72	9	2.37	7	2.34	12	2.92	9	3.11	9	3.48	12
Gariep	1.84	17	4.59	14	2.42	4	2.50	10	2.84	10	2.95	12	3.22	15
Koonap	1.70	19	4.69	10	2.29	11					2.89	14	3.20	17
Komati							2.53	9						
Limpopo							2.10	16						
Matlabas	3.74	1	4.73	8	2.47	2	2.99	4	3.48	1	3.64	1	4.23	1
PAN 3111	3.54	2												
PAN 3118	2.66	10	4.27	16	2.40	5	2.62	7	2.99	8	3.11	10	3.46	13
PAN 3120	2.66	11	4.09	17	2.49	1	3.22	1	3.11	6	3.08	11	3.37	14
PAN 3144					2.22	14	2.17	15						
PAN 3161	2.57	12	5.20	1	2.44	3	2.99	5	3.30	4	3.40	3	3.88	7
PAN 3195	3.00	9	4.64	12									3.82	9
PAN 3198	2.27	15												
PAN 3355					2.33	9	2.07	17						
PAN 3368	2.51	13	5.14	2	2.29	10	2.35	11	3.07	7	3.31	6	3.82	8
PAN 3379	1.73	18	4.68	11	2.33	8	2.30	13	2.76	11	2.92	13	3.21	16
Senqu	2.30	14	4.82	5	2.21	15					3.11	8	3.56	11
SST 316	3.23	5	4.97	4									4.10	3
SST 317	3.28	4	4.99	3									4.14	2
SST 347	3.21	7	4.74	7	2.25	13	2.98	6	3.30		3.40	4	3.97	5
SST 356	3.33	3	4.62	13	2.37	6	3.09	3	3.35	2	3.44	2	3.97	6
SST 387	3.22	6	4.75	6	2.18	16	3.14	2	3.32	3	3.38	5	3.98	4
SST 398	3.01	8	4.52	15	2.15	17					3.23	7	3.77	10
Average	**2.74**		**4.72**		**2.32**		**2.59**		**3.13**		**3.21**		**3.72**	
LSD_t(0.05)	**0.35**		**0.24**		**0.17**		**0.22**		**0.11**		**0.13**		**0.20**	

Average hectolitre mass (kg/hl) of entries for the Eastern Free State area (early planting date) during the full or partial period from 2010 – 2013

Cultivar	2013	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Betta–DN							79.63	4						
Caledon					76.36	13	78.81	9						
Elands	76.34	13	80.47	3	76.74	10	78.46	11	78.00	5	77.85	7	78.41	8
Gariep	77.07	8	79.06	9	76.79	8	79.69	3	78.15	4	77.64	9	78.07	10
Koonap	77.95	2	81.51	1	77.66	3					79.04	2	79.73	2
Komati							79.53	5						
Limpopo							78.47	10						
Matlabas	77.71	3	78.97	10	77.56	5	78.38	12	78.16	3	78.08	4	78.34	9
PAN 3111	77.25	6												
PAN 3118	76.63	12	77.17	15	77.60	4	79.43	6	77.71	8	77.13	11	76.90	12
PAN 3120	76.98	9	79.93	7	79.17	1	78.85	8	78.73	2	78.69	3	78.46	6
PAN 3144					76.34	14	78.06	14						
PAN 3161	74.14	19	77.48	13	76.77	9	78.12	13	76.63	11	76.13	13	75.81	16
PAN 3195	75.97	14	76.90	16									76.44	14
PAN 3198	75.92	15												
PAN 3355					75.78	17	75.65	17						
PAN 3368	77.22	7	80.06	6	76.73	11	77.95	16	77.99	6	78.00	5	78.64	4
PAN 3379	76.81	10	78.54	11	77.18	6	78.88	7	77.85	7	77.51	10	77.68	11
Senqu	76.66	11	80.35	5	76.44	12					77.82	8	78.51	5
SST 316	75.73	17	77.67	12									76.70	13
SST 317	77.70	4	80.46	4									79.08	3
SST 347	80.06	1	81.40	2	78.42	2	80.94	1	80.21		79.96	1	80.73	1
SST 356	75.16	18	77.48	13	76.06	15	77.97	15	76.67	10	76.23	12	76.32	15
SST 387	75.92	15	75.69	17	76.04	16	79.74	2	76.85	9	75.88	14	75.81	17
SST 398	77.28	5	79.62	8	76.96	7					77.95	6	78.45	7
Average	**76.76**		**78.99**		**76.98**		**78.74**		**77.90**		**77.71**		**77.89**	
LSD$_t$(0.05)	**0.86**		**0.66**		**0.76**		**0.64**		**0.38**		**0.45**		**0.53**	

Average protein content (%) of entries for the Eastern Free State area (early planting date) during the full or partial period from 2010 – 2013

Cultivar	2013	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Betta–DN							15.64	4						
Caledon					14.89	12	15.17	12						
Elands	16.09	6	12.84	9	14.96	9	15.19	10	14.77	5	14.63	8	14.47	8
Gariep	16.58	4	12.82	11	14.88	13	15.27	9	14.89	4	14.76	6	14.70	6
Koonap	16.74	2	14.12	1	14.83	14					15.23	1	15.43	1
Komati							15.49	6						
Limpopo							15.36	7						
Matlabas	14.99	13	13.09	6	14.96	9	15.85	2	14.72	6	14.35	9	14.04	10
PAN 3111	14.46	18												
PAN 3118	16.62	3	12.95	8	14.97	8	15.65	3	15.05	2	14.85	5	14.79	4
PAN 3120	15.76	10	13.51	3	15.00	6	15.31	8	14.90	3	14.76	7	14.64	7
PAN 3144					15.51	1	15.59	5						
PAN 3161	15.17	12	12.17	16	14.70	15	14.39	15	14.11	9	14.01	11	13.67	14
PAN 3195	15.34	11	12.46	13									13.90	11
PAN 3198	15.87	7												
PAN 3355					15.01	5	15.19	10						
PAN 3368	16.76	1	13.09	6	15.08	4	15.90	1	15.21	1	14.98	2	14.93	2
PAN 3379	15.79	8	11.87	17	14.70	15	15.11	13	14.37	7	14.12	10	13.83	12
Senqu	16.39	5	13.42	4	15.10	2					14.97	3	14.91	3
SST 316	14.63	16	12.27	15									13.45	16
SST 317	14.89	14	13.29	5									14.09	9
SST 347	14.71	15	12.84	9	14.49	17	14.47	14	14.13		14.01	11	13.78	13
SST 356	14.30	19	12.43	14	15.00	6	13.78	17	13.88	11	13.91	14	13.37	17
SST 387	14.54	17	12.52	12	14.91	11	14.08	16	14.01	10	13.99	13	13.53	15
SST 398	15.78	9	13.69	2	15.10	2					14.86	4	14.74	5
Average	**15.55**		**12.90**		**14.95**		**15.14**		**14.55**		**14.53**		**14.25**	
LSD_t(0.05)	**0.56**		**0.52**		**0.39**		**0.39**		**0.23**		**0.27**		**0.39**	

Average falling number (s) of entries for the Eastern Free State area (early planting date) during the full or partial period from 2010 – 2013

Cultivar	2013	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Betta–DN							274	4						
Caledon					299	10	260	8						
Elands	237	14	342	9	319	2	281	2	295	3	299	9	289	13
Gariep	229	15	342	9	299	9	248	9	280	8	290	11	286	14
Koonap	266	9	368	2	322	1					319	1	317	2
Komati							265	7						
Limpopo							223	13						
Matlabas	290	1	347	5	287	14	244	11	292	4	308	4	319	1
PAN 3111	279	4												
PAN 3118	275	6	343	8	289	13	244	10	288	5	302	8	309	5
PAN 3120	289	3	322	17	297	11	226	12	283	7	303	7	305	10
PAN 3144					301	7	274	5						
PAN 3161	205	18	344	7	284	15	216	16	262	9	278	12	275	15
PAN 3195	246	13	370	1									308	7
PAN 3198	212	17												
PAN 3355					309	6	220	14						
PAN 3368	251	12	333	13	296	12	268	6	287	6	293	10	292	12
PAN 3379	261	10	367	3	310	4	286	1	306	1	313	2	314	3
Senqu	257	11	338	12	317	3					304	6	298	11
SST 316	272	7	345	6									308	6
SST 317	290	2	324	16									307	9
SST 347	218	16	326	15	273	16	219	15	259		272	13	272	16
SST 356	271	8	349	4	309	5	276	3	301	2	309	3	310	4
SST 387	200	19	331	14	263	17	117	17	228	11	265	14	265	17
SST 398	277	5	338	11	300	8					305	5	308	8
Average	**254**		**343**		**299**		**243**		**280**		**297**		**299**	
LSD_t(0.05)	**30.77**		**18.11**		**17.50**		**21.20**		**9.80**		**11.97**		**16.24**	

Average yield (ton/ha) of entries for the Eastern Free State area (late planting date) during the full or partial period from 2010 – 2013

Cultivar	2013	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Betta–DN							2.98	14						
Caledon					2.57	7	3.53	6						
Elands	3.35	13	4.19	14	2.65	4	3.40	10	3.40	7	3.40	7	3.77	12
Gariep	3.00	17	4.40	9	2.67	2	3.48	8	3.39	8	3.36	10	3.70	15
Koonap	3.21	15	4.45	7	2.44	9					3.37	8	3.83	11
Komati							3.50	7						
Limpopo							3.15	13						
PAN 3111	4.03	1												
PAN 3144					2.38	12	3.19	12						
PAN 3161	3.53	7	4.85	1	2.60	6	4.14	1	3.78	1	3.66	2	4.19	2
PAN 3195	3.45	9	4.24	12									3.84	9
PAN 3198	3.36	12												
PAN 3355					2.62	5	3.25	11						
PAN 3364														
PAN 3368	3.26	14	4.77	2	2.26	13	3.48	9	3.44	5	3.43	6	4.02	7
PAN 3379	3.05	16	4.35	11	2.67	3	3.60	5	3.42	6	3.36	9	3.70	14
Senqu	3.38	11	4.57	4	2.45	8					3.46	5	3.97	8
SST 316	3.72	4	4.54	5									4.13	3
SST 317	3.69	5	4.37	10									4.03	6
SST 347	3.45	10	4.21	13	2.24	14					3.30	11	3.83	10
SST 356	3.79	3	4.40	8	2.44	10	4.07	2	3.68	3	3.55	4	4.10	4
SST 374	3.62	6	4.48	6	2.70	1	3.71	3	3.63	4	3.60	3	4.05	5
SST 387	3.98	2	4.70	3	2.42	11	3.70	4	3.70	2	3.70	1	4.34	1
SST 398	3.51	8	3.91	15	2.01	15					3.14	12	3.71	13
Average	**3.49**		**4.43**		**2.47**		**3.51**		**3.55**		**3.44**		**3.95**	
LSD_t(0.05)	**0.25**		**0.17**		**0.17**		**0.20**		**0.10**		**0.11**		**0.15**	

Average hectolitre mass (kg/hl) of entries for the Eastern Free State area (late planting date) during the full or partial period from 2010 – 2013

Cultivar	2013	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Betta–DN							79.02	9						
Caledon					77.92	11	81.18	2						
Elands	79.44	4	80.30	4	78.62	6	80.47	5	79.71	2	79.45	3	79.87	3
Gariep	79.17	5	79.89	7	79.00	3	81.47	1	79.88	1	79.35	4	79.53	6
Koonap	81.16	2	81.14	2	79.32	2					80.54	2	81.15	2
Komati							80.73	3						
Limpopo							80.29	6						
PAN 3111	78.96	8												
PAN 3144					78.28	8	78.29	12						
PAN 3161	77.73	15	76.91	14	77.76	13	78.67	11	77.77	8	77.47	11	77.32	15
PAN 3195	76.80	17	77.91	12									77.36	14
PAN 3198	78.03	12												
PAN 3355					76.57	15	78.21	13						
PAN 3364														
PAN 3368	78.84	11	80.19	5	77.97	10	79.56	7	79.14	4	79.00	6	79.52	7
PAN 3379	79.03	6	79.08	9	78.67	5	80.70	4	79.37	3	78.93	8	79.06	9
Senqu	79.49	3	80.00	6	78.43	7					79.31	5	79.75	4
SST 316	77.85	14	77.95	11									77.90	11
SST 317	78.91	9	80.41	3									79.66	5
SST 347	81.44	1	81.84	1	79.93	1					81.07	1	81.64	1
SST 356	77.49	16	77.75	13	76.60	14	79.27	8	77.78	7	77.28	12	77.62	13
SST 374	78.03	12	77.99	10	78.87	4	78.94	10	78.46	5	78.30	9	78.01	10
SST 387	79.03	6	76.77	15	77.85	12	77.88	14	77.88	6	77.88	10	77.90	11
SST 398	78.90	10	79.74	8	78.26	9					78.97	7	79.32	8
Average	**78.84**		**79.19**		**78.27**		**79.62**		**78.75**		**78.96**		**79.04**	
LSD_t(0.05)	**0.53**		**0.66**		**0.47**		**0.53**		**0.27**		**0.32**		**0.44**	

Average protein content (%) of entries for the Eastern Free State area (late planting date) during the full or partial period from 2010 – 2013

Cultivar	2013	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Betta–DN							14.91	3						
Caledon					15.02	5	14.79	5						
Elands	14.54	7	13.04	6	14.64	8	14.85	4	14.27	2	14.07	5	13.79	5
Gariep	14.95	4	12.58	9	14.38	11	14.50	8	14.10	3	13.97	6	13.77	6
Koonap	15.27	3	13.85	2	15.06	3					14.73	2	14.56	3
Komati							14.71	7						
Limpopo							14.75	6						
PAN 3111	13.64	14												
PAN 3144					15.23	1	15.10	2						
PAN 3161	14.27	10	12.11	14	14.14	13	13.88	12	13.60	6	13.51	11	13.19	12
PAN 3195	14.62	6	12.39	12									13.51	7
PAN 3198	14.43	9												
PAN 3355					14.50	9	14.24	10						
PAN 3364														
PAN 3368	15.64	1	13.50	3	15.00	6	15.14	1	14.82	1	14.71	3	14.57	2
PAN 3379	14.47	8	12.05	15	14.10	14	14.25	9	13.72	4	13.54	9	13.26	10
Senqu	14.72	5	13.31	4	14.90	7					14.31	4	14.02	4
SST 316	13.34	16	12.32	13									12.83	14
SST 317	13.83	12	13.10	5									13.47	8
SST 347	13.72	13	12.95	7	14.35	12					13.67	7	13.34	9
SST 356	13.16	17	12.45	11	15.15	2	13.13	14	13.47	7	13.59	8	12.81	15
SST 374	13.96	11	12.54	10	13.96	15	14.04	11	13.63	5	13.49	12	13.25	11
SST 387	13.46	15	12.61	8	14.49	10	13.31	13	13.47	8	13.52	10	13.04	13
SST 398	15.50	2	13.92	1	15.04	4					14.82	1	14.71	1
Average	**14.32**		**12.85**		**14.66**		**14.40**		**13.88**		**13.99**		**13.61**	
LSD_t(0.05)	**0.45**		**0.40**		**0.41**		**0.31**		**0.19**		**0.24**		**0.30**	

Average falling number (s) of entries for the Eastern Free State area (late planting date) during the full or partial period from 2010 – 2013

Cultivar	2013	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Betta–DN							253	10						
Caledon					341	5	268	3						
Elands	279	11	300	12	354	1	261	6	299	2	311	4	290	9
Gariep	267	14	301	11	316	13	265	4	287	6	295	9	284	12
Koonap	318	1	355	1	337	6					337	1	336	1
Komati							257	7						
Limpopo							241	12						
PAN 3111	294	5												
PAN 3144					322	11	268	2						
PAN 3161	219	17	324	4	319	12	224	13	272	7	287	10	272	14
PAN 3195	306	2	340	2									323	2
PAN 3198	290	6												
PAN 3355					342	4	272	1						
PAN 3364														
PAN 3368	276	12	301	10	324	10	251	11	288	5	300	8	289	10
PAN 3379	303	3	328	3	343	3	254	9	307	1	324	2	315	3
Senqu	288	7	315	7	345	2					316	3	302	5
SST 316	299	4	319	5									309	4
SST 317	281	10	296	13									288	11
SST 347	264	15	293	14	291	14					283	11	279	13
SST 356	287	8	312	8	333	7	261	5	298	3	311	5	300	6
SST 374	283	9	316	6	326	9	255	8	295	4	308	6	299	7
SST 387	247	16	275	15	290	15	209	14	255	8	271	12	261	15
SST 398	272	13	309	9	333	8					304	7	290	8
Average	**281**		**312**		**328**		**253**		**288**		**304**		**296**	
LSD_t(0.05)	**17.26**		**13.26**		**24.55**		**27.70**		**11.10**		**11.28**		**10.36**	

Table 4. Agronomic characteristics of wheat cultivars under irrigation

Cultivar	Growth period	Hectolitre mass	Straw strength	Aluminum tolerance	Pre-harvest sprouting
Baviaans (PBR)	Long	**	**	#	***
Buffels (PBR)	Long	**	**	#	***
Duzi (PBR)	Medium	**	**	#	*
Kariega	Long	**	**	#	***
Krokodil (PBR)	Medium	*	**	#	*
Olifants (PBR)	Long	**	**	*	#
PAN 3400 (PBR)	Short-Medium	**	**	?	*
PAN 3471 (PBR)	Medium	***	**	?	#
PAN 3478 (PBR)	Medium-Long	***	**	?	**
PAN 3497 (PBR)	Long	***	**	?	**
Sabie (PBR)	Long	**	**	?	**
SST 806 (PBR)	Medium	***	**	#	#
SST 822 (PBR)	Short	**	***	*	*
SST 835 (PBR)	Medium	**	**	?	#
SST 843 (PBR)	Short	***	***	?	#
SST 866 (PBR)	Medium	**	**	?	*
SST 867 (PBR)	Long	**	***	?	***
SST 875 (PBR)	Short-Medium	***	**	?	*
SST 876 (PBR)	Long	***	***	#	#
SST 877 (PBR)	Long	**	***	?	***
SST 884 (PBR)	Short	**	***	?	#
SST 895 (PBR)	Medium	***	**	?	*
Steenbras (PBR)	Short	***	**	#	#

** Average   ** Good   *** Excellent   # Poor   ?Unkwown*

PBR Cultivars protected by Plant Breeders' Rights

Table 5. Disease resistance or susceptibility of wheat cultivars recommended for cultivation under irrigation.

