POTATO INDUSTRY RESEARCH STRATEGY: 2018-20
MISSION
To provide knowledge to enhance the sustainability of the South African potato industry

VISION
Knowledge towards excellence in the South African potato industry

BACKGROUND TO RESEARCH AND RESEARCH FUNDING IN THE POTATO INDUSTRY
Potatoes South Africa’s first application for statutory measures on potatoes, which included a statutory levy, was approved by the then Minister of Agriculture and promulgated in the Government Gazette on 10 September 2004. One of the purposes of the statutory measures is to fund basic and applied research, including cultivar development and evaluation, and the dissemination of all relevant information.

STAKEHOLDERS

Potato Industry Development Trust (PIDT)
To conform to the purpose of the statutory measure, the Potato Industry Development Trust (PIDT) was established. The main objective of the PIDT is to promote and enhance the potato industry in South Africa. This means that the statutory income held in the Trust will be used solely for projects that are reconcilable with the aims of the Trust and in the interests of the potato industry. Research must therefore be needs driven and identified by all interested stakeholders.

Role of the PIDT in respect of research management:
- Approve the funding of research projects
- Ensure compliance with the Potato Industry Research Strategy

PIDT Research Advisory Committee
The PIDT appoints members representing each of the business units of PSA to advise the Trust on:
- Research governance compliance
- Whether research priorities are addressed
- Recommendations regarding research funding decisions

PIDT Risk and Audit Committee
The PIDT Risk and Audit Committee advises the Trust on:
- Corporate governance
- Compliance with budget

Potatoes South Africa Board of Directors
All potato production regions and the National Seed Growers’ Committee are represented on the Board of Directors (BoD) of Potatoes South Africa by the chairpersons of the regional management bodies and the chairperson of the aforementioned committee. The annual research budget, together with project reports and proposals for recommended new projects, are submitted to the BoD in March every year.

Role of the BoD with respect to research management:
- Approve the Potato Industry Research Strategy
- Make recommendations regarding the annual research budget
- Oversees the implementation processes

Potatoes South Africa Audit Committee
The role of the Audit Committee in respect of research management is to:
- Ensure corporate governance
- Ensure compliance with budget

Potatoes South Africa Research Committee
The Research Committee has five ware potato producer members, each representing a total production region of 10,000 hectares, as well as two producers representing the seed growers in South Africa. The chairperson is appointed by the Board of Directors. The Research Committee co-opts persons representing various stakeholders in the industry, for example the Potato Certification Service, Potato Laboratory Services and processing companies.

The role of the Research Committee is to:
- Develop and maintain a research strategy
- Determine priorities for research project funding
- Prioritise projects against evaluation criteria (see below)
- Identify research projects to be funded

Expert Advisory Group
The Research Committee and Manager: Research and Development relies heavily on the inputs of expert advisory groups to assist in screening research proposals.

The role of expert advisory groups is to:
- Pre-screen proposals
- Assess project progress reports

Research Management and Administrative Support
The role of PSA’s Department: Research and Development is to:
- Call for proposals
- Administer proposals
• Manage the proposal evaluation process
• Manage the quality of proposals
• Communicate research project decisions

Other stakeholders
• Producers (seed and ware potato producers)
• Research institutions
• Research funders
• Input suppliers
• Research service providers
• Relevant government-/state-owned entities (all spheres)
• Consumers
• Processing companies

STRATEGIC GOALS
• Research and development
• Research information provision
• Information/technology transfer
• Capacity management

DRIVERS OF RESEARCH
• Industry sustainability at an economical, ecological and social level
• Innovation

RESEARCH AND DEVELOPMENT AREAS IN THE VALUE CHAIN

FARMER DEVELOPMENT
According to the database of Potatoes South Africa (2016) there are 540 active commercial potato producers. In 1993 almost 56 000 hectares of potatoes were planted by more than 2 000 producers, with an average of 27 hectares planted per producer. In respect of the 2016 crop year, 540 producers planted potatoes on 53 700 hectares, yielding a crop of 2.14 million tons under drought conditions. Thus, approximately 97 hectares of potatoes were planted per producer. As the cost squeeze is evident in the potato industry, farmers are relying more and more on economies of scale to survive. Potato production is not only costly, but also highly capital intensive.

POTATO PRODUCTION
In South Africa, potatoes are not categorised as a seasonal product. Due to the different climatic conditions – e.g. temperature, rainfall and soil type – in the 16 production regions, potatoes are planted and marketed at different times by the relevant regions to ensure a continuous supply of fresh potatoes throughout the year. Potatoes are grown mainly under irrigation, but in some of the production regions potatoes are grown successfully under dryland conditions. Potatoes are mainly grown in a three-to-five-year rotation with maize, grasses, legumes and wheat.

Compared to the world average of 860 mm of rainfall per year, South Africa's average annual rainfall is 450 mm; more than 60 % of the country receives less than 511 mm and is characterised by the occurrence of frequent droughts. In contrast, devastating floods are also not uncommon. Notwithstanding these unfavourable agricultural conditions, South Africa is self-sufficient in potatoes.

The primary change in commercial potato crop production during the past few years has been the decline in the number of potato producers, while the average yield per hectare and therefore the size of the crop has increased. The cultivation of potatoes under dryland conditions decreased from almost 50 % of the total hectares planted in 1990, to 19 % in 2016. Despite the decline in hectares planted, the yield increased from 21.1 t/ha in 1990 to 43 t/ha in 2013-16. This increase can be attributed mainly to increased production under irrigation, the use of quality seed potatoes, the availability of improved cultivars and the application of research results.