Cultivar	Stem Rust	Leaf Rust	Stripe Rust	Head blight
Baviaans (PBR)	S	MS	R	MS
Buffels (PBR)	S	R/S	R	?
Duzi (PBR)	S	S	R	MS
Kariega	S	MS	R	MS
Krokodil (PBR)	MS	S	S	S
Olifants (PBR)	S	S	R	MS
PAN 3400 (PBR)	MSS	S	R	?
PAN 3471 (PBR)	S	MRMS	R	S
PAN 3478 (PBR)	S	MSS	R	MS
PAN 3497 (PBR)	MSS	S	R	?
Sabie (PBR)	S	MS	R	?
SST 806 (PBR)	S	MS	R	HS
SST 822 (PBR)	MS	MS	R	S
SST 835 (PBR)	MS	MS	MR	HS
SST 843 (PBR)	MS	MS	R	S
SST 866 (PBR)	S	MS	R/MS	?
SST 867 (PBR)	S	MS	MR	?
SST 875 (PBR)	S	MR	R	?
SST 876 (PBR)	S	MS	MR	HS
SST 877 (PBR)	S	MS	R/MS	?
SST 884 (PBR)	MR	S	R	?
SST 895 (PBR)	MRMS	R	R	?
Steenbras (PBR)	R	MR	S	S

S=Susceptible MS= Moderately susceptible HS=Highly susceptible APR=Adult plant resistance

R=Resistant MR=Moderately resistant ?=Unknown / = 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/ m². 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:

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

These calculations have been included in the plants/m² table (Table 5), where calculated seeding rate (kg/ha) at the range of thousand kernel mass values and target plants/m² at a 90% establishment % were done. The optimum plants/m² per cultivar for each region is included in the planting spectrum tables. With the optimum plants/m² and the 1000 kernel mass of the seedlot, the applicable seeding rate (kg seed/ha) can be determined.

Table 5. 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

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

Cultivar	Petrusville Hopetown	Bothaville Wesselsbron Bultfontein	Douglas Prieska	Vaalharts	Modder river Kimberley Barkly-West	Ventersdorp Klerksdorp Lichtenburg	Recommended kg seed/ha	Plants/m²
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
Buffels (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	175-250
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
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
Olifants (PBR)	1/6-15/7	1/6-15/7	1/6-10/7	1/6-30/6	1/6-30/6	1/6-10/7	80-130	250-300
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	110-130	275-325
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	100-120	250-325
PAN 3478 (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	90-110	225-300
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	90-110	225-275
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)	1/6-15/7	10/6-31/7	1/6-15/7	15/6-10/7	1/6-15/7	10/6-15/7	100-120	275-325
SST 822 (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 835 (PBR)	15/6-20/7	10/6-31/7	15/6-20/7	15/6-10/7	10/6-20/7	10/6-10/7	110-140	275-325
SST 843 (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	110-140	275-325
SST 866 (PBR)	1/6-15/7	10/6-31/7	1/6-15/7	15/6-10/7	1/6-15/7	10/6-15/7	100-120	275-350
SST 867 (PBR)	1/6-15/7	1/6-15/7	1/6-10/7	1/6-30/6	1/6-30/6	1/6-10/7	100-120	275-350
SST 875 (PBR)	15/6-20/7	10/6-31/7	15/6-20/7	15/6-10/7	10/6-20/7	10/6-10/7	100-120	275-350
SST 876 (PBR)	15/6-15/7	10/6-31/7	1/6-15/7	15/6-10/7	1/6-15/7	10/6-10/7	120-140	300-375
SST 877 (PBR)	1/6-15/7	1/6-15/7	1/6-10/7	1/6-30/6	1/6-30/6	1/6-10/7	100-120	275-350
SST 884 (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	110-140	275-325
SST 895 (PBR)	15/6-20/7	10/6-31/7	15/6-20/7	15/6-10/7	10/6-20/7	10/6-10/7	110-140	275-325
Steenbras (PBR)	20/6-31/7	25/6-31/7	25/6-31/7	15/6-15/7	15/6-25/7	25/6-25/7	100-120	275-350

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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/m²
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
Buffels (PBR)	20/5-30/6	25/5-30/6	25/5-30/6	10/5-30/6	20/5-15/6	100-130	225-275
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
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
Olifants (PBR)	20/5-20/6	25/5-20/6	25/5-20/6	10/5-10/6	10/5-25/6	100-130	275-300
PAN 3400 (PBR)	25/5-5/7	7/6-5/7	1/6-5/7	15/5-30/6	25/5-20/6	110-130	275-325
PAN 3471 (PBR)	20/5-30/6	25/5-30/6	25/5-30/6	10/5-30/6	20/5-15/6	100-120	250-325
PAN 3478 (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
PAN 3497 (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
Sabie (PBR)	20/5-15/6	25/5-15/6	25/5-15/6	10/5-10/6	1/5-25/5	80-120	225-275
SST 806 (PBR)	20/5-30/6	20/5-30/6	20/5-30/6	20/5-30/6	20/5-15/6	110-140	275-350
SST 822 (PBR)	1/6-30/6	7/6-7/7	1/6-15/7	25/5-30/6	25/5-20/6	160-200	325-400
SST 835 (PBR)	20/5-30/6	1/6-30/6	25/5-30/6	15/5-20/6	20/5-15/6	110-140	275-350
SST 843 (PBR)	1/6-30/6	7/6-7/7	1/6-15/7	25/5-30/6	25/5-20/6	110-140	275-350
SST 866 (PBR)	20/5-30/6	20/5-30/6	20/5-30/6	20/5-30/6	20/5-15/6	110-120	280-325
SST 867 (PBR)	20/5-20/6	25/5-20/6	25/5-20/6	10/5-10/6	10/5-25/6	110-120	280-325
SST 875 (PBR)	20/5-30/6	1/6-30/6	25/5-30/6	15/5-20/6	20/5-15/6	110-120	280-325
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)	20/5-20/6	25/5-20/6	25/5-20/6	10/5-10/6	10/5-25/6	110-120	280-325
SST 884 (PBR)	1/6-30/6	7/6-7/7	1/6-15/7	25/5-30/6	25/5-20/6	110-140	275-350
SST 895 (PBR)	20/5-30/6	1/6-30/6	25/5-30/6	15/5-20/6	20/5-15/6	110-140	275-350
Steenbras (PBR)	1/6-30/6	1/6-7/7	1/6-30/6	20/5-20/6	25/5-30/6	120-140	300-375

All the abovementioned cultivars qualify for all the grades of the bread class.

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

Cultivar	Tarlton/ Hekpoort/ Magalies burg	Badplaas/ Stofberg	Ohrigstad/ Steel poort/ Burgers fort	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
Buffels (PBR)	20/5-15/7	15/5-30/6	1/5-15/6	1/5-10/6	15/5-20/6	100-130	225-275
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
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
Olifants (PBR)	20/5-20/6	10/5-20/6	25/4-10/6	1/5-25/5	15/5-15/6	100-130	275-300
PAN 3400 (PBR)	25/5-15/7	20/5-15/7	10/5-25/6	6/5-10/6	20/5-25/6	110-130	275-325
PAN 3471 (PBR)	20/5-15/7	15/5-30/6	1/5-15/6	1/5-10/6	15/5-20/6	100-120	250-325
PAN 3478 (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
PAN 3497 (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
Sabie (PBR)	20/5-20/6	10/5-20/6	25/4-25/5	1/5-25/5	15/5-15/6	80-120	225-275
SST 806 (PBR)	20/5-30/6	15/5-30/6	1/5-31/5	1/5-31/5	15/5-20/6	110-140	275-350
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	110-140	275-350
SST 843 (PBR)	1/6-30/6	30/5-15/7	15/5-30/6	6/5-5/6	20/5-20/6	110-140	275-350
SST 866 (PBR)	20/5-30/6	15/5-30/6	1/5-31/5	1/5-31/5	15/5-20/6	110-120	280-325
SST 867 (PBR)	20/5-20/6	10/5-20/6	25/4-10/6	1/5-25/5	15/5-15/6	110-120	280-325
SST 875 (PBR)	10/6-15/7	15/5-30/6	1/5-31/5	1/5-7/6	15/5-25/6	110-120	280-325
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	25/4-10/6	1/5-25/5	15/5-15/6	110-120	280-325
SST 884 (PBR)	1/6-30/6	30/5-15/7	15/5-30/6	6/5-5/6	20/5-20/6	110-140	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	110-140	275-350
Steenbras (PBR)	15/6-15/7	1/6-15/7	20/5-30/6	10/5-10/6	20/5-20/6	120-140	300-375

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

Cultivar	Fish River/Elliot	Lower Orange River Louwna/ Tosca	Recommended kg seed/ha	Plants/m²	Aliwal-North Smithfield	Eastern Highveld	Recommended kg seed/ha	Plants/m²
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
Buffels (PBR)	15/6-15/7	1/6-15/7	110-130	275-325	10/6-15/7	25/6-25/7	100-130	175-250
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	-	-	-
Olifants (PBR)	1/6-30/6	1/6-30/6	110-130	300-325	10/6-30/6	25/6-31/7	80-130	250-300
PAN 3400 (PBR)	20/6-25/7	10/6-25/7	120-140	300-350	20/6-25/7	30/6-5/8	110-130	275-325
PAN 3471 (PBR)	15/6-15/7	1/6-15/7	110-130	275-325	10/6-15/7	25/6-25/7	100-120	250-325
PAN 3478 (PBR)	1/6-25/6	1/6-25/6	100-120	250-300	10/6-30/6	25/6-25/7	90-110	225-275
PAN 3497 (PBR)	1/6-25/6	1/6-25/6	100-120	250-300	10/6-30/6	25/6-25/7	90-110	225-275
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)	-	15/6-15/7	120-140	300-350	15/6-15/7	15/6-10/7	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	15/6-15/7	120-150	300-350	15/6-15/7	25/6-7/8	120-150	275-325
SST 843 (PBR)	1/7-31/7	30/6-30/7	160-200	350-400	30/6-31/7	25/6-15/8	120-150	275-325
SST 866 (PBR)	15/6-15/7	15/6-15/7	110-120	260-300	15/6-15/7	25/6-7/8	110-120	280-325
SST 867 (PBR)	1/6-30/6	1/6-30/6	110-120	260-300	10/6-30/6	15/6-10/7	110-120	280-325
SST 875 (PBR)	15/6-15/7	15/6-15/7	110-120	260-300	15/6-15/7	25/6-7/8	110-120	280-325
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	1/6-30/6	110-120	260-300	10/6-30/6	15/6-10/7	110-120	280-325
SST 884 (PBR)	1/7-31/7	30/6-30/7	160-200	350-400	30/6-31/7	25/6-15/8	120-150	275-325
SST 895 (PBR)	15/6-15/7	15/6-15/7	120-150	300-350	15/6-15/7	25/6-7/8	120-150	275-325
Steenbras (PBR)	15/7-30/7	15/6-30/7	120-140	325-400	25/6-25/7	25/6-31/7	100-120	275-350

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Optimum planting date and planting densities for wheat in the KwaZulu-Natal

Cultivar	Natal	Recommended kg seed/ha	Plants/m^2
Baviaans (PBR)	1/6-30/6	100-120	250-300
Buffels (PBR)	1/6-30/6	80-110	225-275
Duzi (PBR)	1/6-30/6	100-130	250-300
Kariega	1/6-30/6	80-110	225-275
Olifants (PBR)	1/6-10/7	100-120	275-300
PAN 3400 (PBR)	10/6-5/7	110-130	275-325
PAN 3471 (PBR)	1/6-30/6	100-130	275-325
PAN 3478 (PBR)	1/6-30/6	100-120	250-300
PAN 3497 (PBR)	1/6-30/6	100-120	250-300
Sabie (PBR)	1/6-30/6	80-110	225-275
SST 806 (PBR)	1/6-30/6	120-140	275-350
SST 822 (PBR)	25/6-30/7	160-200	325-400
SST 835 (PBR)	1/6-5/7	120-140	275-350
SST 843 (PBR)	25/6-30/7	120-140	275-350
SST 866 (PBR)	1/6-10/7	120-140	275-350
SST 867 (PBR)	1/6-30/6	120-140	275-350
SST 875 (PBR)	1/6-5/7	120-140	275-350
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)	25/6-30/7	120-140	275-350
SST 895 (PBR)	1/6-5/7	120-140	275-350
Steenbras (PBR)	25/6-30/7	120-140	300-375

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Average yield (ton/ha) of entries for the Cooler Central irrigation area (early planting date) during the full or partial period from 2010 – 2013

Cultivar	2013	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Baviaans			9.73	18	10.31	25	7.92	19						
Buffels	8.77	17	10.35	7	10.52	20	7.51	21	9.29	13	9.88	10	9.56	10
CRN 826			9.42	25	11.35	4	8.95	2						
Duzi	8.93	10	9.46	24	10.83	17	7.98	17	9.30	12	9.74	15	9.20	18
Kariega			8.95	27	10.36	24	7.94	18						
Krokodil	8.86	13	10.01	15	10.92	16	8.31	12	9.52	9	9.93	9	9.43	13
Olifants			9.51	23	10.71	18	8.29	14						
PAN 3400	9.20	2	10.18	11									9.69	5
PAN 3434					10.38	23	8.29	13						
PAN 3471	9.17	3	10.59	3	11.15	10	8.71	5	9.90	3	10.30	3	9.88	2
PAN 3478	8.82	15	10.35	8	11.19	7	8.53	10	9.72	5	10.12	6	9.59	7
PAN 3489	9.05	5	10.67	1									9.86	3
PAN 3497	9.22	1	10.67	1									9.94	1
Sabie	8.79	16	10.02	14	10.49	21	8.02	16	9.33	10	9.77	14	9.41	14
SST 806	8.97	7	10.34	9	11.66	1	9.06	1	10.01	1	10.32	2	9.66	6
SST 815			10.41	5	11.17	8								
SST 816			9.96	17	11.22	6								
SST 822	7.75	23	8.95	28	10.59	19	8.05	15	8.83	14	9.09	19	8.35	22
SST 835	9.07	4	10.38	6	11.58	2	8.88	4	9.98	2	10.34	1	9.72	4
SST 843	7.70	24	8.79	30	9.75	28	7.77	20	8.50	15	8.75	20	8.25	23
SST 866	8.90	11	10.13	12	10.98	13	8.68	7	9.67	6	10.00	7	9.51	11
SST 867	8.42	20	9.40	26	11.00	12	8.40	11	9.31	11	9.61	16	8.91	21
SST 875	8.99	6	10.18	10	11.33	5	8.93	3	9.86	4	10.17	5	9.58	8
SST 876	8.85	14	10.07	13	10.98	13	8.56	8	9.62	7	9.97	8	9.46	12
SST 877	8.43	19	10.00	16	11.17	8	8.55	9	9.54	8	9.87	11	9.22	16
SST 878							8.71	5						
SST 884	8.66	18	10.50	4	11.36	3					10.17	4	9.58	9
SST 895	8.88	12	9.55	22	11.11	11					9.85	12	9.21	17
SST 896	8.96	8												
Steenbras			8.84	29	10.00	27								
Tamboti	8.93	9	9.59	20	10.96	15					9.83	13	9.26	15
Timbavati	8.16	22	9.73	19	10.42	22					9.44	17	8.94	19
Umlazi	8.32	21	9.57	21	10.29	26					9.39	18	8.94	20
Average	**8.74**		**9.88**		**10.85**		**8.38**		**9.49**		**9.83**		**9.35**	
LSD$_t$(0,05)	**0.24**		**0.21**		**0.25**		**0.24**		**0.12**		**0.13**		**0.16**	

Average hectolitre mass (kg/hl) of entries for the Cooler Central irrigation area (early planting date) during the full or partial period from 2010 – 2013

Cultivar	2013	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Baviaans			82.05	19	82.65	17	80.34	12						
Buffels	78.51	23	82.72	7	81.77	28	79.21	21	80.55	15	81.00	16	80.62	16
CRN 826			81.34	27	83.69	5	81.16	6						
Duzi	79.32	22	81.50	24	82.16	25	79.84	15	80.71	14	80.99	17	80.41	20
Kariega			81.24	28	82.48	20	79.80	16						
Krokodil	78.49	24	82.15	16	82.28	22	80.20	14	80.78	12	80.97	18	80.32	21
Olifants			81.70	22	81.98	26	79.63	19						
PAN 3400	80.77	9	82.77	6									81.77	9
PAN 3434					82.49	19	79.74	17						
PAN 3471	81.25	5	82.60	11	83.66	8	81.33	3	82.21	5	82.50	5	81.93	7
PAN 3478	81.33	3	82.67	8	84.01	2	81.77	1	82.45	2	82.67	2	82.00	5
PAN 3489	81.73	1	82.87	5									82.30	1
PAN 3497	81.09	7	83.47	1									82.28	2
Sabie	79.44	21	81.67	23	82.26	23	79.71	18	80.77	13	81.12	15	80.56	17
SST 806	81.45	2	82.99	3	84.09	1	81.32	4	82.46	1	82.84	1	82.22	3
SST 815			83.39	2	83.67	6								
SST 816			82.60	11	83.52	10								
SST 822	80.59	12	82.14	17	82.74	16	80.68	9	81.54	10	81.82	11	81.37	12
SST 835	81.29	4	82.62	10	83.67	6	81.38	2	82.24	4	82.53	4	81.96	6
SST 843	80.96	8	82.65	9	83.77	3	80.90	7	82.07	6	82.46	6	81.81	8
SST 866	80.52	13	81.98	20	83.52	10	80.65	10	81.67	8	82.01	9	81.25	13
SST 867	80.17	14	82.08	18	83.63	9	80.76	8	81.66	9	81.96	10	81.13	14
SST 875	80.67	11	82.19	15	83.31	13	80.64	11	81.70	7	82.06	7	81.43	11
SST 876	81.15	6	82.89	4	83.75	4	81.24	5	82.26	3	82.60	3	82.02	4
SST 877	79.63	17	81.77	21	82.88	15	80.25	13	81.13	11	81.43	12	80.70	15
SST 878							79.55	20						
SST 884	79.64	16	81.35	26	82.55	18					81.18	13	80.50	18
SST 895	80.71	10	82.24	14	83.19	14					82.05	8	81.48	10
SST 896	79.49	20												
Steenbras			82.47	13	83.38	12								
Tamboti	79.51	19	81.46	25	82.45	21					81.14	14	80.49	19
Timbavati	79.58	18	80.69	30	82.23	24					80.83	20	80.14	23
Umlazi	79.73	15	80.85	29	81.98	26					80.85	19	80.29	22
Average	**80.29**		**82.17**		**82.99**		**80.48**		**81.61**		**81.75**		**81.26**	
LSDt (0,05)	**0.63**		**0.46**		**0.36**		**0.37**		**0.22**		**0.29**		**0.39**	

Average protein content (%) of entries for the Cooler Central irrigation area (early planting date) during the full or partial period from 2010 – 2013

Cultivar	2013	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Baviaans			11.40	29	11.93	10	12.32	5						
Buffels	12.24	8	11.56	19	11.86	12	12.46	2	12.03	5	11.89	9	11.90	12
CRN 826			12.32	4	11.73	19	12.20	9						
Duzi	12.35	4	11.71	9	12.33	4	12.14	13	12.13	3	12.13	3	12.03	4
Kariega			11.71	9	11.89	11	12.20	9						
Krokodil	11.37	24	11.24	30	11.30	28	12.20	9	11.53	15	11.30	20	11.31	23
Olifants			12.39	3	12.66	3	12.50	1						
PAN 3400	12.27	7	11.73	7									12.00	5
PAN 3434					11.79	17	12.35	4						
PAN 3471	11.91	20	11.41	27	11.72	21	12.14	13	11.80	12	11.68	18	11.66	20
PAN 3478	12.07	16	11.65	13	11.86	12	12.07	17	11.91	9	11.86	11	11.86	13
PAN 3489	11.73	22	11.61	16									11.67	19
PAN 3497	11.74	21	11.43	26									11.59	21
Sabie	12.29	6	11.70	11	12.08	7	12.24	8	12.08	4	12.02	6	12.00	6
SST 806	12.10	14	11.46	25	11.73	19	12.38	3	11.92	8	11.76	15	11.78	16
SST 815			11.57	18	11.62	23								
SST 816			11.41	27	11.94	9								
SST 822	12.94	2	12.51	2	12.83	2	12.28	6	12.64	2	12.76	2	12.73	2
SST 835	12.06	17	11.63	14	11.70	22	11.92	20	11.83	10	11.80	14	11.85	14
SST 843	13.76	1	13.61	1	13.35	1	12.26	7	13.25	1	13.57	1	13.69	1
SST 866	11.97	19	11.50	21	11.59	26	11.85	21	11.73	13	11.69	17	11.74	18
SST 867	12.08	15	11.48	22	11.62	23	12.11	16	11.82	11	11.73	16	11.78	16
SST 875	11.58	23	11.47	23	11.32	27	12.00	19	11.59	14	11.46	19	11.53	22
SST 876	12.21	9	11.62	15	11.84	14	12.12	15	11.95	7	11.89	8	11.92	9
SST 877	12.19	10	11.72	8	11.82	15	12.19	12	11.98	6	11.91	7	11.96	7
SST 878							12.06	18						
SST 884	12.01	18	11.81	6	11.61	25					11.81	12	11.91	10
SST 895	12.18	11	11.92	5	12.20	5					12.10	4	12.05	3
SST 896	12.34	5												
Steenbras			11.59	17	12.07	8								
Tamboti	12.15	12	11.67	12	11.80	16					11.87	10	11.91	10
Timbavati	12.15	12	11.47	23	11.79	17					11.80	13	11.81	15
Umlazi	12.37	3	11.53	20	12.20	5					12.03	5	11.95	8
Average	**12.17**		**11.73**		**11.94**		**12.19**		**12.01**		**11.95**		**11.94**	
LSD (0,05)	**0.36**		**0.26**		**0.28**		**0.30**		**0.15**		**0.17**		**0.21**	

Average falling number (s) of entries for the Cooler Central irrigation area (early planting date) during the full or partial period from 2010 – 2013

Cultivar	2013	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Baviaans			361	27	371	12	329	15						
Buffels	334	11	370	18	374	9	330	14	352	8	359	11	352	12
CRN 826			363	24	370	15	348	6						
Duzi	326	18	363	23	358	23	315	20	341	14	349	16	345	18
Kariega			365	21	363	20	312	21						
Krokodil	303	24	342	30	327	28	325	18	324	15	324	20	322	23
Olifants			381	7	381	4	326	16						
PAN 3400	322	20	373	14									347	15
PAN 3434					365	18	338	11						
PAN 3471	330	13	354	29	366	17	343	10	348	10	350	15	342	20
PAN 3478	329	16	362	26	380	5	337	13	352	7	357	12	346	17
PAN 3489	335	10	367	20									351	13
PAN 3497	326	19	371	15									348	14
Sabie	330	13	362	25	360	22	325	17	344	11	351	14	346	16
SST 806	340	2	375	11	383	2	349	5	362	1	366	4	358	7
SST 815			370	17	377	8								
SST 816			370	16	373	10								
SST 822	308	22	356	28	354	25	345	9	341	13	339	19	332	22
SST 835	332	12	383	3	379	6	338	12	358	4	364	5	357	8
SST 843	339	5	382	4	381	3	324	19	357	6	367	3	360	3
SST 866	338	6	382	5	370	13	350	4	360	2	363	6	360	4
SST 867	320	21	368	19	358	24	356	1	350	9	349	17	344	19
SST 875	337	7	373	13	371	11	350	3	358	3	360	8	355	10
SST 876	330	15	383	2	368	16	347	7	357	5	360	9	356	9
SST 877	308	23	364	22	352	27	352	2	344	11	342	18	336	21
SST 878							345	8						
SST 884	340	3	382	6	387	1					370	2	361	2
SST 895	344	1	391	1	379	7					371	1	367	1
SST 896	337	8												
Steenbras			375	12	353	26								
Tamboti	327	17	378	9	364	19					356	13	353	11
Timbavati	336	9	380	8	370	14					362	7	358	6
Umlazi	340	4	378	9	360	21					359	10	359	5
Average	**330**		**371**		**368**		**337**		**350**		**356**		**350**	
LSD (0,05)	**8.22**		**7.29**		**10.75**		**15.95**		**6.46**		**5.19**		**5.45**	

Average yield (ton/ha) of entries for the Cooler Central irrigation area (late planting date) during the full or partial period from 2010 – 2013

Cultivar	2013	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Baviaans			7.41	27	7.83	23	6.46	16						
Buffels	7.39	24	8.21	7	7.84	22	5.94	21	7.34	13	7.81	15	7.80	16
CRN 826			7.98	14	8.44	3	6.81	7						
Duzi	7.48	19	7.70	21	7.91	19	6.38	18	7.37	12	7.70	16	7.59	21
Kariega			7.16	29	7.95	17	6.46	17						
Krokodil	8.47	5	7.98	16	8.15	12	6.83	6	7.86	5	8.20	8	8.22	7
Olifants			7.48	24	6.86	28	6.50	14						
PAN 3400	8.48	4	8.19	8									8.33	4
PAN 3434					7.92	18	6.84	5						
PAN 3471	8.15	11	8.73	1	8.07	14	7.31	1	8.06	1	8.32	4	8.44	2
PAN 3478	7.88	16	8.61	2	8.28	10	7.20	2	7.99	3	8.25	5	8.24	6
PAN 3489	8.10	12	7.99	12									8.04	12
PAN 3497	7.46	22	8.33	5									7.90	14
Sabie	7.92	15	7.46	25	7.64	24	6.29	19	7.33	14	7.67	17	7.69	19
SST 806	8.26	8	8.60	3	8.33	7	6.98	3	8.04	2	8.40	3	8.43	3
SST 815			8.42	4	7.88	20								
SST 816			8.02	11	8.36	6								
SST 822	7.47	21	7.98	15	8.17	11	6.62	12	7.56	10	7.87	13	7.72	18
SST 835	8.06	13	8.14	9	8.55	2	6.76	10	7.88	4	8.25	6	8.10	10
SST 843	7.70	18	7.16	30	7.43	26	6.29	20	7.14	15	7.43	20	7.43	23
SST 866	8.15	10	7.99	13	8.30	8	6.93	4	7.84	6	8.15	9	8.07	11
SST 867	7.86	17	7.84	19	7.85	21	6.46	15	7.50	11	7.85	14	7.85	15
SST 875	8.28	7	7.93	17	8.09	13	6.72	11	7.76	8	8.10	10	8.11	9
SST 876	8.24	9	7.61	22	8.05	15	6.77	8	7.67	9	7.97	11	7.92	13
SST 877	7.97	14	8.24	6	8.40	4	6.59	13	7.80	7	8.20	7	8.11	8
SST 878							6.76	9						
SST 884	8.81	1	8.10	10	8.36	5					8.42	1	8.46	1
SST 895	8.65	2	7.87	18	8.67	1					8.40	2	8.26	5
SST 896	8.64	3												
Steenbras			7.43	26	7.43	27								
Tamboti	8.30	6	7.24	28	8.28	9					7.94	12	7.77	17
Timbavati	7.46	23	7.72	20	7.45	25					7.54	19	7.59	20
Umlazi	7.47	20	7.50	23	7.95	16					7.64	18	7.49	22
Average	**8.03**		**7.90**		**8.01**		**6.66**		**7.68**		**8.01**		**7.98**	
LSD (0,05)	**0.18**		**0.20**		**0.26**		**0.25**		**0.11**		**0.12**		**0.13**	

Average hectolitre mass (kg/hl) of entries for the Cooler Central irrigation area (late planting date) during the full or partial period from 2010 – 2013

Cultivar	2013	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Baviaans			77.43	23	82.25	22	78.91	17						
Buffels	77.54	20	77.57	20	82.47	19	77.95	21	78.88	15	79.19	16	77.56	18
CRN 826			77.11	25	83.31	5	80.04	8						
Duzi	77.63	19	77.48	22	82.06	24	79.50	13	79.17	14	79.06	17	77.56	18
Kariega			77.23	24	82.09	23	78.57	19						
Krokodil	78.24	10	77.10	26	82.63	17	79.83	10	79.45	11	79.32	14	77.67	17
Olifants			76.73	30	81.41	27	78.39	20						
PAN 3400	78.74	6	78.58	5									78.66	5
PAN 3434					82.45	20	79.03	16						
PAN 3471	78.97	2	78.87	2	83.30	7	80.72	3	80.47	2	80.38	1	78.92	2
PAN 3478	78.76	5	78.43	8	83.68	1	81.67	1	80.64	1	80.29	2	78.60	7
PAN 3489	79.52	1	78.02	15									78.77	3
PAN 3497	78.74	6	79.59	1									79.17	1
Sabie	77.72	17	78.14	12	82.44	21	78.65	18	79.24	13	79.43	13	77.93	13
SST 806	77.85	16	77.91	17	83.43	4	80.24	5	79.86	6	79.73	9	77.88	14
SST 815			78.80	3	83.22	8								
SST 816			78.33	10	83.59	3								
SST 822	78.17	11	78.37	9	82.96	13	79.74	12	79.81	8	79.83	6	78.27	9
SST 835	78.44	8	78.61	4	82.98	12	80.05	6	80.02	5	80.01	5	78.53	8
SST 843	78.90	4	78.32	11	82.99	11	80.75	2	80.24	4	80.07	4	78.61	6
SST 866	78.08	13	78.04	14	83.10	10	80.05	6	79.82	7	79.74	8	78.06	11
SST 867	77.97	14	77.61	18	83.66	2	79.87	9	79.78	9	79.75	7	77.79	16
SST 875	77.94	15	77.99	16	82.93	14	79.81	11	79.67	10	79.62	11	77.97	12
SST 876	78.92	3	78.54	6	83.31	5	80.48	4	80.31	3	80.26	3	78.73	4
SST 877	77.69	18	77.04	27	83.18	9	79.30	15	79.30	12	79.30	15	77.37	21
SST 878							79.33	14						
SST 884	77.43	22	76.89	29	81.19	28					78.50	19	77.16	22
SST 895	78.12	12	77.60	19	82.69	16					79.47	12	77.86	15
SST 896	77.34	23												
Steenbras			78.44	7	82.51	18								
Tamboti	78.33	9	78.06	13	82.74	15					79.71	10	78.20	10
Timbavati	76.84	24	77.03	28	81.54	26					78.47	20	76.94	23
Umlazi	77.46	21	77.52	21	81.78	25					78.92	18	77.49	20
Average	**78.14**		**77.91**		**82.71**		**79.66**		**79.78**		**79.55**		**78.07**	
LSD$_t$(0,05)	**0.64**		**0.25**		**0.39**		**0.46**		**0.26**		**0.29**		**0.38**	

Average protein content (%) of entries for the Cooler Central irrigation area (late planting date) during the full or partial period from 2010 – 2013

Cultivar	2013	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Baviaans			12.83	5	11.96	6	13.20	3						
Buffels	11.96	9	12.47	17	11.93	8	12.94	14	12.33	6	12.12	8	12.22	7
CRN 826			12.95	3	11.43	20	13.20	3						
Duzi	12.10	4	12.58	12	12.19	3	12.88	17	12.44	2	12.29	2	12.34	5
Kariega			12.81	6	11.83	11	13.12	6						
Krokodil	11.38	24	11.59	30	10.93	28	13.40	1	11.83	15	11.30	20	11.49	23
Olifants			13.33	2	12.55	2	13.21	2						
PAN 3400	11.89	11	12.54	13									12.22	7
PAN 3434					11.87	9	13.03	11						
PAN 3471	11.69	20	12.32	27	11.56	18	12.78	20	12.09	11	11.86	15	12.01	20
PAN 3478	12.10	4	12.67	8	11.76	13	13.12	6	12.41	5	12.18	5	12.39	3
PAN 3489	11.75	17	12.52	14									12.14	14
PAN 3497	11.78	15	12.44	21									12.11	15
Sabie	11.81	14	12.76	7	11.94	7	13.17	5	12.42	4	12.17	6	12.29	6
SST 806	11.70	19	12.46	19	11.51	19	13.12	6	12.20	8	11.89	12	12.08	17
SST 815			12.65	10	11.22	25								
SST 816			12.37	25	11.58	17								
SST 822	12.25	2	12.87	4	11.73	14	12.84	19	12.42	3	12.28	3	12.56	2
SST 835	11.58	23	12.47	17	11.60	16	12.98	12	12.16	9	11.88	13	12.03	19
SST 843	13.44	1	14.28	1	13.24	1	13.05	10	13.50	1	13.65	1	13.86	1
SST 866	11.69	20	12.13	28	11.22	25	12.91	16	11.99	14	11.68	18	11.91	21
SST 867	11.84	13	12.48	15	11.24	24	12.72	21	12.07	12	11.85	16	12.16	12
SST 875	11.64	22	12.07	29	11.31	23	13.07	9	12.02	13	11.67	19	11.86	22
SST 876	11.97	8	12.43	22	11.84	10	12.97	13	12.30	7	12.08	9	12.20	11
SST 877	11.75	17	12.46	19	11.37	22	12.94	14	12.13	10	11.86	14	12.11	16
SST 878							12.85	18						
SST 884	11.77	16	12.39	24	11.22	25					11.79	17	12.08	17
SST 895	12.07	7	12.66	9	12.04	5					12.26	4	12.37	4
SST 896	12.14	3												
Steenbras			12.61	11	11.40	21								
Tamboti	11.93	10	12.48	15	11.69	15					12.03	10	12.21	10
Timbavati	12.09	6	12.34	26	12.06	4					12.16	7	12.22	7
Umlazi	11.87	12	12.41	23	11.81	12					12.03	11	12.14	13
Average	**11.92**		**12.58**		**11.72**		**13.02**		**12.29**		**12.05**		**12.21**	
LSD$_t$(0,05)	**0.30**		**0.45**		**0.41**		**0.35**		**0.19**		**0.22**		**0.26**	

Average falling number (s) of entries for the Cooler Central irrigation area (late planting date) during the full or partial period from 2010 – 2013

Cultivar	2013	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Baviaans			391	2	394	19	347	7						
Buffels	372	14	372	19	389	23	349	6	370	9	378	14	372	11
CRN 826			379	12	398	16	336	17						
Duzi	368	16	381	9	391	21	343	10	371	8	380	10	375	9
Kariega			393	1	401	8	340	15						
Krokodil	333	24	322	30	353	28	334	18	335	15	336	20	327	23
Olifants			369	21	406	1	336	16						
PAN 3400	374	9	384	8									379	5
PAN 3434					394	20	345	8						
PAN 3471	374	10	388	3	401	7	341	11	376	3	387	2	381	2
PAN 3478	381	2	385	6	400	9	345	9	378	1	389	1	383	1
PAN 3489	376	4	358	28									367	18
PAN 3497	362	20	362	26									362	20
Sabie	367	18	386	5	395	18	341	13	372	7	383	8	376	8
SST 806	373	13	381	10	403	4	333	19	372	6	385	5	377	7
SST 815			385	7	404	3								
SST 816			367	22	400	11								
SST 822	347	23	363	25	377	27	340	14	357	14	362	19	355	22
SST 835	374	8	358	27	399	12	331	20	366	13	377	15	366	19
SST 843	375	7	367	23	400	9	327	21	367	12	381	9	371	12
SST 866	373	11	373	18	405	2	357	3	377	2	384	6	373	10
SST 867	355	22	380	11	384	26	352	5	368	11	373	18	367	17
SST 875	370	15	371	20	395	17	358	1	374	5	379	12	370	14
SST 876	380	3	378	13	401	6	341	11	375	4	386	4	379	6
SST 877	359	21	378	14	387	24	354	4	369	10	374	16	368	16
SST 878							358	2						
SST 884	376	4	349	29	398	14					374	17	362	21
SST 895	383	1	376	15	402	5					387	3	379	4
SST 896	375	6												
Steenbras			366	24	386	25								
Tamboti	367	17	374	17	399	13					380	11	370	13
Timbavati	363	19	375	16	398	15					379	12	369	15
Umlazi	373	12	386	4	391	22					383	7	380	3
Average	**369**		**373**		**395**		**343**		**368**		**378**		**370**	
LSD (0,05)	**9.18**		**10.60**		**8.79**		**17.89**		**6.29**		**5.60**		**7.15**	

Average yield (ton/ha) of entries for the Warmer Northern irrigation area (early planting date) during the full or partial period from 2010 – 2013z