Yield per hectare has levelled off during the past three to four years. In addition, production costs – mainly due to the increased price of fertilizer, energy (fuel and electricity) and labour – increased dramatically. This leads to a very low return on investment for a farmer, which places tremendous pressure on farmers to improve resource use efficiency and consequently profitability. Well-targeted research will contribute towards improved efficiency.

As potato is a cool climate crop, production in most production regions takes place in a climate not optimal for potato production. Temperatures in excess of 30°C and fluctuating daily temperatures cause stress in plants, which in turn limits the yield potential of even the best-adapted cultivars. The potato plant is susceptible to a range of foliar diseases, including the viral diseases early blight, late blight and brown spot, as well as soil- and seed-borne diseases such as bacterial wilt, common scab, soft rot and powdery scab. Some of these pathogens have the ability to survive in the soil for many years, thus limiting the use of scarce arable land. Pests such as aphid, potato tuber moth, leaf miner and nematodes cause a direct reduction in yield, while aphid and thrip act as vectors of viral diseases. Research on...
pests and diseases and their control is vitally important to limit their yield-reducing effect.

PRODUCT DEVELOPMENT
The success of potato production in South Africa depends to a large extent on the availability of cultivars adapted to the local climatic conditions, and acceptable to the diverse but sophisticated market. Ten years ago, the dominant cultivars were of local origin (BP1, Up-to-Date and VanderPlank). The scenario has changed to one where the market is dominated by one foreign cultivar, namely Mondial, followed by Sifra. The change was brought about by the high yield potential and adaptability of Mondial. Production of the old cultivars is now limited to a small number of farmers supplying niche markets.

The industry is dependent upon foreign cultivars for higher yield, resistance to yield-reducing diseases and innovations in the market. The importation, administration and development of new cultivars are done by local licence holders on behalf of foreign breeders. An important aspect of modern cultivars is that they are all protected by plant breeders’ rights legislation. Many new cultivars are imported every year and, to support both the licence holders and farmers to speed up the development and establishment of improved cultivars, the research programme manages cultivar evaluation trials in the majority of production regions through regional potato working groups.

RESEARCH BENEFITS FOR THE POTATO INDUSTRY
- Improved market-related yield
- Improved food security and nutrition
- Improved business competitiveness
- Sustainable production practices
- Improved food safety
- Improved risk mitigation
- Product development
- Market development
- Increased use of potatoes

RESEARCH PROJECT EVALUATION CRITERIA
Non-negotiable Criteria
- Accuracy of the problem statement
- Quality of the literature review
- Research methodology
- Clarity of research milestones
- Research capacity of the team

Weighted Criteria
- Maximise research objectives relevant to end-user needs
- Maximise impact on competitive production
- Maximise sustainable benefits to the industry
- Maximise cost effectiveness
RESEARCH AREAS

POTATO PRODUCTION

Focus area 1. Insect control

Vectors of virus diseases

Various aphid species transmit the common potato viruses known as potato virus Y (PVY) and potato leaf roll virus (PLRV), from one plant to another, whereas thrips transmit the less common virus, tomato spotted wilt virus (TSWV), also known as “kromnek”. The importance of aphids thus stems from their extremely effective transmission of virus. Virus infection leads to downgrading of seed potato lots during certification, decreased yield and tuber symptoms caused by modern strains of PVY. A national aphid monitoring network has been established, and aphid occurrence is communicated to farmers. However, the lack of control of virus in many seed production areas keeps aphids high on the research agenda.

Other insects

Potato leaf miner and potato tuber moth are regarded as the most significant pest problems for potato production in South Africa. Effective monitoring methods and chemical remedies are available for potato tuber moth. Uncontrolled infestations during the growing season can lead to varying crop losses, and damage to tubers is still one of the major reasons for downgrading on markets, especially for regions where dryland production is prevalent. Control by means of chemical and biological remedies and cultivation methods have been developed and packaged and are available. Regular technology transfer sessions are, however, needed to maintain the level of knowledge in the field.

Recent uncontrolled potato leaf miner outbreaks have caused serious damage. The spraying of chemical remedies has not always been successful in controlling such outbreaks. Research is needed to identify the causes of the failure of conventional spraying programmes to control this pest.

White fly and red spider mite are minor pests affecting potato.

Below-ground insects

Potato snout beetle is an indigenous, but elusive potato pest. Outbreaks are reported from time to time, but in general the insect is controlled though chemical remedies applied for other pests and through rotation with non-host plants. Cut worms, grubs and millipedes are also reported from time to time, but are of minor importance, particularly for small-scale/subsistence farmers.

Focus area 2. Disease control

Soil- and seed-borne diseases

A number of soil and seed-borne diseases occur in South Africa and collectively cause considerable yield and quality losses. Bacterial wilt, which is considered one of the limiting factors in many African countries, has been brought under control in South Africa through strict measures set out in the South African Seed Potato Certification Scheme, as well as disciplined control measures by growers through effective crop rotation programmes. Potato wilt diseases (fusarium wilt, verticillium wilt, and sclerotium wilt), as well as tuber diseases (silver scurf, black dot/anthracnose, dry rot, sclerotium rot, black scurf, and grey mould) are not considered major problems currently, probably as a result of the adoption of research results in the past and the availability of effective agricultural remedies.