Cultivar	2013	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Baviaans			7.22	25	6.85	12	6.69	15						
Buffels	6.33	23	7.02	28	6.18	26	6.50	18	6.51	13	6.51	20	6.68	21
CRN 826			7.65	16	6.71	18	7.20	5						
Duzi	7.01	12	7.76	13	6.71	17	6.70	14	7.05	9	7.16	9	7.38	10
Kariega			7.05	27	6.81	13	6.61	17						
Krokodil	6.88	17	7.50	18	6.63	19	7.79	2	7.20	4	7.00	14	7.19	16
Olifants			7.76	12	6.54	20	6.90	10						
PAN 3400	7.87	1	7.96	5									7.92	1
PAN 3434					6.47	23	6.80	12						
PAN 3471	7.09	10	8.16	1	6.97	8	7.82	1	7.51	1	7.41	4	7.63	6
PAN 3478	7.36	7	7.82	9	7.02	6	7.26	4	7.36	3	7.40	5	7.59	7
PAN 3489	7.57	4	7.98	4									7.77	4
PAN 3497	7.16	8	7.85	8									7.51	9
Sabie	6.96	14	7.51	17	6.92	10	6.66	16	7.01	10	7.13	11	7.23	15
SST 806	7.55	5	8.03	2	7.28	1	6.89	11	7.44	2	7.62	1	7.79	3
SST 815			7.66	15	6.72	15								
SST 816			8.02	3	6.98	7								
SST 822	7.09	10	7.47	20	5.96	28	6.22	19	6.68	12	6.84	15	7.28	14
SST 835	7.37	6	7.68	14	6.46	24	7.09	6	7.15	6	7.17	8	7.53	8
SST 843	6.12	24	7.19	26	6.49	22	5.97	21	6.44	15	6.60	19	6.66	23
SST 866	6.57	20	7.40	21	7.08	4	6.90	9	6.99	11	7.01	13	6.98	18
SST 867	6.57	20	7.30	22	6.02	27	6.06	20	6.49	14	6.63	18	6.94	20
SST 875	6.95	15	7.79	11	6.80	14	7.07	7	7.15	5	7.18	7	7.37	11
SST 876	7.01	12	7.30	23	6.94	9	7.29	3	7.13	7	7.08	12	7.15	17
SST 877	6.91	16	7.80	10	6.72	16	6.93	8	7.09	8	7.14	10	7.36	12
SST 878							6.79	13						
SST 884	7.74	2	7.86	7	7.20	3					7.60	2	7.80	2
SST 895	7.59	3	7.88	6	7.23	2					7.57	3	7.73	5
SST 896	6.82	18												
Steenbras			6.90	29	6.38	25								
Tamboti	6.71	19	7.23	24	6.49	21					6.81	16	6.97	19
Timbavati	6.56	22	6.77	30	6.90	11					6.74	17	6.66	22
Umlazi	7.12	9	7.49	19	7.03	5					7.21	6	7.30	13
Average	**7.04**		**7.57**		**6.73**		**6.86**		**7.01**		**7.09**		**7.32**	
LSD$_t$(0,05)	**0.67**		**0.46**		**0.29**		**0.45**		**0.22**		**0.24**		**0.40**	

Average hectolitre mass (kg/hl) of entries for the Warmer Northern irrigation area (early planting date) during the full or partial period from 2010 – 2013

Cultivar	2013	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Baviaans			81.33	19	82.05	18	78.95	20						
Buffels	79.70	24	80.85	28	81.63	26	80.02	18	80.55	14	80.73	20	80.28	23
CRN 826			82.39	6	82.18	14	82.09	1						
Duzi	80.40	15	80.69	30	81.74	23	80.62	16	80.86	13	80.94	15	80.55	20
Kariega			80.88	27	81.78	22	80.72	13						
Krokodil	79.80	22	80.76	29	81.88	21	79.74	19	80.55	15	80.81	19	80.28	22
Olifants			81.10	23	81.72	25	81.13	12						
PAN 3400	81.00	9	81.52	18									81.26	12
PAN 3434					82.18	14	80.68	15						
PAN 3471	81.70	2	82.21	9	82.75	5	82.04	3	82.18	1	82.22	2	81.96	3
PAN 3478	81.70	2	81.99	11	82.92	3	82.07	2	82.17	2	82.20	3	81.85	4
PAN 3489	82.40	1	82.81	2									82.61	1
PAN 3497	81.20	6	82.45	5									81.83	5
Sabie	80.40	15	81.25	21	82.39	10	80.70	14	81.19	10	81.35	13	80.83	16
SST 806	81.40	4	82.62	3	82.87	4	81.58	8	82.12	3	82.30	1	82.01	2
SST 815			82.88	1	82.65	6								
SST 816			82.28	8	83.15	1								
SST 822	80.30	18	81.92	13	82.06	17	81.39	9	81.42	8	81.43	11	81.11	13
SST 835	81.30	5	82.20	10	81.91	20	81.95	4	81.84	6	81.80	7	81.75	7
SST 843	81.10	7	81.90	14	83.02	2	81.94	6	81.99	5	82.01	5	81.50	9
SST 866	80.60	14	81.57	17	82.13	16	81.17	11	81.37	9	81.43	10	81.09	14
SST 867	80.70	12	81.31	20	82.05	18	80.30	17	81.09	11	81.35	12	81.01	15
SST 875	80.70	12	81.94	12	82.21	12	81.95	4	81.70	7	81.62	8	81.32	10
SST 876	81.10	7	82.46	4	82.53	7	81.87	7	81.99	4	82.03	4	81.78	6
SST 877	80.40	15	80.90	26	81.20	28	81.38	10	80.97	12	80.83	18	80.65	18
SST 878							78.09	21						
SST 884	80.10	20	81.22	22	82.25	11					81.19	14	80.66	17
SST 895	81.00	9	82.38	7	82.48	8					81.95	6	81.69	8
SST 896	80.10	20												
Steenbras			81.85	15	82.45	9								
Tamboti	80.90	11	81.69	16	82.20	13					81.60	9	81.30	11
Timbavati	80.30	18	80.91	25	81.45	27					80.89	16	80.61	19
Umlazi	79.80	22	81.06	24	81.73	24					80.86	17	80.43	21
Average	**80.75**		**81.71**		**82.20**		**80.97**		**81.46**		**81.48**		**81.23**	
LSD$_t$(0,05)	**0.57**		**0.76**		**0.56**		**0.87**		**0.45**		**0.39**		**0.52**	

Average protein content (%) of entries for the Warmer Northern irrigation area (early planting date) during the full or partial period from 2010 – 2013

Cultivar	2013	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Baviaans			11.25	8	10.45	11	10.71	12						
Buffels	10.21	4	10.92	23	10.77	5	10.96	5	10.72	4	10.63	5	10.57	8
CRN 826			11.06	15	10.36	15	10.89	9						
Duzi	10.24	3	11.26	7	10.76	6	11.08	4	10.84	3	10.75	3	10.75	3
Kariega			11.27	6	10.42	13	10.95	6						
Krokodil	9.68	22	10.84	25	10.09	27	9.82	20	10.11	15	10.20	19	10.26	20
Olifants			11.59	4	10.89	4	11.57	3						
PAN 3400	10.19	5	10.97	21									10.58	6
PAN 3434					10.43	12	10.92	8						
PAN 3471	9.76	19	10.80	27	10.04	28	10.39	18	10.25	14	10.20	20	10.28	19
PAN 3478	9.61	23	11.24	9	10.28	21	10.94	7	10.52	8	10.38	13	10.43	15
PAN 3489	9.81	14	11.14	12									10.48	12
PAN 3497	9.78	18	10.72	29									10.25	21
Sabie	9.71	20	11.33	5	10.46	10	10.81	10	10.58	7	10.50	8	10.52	10
SST 806	9.79	16	10.93	22	10.35	17	10.67	14	10.44	9	10.36	15	10.36	18
SST 815			11.00	17	10.19	26								
SST 816			11.04	16	10.20	25								
SST 822	11.14	2	12.21	2	11.14	2	11.67	2	11.54	2	11.50	2	11.68	2
SST 835	9.99	11	10.98	19	10.31	20	10.38	19	10.42	11	10.43	11	10.49	11
SST 843	11.80	1	12.60	1	11.94	1	12.83	1	12.29	1	12.11	1	12.20	1
SST 866	9.69	21	10.68	30	10.32	18	10.62	15	10.33	13	10.23	18	10.19	23
SST 867	10.12	6	11.23	10	10.63	7	10.70	13	10.67	5	10.66	4	10.68	4
SST 875	9.94	13	10.85	24	10.24	23	10.58	16	10.40	12	10.34	16	10.40	16
SST 876	9.79	16	11.16	11	10.25	22	10.50	17	10.43	10	10.40	12	10.48	13
SST 877	10.01	10	11.14	12	10.47	9	10.81	10	10.61	6	10.54	6	10.58	7
SST 878							9.74	21						
SST 884	10.08	7	10.99	18	10.32	18					10.46	10	10.54	9
SST 895	10.04	9	11.14	12	10.41	14					10.53	7	10.59	5
SST 896	9.99	11												
Steenbras			11.94	3	10.96	3								
Tamboti	9.81	14	10.98	19	10.61	8					10.47	9	10.40	16
Timbavati	9.61	23	10.80	27	10.36	15					10.26	17	10.21	22
Umlazi	10.08	7	10.81	26	10.21	24					10.37	14	10.45	14
Average	**10.04**		**11.16**		**10.50**		**10.84**		**10.67**		**10.57**		**10.58**	
LSD (0,05)	**0.53**		**0.51**		**0.36**		**0.53**		**0.24**		**0.26**		**0.39**	

Average falling number (s) of entries for the Warmer Northern irrigation area (early planting date) during the full or partial period from 2010 – 2013

Cultivar	2013	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Baviaans			367	17	332	19	350	13						
Buffels	309	14	371	13	339	15	352	10	343	7	340	9	340	11
CRN 826			374	7	342	12	365	5						
Duzi	301	18	332	29	324	25	337	17	324	14	319	19	316	22
Kariega			380	2	324	26	352	9						
Krokodil	264	24	324	30	290	28	301	20	295	15	293	20	294	23
Olifants			345	26	355	4	392	1						
PAN 3400	310	12	380	3									345	7
PAN 3434					328	21	343	15						
PAN 3471	297	21	372	12	341	13	350	12	340	10	336	14	334	17
PAN 3478	317	7	369	16	333	17	355	8	343	6	339	10	343	9
PAN 3489	296	22	343	27									320	21
PAN 3497	299	20	371	13									335	16
Sabie	313	11	365	19	333	16	351	11	340	9	337	13	339	13
SST 806	353	1	376	5	354	5	366	2	363	1	361	1	365	1
SST 815			355	23	350	8								
SST 816			348	25	351	7								
SST 822	300	19	356	22	326	23	319	19	325	13	327	18	328	18
SST 835	324	4	371	13	345	10	349	14	347	4	346	4	347	5
SST 843	277	23	364	20	357	1	365	4	341	8	333	17	321	20
SST 866	326	3	381	1	354	6	366	3	357	2	354	3	354	2
SST 867	310	13	373	8	333	18	338	16	338	11	339	12	341	10
SST 875	308	15	365	18	344	11	360	7	344	5	339	11	336	15
SST 876	315	10	372	11	350	9	360	6	349	3	345	5	343	8
SST 877	305	16	372	10	326	24	329	18	333	12	334	16	338	14
SST 878							288	21						
SST 884	304	17	349	24	355	3					336	15	327	19
SST 895	334	2	373	9	357	2					355	2	353	3
SST 896	318	6												
Steenbras			334	28	309	27								
Tamboti	316	9	376	6	331	20					341	7	346	6
Timbavati	320	5	378	4	327	22					342	6	349	4
Umlazi	316	8	363	21	340	14					340	8	339	12
Average	**310**		**363**		**337**		**347**		**339**		**338**		**337**	
LSD$_t$(0,05)	**12.93**		**6.40**		**13.69**		**12.81**		**7.30**		**8.44**		**11.23**	

Average yield (ton/ha) of entries for the Warmer Northern irrigation area (late planting date) during the full or partial period from 2010 – 2013

Cultivar	2013	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Baviaans			6.36	21	6.61	13	7.03	5						
Buffels	6.59	24	6.38	19	6.34	26	6.27	19	6.39	14	6.44	19	6.49	21
CRN 826			6.24	23	6.63	12	7.01	6						
Duzi	7.02	16	7.35	1	6.89	6	6.53	15	6.95	5	7.09	3	7.19	3
Kariega			6.19	26	6.40	24	6.65	14						
Krokodil	7.28	8	6.53	16	6.35	25	6.90	9	6.77	9	6.72	14	6.91	11
Olifants			6.20	25	6.48	21	6.47	17						
PAN 3400	7.06	15	6.93	5									7.00	9
PAN 3434					6.51	18	7.12	3						
PAN 3471	7.22	9	6.82	8	6.87	7	7.25	1	7.04	3	6.97	6	7.02	6
PAN 3478	7.48	5	6.49	17	6.75	10	7.01	6	6.93	6	6.91	8	6.99	10
PAN 3489	7.47	6	6.55	15									7.01	8
PAN 3497	6.80	21	6.33	22									6.57	20
Sabie	6.95	18	6.58	12	6.51	19	6.50	16	6.64	11	6.68	15	6.77	15
SST 806	6.98	17	6.75	9	6.77	9	6.94	8	6.86	8	6.83	11	6.87	12
SST 815			7.11	3	6.49	20								
SST 816			6.93	5	6.92	5								
SST 822	6.70	23	6.48	18	6.61	14	5.79	21	6.40	13	6.60	16	6.59	19
SST 835	7.49	4	6.57	13	6.56	17	6.89	10	6.88	7	6.87	10	7.03	5
SST 843	7.10	13	6.09	28	6.48	22	6.46	18	6.53	12	6.56	17	6.60	18
SST 866	7.53	3	7.00	4	7.00	4	6.84	11	7.09	2	7.18	1	7.27	1
SST 867	7.16	11	5.67	30	6.00	28	6.08	20	6.23	15	6.28	20	6.42	23
SST 875	6.90	19	7.14	2	7.29	2	7.13	2	7.12	1	7.11	2	7.02	6
SST 876	7.56	2	6.90	7	6.59	16	7.09	4	7.03	4	7.02	4	7.23	2
SST 877	7.17	10	6.18	27	6.82	8	6.75	13	6.73	10	6.72	13	6.68	17
SST 878							6.83	12						
SST 884	6.83	20	6.63	10	7.18	3					6.88	9	6.73	16
SST 895	7.07	14	6.56	14	7.37	1					7.00	5	6.82	14
SST 896	6.73	22												
Steenbras			6.24	23	6.28	27								
Tamboti	7.67	1	6.61	11	6.59	15					6.96	7	7.14	4
Timbavati	7.11	12	5.75	29	6.46	23					6.44	18	6.43	22
Umlazi	7.30	7	6.37	20	6.64	11					6.77	12	6.84	13
Average	**7.13**		**6.53**		**6.66**		**6.74**		**6.77**		**6.80**		**6.85**	
LSD (0,05)	**0.52**		**0.62**		**0.36**		**0.47**		**0.24**		**0.27**		**0.41**	

Average hectolitre mass (kg/hl) of entries for the Warmer Northern irrigation area (late planting date) during the full or partial period from 2010 – 2013

Cultivar	2013	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Baviaans			81.08	16	81.98	15	81.62	9						
Buffels	82.50	19	79.90	28	81.66	23	80.84	20	81.23	15	81.35	18	81.20	21
CRN 826			81.89	8	82.61	7	82.15	4						
Duzi	82.20	21	81.46	13	81.91	17	81.11	18	81.67	10	81.86	11	81.83	14
Kariega			80.79	21	81.50	25	81.14	17						
Krokodil	82.70	14	80.40	26	81.70	22	81.67	8	81.62	11	81.60	16	81.55	18
Olifants			80.44	25	81.89	18	81.31	14						
PAN 3400	83.10	7	80.99	18									82.04	12
PAN 3434					81.95	16	81.58	10						
PAN 3471	83.90	1	82.60	4	82.01	13	82.53	2	82.76	2	82.84	3	83.25	2
PAN 3478	83.90	1	82.79	3	83.55	1	83.14	1	83.34	1	83.41	1	83.34	1
PAN 3489	83.40	4	83.06	2									83.23	3
PAN 3497	83.70	3	81.31	15									82.51	5
Sabie	82.20	21	80.86	20	81.79	19	81.07	19	81.48	13	81.62	15	81.53	19
SST 806	82.90	10	81.80	9	82.56	8	82.28	3	82.39	5	82.42	6	82.35	8
SST 815			83.24	1	82.08	12								
SST 816			81.73	10	82.68	6								
SST 822	82.30	20	81.38	14	82.41	10	81.56	11	81.91	8	82.03	9	81.84	13
SST 835	82.80	13	81.61	11	82.78	5	81.97	6	82.29	6	82.40	7	82.21	10
SST 843	83.00	8	81.94	7	83.12	2	81.98	5	82.51	4	82.69	4	82.47	6
SST 866	82.60	17	80.74	22	81.57	24	81.52	13	81.61	12	81.64	14	81.67	16
SST 867	83.30	5	80.93	19	81.74	20	81.54	12	81.88	9	81.99	10	82.11	11
SST 875	82.90	10	81.55	12	82.38	11	81.21	15	82.01	7	82.28	8	82.23	9
SST 876	83.30	5	82.54	5	83.03	3	81.84	7	82.68	3	82.96	2	82.92	4
SST 877	82.90	10	79.88	29	81.29	27	81.19	16	81.31	14	81.36	17	81.39	20
SST 878							80.22	21						
SST 884	81.80	23	80.39	27	81.29	27					81.16	20	81.09	22
SST 895	82.60	17	82.23	6	82.96	4					82.60	5	82.41	7
SST 896	81.80	23												
Steenbras			81.08	16	82.44	9								
Tamboti	83.00	8	80.49	24	81.99	14					81.83	12	81.74	15
Timbavati	82.70	14	79.41	30	81.44	26					81.18	19	81.06	23
Umlazi	82.70	14	80.54	23	81.73	21					81.66	13	81.62	17
Average	**82.84**		**81.30**		**82.14**		**81.59**		**82.05**		**82.04**		**82.07**	
LSD$_t$(0,05)	**0.77**		**0.91**		**0.89**		**0.58**		**0.41**		**0.55**		**0.61**	

Average protein content (%) of entries for the Warmer Northern irrigation area (late planting date) during the full or partial period from 2010 – 2013

Cultivar	2013	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Baviaans			10.53	25	10.43	23	10.55	19						
Buffels	11.31	5	10.90	14	10.64	14	11.07	8	10.98	5	10.95	5	11.11	6
CRN 826			10.71	17	10.80	9	10.88	13						
Duzi	11.24	9	10.52	26	10.79	10	11.26	6	10.95	7	10.85	10	10.88	15
Kariega			10.48	28	10.85	8	11.29	4						
Krokodil	10.60	24	10.50	27	10.23	27	10.40	20	10.43	15	10.44	20	10.55	23
Olifants			11.42	5	11.29	2	11.85	2						
PAN 3400	11.27	6	11.23	8									11.25	5
PAN 3434					10.55	18	10.78	15						
PAN 3471	11.34	4	11.27	7	10.55	18	10.89	11	11.01	4	11.05	4	11.31	4
PAN 3478	11.25	8	10.91	13	10.25	26	11.05	9	10.87	10	10.80	14	11.08	8
PAN 3489	10.63	23	10.60	22									10.62	22
PAN 3497	10.65	22	10.59	23									10.62	21
Sabie	11.26	7	10.94	11	10.39	24	11.28	5	10.97	6	10.86	9	11.10	7
SST 806	10.83	18	10.95	10	10.98	5	10.75	16	10.88	9	10.92	7	10.89	14
SST 815			10.68	19	10.66	13								
SST 816			10.88	15	11.28	3								
SST 822	11.73	2	11.58	3	11.25	4	11.47	3	11.51	2	11.52	2	11.66	2
SST 835	10.82	20	11.04	9	10.58	16	10.84	14	10.82	11	10.81	13	10.93	12
SST 843	12.08	1	12.38	1	12.14	1	11.98	1	12.15	1	12.20	1	12.23	1
SST 866	11.02	17	10.47	29	10.20	28	10.89	11	10.65	13	10.56	19	10.75	19
SST 867	10.83	18	11.30	6	10.56	17	11.11	7	10.95	8	10.90	8	11.07	9
SST 875	10.82	20	10.65	20	10.36	25	10.59	18	10.61	14	10.61	18	10.74	20
SST 876	11.15	12	10.69	18	10.71	12	10.70	17	10.81	12	10.85	10	10.92	13
SST 877	11.24	9	11.71	2	10.89	6	10.94	10	11.20	3	11.28	3	11.48	3
SST 878							10.08	21						
SST 884	11.09	15	10.93	12	10.77	11					10.93	6	11.01	10
SST 895	11.07	16	10.86	16	10.61	15					10.85	12	10.97	11
SST 896	11.42	3												
Steenbras			11.58	3	10.87	7								
Tamboti	11.10	14	10.64	21	10.54	20					10.76	15	10.87	16
Timbavati	11.14	13	10.59	23	10.45	22					10.73	16	10.87	17
Umlazi	11.19	11	10.44	30	10.53	21					10.72	17	10.82	18
Average	**11.13**		**10.93**		**10.72**		**10.98**		**10.98**		**10.93**		**11.03**	
LSD (0,05)	**0.56**		**0.52**		**0.63**		**0.45**		**0.31**		**0.39**		**0.42**	

Average falling number (s) of entries for the Warmer Northern irrigation area (late planting date) during the full or partial period from 2010 – 2013

Cultivar	2013	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Baviaans			339	19	361	16	371	7						
Buffels	344	14	328	22	363	15	350	17	346	11	345	13	336	17
CRN 826			359	5	364	14	379	3						
Duzi	344	16	313	28	352	23	347	18	339	12	336	17	328	20
Kariega			339	20	357	21	374	5						
Krokodil	314	24	302	30	324	28	328	21	317	15	314	20	308	23
Olifants			381	1	387	1	381	2						
PAN 3400	344	14	326	24									335	18
PAN 3434					358	19	356	15						
PAN 3471	352	11	350	11	372	10	375	4	362	5	358	8	351	8
PAN 3478	345	13	352	8	370	11	358	12	356	8	356	10	348	10
PAN 3489	358	5	355	6									356	6
PAN 3497	339	19	328	22									333	19
Sabie	347	12	325	25	357	20	356	14	346	10	343	16	336	16
SST 806	362	2	371	2	373	9	365	9	368	1	369	1	366	1
SST 815			342	14	376	7								
SST 816			349	12	381	2								
SST 822	323	23	309	29	353	22	359	11	336	14	328	19	316	22
SST 835	362	3	352	7	359	17	359	10	358	6	358	9	357	5
SST 843	352	10	366	4	377	6	374	6	368	2	365	3	359	3
SST 866	367	1	350	10	380	4	367	8	366	3	366	2	359	4
SST 867	344	17	340	17	351	24	352	16	347	9	345	12	342	12
SST 875	360	4	341	15	373	8	357	13	358	7	358	7	351	9
SST 876	356	6	341	16	379	5	383	1	365	4	359	6	348	10
SST 877	329	22	321	26	351	25	345	19	337	13	334	18	325	21
SST 878							345	20						
SST 884	353	8	352	8	381	3					362	5	352	7
SST 895	356	7	368	3	369	12					364	4	362	2
SST 896	352	9												
Steenbras			317	27	347	27								
Tamboti	335	20	347	13	351	26					344	14	341	13
Timbavati	335	21	339	18	358	18					344	15	337	15
Umlazi	342	18	334	21	367	13					348	11	338	14
Average	**346**		**341**		**364**		**361**		**351**		**350**		**343**	
LSD (0,05)	**14.46**		**19.09**		**16.53**		**22.62**		**10.45**		**10.22**		**12.52**	

Average yield (ton/ha) of entries for the Eastern Highveld irrigation area (early planting date) during the full or partial period from 2010 – 2012

Cultivar	2013*	R	2012	R	2011	R	2010	R	3 year average 2010-2012	R	2 year average 2011-2012	R
Baviaans			7.87	20	7.43	25	5.23	18	6.84	15	7.65	20
Buffels	---	---	7.72	22	7.10	27	4.93	21	6.58	19	7.41	25
CRN 826			8.42	4	8.73	7	5.90	4	7.69	4	8.58	4
Duzi	---	---	8.59	2	7.94	15	5.29	16	7.27	8	8.26	9
Kariega			7.99	17	7.22	26	5.24	17	6.82	16	7.61	22
Krokodil	---	---	8.27	9	7.60	21	5.38	14	7.08	13	7.93	17
Olifants			8.02	16	6.82	28	5.57	9	6.80	17	7.42	24
PAN 3400	---	---	8.32	8								
PAN 3434					7.79	17	5.60	8				
PAN 3471	---	---	8.19	13	9.24	1	6.15	2	7.86	1	8.72	1
PAN 3478	---	---	8.21	12	8.52	9	6.41	1	7.71	3	8.36	6
PAN 3489	---	---	8.26	10								
PAN 3497	---	---	8.79	1								
Sabie	---	---	7.92	19	7.65	20	5.49	10	7.02	14	7.78	19
SST 806	---	---	8.22	11	8.96	3	5.81	5	7.66	5	8.59	3
SST 815			8.34	7	8.18	13					8.26	10
SST 816			8.35	6	8.36	12					8.35	7
SST 822	---	---	7.25	27	8.74	6	5.31	15	7.10	12	7.99	15
SST 835	---	---	8.46	3	8.91	4	5.97	3	7.78	2	8.68	2
SST 843	---	---	7.07	30	7.85	16	5.14	20	6.69	18	7.46	23
SST 866	---	---	7.70	23	8.90	5	5.47	12	7.36	6	8.30	8
SST 867	---	---	8.09	15	7.73	19	5.79	6	7.20	11	7.91	18
SST 875	---	---	8.40	5	8.47	10	5.21	19	7.36	7	8.43	5
SST 876	---	---	7.98	18	8.17	14	5.48	11	7.21	9	8.08	14
SST 877	---	---	7.87	21	8.37	11	5.39	13	7.21	10	8.12	13
SST 878							5.61	7				
SST 884	---	---	7.63	25	8.70	8					8.17	11
SST 895	---	---	7.30	26	9.00	2					8.15	12
SST 896	---	---										
Steenbras			7.18	29	7.52	24					7.35	27
Tamboti	---	---	7.69	24	7.57	22					7.63	21
Timbavati	---	---	7.21	28	7.55	23					7.38	26
Umlazi	---	---	8.17	14	7.78	18					7.98	16
Average	---	---	**7.98**		**8.10**		**5.54**		**7.22**		**8.02**	
LSD$_t$(0,05)	---	---	**0.56**		**0.45**		**0.37**		**0.22**		**0.35**	

** Due to unforeseen circumstances no trials (2013) were processed for the Eastern Highveld early planting dates*

Average hectolitre mass (kg/hl) of entries for the Eastern Highveld irrigation area (early planting date) during the full or partial period from 2010 – 2012

Cultivar	2013*	R	2012	R	2011	R	2010	R	3 year average 2010-2012	R	2 year average 2011-2012	R
Baviaans			80.31	19	81.59	14	76.78	11	79.56	11	80.95	15
Buffels	---	---	79.35	29	81.24	19	76.13	14	78.91	14	80.30	24
CRN 826			81.89	4	82.66	11	77.27	9	80.61	8	82.28	7
Duzi	---	---	80.12	22	81.04	22	75.23	16	78.80	15	80.58	19
Kariega			79.76	24	80.87	24	76.62	12	79.08	12	80.32	23
Krokodil	---	---	81.22	14	79.78	28	75.08	19	78.69	17	80.50	21
Olifants			79.62	26	81.58	15	74.96	20	78.72	16	80.60	18
PAN 3400	---	---	80.82	16								
PAN 3434					81.43	17	77.66	6				
PAN 3471	---	---	81.47	12	83.19	3	78.11	2	80.92	4	82.33	6
PAN 3478	---	---	81.73	7	83.41	2	78.92	1	81.35	1	82.57	2
PAN 3489	---	---	82.09	1								
PAN 3497	---	---	81.58	9								
Sabie	---	---	79.41	27	80.30	27	76.23	13	78.65	19	79.86	26
SST 806	---	---	81.76	5	83.67	1	77.83	3	81.09	2	82.72	1
SST 815			81.91	2	82.50	12					82.21	8
SST 816			81.48	11	82.79	8					82.14	9
SST 822	---	---	80.19	21	82.09	13	74.92	21	79.07	13	81.14	13
SST 835	---	---	81.65	8	83.18	4	77.58	7	80.80	5	82.42	4
SST 843	---	---	81.91	2	83.09	5	77.83	3	80.94	3	82.50	3
SST 866	---	---	81.23	13	82.67	10	75.87	15	79.92	9	81.95	11
SST 867	---	---	80.66	17	81.48	16	77.29	8	79.81	10	81.07	14
SST 875	---	---	81.76	5	83.04	6	77.12	10	80.64	7	82.40	5
SST 876	---	---	81.49	10	82.74	9	77.80	5	80.68	6	82.12	10
SST 877	---	---	80.12	22	80.73	25	75.20	17	78.68	18	80.43	22
SST 878							75.19	18				
SST 884	---	---	79.76	24	81.34	18					80.55	20
SST 895	---	---	80.92	15	82.84	7					81.88	12
SST 896	---	---										
Steenbras			80.65	18	81.19	21					80.92	16
Tamboti	---	---	80.24	20	81.23	20					80.74	17
Timbavati	---	---	78.56	30	80.54	26					79.55	27
Umlazi	---	---	79.39	28	80.92	23					80.16	25
Average	---	---	**80.77**		**81.90**		**76.65**		**79.84**		**81.30**	
LSD (0,05)	---	---	**0.73**		**0.68**		**0.72**		**0.66**		**0.50**	

** Due to unforeseen circumstances no trials (2013) were processed for the Eastern Highveld early planting dates*

Average protein content (%) of entries for the Eastern Highveld irrigation area (early planting date) during the full or partial period from 2010 – 2012

Cultivar	2013*	R	2012	R	2011	R	2010	R	3 year average 2010-2012	R	2 year average 2011-2012	R
Baviaans			11.84	11	12.99	17	13.68	8	12.84	9	12.42	15
Buffels	---	---	11.73	16	13.25	11	13.92	3	12.97	7	12.49	11
CRN 826			11.71	18	12.90	21	13.66	10	12.76	11	12.31	20
Duzi	---	---	11.59	26	13.33	7	13.56	13	12.83	10	12.46	13
Kariega			11.99	10	13.19	14	13.83	4	13.00	6	12.59	9
Krokodil	---	---	10.81	30	11.97	28	13.02	20	11.93	19	11.39	27
Olifants			12.44	3	14.10	2	14.32	2	13.62	2	13.27	2
PAN 3400	---	---	11.61	25								
PAN 3434					13.31	8	13.57	11				
PAN 3471	---	---	11.79	12	12.73	26	13.43	16	12.65	17	12.26	22
PAN 3478	---	---	11.62	24	13.49	6	13.57	11	12.89	8	12.56	10
PAN 3489	---	---	11.69	19								
PAN 3497	---	---	11.73	16								
Sabie	---	---	12.05	8	13.62	4	13.77	6	13.15	4	12.84	5
SST 806	---	---	11.75	15	12.92	19	13.47	15	12.71	12	12.34	18
SST 815			11.52	27	12.82	23					12.17	25
SST 816			11.66	21	13.04	15					12.35	17
SST 822	---	---	12.72	2	13.69	3	13.80	5	13.40	3	13.21	3
SST 835	---	---	11.79	12	12.81	24	13.38	17	12.66	15	12.30	21
SST 843	---	---	13.63	1	14.76	1	14.81	1	14.40	1	14.20	1
SST 866	---	---	12.00	9	12.90	21	13.17	18	12.69	13	12.45	14
SST 867	---	---	11.64	23	12.79	25	13.54	14	12.66	16	12.22	23
SST 875	---	---	11.24	29	12.43	27	13.13	19	12.27	18	11.84	26
SST 876	---	---	12.36	4	13.28	10	13.74	7	13.13	5	12.82	6
SST 877	---	---	11.43	28	12.92	19	13.67	9	12.67	14	12.18	24
SST 878							12.64	21				
SST 884	---	---	11.66	21	12.97	18					12.32	19
SST 895	---	---	12.22	6	13.25	11					12.74	7
SST 896	---	---										
Steenbras			11.78	14	13.04	15					12.41	16
Tamboti	---	---	11.69	19	13.24	13					12.47	12
Timbavati	---	---	12.28	5	13.59	5					12.94	4
Umlazi	---	---	12.08	7	13.31	8					12.70	8
Average	---	---	**11.87**		**13.17**		**13.60**		**12.91**		**12.53**	
LSD (0,05)	---	---	**0.65**		**0.45**		**0.43**		**0.27**		**0.39**	

** Due to unforeseen circumstances no trials (2013) were processed for the Eastern Highveld early planting dates*

Average falling number (s) of entries for the Eastern Highveld irrigation area (early planting date) during the full or partial period from 2010 – 2012

Cultivar	2013*	R	2012	R	2011	R	2010	R	3 year average 2010-2012	R	2 year average 2011-2012	R
Baviaans			358	10	393	13	268	3	340	4	375	9
Buffels	---	---	358	9	384	19	281	1	341	3	371	16
CRN 826			355	13	395	9	216	11	322	11	375	10
Duzi	---	---	333	27	340	27	173	18	282	18	337	26
Kariega			354	15	388	17	258	7	333	5	371	14
Krokodil	---	---	310	30	324	28	148	21	260	19	317	27
Olifants			348	20	397	8	172	19	306	15	372	13
PAN 3400	---	---	352	16								
PAN 3434					394	11	247	8				
PAN 3471	---	---	331	28	394	12	177	17	300	17	362	21
PAN 3478	---	---	363	6	401	4	222	10	329	7	382	5
PAN 3489	---	---	329	29								
PAN 3497	---	---	348	19								
Sabie	---	---	352	17	382	21	215	12	317	14	367	19
SST 806	---	---	355	14	400	5	215	13	323	10	377	7
SST 815			360	8	395	10					377	8
SST 816			346	22	400	6					373	12
SST 822	---	---	362	7	380	22	242	9	328	8	371	15
SST 835	---	---	357	11	392	15	210	14	320	12	374	11
SST 843	---	---	374	2	402	3	259	6	345	2	388	2
SST 866	---	---	389	1	399	7	260	5	349	1	394	1
SST 867	---	---	342	25	371	24	260	4	325	9	357	23
SST 875	---	---	334	26	384	18	193	16	304	16	359	22
SST 876	---	---	366	4	392	14	197	15	318	13	379	6
SST 877	---	---	344	24	366	25	277	2	329	6	355	24
SST 878							158	20				
SST 884	---	---	356	12	408	1					382	4
SST 895	---	---	371	3	403	2					387	3
SST 896	---	---										
Steenbras			346	23	361	26					353	25
Tamboti	---	---	347	21	391	16					369	17
Timbavati	---	---	363	5	372	23					367	18
Umlazi	---	---	350	18	383	20					366	20
Average	---	---	**352**		**385**		**221**		**319**		**369**	
LSD (0,05)	---	---	**20.39**		**16.05**		**32.02**		**8.49**		**12.84**	

** Due to unforeseen circumstances no trials (2013) were processed for the Eastern Highveld early planting dates*

Average yield (ton/ha) of entries for the Eastern Highveld irrigation area (late planting date) during the full or partial period from 2010 – 2013

Cultivar	2013*	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Baviaans			6.80	24	5.67	19	4.85	16						
Buffels	7.29	10	7.61	16	6.02	10	4.64	21	6.39	8	6.97	7	7.45	9
CRN 826			7.72	14	6.41	2	5.80	5						
Duzi	7.03	14	6.18	29	5.92	13	4.77	17	5.98	12	6.38	16	6.60	20
Kariega			6.25	28	5.02	27	4.70	18						
Krokodil	6.71	17	7.85	10	3.67	28	4.67	20	5.72	14	6.08	17	7.28	13
Olifants			7.60	17	5.21	26	5.07	13						
PAN 3400	7.37	8	7.43	20									7.40	10
PAN 3434					5.64	20	5.24	12						
PAN 3471	7.82	2	8.51	1	5.70	17	5.95	2	7.00	1	7.34	2	8.16	1
PAN 3478	7.83	1	7.76	13	6.20	7	5.84	3	6.91	4	7.26	3	7.79	5
PAN 3489	7.78	3	7.84	11									7.81	4
PAN 3497	7.68	6	8.43	2									8.05	2
Sabie	7.53	7	6.36	27	5.78	16	4.91	15	6.15	11	6.56	14	6.95	18
SST 806	6.84	15	8.12	3	6.76	1	6.20	1	6.98	2	7.24	4	7.48	7
SST 815			7.83	12	6.04	9								
SST 816			7.69	15	5.81	15								
SST 822	4.43	24	7.50	19	6.23	5	5.31	11	5.87	13	6.05	19	5.97	22
SST 835	7.71	5	8.10	4	6.38	3	5.72	7	6.98	3	7.40	1	7.91	3
SST 843	4.52	23	6.70	25	5.68	18	4.67	19	5.39	15	5.63	20	5.61	23
SST 866	6.55	21	7.87	9	6.21	6	5.78	6	6.60	5	6.87	9	7.21	15
SST 867	7.23	12	7.30	21	5.50	23	5.80	4	6.46	7	6.68	12	7.27	14
SST 875	7.08	13	7.87	8	6.00	12	5.37	10	6.58	6	6.98	6	7.48	8
SST 876	6.63	18	7.97	5	5.60	22	4.98	14	6.29	10	6.73	11	7.30	12
SST 877	6.56	20	7.51	18	5.61	21	5.68	8	6.34	9	6.56	13	7.03	17
SST 878							5.39	9						
SST 884	6.40	22	7.93	6	6.29	4					6.87	10	7.17	16
SST 895	7.35	9	7.88	7	6.20	8					7.14	5	7.62	6
SST 896	6.63	19												
Steenbras			7.09	22	5.23	25								
Tamboti	7.77	4	6.89	23	6.00	11					6.89	8	7.33	11
Timbavati	6.80	16	6.07	30	5.34	24					6.07	18	6.43	21
Umlazi	7.27	11	6.52	26	5.88	14					6.55	15	6.89	19
Average	**6.95**		**7.44**		**5.79**		**5.30**		**6.38**		**6.71**		**7.23**	
LSD$_t$(0,05)	**0.96**		**0.53**		**0.48**		**0.51**		**0.28**		**0.35**		**0.50**	