However, as in most potato producing counties in the world, common scab, powdery scab, bacterial soft rot and root-knot nematode remain major production-limiting diseases in South Africa.

Soft rot is caused by a group of bacterial species (Pectobacterium and Dickeya). Although these are opportunistic pathogens, they are extremely successful when conditions are favourable for disease development, causing considerable losses during warm, wet seasons. Although a lot is known about the pathogens and the conditions favourable to the disease, little is known about the effect of local cultivars, climate, soil and production methods on disease development and the control thereof.

Common scab has been known to occur in South Africa for many years and occurs commonly throughout the country. Despite research in South Africa and elsewhere in the world, control remains very difficult. This bacterial disease is caused by a complex of species of the genus Streptomyces. Control of common scab is thought by specialists internationally to be complicated by the fact that various Streptomyces species – some indigenous to specific areas – cause scab symptoms. The disease is controlled successfully by the planting of tolerant cultivars. Periodic evaluation of cultivars for tolerance to common scab is required.

Powdery scab is a relatively new disease in South Africa and is caused by the fungus Spongosora subterranea. Currently, it is thought that the disease has spread to most production regions. Symptoms are galls on roots, which restrict nutrient and water uptake, and pustules on tubers, which result in the downgrading of seed potatoes and ware potatoes on the market. The pathogen can survive in soil for decades through resistant spore balls in the soil. Research information such as relative susceptibility of popular cultivars,
alternative host plants, and cultivation methods under local conditions is required to limit the spread of the disease and to develop management strategies.

Nematodes are not classic fungal or bacterial pathogens. However, due to their effect on crops and the control measures available to manage the diseases they cause on plants, nematodes are discussed under soil-borne diseases. Nematodes are a soil-borne problem for potato production around the world. In the past, soil fumigation remedies were applied successfully to control their effect. Following the withdrawal of MeBr and Aldicarb, farmers no longer have these options available. Therefore, alternative methods of control need to be developed.

Foliar diseases
Late blight is regarded as one of the major constraints to potato production in many countries, including those in central Africa. Pathologists worldwide are monitoring the occurrence of mating types, which could lead to new forms of late blight. In South Africa, the climate in most production regions is not conducive to disease development, and a survey conducted some years ago showed that only one mating type occurs in Southern Africa.

Early blight, brown spot and grey mould are not currently regarded as serious threats to potato production in South Africa, as chemical remedies to effectively manage the diseases are available. The industry recently funded a project on brown spot to confirm the causal agent and, although reports on outbreaks are occasionally received, the disease is not regarded as a major constraint currently. The ability of the pathogens that cause early blight and brown spot to develop resistance to fungicides is well known. This aspect may become more important in the near future in South Africa.

Viral diseases
Although several viral diseases have been reported in South Africa, two – potato virus Y (PVY) and potato leaf roll virus (PLRV) – commonly result in downgrading of seed and reduction in yield. Tomato spotted wilt virus (TSWV) is reported occasionally. Management of viral diseases is built on three pillars, i.e. correct identification of the virus, limitation of the virus source, and limitation of the virus vector. Resistance or tolerance of cultivars to PVY and TSWV can also contribute to improved management.

The NTN and Wilga strains of PVY are now the dominant strains in South Africa. As the NTN strain often occurs symptomless in plants, correct identification is important. PCR technology has been developed and is available at research laboratories and at Plantovita, the controlling seed testing laboratory in South Africa.

Post-harvest/storage diseases
Ware potatoes are generally not stored for more than a few days in South Africa. In many areas, however, potatoes are left in the ground for weeks or months to spread harvesting and marketing. Fusarium dry rot and the silver scurf/black dot complex can lead to losses and downgrading on the market. Symptomatic tubers are generally easy to recognise, and affected tubers are discarded during the grading process. Farmers manage these diseases by maintaining a good crop rotation programme. The treatment of seed tubers against silver scurf and black dot is currently receiving attention from the Potato Certification Service and seed growers. Silver scurf/black dot is, however, a disease complex that may become more important as the disease spreads.

Focus area 3. Agronomy

Water usage and quality
Water is the most valuable resource in South Africa, on both a macro-economic and farm level. At the same time, maximum yield can only be attained if enough water is available to the potato crop. Research on water usage by potato plants under local conditions was done in previous years, and this was followed up by research on irrigation scheduling. The fact that new laws on water usage will place restrictions of water availability on farms, together with increasing energy costs, will increasingly necessitate irrigation scheduling by potato farmers. Concerns about the quality of irrigation water in terms of both biological and chemical properties have been raised and need to be investigated.

Plant nutrition
Plant nutrition is an aspect of production that has been studied extensively, and input suppliers play a valuable role in supporting farmers. In light of fertiliser costs, two research projects were carried out recently. These revealed that the fertiliser requirements of new potato cultivars are no different from those of the old ones. One aspect of plant nutrition that requires more knowledge transfer is the internal tuber defects related to fertiliser uptake, i.e. hollow hart, brown spot and black heart.