** Only Danielsrus data*

Average hectolitre mass (kg/hl) of entries for the Eastern Highveld irrigation area (late planting date) during the full or partial period from 2010 – 2013

Cultivar	2013*	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Baviaans			77.79	19	80.46	10	76.80	14						
Buffels	79.40	12	77.81	17	77.48	26	76.90	13	77.90	11	78.23	14	78.61	14
CRN 826			77.34	24	80.54	9	77.60	7						
Duzi	78.23	20	77.76	20	78.98	20	75.90	18	77.72	12	78.32	13	77.99	19
Kariega			77.15	26	78.41	23	76.60	15						
Krokodil	79.00	17	78.26	12	75.71	28	74.00	21	76.74	15	77.66	19	78.63	13
Olifants			77.54	22	77.45	27	76.60	15						
PAN 3400	79.38	13	78.13	14									78.75	12
PAN 3434					80.16	15	77.60	7						
PAN 3471	80.08	6	78.74	8	81.53	3	78.30	3	79.66	2	80.11	2	79.41	4
PAN 3478	80.73	2	77.55	21	82.41	1	78.70	1	79.85	1	80.23	1	79.14	6
PAN 3489	81.90	1	78.81	7									80.36	2
PAN 3497	80.48	3	80.39	1									80.43	1
Sabie	78.80	18	76.85	29	78.55	22	76.00	17	77.55	13	78.07	17	77.83	21
SST 806	79.85	9	78.01	15	81.81	2	78.60	2	79.57	3	79.89	3	78.93	10
SST 815			79.03	4	80.15	16								
SST 816			79.45	2	80.83	8								
SST 822	76.50	24	77.81	17	79.18	19	74.60	20	77.02	14	77.83	18	77.16	22
SST 835	79.93	8	78.14	13	81.11	4	77.60	7	79.19	6	79.72	6	79.03	9
SST 843	78.05	21	78.90	6	80.31	12	78.00	5	78.82	8	79.09	11	78.48	16
SST 866	79.63	10	78.96	5	81.03	5	77.10	11	79.18	7	79.87	4	79.29	5
SST 867	80.30	5	77.45	23	80.26	14	77.10	11	78.78	9	79.34	9	78.88	11
SST 875	79.05	16	79.13	3	81.03	5	77.90	6	79.28	5	79.74	5	79.09	7
SST 876	79.60	11	78.56	9	81.01	7	78.10	4	79.32	4	79.72	6	79.08	8
SST 877	79.10	15	77.26	25	80.38	11	77.20	10	78.49	10	78.91	12	78.18	18
SST 878							75.70	19						
SST 884	77.00	23	76.99	28	78.89	21					77.63	20	76.99	23
SST 895	79.18	14	77.83	16	80.28	13					79.09	10	78.50	15
SST 896	77.65	22												
Steenbras			78.45	11	79.76	17								
Tamboti	80.43	4	78.53	10	79.44	18					79.46	8	79.48	3
Timbavati	79.98	7	76.80	30	77.66	25					78.15	15	78.39	17
Umlazi	78.80	18	77.04	27	78.39	24					78.08	16	77.92	20
Average	**79.29**		**78.08**		**79.76**		**77.00**		**78.60**		**78.96**		**78.72**	
LSD$_t$(0,05)	**1.05**		**0.81**		**1.73**		**1.04**		**0.48**		**0.88**		**0.63**	

** Only Danielsrus data*

Average protein content (%) of entries for the Eastern Highveld irrigation area (late planting date) during the full or partial period from 2010 – 2013 (Danielsrus site only)

Cultivar	2013*	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Baviaans			13.71	16	13.86	13	15.04	8						
Buffels	12.98	10	13.69	17	13.89	11	15.43	4	14.00	7	13.52	10	13.34	11
CRN 826			13.33	27	13.73	17	14.61	15						
Duzi	13.38	5	13.93	10	14.41	6	14.80	11	14.13	4	13.91	3	13.65	5
Kariega			14.38	4	14.40	7	15.43	4						
Krokodil	11.29	24	12.54	30	12.69	28	13.33	21	12.46	15	12.17	20	11.92	23
Olifants			14.44	2	14.66	3	15.94	2						
PAN 3400	12.72	17	13.75	14									13.24	15
PAN 3434					13.47	23	14.73	12						
PAN 3471	12.54	21	13.50	24	13.51	21	14.46	17	13.50	13	13.18	17	13.02	19
PAN 3478	12.60	18	13.66	19	14.05	10	15.12	7	13.86	10	13.44	13	13.13	18
PAN 3489	12.58	20	14.13	7									13.35	10
PAN 3497	12.86	12	13.53	23									13.19	16
Sabie	12.60	18	14.24	6	14.53	4	15.49	3	14.22	3	13.79	6	13.42	9
SST 806	13.80	4	13.85	13	13.75	16	14.65	14	14.01	6	13.80	5	13.83	3
SST 815			13.91	12	13.81	15								
SST 816			13.38	26	13.39	25								
SST 822	14.63	2	14.38	3	14.81	2	14.98	9	14.70	2	14.60	2	14.50	2
SST 835	12.25	23	13.64	20	13.72	18	14.50	16	13.53	12	13.20	16	12.94	22
SST 843	16.19	1	15.80	1	15.53	1	16.47	1	16.00	1	15.84	1	15.99	1
SST 866	12.82	14	13.72	15	13.50	22	14.33	18	13.59	11	13.35	15	13.27	14
SST 867	12.84	13	14.32	5	13.12	26	15.24	6	13.88	9	13.42	14	13.58	8
SST 875	12.99	9	12.93	29	12.82	27	14.25	19	13.25	14	12.91	19	12.96	21
SST 876	13.94	3	13.56	22	13.86	14	14.90	10	14.06	5	13.79	7	13.75	4
SST 877	12.73	15	13.92	11	14.20	8	14.73	12	13.90	8	13.62	9	13.33	12
SST 878							13.93	20						
SST 884	12.50	22	13.49	25	13.41	24					13.13	18	13.00	20
SST 895	13.13	8	14.08	9	14.45	5					13.88	4	13.60	7
SST 896	13.19	6												
Steenbras			13.27	28	13.61	20								
Tamboti	12.73	16	13.61	21	14.15	9					13.50	11	13.17	17
Timbavati	13.15	7	14.10	8	13.88	12					13.71	8	13.62	6
Umlazi	12.93	11	13.69	18	13.72	19					13.45	12	13.31	13
Average	**13.06**		**13.82**		**13.89**		**14.87**		**13.94**		**13.61**		**13.44**	
LSD$_t$(0,05)	**1.29**		**0.56**		**0.59**		**0.50**		**0.33**		**0.43**		**0.58**	

** Only Danielsrus data*

Average falling number (s) of entries for the Eastern Highveld irrigation area (late planting date) during the full or partial period from 2010 – 2013 (Danielsrus site only)

Cultivar	2013*	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Baviaans			346	12	386	7	244	7						
Buffels	259	20	371	4	365	17	304	2	325	3	332	12	315	13
CRN 826			275	30	378	11	194	13						
Duzi	303	8	359	9	343	24	223	12	307	7	335	9	331	5
Kariega			361	8	367	16	261	4						
Krokodil	210	24	345	13	302	28	133	21	247	15	286	20	277	22
Olifants			323	20	389	4	163	17						
PAN 3400	302	9	337	17									319	8
PAN 3434					372	12	312	1						
PAN 3471	269	17	314	22	341	25	160	19	271	14	308	17	291	18
PAN 3478	274	15	368	5	387	5	255	6	321	4	343	7	321	7
PAN 3489	232	23	293	28									262	23
PAN 3497	284	13	351	10									318	11
Sabie	330	2	372	3	356	21	243	8	325	2	353	3	351	2
SST 806	260	19	311	24	397	1	168	15	284	13	323	15	285	20
SST 815			344	14	382	9								
SST 816			301	27	371	13								
SST 822	237	22	337	16	333	26	243	9	287	10	302	18	287	19
SST 835	319	3	302	26	379	10	168	16	292	9	333	10	311	14
SST 843	279	14	335	18	363	19	302	3	320	5	326	14	307	15
SST 866	310	6	326	19	395	2	242	10	318	6	343	6	318	10
SST 867	316	5	376	2	370	14	259	5	330	1	354	2	346	3
SST 875	304	7	310	25	385	8	141	20	285	12	333	11	307	16
SST 876	273	16	321	21	358	20	191	14	286	11	317	16	297	17
SST 877	261	18	378	1	351	22	236	11	306	8	330	13	319	9
SST 878							161	18						
SST 884	242	21	313	23	344	23					300	19	278	21
SST 895	288	12	362	7	393	3					348	4	325	6
SST 896	288	11												
Steenbras			278	29	306	27								
Tamboti	296	10	339	15	387	6					341	8	317	12
Timbavati	346	1	366	6	365	18					359	1	356	1
Umlazi	317	4	347	11	368	15					344	5	332	4
Average	**283**		**335**		**365**		**219**		**300**		**330**		**312**	
LSD$_t$(0,05)	**71.11**		**41.53**		**31.48**		**64.02**		**24.36**		**24.56**		**35.01**	

** Only Danielsrus data*

Average yield (ton/ha) of entries for the KwaZulu-Natal area during the full or partial period from 2010 – 2013

Cultivar	2013*	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Baviaans			6.82	28	7.67	17	5.83	12						
Buffels	6.89	20	7.35	24	7.04	24	4.92	21	6.55	15	7.09	17	7.12	21
CRN 826			8.53	5	7.69	16	6.17	7						
Duzi	7.28	15	7.75	19	8.46	8	5.95	11	7.36	9	7.83	9	7.51	15
Kariega			6.90	27	7.40	21	5.13	20						
Krokodil	7.75	5	8.61	3	8.69	5	5.60	16	7.66	6	8.35	2	8.18	3
Olifants			7.91	16	7.28	23	5.60	15						
PAN 3400	7.31	13	7.87	18									7.59	14
PAN 3434					8.03	12	5.43	19						
PAN 3471	7.64	8	8.34	8	8.56	7	6.53	2	7.77	3	8.18	6	7.99	5
PAN 3478	7.11	17	8.43	6	9.02	2	6.22	6	7.70	5	8.19	5	7.77	7
PAN 3489	8.24	1	7.94	15									8.09	4
PAN 3497	7.46	10	8.06	12									7.76	9
Sabie	7.93	3	6.54	29	7.01	25	5.58	17	6.76	13	7.16	16	7.23	18
SST 806	7.70	6	8.90	1	8.72	4	6.16	8	7.87	1	8.44	1	8.30	2
SST 815			8.34	9	8.26	10								
SST 816			8.72	2	8.56	6								
SST 822	6.59	23	7.89	17	7.52	19	5.98	10	7.00	11	7.33	13	7.24	17
SST 835	8.02	2	8.61	3	8.34	9	6.24	5	7.80	2	8.32	3	8.31	1
SST 843	6.34	24	7.44	23	7.74	15	5.74	14	6.82	12	7.17	15	6.89	22
SST 866	7.66	7	8.27	11	7.65	18	6.12	9	7.43	8	7.86	8	7.96	6
SST 867	7.07	18	7.18	25	6.75	27	5.48	18	6.62	14	7.00	19	7.13	20
SST 875	7.87	4	7.58	21	9.14	1	6.31	4	7.72	4	8.20	4	7.72	10
SST 876	6.93	19	8.37	7	8.74	3	6.61	1	7.66	7	8.01	7	7.65	12
SST 877	7.37	11	7.98	14	8.06	11	5.76	13	7.29	10	7.80	11	7.67	11
SST 878							6.33	3						
SST 884	6.80	21	7.69	20	7.50	20					7.33	14	7.24	16
SST 895	7.23	16	8.31	10	7.88	14					7.81	10	7.77	8
SST 896	7.36	12												
Steenbras			7.52	22	8.02	13								
Tamboti	7.30	14	8.00	13	7.33	22					7.54	12	7.65	12
Timbavati	6.66	22	6.10	30	6.63	28					6.46	20	6.38	23
Umlazi	7.52	9	6.92	26	6.84	26					7.09	18	7.22	19
Average	**7.33**		**7.83**		**7.88**		**5.89**		**7.33**		**7.66**		**7.58**	
LSD_t(0,05)	**0.62**		**0.97**		**1.04**		**0.39**		**0.33**		**0.55**		**0.61**	

** Only Bergville data*

Average hectolitre mass (kg/hl) of entries for the KwaZulu-Natal area during the full or partial period from 2010 – 2013

Cultivar	2013*	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Baviaans			83.28	17	81.53	19	78.00	10						
Buffels	78.69	1	81.22	26	80.75	25	76.50	19	79.29	11	80.22	14	79.96	7
CRN 826			84.93	3	82.10	15	78.70	5						
Duzi	78.53	2	82.33	21	81.45	20	77.10	14	79.85	9	80.77	7	80.43	5
Kariega			80.65	27	81.08	24	77.00	16						
Krokodil	75.52	12	83.03	19	82.70	12	75.60	20	79.21	12	80.42	12	79.28	12
Olifants			83.30	16	81.64	18	78.00	10						
PAN 3400	74.44	18	83.73	12									79.09	16
PAN 3434					81.15	23	76.90	18						
PAN 3471	76.74	7	84.45	7	83.70	7	79.70	1	81.15	1	81.63	2	80.60	3
PAN 3478	76.26	8	81.75	24	84.80	1	79.60	2	80.60	4	80.94	5	79.01	17
PAN 3489	75.27	14	83.43	15									79.35	10
PAN 3497	78.00	5	84.28	9									81.14	2
Sabie	75.50	13	80.60	28	80.08	26	77.00	16	78.29	14	78.73	19	78.05	22
SST 806	75.14	15	85.62	1	83.78	6	78.70	5	80.81	3	81.51	3	80.38	6
SST 815			84.53	6	82.10	15								
SST 816			85.00	2	84.20	3								
SST 822	74.26	20	84.40	8	82.45	13	78.10	8	79.80	10	80.37	13	79.33	11
SST 835	74.20	21	84.68	5	83.25	10	78.20	7	80.08	6	80.71	9	79.44	9
SST 843	74.07	22	83.90	11	83.33	9	79.00	3	80.07	8	80.43	11	78.99	18
SST 866	78.41	3	84.08	10	83.03	11	78.00	10	80.88	2	81.84	1	81.25	1
SST 867	75.76	11	82.18	23	81.25	22	77.10	14	79.07	13	79.73	16	78.97	19
SST 875	76.16	10	82.20	22	83.85	5	78.10	8	80.08	7	80.74	8	79.18	15
SST 876	74.79	17	83.73	12	83.88	4	78.90	4	80.32	5	80.80	6	79.26	14
SST 877	74.89	16	81.53	25	81.30	21	74.40	21	78.03	15	79.24	18	78.21	21
SST 878							77.40	13						
SST 884	73.89	23	83.23	18	82.18	14					79.77	15	78.56	20
SST 895	76.23	9	84.80	4	83.45	8					81.49	4	80.52	4
SST 896	74.41	19												
Steenbras			83.58	14	84.28	2								
Tamboti	77.17	6	82.42	20	81.75	17					80.45	10	79.80	8
Timbavati	73.73	24	79.58	30	79.73	28					77.68	20	76.66	23
Umlazi	78.22	4	80.33	29	80.08	26					79.54	17	79.28	12
Average	**75.85**		**83.09**		**82.31**		**77.71**		**79.84**		**80.35**		**79.42**	
LSD (0,05)	**3.57**		**2.36**		**1.34**		**1.11**		**1.09**		**1.75**		**2.43**	

** Only Bergville data*

Average protein content (%) of entries for the KwaZulu-Natal area during the full or partial period from 2010 – 2013

Cultivar	2013*	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Baviaans			13.68	6	13.12	4	13.21	18						
Buffels	14.10	7	13.22	14	13.07	6	13.59	8	13.50	5	13.46	7	13.66	9
CRN 826			13.16	18	12.85	13	13.49	11						
Duzi	13.63	18	13.07	22	12.76	16	13.44	12	13.22	10	13.15	14	13.35	18
Kariega			14.18	4	12.97	10	13.43	13						
Krokodil	12.96	24	12.30	30	11.95	27	12.18	20	12.35	15	12.40	20	12.63	23
Olifants			14.65	2	14.49	2	14.98	2						
PAN 3400	13.78	14	12.82	28									13.30	20
PAN 3434					12.87	12	13.70	6						
PAN 3471	13.58	20	13.04	23	12.16	25	13.38	16	13.04	12	12.93	17	13.31	19
PAN 3478	13.76	15	13.18	16	12.43	23	13.76	4	13.28	8	13.12	15	13.47	13
PAN 3489	13.64	17	13.15	19									13.39	17
PAN 3497	14.18	6	13.07	21									13.63	10
Sabie	13.48	21	14.43	3	13.11	5	13.57	10	13.65	4	13.67	5	13.95	6
SST 806	14.05	8	13.37	12	12.83	14	13.58	9	13.45	7	13.41	8	13.71	8
SST 815			12.94	26	12.61	19								
SST 816			13.17	17	12.64	18								
SST 822	14.96	2	13.49	8	13.44	3	13.94	3	13.96	2	13.96	2	14.22	2
SST 835	13.59	19	13.43	11	12.44	22	13.41	15	13.22	11	13.15	13	13.51	12
SST 843	16.06	1	14.98	1	14.82	1	15.35	1	15.30	1	15.29	1	15.52	1
SST 866	13.85	11	13.02	24	11.86	28	13.23	17	12.99	13	12.91	18	13.43	16
SST 867	14.55	3	13.48	9	12.99	8	13.66	7	13.67	3	13.67	4	14.01	5
SST 875	13.32	23	12.80	29	12.02	26	13.17	19	12.83	14	12.71	19	13.06	22
SST 876	13.82	13	13.21	15	12.53	21	13.43	13	13.25	9	13.19	12	13.51	11
SST 877	14.01	9	13.45	10	12.74	17	13.76	4	13.49	6	13.40	9	13.73	7
SST 878							12.15	21						
SST 884	13.67	16	13.23	13	13.02	7					13.31	10	13.45	14
SST 895	14.42	4	13.64	7	12.91	11					13.66	6	14.03	4
SST 896	13.84	12												
Steenbras			12.86	27	12.35	24								
Tamboti	13.94	10	12.95	25	12.79	15					13.23	11	13.44	15
Timbavati	14.28	5	13.93	5	12.98	9					13.73	3	14.10	3
Umlazi	13.38	22	13.14	20	12.60	20					13.04	16	13.26	21
Average	**13.95**		**13.37**		**12.83**		**13.54**		**13.41**		**13.37**		**13.64**	
LSD (0,05)	**0.58**		**0.66**		**0.54**		**0.52**		**0.32**		**0.35**		**0.45**	