Cultivation practices
Soil cultivation is necessary to prepare soil for the potato plant to grow and yield to its full potential. A number of different steps are normally required before planting. In the current milieu of high fertiliser, fuel and electricity prices and labour costs, coupled with the fact that cultivation has an effect on soil structure and can have a negative effect on yield, cultivation practices need to be revisited.
Crop rotation
Crop rotation plays a critical role in potato production in terms of nutrient usage, soil structure and soil-borne diseases such as root-knot nematode, bacterial wilt and common and powdery scab, as well as below-ground insects such as potato snout beetle. In seed potato production, the main concern with crop rotation is to limit soil-borne diseases; therefore the Certification Scheme prescribes a minimum rotation period between seed potato plantings. Where bacterial wilt and golden cyst nematodes have occurred, the minimum period is eight years and specific rotation crops are prescribed.

Rotation crops in South Africa typically include maize, wheat, sunflower, legumes and forage crops, and in some regions also vegetable crops such as onions and cucurbits. The overall objective of crop rotation is to establish a system that guarantees profitable and sustainable farming. The choice of suitable rotation crops is further complicated by the fact that different soil-borne pathogens have different hosts, and also by the profitability of the rotation crops in a specific region.

Soil health and crop rotation
Soil health is the integration and optimisation of the physical, chemical and biological properties for specific soil types to improve productivity in a sustainable manner. Intensive agronomic crop production has contributed to gradual deterioration of soil health, resulting in reduced yield and profitability. In addition to this, and to some extent as a result of this, soil-borne diseases are becoming more difficult to control. For some diseases there exist very few to no chemical control options. Soil-borne diseases that have become a major problem in potato production in South Africa include powdery scab, common scab and root-knot nematode. Current options are limited to broad-spectrum soil fumigants, which have proven to be inconsistent at best. In addition, these fumigants not only have a detrimental effect on the soil ecology, but also adversely impact on air quality and may contribute broadly to environmental degradation. Such practices result in major ecological disturbances to the production system by sterilising the soil and destroying beneficial micro-organisms. Pathogenic micro-organisms that are introduced by planting material proliferate under these sterile conditions where no competition is offered by beneficial micro-organisms. This is especially problematic for the potato industry, as potatoes are clonally propagated by planting whole seed tubers or seed pieces, which promotes the spreading of pathogens from one area to another. A more sustainable approach needs to be investigated, ultimately demanding the development of a soil health strategy for potato production.

Seed quality
In South Africa fresh potatoes are available throughout the year, because potatoes are produced during different times of the year in the different production regions, meaning that plant-ready seed is required throughout the year. To meet the demand, seed potatoes are produced in different production regions (KwaZulu-Natal, Western Free State, North West, Sandveld, North-eastern Cape and the Mpumalanga Highveld), each with its own set of environmental conditions that affect the physiology of tubers. As potato seed is propagated vegetatively/clonally, a number of pathogens can be spread through infected seed tubers. Quality assurance in terms of disease tolerance, variety purity and quantity per unit is assured by the Certification Scheme. However, seed quality is not limited to the aspects managed under the Certification Scheme. Aspects such as physiological age, size and uniformity in size have a major impact on the performance of plants, and thus yield at the end of the season.

Of all the different input costs, the cost of seed potatoes comprises the biggest component – in some areas as much as 20 to 30 %. This, together with the fact that seed quality has a pronounced effect on yield and quality, necessitates that seed potatoes of appropriate quality are available and that ware potato growers use seed as efficiently as possible. Trust between seed potato growers and ware potato producers, and knowledge of factors affecting seed potato quality and performance, form the basis of the efficient use of seed. Research-based information on a number of questions relating to seed potato quality will contribute to improved use of seed potatoes in South Africa.

Weed control
Common weed plants (nutsedge, broad-leaf weeds and grasses) can cause yield reduction if not managed, but effective chemical remedies and cultivation practices are generally effective in controlling weeds. Controlling volunteer potatoes is a great deal more difficult than the control of most other weeds. The plant is hardy, a vigorous grower, and the biology and physiology of germination make it difficult to achieve control. The absence of cold winter temperatures makes the control of volunteer potato populations in South Africa very difficult. The population of tubers that are either exposed on the soil surface or very close to the soil surface will be reduced by bird and rodent damage, grazing animals, and exposure to fungi and bacteria. It is therefore clear that the management of tuber depth is crucial.

Some varieties of potato are capable of producing large numbers of true seed, as well as tubers, if not controlled, and although the main volunteer problems
are caused by the tubers, germinating seeds can also cause problems if plants are allowed to form seed. Many methods of control are available to the producer, including cultivation, crop competition and the use of herbicides. Unfortunately, none of these methods are the “silver bullet”, and combining these methods in an integrated plan appears to be the best management tool.

**PRODUCT DEVELOPMENT**

**Focus area 1. Cultivar development**

* Cultivar evaluation
  
Maximum temperatures in South Africa are generally higher than optimal for potato plant growth. In some regions, temperatures >35°C are regularly recorded. In addition, the diurnal temperature fluctuation can be as much as 20°C during spring and autumn in some production regions. Consequently, the yield potential of all cultivars is lower than in some other potato-producing countries. The selection of cultivars able to produce high yields under local conditions is therefore one of the most critical research needs for the potato industry. As the average temperature is expected to increase as a result of climate change, cultivar evaluation is also expected to enjoy high priority into the future.

The vast majority of cultivars currently planted were developed abroad and licensed to local agents who are responsible for the screening, evaluation and commercialisation of the cultivars. Most regional potato workgroups plant at least one cultivar evaluation trial every year to evaluate potential candidates for adaptability under regional climate conditions and cultivation practices. The availability of the results of many workgroup trials from around the country makes it possible to analyse results to identify widely adapted high-yielding cultivars.
## POTATO PRODUCTION

### Research area 1. Insect management

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<th>Outcomes</th>
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<tr>
<td><strong>Aphid</strong></td>
<td>The importance of plant aphids lies in the fact that they are vectors of the most devastating viral diseases, namely PVY and PLRV. The two most common species are the green peach aphid, <em>Myzus persicae</em>, and the potato aphid, <em>Macrosiphum euphorbiae</em>. Both feed on various plant species. In order to manage virus, aphids need to be managed through monitoring, the limiting of alternative host plants, effective spraying programmes, and the planting of border crops to reduce aphid infestation. Aphid management is difficult because aphids feed on many plant species; they have a short lifecycle during warm seasons and are asexually reproduced. Winged aphids fly or are carried by wind currents to new plantings when populations become high. They are very small and can easily be missed during field inspection. They are also an extremely effective vector of virus diseases, as virus can be transmitted to healthy plants in a matter of a few seconds, thus making it necessary to maintain a rigorous and preventative management programme.</td>
<td>The monitoring and identification of aphids through a network of suction traps in seed production regions provide seed growers with information of aphid flight patterns and numbers. Information about the effect of climate and agro-ecological factors on aphid flight patterns in different seed production regions is supplied to seed growers. Alternative hosts of the most common aphid species, which include crops, pastures and weed species, have been identified and this knowledge is used by farmers in an integrated aphid management programme. The risk of infection is further estimated by monitoring the number of aphids already infected with virus. This information can reduce spraying if aphids are virus free. Regular information sessions on aphid monitoring, aphid behaviour, lifecycle and management are held in seed production regions to maintain the level of expertise in the field.</td>
<td>A</td>
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<td><strong>Potato tuber moth (PTM)</strong></td>
<td>The potato tuber moth (<em>Phthorimaea operculella</em>) was accidentally introduced into South Africa approximately 100 years ago and is recognised as the second most important insect pest. PTM occurs wherever plants of the potato family are found and is especially damaging in areas with a hot, dry climate. Extensive research has been done in South Africa on the lifecycle and control of potato tuber moth, and many registered chemical remedies are available to manage the pest. Pheromone traps to monitor moth numbers have been developed and are available.</td>
<td>Regular technology transfer sessions are held to maintain and refresh knowledge of the potato tuber moth lifecycle and management in the field. Information includes spraying programmes to avoid resistance of PTM to pesticides.</td>
<td>A</td>
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Despite the knowledge available, major losses occur from time to time in most production regions, and PTM damage remains one of the major causes of downgrading of tubers on the fresh produce markets. The reason for the situation is possibly the role of climate (not all seasons are conducive to massive infestation) and production practices (cull heaps, availability of alternative host plants in the nearby vicinity, etc.). Management strategies for PTM must always from part of the production planning activities of farmers.

**Potato leaf miner**

The potato leaf miner (*Liriomyza huidobrensis*) has been identified as the most damaging insect pest of 2016. It can cause serious damage and was detected for the first time in the Sandveld in 1999.

In addition to potatoes, the leaf miner attacks almost all other vegetables and several weed species. Effective registered agricultural remedies are available; however, there are certain times when control is almost impossible.

The efficacy of insecticides registered for use on potato leaf miner has been evaluated and the information is used to develop spraying programmes.

Information is available on the activity of flies around potato fields and the ability of flies to emerge from pupae beneath the ground.

The potential to develop traps for the potato leaf miner has been investigated.

**Below-ground insects**

Potato snout beetle, cut worm, grubs and millipedes are insect pests of lesser importance, but the group is regularly noted as being problematic. Potato snout beetle occurs from time to time in production regions such as the Eastern and Western Free State and KwaZulu-Natal, but can be limited effectively through appropriate cultivation methods, rotation programmes and agrochemicals. Technology transfer sessions, workshops, discussions groups, etc. should be held from time to time to refresh the knowledge of farmers and representatives.

Technology transfer sessions are held to maintain and refresh knowledge of the potato snout beetle, cut worm, grubs and millipedes and management in the field. Information includes spraying programmes to avoid resistance of leaf miner to pesticides.

Technology transfer sessions are held to maintain and refresh knowledge of the potato snout beetle, cut worm, grubs and millipedes and management in the field. Information includes cultivation methods known to limit the pests on potato, as well as spraying programmes.
## Research area 2. Disease management

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| Streptomyces diseases (common scab and fissure scab) | **Common scab**, caused by *Streptomyces* species, is a bacterial soil-borne disease that occurs worldwide. It is difficult to control due to the pathogen species complex, which varies from area to area, and the interaction between the pathogens, the host plant genetics, soil composition, climate, soil microbes and cultivation methods. The pathogen is known to survive in soil for many years, as it survives on alternative host plants, and as a saprophyte on plant rests.  

The success of chemical control of common scab is limited due to the complex interactions of the elements mentioned above. Experts on the disease worldwide recommend an integrated disease management approach to contain the disease which includes cultivar choice, crop rotation, soil health maintenance, cultivation methods and judicious use of agricultural remedies. Management of soil moisture levels has proven to be the most effective way to limit the disease in countries such as the UK. As 90% of potatoes in South Africa are irrigated judicious irrigation scheduling could be a valuable tool in our strategies to manage common scab.  