** Only Bergville data*

Average falling number (s) of entries for the KwaZulu-Natal area during the full or partial period from 2010 – 2013

Cultivar	2013*	R	2012	R	2011	R	2010	R	4 year average 2010-2013	R	3 year average 2011-2013	R	2 year average 2012-2013	R
Baviaans			410	1	358	11	311	5						
Buffels	330	4	397	26	340	24	312	3	345	3	356	8	364	7
CRN 826			410	1	355	15	245	19						
Duzi	318	8	410	1	344	23	286	10	339	4	357	6	364	6
Kariega			410	1	346	22	312	3						
Krokodil	284	18	358	30	330	26	258	16	307	15	324	19	321	22
Olifants			410	1	369	7	276	13						
PAN 3400	320	7	410	1									365	5
PAN 3434					348	19	312	1						
PAN 3471	280	19	406	21	368	8	249	17	326	10	351	10	343	17
PAN 3478	332	3	410	1	371	6	299	7	353	1	371	3	371	3
PAN 3489	302	11	405	23									353	11
PAN 3497	287	15	410	1									348	14
Sabie	350	1	410	1	357	13	293	8	353	2	372	2	380	1
SST 806	243	23	410	1	371	5	233	20	314	13	341	15	327	21
SST 815			410	1	358	11								
SST 816			392	28	374	2								
SST 822	266	20	410	1	332	25	280	12	322	11	336	17	338	18
SST 835	252	21	410	1	356	14	245	18	316	12	339	16	331	19
SST 843	195	24	401	24	372	4	290	9	314	14	322	20	298	23
SST 866	291	14	408	18	346	21	282	11	332	8	348	12	349	13
SST 867	295	13	410	1	328	27	312	1	336	6	344	14	352	12
SST 875	298	12	391	29	360	10	270	15	330	9	349	11	344	16
SST 876	286	17	409	16	376	1	275	14	337	5	357	7	347	15
SST 877	309	9	408	19	326	28	300	6	336	7	347	13	358	9
SST 878							196	21						
SST 884	248	22	409	17	349	17					335	18	328	20
SST 895	338	2	410	1	374	2					374	1	374	2
SST 896	286	16												
Steenbras			401	25	352	16								
Tamboti	325	5	407	20	346	20					359	5	366	4
Timbavati	304	10	405	22	348	18					352	9	355	10
Umlazi	325	5	397	27	365	9					362	4	361	8
Average	**294**		**405**		**354**		**278**		**331**		**350**		**349**	
LSD (0,05)	**48.44**		**18.17**		**25.02**		**27.66**		**16.33**		**18.76**		**25.90**	

** Only Bergville data*


vkb
SEED PLANT

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, supple- mentation 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 $Al3^{+}$ - 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

Excellent tolerance	Moderate tolerance	Poor tolerance	Unknown tolerance
PAN 3118 (PBR)	Gariep	Elands (PBR)	Matlabas (PBR)
PAN 3120 (PBR)		Komati (PBR)	SST 347 (PBR)
PAN 3161 (PBR)		PAN 3144 (PBR)	SST 356 (PBR)
PAN 3355 (PBR)		PAN 3368 (PBR)	SST 374 (PBR)
PAN 3379 (PBR)			SST 387 (PBR)

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

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 (kgP/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

METHODS TO INCREASE HERBICIDE EFFICACY

There are various methods to increase herbicide efficacy.

Increase the herbicide rate

Herbicide efficacy usually increases with rate. Higher rates will often overcome poor performance as a result of adverse environments. Increase in herbicide rate to overcome environmental constraints has disadvantages and should not be regarded as the only option to enhance herbicide efficacy. The disadvantages of high rates are discussed below.

Cost ineffective

High herbicide use rates are costly and should only be used when other options are unavailable.

Environmental concern

Most herbicides are safe at recommended rates, but some may have soil residual or may leach. High rates increase the potential of residual in the soil, surface water or ground water. Every effort should be made to optimise herbicide efficacy with methods which do not involve higher rates.

Unstable performance

Herbicide absorption is often very dependent on the climatic conditions during and just after spraying. If the rate of a herbicide is increased to a level that acceptable control is obtained under sub-optimal conditions, then probably too much herbicide is applied under optimal conditions. The same argument applies to crop damage. A high herbicide rate, which causes no damage under poor conditions, could injure a crop under optimal conditions.

Avoiding limiting factors

Another way of getting the most from a herbicide is to always spray under optimal climatic conditions. This will ensure adequate absorption in most cases. The limiting factors which should be avoided include the following:

- Low humidity
- Moisture stressed plants
- Wind
- Rain directly after application
- Water with high salt concentrations

Avoiding these limiting factors sounds good on paper, but is almost impossible in practice. However, herbicides should be applied under favourable conditions whenever possible. The variability, unpredictability and harshness of the South African climate is well known. Other methods for optimising herbicide efficacy must be investigated.

Adjuvants

Adjuvants are substances which compensate, to a degree, for herbicide limiting environmental factors. They stabilise herbicide efficacy under various conditions, increase efficacy under harsh conditions and reduce potential of crop injury under optimal conditions compared to the use of high rates. Most herbicides are used at lower rates when applied with adjuvants accounting for the reduced crop injury under optimal environments. Adjuvants may not be needed with a high rate of herbicide or when avoiding stress conditions. Higher rates however, could be expensive and avoiding stress conditions is not always possible. Adjuvants often are only effective with certain herbicides and may not totally overcome harsh conditions. The important point is that herbicides often are specific and consideration must still be given to stress conditions, specific herbicides, spray volume and spray carrier salts.

MISCONCEPTIONS REGARDING ADJUVANTS AND HERBICIDE EFFICACY

There are many misconceptions about adjuvants.

Wetting/Spreading

The most common misconception is that adjuvants which wet the leaf effectively are always the most effective. It is true that certain herbicides are more effective with "effective spreaders", but this is not a general rule with all herbicides.

Crop damage (phytotoxicity)

It is extremely convenient to blame crop damage of certain herbicides on the adjuvant applied with the herbicide. Adjuvants are often characterised as "too hot" for certain herbicides. One must however bear in mind that adjuvants only improve the activity of herbicides and seldom have phytotoxic effects of their own. Crop damage results from too much herbicide penetrating and damaging the crop. It is then ultimately an excess of herbicide which causes the damage and not the adjuvant. Herbicides, at recommended lower rates applied with adjuvants, normally result in more stable herbicides as far as efficacy and selectivity on the crop is concerned. This is a result of similar amounts of herbicide penetrating the weeds and crop under most climatic conditions. Adjuvants are therefore not the cause of herbicide damage on crops. On the contrary, they may decrease crop damage by allowing for lower herbicide use rates under various conditions.

Similar adjuvant enhancement of herbicide efficacy

Another misconception is that adjuvants are all similar in action and that one adjuvant may be substituted for another. This may be true if the rate of the herbicide is high enough to give total weed control, but not when the herbicide is applied at low economical rates under adverse climatic conditions. The sole purpose of adjuvants is to increase the efficacy of herbicides when using low, economical rates.

Certain adjuvants are superior to others and may be used universally

Since the first adjuvants were applied it has always been the aim of adjuvant manufacturers and scientists alike to create a "blockbuster" adjuvant which may be used universally with all herbicides. Up to date there is no such miracle adjuvant and adjuvants are normally only beneficial to certain herbicides. Adjuvants have limitations just as any other agricultural product. Both advantages and disadvantages of adjuvants need to be understood for correct usage. Advantageous adjuvants could become disadvantageous if used incorrectly. Poor efficacy or crop damage could result.

ACIDIFICATION

Some herbicides applied at low pH are more effective than at high pH for certain reasons. Before herbicides are acidified as a standard practice, it is important to understand the reasons for acidification and that acidification is not always beneficial. It is also necessary to understand that there are, barring the acid products, also surfactants which without the addition of any acid have the ability to acidify the spray solution. These surfactants include the phosphate esters and have the dual purpose of acidification and the other properties contained by surfactants.

When must spray solutions be acidified?

Only when specified on the label.

- Never omit the registered acidifier or buffer.
- Do not acidify spray solutions as a standard practice when not recommended.
- Never substitute one buffer or acidifier with another as the acids differ in different products. If necessary only substitute products with the same acids.

Method of acidification

Labels are very specific on the amount of acidifier to be added and the sequence order of addition. Buffers and acidifiers are normally added prior to the herbicide and the other adjuvants. Excess acidification may cause herbicide breakdown or interfere with uptake by the plant. Label recommendations on amount of product and sequence of mixing are designed to optimise compatibility over a wide range of conditions.

Acidification is not always beneficial

Although acidification is sometimes advantageous, it may be disadvantageous with certain herbicides. This once again proves that no adjuvant is universal in its use and that adjuvants are herbicide specific.

CONDITIONS DURING AND JUST AFTER SPRAYING

Optimal conditions for herbicide application could allow for efficacy even when recommendations are not followed. Improper applications however, will severely reduce efficacy under adverse conditions such as low humidity. These improper applications could be omission of or use of the wrong adjuvant or unregistered mixtures. The following conditions may adversely affect herbicide absorption, especially when the right choice of adjuvant and herbicide mixtures determine efficacy:

Low humidity and wind

Spray solution droplets on weed leaf surfaces under low humidity and windy conditions are prone to rapid evaporation. Adjuvants which increase the rate of penetration or decrease the rate of evaporation under these conditions will increase herbicide penetration and increase herbicide efficacy. On the other hand, any factor which decreases rate of penetration will decrease the amount of herbicide absorbed and the subsequent efficacy of the herbicide. These factors include the omission of the registered adjuvant, the use of the wrong adjuvant or the application of antagonistic mixtures of herbicides.

Sunlight (Ultraviolet light)

Certain herbicides are prone to breakdown by ultraviolet light on the leaf surface. Any factors decreasing the rate of uptake of these herbicides will increase the chance of ultraviolet breakdown and decrease herbicide efficacy. These factors could include wrong choice or omission of the registered adjuvant, antagonistic mixtures or the time of day applied.

Rain

Herbicides are classified as rainfast after a certain period of time. This means that rain after this period of time will not decrease herbicide efficacy. Rainfastness in many instances just indicates that the herbicide has been absorbed into the weed. Rate of penetration will decrease the effect of wash-off from raindrops and will make the herbicide rainfast. Rapid penetration could have additional advantages such as protecting the herbicide droplet against factors such as low humidity, wind or ultraviolet light breakdown.

Moisture stress

Weeds under soil moisture stress do not grow actively and are not receptive to efficient herbicide uptake. Any factor which decreases absorption or rate of absorption will devastate herbicide efficacy on moisture stressed weeds. Even adjuvants cannot negate the negative absorption response from moisture stressed plants.

Chemical factors

Adjuvants

Adjuvants partially overcome the influence of stress conditions on herbicides. The wrong adjuvant choice can therefore decrease herbicide efficacy under stress conditions. A good knowledge of adjuvants is therefore essential if replacing one adjuvant with another.

Mixtures

Antagonistic herbicide mixtures are a major source for decreased herbicide efficacy. Antagonistic herbicides affect one another's absorption and the resulting efficacy. These mixtures are most pronounced under adverse climatic conditions.

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 Institute at a cost of R50 (+ R6 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 is a small (<2.0 mm), spindle shaped, pale yellow-green to grey-green aphid with extremely short antennae and a "double tail"(Figure 1a).

Figure 1a: 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. In 2011 the distribution of the RWA biotypes was similar to the previous years, but a new biotype, RWASA4 was recorded in the Eastern Free State (Fig: 1 b).

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)	MR	S	S	S
Gariep	R	S	S	S
Koonap (PBR)	MR	S	S	S
Matlabas (PBR)	R	S	S	S
Senqu (PBR)	R	S	S	R
PAN 3118 (PBR)	S	S	S	S
PAN 3120 (PBR)	S	S	S	S
PAN 3161 (PBR)	R	R	R	S
PAN 3195 (PBR)	R	S	S	S
PAN 3368 (PBR)	MR	MR	R	R
PAN 3379 (PBR)	R	R	R	R
SST 316 (PBR)	MR	S	S	S
SST 317 (PBR)	MR	S	S	S
SST 347 (PBR)	R	S	S	S
SST 356 (PBR)	MR	S	S	S
SST 374 (PBR)	R	S	S	S
SST 387 (PBR)	R	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 Russian wheat aphid for the past 12 years and it is recomended to still plant cultivars with resistance to RWASA1. It is not possible to visually distinguish between the biotypes, however damage symptoms can easily be recognized. 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 10)

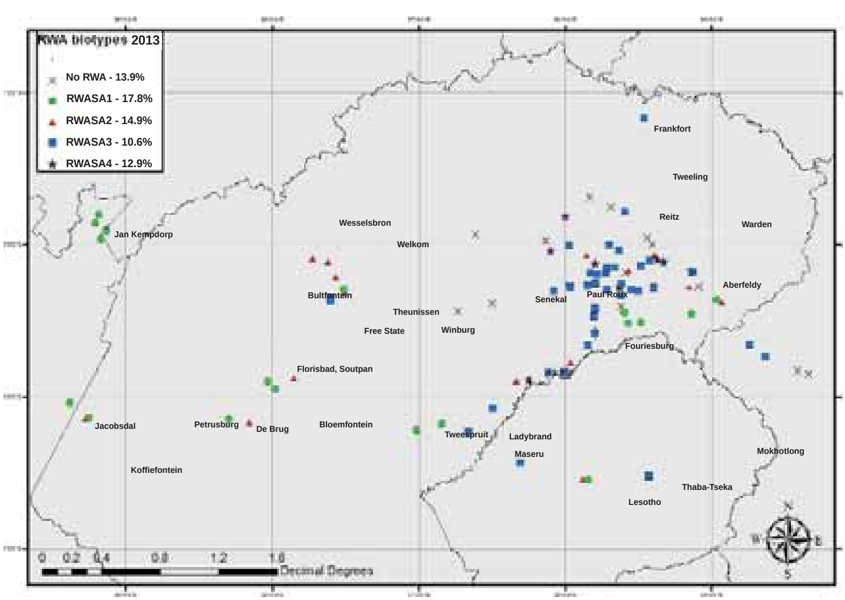


Fig 1b: Distribution of Russian wheat aphid biotypes in the Summer rainfall area in South Africa during in 2012

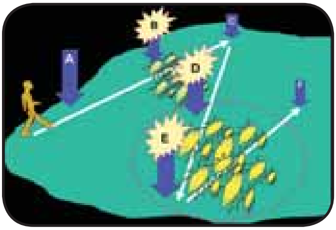
Table 2. The minimum infestation levels that necessitate spraying against Russian wheat aphid at various yield potentials

Yield potential (ton ha-1)	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.

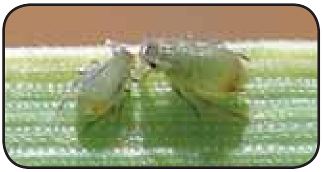


Figure 1c: Oat aphid

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 1c). A green and brown form of the English grain aphid (Fig 1d) 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 1e). The siphunculi of this aphid are the same colour as the body.

Figure 1d: English grain aphid

Figure 1e: Rose grain aphid

These aphids are less harmful than Russian wheat aphid and all three of them can occur simultaneously. 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. 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. 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 beatween 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 speckeled 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 up-take and translocation of systemic insecticides. Producers should also take note that rain showers of 12mm 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 20mm 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 20mm. 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 40mm 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 12-15mm 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 2a) infests the wheat and barley crop under irrigation in the Northern Cape, North West and the Western Free State. The female drills holes in leaves with her ovipositor and eggs are laid in some, while the rest of the holes 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 2b) and can't be revived by spraying insecticides. The fully grown larvae escape from the leaf and pupate in the soil (Fig 2c). The adult flies hatch from the pupae at a later stage. The amount of yield loss caused by this insect is still uncertain.

Figure 2a. Adult leaf miner fly

Figure 2b. Mined portion of the wheat leafs which turned brown

Figure 2c. 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.

Figure 2d. False armyworm larve

DISEASES OF SMALL GRAINS

Diseases of small grains affect small grain production by reducing yield and impairing quality. To maximize 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

The rusts are widespread and important diseases of small grains, but they also infect many other wild and cultivated grasses. In South Africa, urediniospores play a major role in the development of rust epidemics. In the non-crop season, rust pathogens are able to survive on volunteer plants. The wind dispersed urediniospores formed on these plants are a source of inoculum for the disease. In the following season, small grain crops are infected by the urediniospores and first symptoms are typical urediniospore pustules. Later in the season, as another kind of dark coloured spore, known as teliospores, develop within lesions, the lesions start to appear black in colour. In other countries, teliospores produce basidiospores that infect an alternate host and play an important role in the sexual disease cycle but the alternate host plants, that these spores infect, do not occur within the small grain production areas in South Africa and thus teliospores are not of importance in our cultivation systems.

All the rust diseases can affect grain yield and quality, although the extent to which a cultivar will be affected will depend on the level of susceptibility of that cultivar, environmental conditions that favour the proliferation of the disease and the levels of inoculum present. In general, stem rust is more devastating than leaf rust or stripe rust, but as mentioned, the cultivar and area under production should also be considered. Devastating crop losses and even total crop losses have been experienced as a result of rust diseases and it remains one of the biggest challenges to the successful cultivation of small grains. Breeding and planting cultivars that are resistant to rust is one of the most important ways of controlling the disease. Several research groups in South Africa are dedicated to the development of rust resistant cultivars. However, the process of breeding resistant lines takes time and usually it takes a number of years before a new resistant cultivar becomes commercially available. Moreover, rust diseases may overcome the host resistance, so the use of fungicides forms an important part of the control of these diseases on susceptible cultivars. In South Africa, the application of fungicides for the control of rust is widely practiced. Foliar fungicides are generally applied twice in a season.

Stem rust

Puccinia graminis f. sp. ***tritici*** – wheat, barley, triticale

Puccinia graminis f. sp. ***avenae*** – oats

Puccinia graminis f. sp. ***secalis*** – rye

Stem rust (photos 1, 2 and 3), also known as black rust, is a widespread and economically important disease of a number of cereal grains. Disease symptoms occur on leaf sheaths, leaf blades, stems and spikes. The epidermis is ruptured by elongated oval shaped pustules (uredia), which contain masses of red-brown coloured urediniospores. These pustules may converge so that big parts of the stem appear red-brown in colour.