Research efforts should thus aim to make information available to enable farmers in different production areas to develop integrated disease management strategies to manage common scab.  

**Fissure scab** was described for the first time in 2012 and is caused by *Streptomyces* isolates not previously known to scientists. Conditions favourable for disease development and tolerance of popular cultivars are not known at this stage. As symptoms similar to fissure scab can be caused by *Rhizoctonia*, the cause(s) of fissure scab must be confirmed, and the need for a rapid diagnostic test for use during seed certification has been identified.  

Updated knowledge of alternative hosts plants (crops and weeds) for common scab is available and is used to develop crop rotation programmes to reduce common scab levels and the survival of the pathogen in soil.                                                                                                                                                                                                 |                                                                                                                                                                                                 | C        |
| | Effective chemical and biological remedies against the common scab complex in South Africa have been identified for use in an integrated disease management programme.                                                                                                                                                                                                 |                                                                                                                                                                                                 | B        |
| | The role of soil moisture levels during plant growth stages, when tubers are susceptible to infection, have been tested in various production regions, and irrigation scheduling can be applied to limit infection and thus disease development.                                                                                                                                                                                                 |                                                                                                                                                                                                 | C        |
| | Cover crops and green manures that can contribute to common scab-suppressive soil have been evaluated and are included in rotation programmes to reduce common scab.  

Knowledge of the pathogenic *Streptomyces* species occurring in different production areas, and the disease symptoms caused by them, exists and is used to develop relevant IDM strategies.  

The role of soil temperature and moisture levels created by local climate and production methods on survival of the pathogens is known, and the knowledge is used in IDM strategies.  

The cause(s) of fissure scab have been confirmed.  

A rapid diagnostic tool to identify the causes of fissure scab is available for use in potato testing laboratories.  

Conditions conducive to the development of fissure scab are known, and farmers apply the knowledge in integrated disease management.                                                                                                                                                                                                 |                                                                                                                                                                                                 | A        |
**Powdery scab**

Powdery scab is caused by the fungus *Spongospora subterranea* f.sp. *subterranea*, a member of the lower fungi known as slime moulds that produce zoosporangia. As powdery scab generally occurs under cool soil temperatures, it was previously assumed that it would not become a problem under local environmental conditions. However, sporadic outbreaks of powdery scab have occurred in various local potato production regions since the first half of the 20th century. In the past few years, the disease has become a serious problem in certain potato production regions, and a seasonal problem in other regions.

Powdery scab is extremely difficult to manage, as resting spore balls can survive in the soil for decades. Control by means of chemicals is generally not effective. Although some cultivars are more tolerant, no cultivar is resistant to the disease and even low levels of spores in soil can lead to serious disease development if the conditions are favourable.

The only recognised approach to managing powdery scab is through an integrated disease management (IDM) strategy. In order to develop IDM strategies, the South African potato industry needs as much knowledge as possible about the behaviour of the pathogen under local climate, soil and cultivation practices, as well as the relative tolerance of local cultivars and the value of agricultural remedies.

| Knowledge of the relevant tolerance of the most popular cultivars against powdery scab in South Africa is used for informed cultivar choices in areas where common scab is a risk. | A |
| Updated knowledge of alternative hosts plants (crops and weeds) for powdery scab is available and is used to develop crop rotation programmes to reduce pathogen levels and survival in local soils. | C |
| Effective chemical and biological remedies against powdery scab in South Africa have been identified for use in an IDM programme. | B |
| The role of soil moisture levels during plant growth stages, when tubers are susceptible to infection, has been tested in various potato production regions, and relevant irrigation scheduling is applied to limit infection and thus disease development. | A |
| Cover crops and green manures that can contribute to restoring soil health have been evaluated and are included in rotation programmes to reduce powdery scab. | A |
| The role of soil temperature and moisture levels created by local climate and production methods on the survival of the pathogen is known, and the knowledge is used in IDM strategies. | A |
| Knowledge regarding the relative importance of soil and seed inoculum levels is available and used in risk assessment strategies. | B |
| Guidelines for the integrated management of powdery scab are available and are regularly updated. | A |
Blackleg and soft rot diseases cause major losses worldwide and are caused by a complex of bacterial pathogens of various species within two major genera, namely *Pectobacterium* spp. and *Dickeya* spp. The species of interest on potato are *Pectobacterium atrosepticum* (Pa), *Pectobacterium carotovorum* subsp. *carotovorum* (Pcc), *Pectobacterium subsp. brasiliense* (Pcb), *Pectobacterium wasabiae* (Pw), *Dickeya dadantii* (Dd) and *Dickeya solani* (Ds).

Ds is not currently present in South Africa and is therefore a quarantine disease. In the South African potato production regions, the occurrence of blackleg and soft rot have been sporadic and are associated with specific climatic conditions. These conditions must be further investigated and include, but are not limited to, the role of water, temperature and inoculum levels in the soil and on tubers and host plants in disease development, as well as cultivar tolerance.

As soft rot and blackleg are not controlled by chemical remedies, research efforts should be directed toward alternative approaches to control these diseases.

| Knowledge of the relevant tolerance of the most popular cultivars against the soft rot and blackleg pathogens in South Africa is used for informed cultivar choice in areas or lands where common scab is prevalent. | A |
| Updated knowledge of alternative host plants (crops and weeds) for soft rot and blackleg is available and is used to develop crop rotation programmes to reduce common scab levels and the survival of the pathogen in the soil. | B |
| Effective sterilising agents (wash-water treatment), chemical seed treatments and biological remedies against soft rot and blackleg pathogens in South Africa have been identified for use in an IDM programme. | B |
| The role of climate (moisture and temperature) in disease development has been tested in various potato production regions. | A |
| The role of soil and tuber inoculum levels has been tested in various potato production regions. | B |
| Cover crops and green manures, which can contribute to restoring soil heath, have been evaluated and are included in rotation programmes to reduce soft rot and blackleg in different potato production regions. | A |
| Methods of management aimed at the genetic and metabolic level of disease development are available. | A |
| There is continuous monitoring of bacterial species that cause blackleg and soft rot in South Africa. | C |
| Guidelines for the management of soft rot and black leg are available and are updated as required. | B |
### Nematodes

Nematodes form a very important part of soil microflora and are one of the most abundant groups in soil. Soil nematodes occupy key positions in the detritus food web, and can be placed in at least five trophic (feeding) or functional groups. They feed on most soil organisms (fungi, bacteria, nematodes, mites, unicellular algae and lichen) and are also a food source for some of these organisms. Most soil nematodes play a beneficial role in the ecosystem processes and are neither parasites nor pests. Beneficial nematodes play an important role in the soil food web by controlling the cycling of minerals and nutrients, controlling the degree of decomposition by regulating the behaviour of the microbial community, and breaking down organic material into various minerals and organic nutrients. Due to the diversity of feeder groups within the nematodes, the population composition of soil can be used as an indication of the condition or health of soil.

Of the parasitic nematodes, the root-knot nematode (RKN) (*Meloidogyne* spp) is the best-known plant parasitic nematode in potato production. Lesion nematodes not only cause direct damage to plants, but they also move in and out of roots, leaving wounds through which soil-borne pathogens can easily enter roots. Plant parasitic nematodes became a severe threat following the withdrawal of aldicarb and other effective nematicides from the market. Since there is a movement away from hard/red-label chemical remedies, more environmentally friendly options need to be investigated and tested in combination with new chemistry.

<table>
<thead>
<tr>
<th>Activity</th>
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<tbody>
<tr>
<td>There is knowledge of the effect of different rotation crops on the nematode population.</td>
<td>A</td>
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<tr>
<td>Rotation, cover crops and green manures, which can contribute to the restoration of soil health, have been evaluated and are included in rotation programmes to reduce plant parasitic nematodes in soil.</td>
<td>A</td>
</tr>
<tr>
<td>Alternative control methods against RKN in South Africa, such as new chemistry, soil solarisation, plant extracts and biological remedies, have been identified for use in an IDM programme.</td>
<td>A</td>
</tr>
<tr>
<td>Knowledge of the relevant tolerance of the most popular cultivars against RKN in South Africa is used for informed cultivar choice in areas or lands where RKN is prevalent.</td>
<td>C</td>
</tr>
<tr>
<td>There is continuous monitoring of RKN species that pose a threat to potato production in South Africa.</td>
<td>C</td>
</tr>
<tr>
<td>To develop a soil health indicator based on the nematode population composition of soil.</td>
<td>A</td>
</tr>
<tr>
<td>Guidelines for the management of nematodes have been developed.</td>
<td>A</td>
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### Verticillium wilt

Early dying and wilting caused by *Verticillium* species can cause significant losses, especially

<table>
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<tr>
<td>A survey has been carried out in the Sandveld and information is available on the virulence of <em>Verticillium</em> species present on potato and rotation crops.</td>
<td>A</td>
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<tr>
<td>Knowledge of the <em>Verticillium</em> species and their virulence on potato and rotation crops is applied as part of an integrated disease strategy for the control of early dying in the Sandveld.</td>
<td>C</td>
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### Alternaria diseases (early blight and brown spot)

*Alternaria solani* and *A. alternata* are two closely related pathogens causing brown spot and early blight. Pathologists in northern Europe refer to “the early blight complex caused by closely related Alternaria species”. In South Africa, the time of disease onset and the symptoms caused by the two pathogens are distinguishable; therefore it is possible to refer to early blight and brown spot.

Physiological status and climatic conditions play a critical role in disease development, and currently the diseases are controlled by chemical remedies. The majority of the remedies are single-site remedies and the pathogens have the ability to develop resistance against these remedies.

- The influence of cultural practices in brown spot disease development has been determined and is included in the IDM strategy.  
- Knowledge of the relevant tolerance of the most popular cultivars against brown spot in South Africa is used for informed cultivar choice in areas or lands where brown spot is prevalent.
- Knowledge of the resistance of *A. solani* and *A. alternata* isolates against Qol and SDHI fungicides is available and is being applied to manage the diseases.

### Silver scurf and black dot

Silver scurf and black dot are known as blemish diseases which can cause losses as a result of downgrading of table potatoes on the market, as well as seed potatoes. Silver scurf has a limited host range and survival in soil. However, black dot has a wide range of host plants and survives in the soil for up to 8 years. Worldwide, the importance of this disease complex has increased, especially as a result of consumer demand and the fact that infected tubers are susceptible to rooting pathogens. Extensive research has been carried out at the ARC prior to 2000 and the knowledge generated in the process is still relevant.