Leaf rust

Puccinia triticina – wheat, triticale

Puccinia hordei – barley

Leaf rust (photo 4), also known as brown rust, occurs commonly in areas where wheat and barley are grown. Orange brown elliptical pustules are found scattered at random on the leaves. The pustules may be surrounded by a yellow halo. Under high disease pressure, pustules appear on the ears of the grain.

Stripe rust

Puccinia striiformis f. sp.***tritici*** – wheat, barley

Puccinia striiformis f. sp.***hordei*** – barley

Stripe rust (photos 5, 6 and 7), also known as yellow rust, occurs throughout the small grain production areas of South Africa, but is found more frequently in the Free State. Typical stripe rust symptoms consist of yellow to orange coloured pustules that develop in narrow stripes on the leaf sheaths and on the inner surfaces of glumes and lemmas of the heads.

Crown rust

Puccinia coronata f. sp. ***avenae*** – oats

Crown rust is a widespread and damaging disease of oats. On susceptible cultivars, bright orange to yellow coloured elongated oval pustules occur mainly on leaves but can also occur on the sheaths and floral structures. The yield and quality of the oats is affected by this disease as the groat mass can be reduced. Planting resistant cultivars is the most effective manner of controlling crown rust although there are currently no resistant cultivars commercially available. Several of the breeders' lines in the SGI oats breeding program show resistance against crown rust and may potentially be released in future. Spraying foliar fungicides can be highly effective for controlling crown rust, but it is often, especially when the oats is produced as animal feed, not economically justified.

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 (photos 8 and 9) 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 (photos 10 and 11) 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 Research Institute)*

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

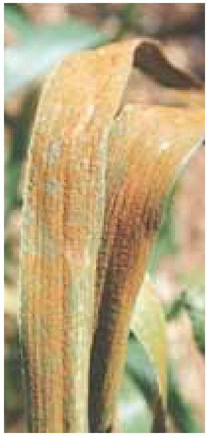
Take-all (photo 12) occurs widely throughout the small grain producing areas in South Africa. This disease affects the roots, crowns and basal stems of small grains, wheat in particular, and wild grasses. It is an important disease in areas where wheat is cultured intensively, the soil pH is neutral 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.

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

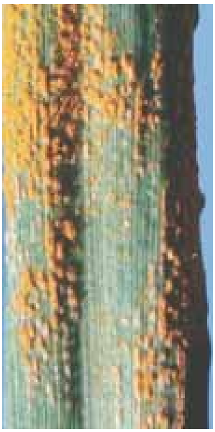
1. Uredinia of stem rust on a wheat ear

2. Uredinia of stem rust on a oat stem

3. Uredinlospores and teliospores of stem rust on a wheat stem



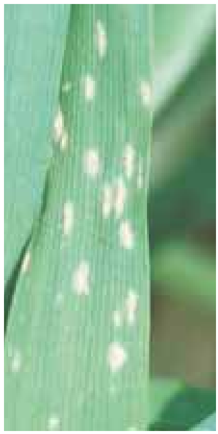
4. Uredinia of leaf rust on wheat leaves



5. Uredinia of stripe rusts on a wheat leaf

6. Uredinia of stripe rust on wheat spikelets

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



8. Cottony white growth of powdery mildew on a barley leaf

Simptoms of small grain diseases

9. Cottony white growth of powdery mildew on the ear of wheat

10. Wheat ear infected with loose smut

11. Oats ear infected with loose smut

12. Blackened crowns of wheat with take-all infection

13. Net form symptom of net blotch on a barley

14. Spot form symptom of net blotch on a barley leaf

15. Wheat ear infected with loose smut

16. A typical eyespot symptom on wheat

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 that are recommended for cultivation under dryland conditions in the summer rainfall region.

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

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

MR = Moderately resistant *? = unknown*

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	Head blight
Baviaans (PBR)	S	MS	R	MS
Buffels (PBR)	S	R/S	R	?
Duzi (PBR)	S	S	R	MS
Kariega	S	MS	R	MS
Krokodil (PBR)	MS	S	S	S
Olifants (PBR)	S	S	R	MS
PAN 3400 (PBR)	MSS	S	R	?
PAN 3471 (PBR)	S	MRMS	R	S
PAN 3478 (PBR)	S	MSS	R	MS
PAN 3497 (PBR)	MSS	S	R	?
Sabie (PBR)	S	MS	R	?
SST 806 (PBR)	S	MS	R	HS
SST 822 (PBR)	MS	MS	R	S
SST 835 (PBR)	MS	MS	MR	HS
SST 843 (PBR)	MS	MS	R	S
SST 866 (PBR)	S	MS	R/MS	?
SST 867 (PBR)	S	MS	MR	?
SST 875 (PBR)	S	MR	R	?
SST 876 (PBR)	S	MS	MR	HS
SST 877 (PBR)	S	MS	R/MS	?
SST 884 (PBR)	MR	S	R	?
SST 895 (PBR)	MRMS	R	R	?
Steenbras (PBR)	R	MR	S	S

S=Susceptible MS= Moderately susceptible HS=Highly susceptible APR=Adult plant resistance

R=Resistant MR=Moderately resistant ?=Unknown / = mixed for rust reaction

PBR Cultivars protected by Plant Breeders' Rights
** SST 866: Subject to variety listing*
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	

Diseases must be identified correctly. For this purpose the reader may consult relevant publications such as the booklet "Wheat Diseases in South Africa" by D B Scott, which is obtainable from the ARC-Small Grain Institute, Private Bag X29, Bethlehem 9700, at the price of R20-00 (VAT included). Postage amounts to R10-00.

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 2014

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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 programmes running in the irrigation areas since 1991 were therefore aimed at identifying the most suitable cultivar with the optimum planting date, 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 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 or keep it in stock without the necessary authorization or licence 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 cultivator 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 forthis peace of mind to 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, Cocktail, Puma, Marthe and Cristalia are at this point in time the only recommended cultivars for commercial production of malting barley under irrigation. The ratio of production between these four 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 all four commercial 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 to the producer 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 and heat stress occur during the grain filling period and 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 (%)
Puma	ME	MS	G	M	M
Cocktail	M	MS	G	M	ML
Marthe	ME	M	M	M	G
Cristalia	ME	M	G	M	G

Growth period: ME = Medium Early; M = Medium
Straw length: MS = Medium Short; M = Medium
Straw strength: G = Good; M = Medium
Peduncle strength: M = Medium
Kernel Plumpness (%) M = Medium; ML = Medium Low

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 dates for the different irrigation areas are as follows:

Region	June				July			
	1	2	3	4	1	2	3	4
Vaalharts / Taung								
Riet River								
Douglas								
Luckhoff/Hopetown								
Barkly-West								

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 100 kg/ha depending on the status of the seedbed, the planting date, irrigation method and the planter used. The average recommended planting density is 80 kg/ha if the seed have 100% germination capacity and a thousand kernel mass of approximately 40 grams. There must be aimed at establishing 130 to 140 plants/m² at harvesting. Due to this reason 60 to 80 kg seed per hectare ought to be sufficient under centre pivot conditions where seedbed preparation is optimum, it is important to note that seedbed preparation plays a vital role where lower planting densities is used. It is essential not to use a too high planting density for Marthe, as this will enhance the possibility of lodging. It can be considered to increase the planting density of Cristalia in order to insure the optimum plant population (80 – 100 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. 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 Mass (g) of Seed	**Target number of plants/m² 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 four seasons are shown in the following three tables.

Table 2. Average yield (ton/ha) of barley cultivars in the irrigation regions for the period 2009-2013

Cultivar	2009	2010	2011	2012	2013	Average
Puma	6.70	6.52	9.56	8.38	8.15	**7.86**
Cocktail	6.99	7.61	10.57	9.24	8.78	**8.64**
Marthe	7.02	6.61	9.76	8.54	7.96	**7.98**
Cristalia	7.21	6.98	9.69	8.65	8.19	**8.14**
Average	6.98	6.93	9.90	8.70	8.27	**8.16**

Table 3. Average kernel plumpness (%) of barley cultivars in the irrigation regions for the period 2009-2013

Cultivar	2009	2010	2011	2012	2013	Average
Puma	93.1	90.2	98.7	95.3	96.2	**94.7**
Cocktail	86.4	83.8	97.4	94.5	95.7	**91.6**
Marthe	92.5	92.9	98.4	96.5	96.1	**95.3**
Cristalia	89.4	91.5	97.3	95.4	97.1	**94.1**
Average	90.4	89.6	98.0	95.4	96.3	**93.9**

Table 4. Average kernel nitrogen (%) of barley cultivars in the irrigation regions for the period 2009-2013

Cultivar	2009	2010	2011	2012	2013	Average
Puma	1.86	1.95	1.92	1.86	1.76	**1.87**
Cocktail	1.75	1.78	1.83	1.71	1.64	**1.74**
Marthe	1.82	1.88	1.91	1.88	1.65	**1.83**
Cristalia	1.79	1.79	1.90	1.78	1.70	**1.79**
Average	1.81	1.85	1.89	1.81	1.69	**1.81**

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 which the analyses is below 30 mg/kg (citric acid), or 6 kg P/ha for each 1 mg/kg which 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 5. 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 had 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. It must further be taken into account that the Cocktail, has a genetically higher yield potential and lower kernel nitrogen content than the other cultivars. Due to this Cocktail must be fertilised with approximately 20 to 30 kg N/ha more in order to obtain its genetic potential to achieve the same kernel nitrogen levels than the other cultivars.

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, seem 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 showed 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 been 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.

Currently leaf miners also seem to become an increasing problem in all production areas. For the interim an emergency registration was obtained on the product Unimectin 18EC for the control of leaf miners.

During the 2010 season the false armyworm caused huge damage to plantings, especially in the Vaalharts area. It was, however was noticed throughout the entire production areas 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 10 to 14 weeks after planting. At this specific stage, water stress will have the least negative effect on yield.

Lower planting densities (<140 plants/m^2) can also play a significant role in the decrease of lodging given that the seedbed preparation is optimal. Higher seeding densities (>140 plants/m^2) 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 in 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 therefore 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).

SABM in cooperation with the University of the Free State are currently busy with intensive research with regards to the water requirements of barley and consequently the optimisation of irrigation scheduling for barley. This work is funded by the Winter Cereal Trust and the aim is to launch a computerised irrigation scheduling program for the 2015 barley season after it will be tested at a number of selected producers during the 2014 season.

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. It is therefore crucial that the barley must be harvested as soon as it reaches a moisture content of 12.5% 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 for 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 2011 season the sliding scale and the consequent payment for quality of barley was adjusted. Although the cut-off points for malting grade were not adjusted the different categories within each quality parameter were adjusted and also differentiate between Cocktail and the other cultivars. It is therefore important that producers must verify these changes with their nearest SABM 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 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 or low nitrogen content cannot produce malt of the required quality for brewing purposes. The sliding scale, according to which the price of barley is determined, is based on a base price onto which premiums are added for certain nitrogen levels in the grain. It is important to note that the cut-off and turning points will differ for the coming season and must be confirmed with grain traders. It is important to note that the cut-off and turning points for the different cultivars must be confirmed with grain traders before the start of the season.

Nitrogen content of barley is a characteristic that is genetically, as well as environmentally, influenced. Certain cultivars (Cocktail) 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 homogeneity during the malting process. Thin kernels take up water faster than plump kernels. Thin kernels also have a relatively higher percentage husk, which can give beer a bitter taste. Therefore more uniform kernel plumpness will result in better malt quality. The sliding scale for plump kernels is such that more is paid pro rata for barley with a kernel plumpness that increases, measured above a 2.5 mm sieve. As in the case of nitrogen content, the cut-off point that will be in place for the coming season 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 unfavourable 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. This material generally consists of shrivelled kernels, broken kernels, small weed seeds, glumae, awns, dead insects and dust. There is a base price for barley deliveries within certain specifications and an increasing premium for deliveries with a less screenings. Again the cut-off points must be confirmed with the grain handlers. 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, a good grade and thus a good price.

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.

Foreign matter's cut off point is 2%, while a price incentive applies for foreign matter under 1%. A base price is applicable for barley with a foreign matter content between 1% and 2%, but 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 unfavourable conditions. Barley with a high moisture content (>12.5%) should be dried according to specifications as soon as possible. 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 12.5% will be accepted and a pro rata premium is paid for grain as the moisture content decreases from 12.5% to 9.5%.

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 Maltings representative can be contacted Germination/cultivar purity

BARLEY PASSPORT

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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 100 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 nitrogen fertilisation of 140 kg/ha (depending on the soil type) is optimal in terms of yield and quality. On a cotton rotation system and where a lot of maize stubble are present on the land, as well as on very sandy soils, the nitrogen application rate can be higher (+ 20-30 kg N/ha) and must be applied as a split application to overcome the nitrogen negative period. Directly after Lucerne the N fertilisation needs to be decreased to 100 kg/ha and preferably all needs to be applied with planting.
- Split application of nitrogen fertilisation is more important under overhead irrigation (specifically centre pivot) than under flood irrigation and also on lighter sandy soils. A split of two thirds of the total nitrogen with planting and the rest 6 weeks after emergence, seem to give the best results. In the case of very sandy soils the topdressing can be split into two applications. The last one must, however, not be applied later than the flag leaf stage.
- Judicious planting, fertilisation and irrigation practices should be applied to minimize the problem of 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 discoloured.
- Harvesting must commence as soon as the crop is ready for threshing (12.5% moisture content) in order to minimise 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 the central irrigation area 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 Maltings agricultural advisors:

Burrie Erasmus (Hartswater)	*082 921 7967*
Johannes Kokome (Taung)	*082 921 7981*
Frikkie Lubbe (Kimberley)	*082 921 7994*

OAT 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 oat 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/m^2) 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 oat 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.

Oat 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) over the past four years of testing are given in the following tables.

Long-term yield data (ton/ha) for oat cultivar adaptation trials under irrigation

Cultivar	2013 *	R	2012 *	R	2010	R	2009	R
H06/15	4.46	8	5.73	4	4.59	4		
H06/19					4.19	11		
H07/04	4.98	7	5.64	5	4.62	3		
H07/05					4.43	8		
Heros					3.91	12	3.09	6
Kompasberg	6.31	1	5.77	3	5.02	1	4.07	1
Overberg	5.08	6	5.32	7	4.21	10	3.03	8
Pallinup	5.70	3	5.90	2	4.57	5	3.72	2
Sederberg					3.42	14	3.12	5
Simonsberg	5.15	4	4.89	8	3.84	13		
SSH 405					4.67	2	3.64	3
SSH 421					4.47	7	3.09	6
SSH 491	6.14	2	6.98	1	4.32	9	3.23	4
Towerberg	5.10	5	5.41	6	4.56	6		
Average	**5.37**		**5.71**		**4.34**		**3.37**	
LSD_t(0,05)	**0.32**		**0.65**		**0.41**		**0.50**	

** Only Vaalharts data*

Long-term hectolitre mass data (kg/hl) for oat cultivar adaptation trials under irrigation

Cultivar	2013 *	R	2012 *	R	2010	R	2009	R
H06/15	48.70	4	48.15	7	49.83	7		
H06/19					50.16	4		
H07/04	45.75	8	47.75	8	50.09	5		
H07/05					49.15	11		
Heros					48.35	13	50.99	6
Kompasberg	47.70	7	48.75	5	48.02	14	47.36	8
Overberg	48.10	6	50.45	2	50.68	1	51.03	5
Pallinup	49.75	2	50.40	3	49.79	8	51.74	4
Sederberg					48.98	12	50.38	7
Simonsberg	48.60	5	48.70	6	49.37	10		
SSH 405					49.73	9	53.44	1
SSH 421					50.60	2	52.71	2
SSH 491	50.85	1	52.50	1	50.37	3	52.15	3
Towerberg	49.00	3	49.70	4	49.95	6		
Average	**48.56**		**49.55**		**49.65**		**51.23**	
LSD_t(0,05)	**0.86**		**1.50**		**1.05**		**1.87**	

** Only Vaalharts data*

Long-term yield data (ton/ha) for oat cultivar adaptation trials under dryland conditions (Bethlehem data)

Cultivars	2013	R	2012	R	2010	R	2009	R
H 06/15	2.41	7	3.36	6	0.80	5	2.63	7
H 06/19					0.59	12	2.72	5
H 07/04	2.77	2	2.90	8	0.67	8	2.88	4
H 07/05					0.65	11	2.59	10
Heros					0.66	9	2.98	2
Kompasberg	2.66	5	3.77	2	1.07	1	2.98	3
Overberg	2.77	3	3.47	5	0.87	4	2.62	8
Pallinup	2.29	8	4.34	1	1.02	2	3.03	1
Sederberg					0.20	14	2.06	14
Simonsberg	2.89	1	3.19	7	0.57	13	2.49	12
SSH 405					0.66	10	2.36	13
SSH 421					0.76	6	2.50	11
SSH 491	2.65	6	3.52	4	0.97	3	2.59	9
Towerberg	2.72	4	3.70	3	0.68	7	2.65	6
Average	**2.64**		**3.53**		**0.73**		**2.65**	
CV%	**9.90**		**9.70**		**21.90**		**14.20**	
LSD_t(0,05)	**0.39**		**0.51**		**0.23**		**0.54**	

Long-term hectolitre mass data (kg/hl) for oat cultivar adaptation trials under dryland conditions (Bethlehem data)

Cultivars	2013	R	2012	R	2010	R	2009	R
H 06/15	49.82	7	49.2	5	45.40	11	55.00	7
H 06/19					46.30	6	54.90	8
H 07/04	49.60	8	48.1	7	45.70	9	56.65	2
H 07/05					44.90	13	54.25	12
Heros					45.60	10	56.90	1
Kompasberg	50.20	5	45.6	8	48.40	1	56.10	3
Overberg	50.57	4	51.1	2	47.20	3	55.65	5
Pallinup	50.02	6	49.6	4	48.20	2	55.87	4
Sederberg							52.50	14
Simonsberg	51.10	2	49.0	6	45.20	12	54.35	10
SSH 405					45.90	8	54.67	9
SSH 421					47.10	4	54.30	11
SSH 491	55.30	1	54.5	1	47.00	5	54.22	13
Towerberg	50.77	3	50.5	3	46.20	7	55.30	6
Average	**50.92**		**49.69**		**46.39**		**55.05**	
CV%	**1.80**		**2.20**		**3.30**		**2.00**	
LSD Cultivar	**1.35**		**1.57**		**2.07**		**1.55**	

ARC-SMALL GRAIN INSTITUTE SERVICES

The laboratories of ARC-Small Grain Institute 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.

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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
- Single Kernel Characterisation System (SKCS) analyses, which includes thousand kernel mass, kernel hardness index, kernel diameter and kernel moisture content
- 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
- Alveograph analyses
- Mixolab analyses
- Loaf volume

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Soil Analyses Laboratory

The Analyses Laboratory specializes 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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NOTES

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