- Technology transfer sessions are held to maintain and refresh knowledge of silver scurf and black dot in the field.
- As tuber storage in soil is generally practised by seed potato growers and ware potato producers, there is a need for more information on the effect of the storage period on disease incidence under different soil and climate conditions.
- The effectiveness of different seed treatment chemicals and application methods has been tested, and the available knowledge has led to a decrease in downgrading and rotting.
### Viral diseases

Although several viral diseases have been reported in South Africa, two – potato virus Y (PVY) and potato leaf roll virus (PLRV) – commonly result in the downgrading of seed potatoes and a reduction in yield. Tomato spotted wilt virus (TSWV) is reported occasionally. Management of viral diseases is built on three pillars: correct identification of the virus, limitation of the virus source, and limitation of the virus vector. The resistance or tolerance of cultivars to PVY and TSWV can also contribute towards improved management.

In recent years the NTN and Wilga strains of PVY have been identified using PCR technology; these strains are now the dominant strains in South Africa. As the NTN strain often occurs symptomless in plants, correct identification is important. No new research need has been identified recently. However, there is an urgent need for practical guidelines to develop region-specific virus management strategies.

| Alternative host plants for the major viruses (crop, forage and weed species) have been identified, and the information is being used in integrated virus management strategies. | A |
| Regular surveys are conducted to determine whether new viruses or new virus strains occur in South Africa in order to develop and/or test techniques for identification. | C |
| Technology transfer sessions, which could include discussions and workshops, are carried out from time to time. | B |
| Knowledge of the relevant tolerance of the most popular cultivars against the common viruses in South Africa is used for informed cultivar choice to manage viral diseases. | C |
## Research area 3: Agronomy

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<th>Priority</th>
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<tr>
<td><strong>Cultivation practices</strong></td>
<td>Soil cultivation is necessary to prepare soil for the potato plant to grow and to yield to its full potential. Different steps are normally required before planting. In the current situation of high input, fuel and electricity prices and labour costs, coupled with the fact that cultivation has an effect on soil structure and can have a negative effect on yield, cultivation practices need to be revisited.</td>
<td>The effect of different soil preparation implements has been evaluated in different potato production regions and adapted where required. See “conservation practices”.</td>
<td>B</td>
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<tr>
<td><strong>Volunteer potatoes</strong></td>
<td>During harvest, a percentage of tubers, especially the small tubers, remains in the soil. These tubers have an amazing ability for regrowth and are then known as volunteer potato plants or weeds. As volunteer potato plants support the survival of soil-borne pathogens, the control of volunteer potato plants is critical for maintaining a good rotation programme, especially in respect of seed potato production. Cultivation is not completely successful, as volunteer tubers can occur deep in the soil, and under local climatic conditions the tubers can survive in the soil for a long period of time. Chemical control is thus required. The choice of suitable herbicides is a major problem for seed potato growers, as the sprouting ability and vigour of seed potatoes should not be affected by the herbicide. In the case of ware potato production, the choice is easier as sprouting ability is not required. As soil-borne diseases are a concern for the whole industry, more effective management strategies for volunteer control are required.</td>
<td>Various herbicides have been tested for volunteer management and the most effective ones have been identified. Herbicides identified in glasshouse trials have been tested in potato fields and the information is available to farmers.</td>
<td>B</td>
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<td><strong>Plant nutrition</strong></td>
<td>Plant nutrition is an aspect of production that has been studied extensively, and input suppliers play a valuable role in supporting farmers. As a result of fertiliser costs, farmers are asking whether the same yield can be obtained using less fertiliser, and whether cultivar-specific adjustments can be made for the more efficient use of fertilisers. One aspect of plant nutrition that requires more knowledge transfer is the internal tuber defects related to uptake, i.e. hollow hart, brown spot and black heart.</td>
<td>Best practices for the ecologically sustainable use of N are available and can be adapted for specific potato production regions as the need arises. The effect of plant nutrition on the internal quality of tubers has been determined, and appropriate fertiliser programmes have been developed. The need for information on the cultivar-specific need for nutrients is identified from time to time, and trials to generate a better understanding are undertaken in the specific potato production regions.</td>
<td>A C</td>
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Seed quality

Costs related to certified seed comprise the biggest component of input costs in South Africa. Every step of production, harvesting, post-harvest handling, delivery and on-farm handling can affect the performance of the plants after planting. Seed potato production and supply in South Africa is complicated by the fact that potatoes are planted throughout the year in various potato production regions, thus plant-ready seed potatoes are required throughout the year. This means that seed potatoes are produced in various regions in different seasons and that the internal quality of seed potatoes varies accordingly. This situation places pressure on all role players in the value chain. More information is required on the effect of practices on the performance of seed potatoes to contribute to our understanding of the performance of seed potatoes after harvest.

In the case of a number of cultivars, there is an availability of knowledge of the effect of climate on the performance of seed potatoes during the seed potato production season.

The effect of the plant readiness of different cultivars on performance after planting has been studied.

Quality of ware potatoes

The quality of ware potatoes is becoming more important as more and more potatoes are being sold as pre-packed products to the consumer. The internal quality of processing potatoes impacts on the quality of the end product and ultimately on the processing sector’s potential to grow. Potatoes destined for export must travel well, be free of rotting, and lose little weight.

Quality of potatoes is determined by external qualities such as skin finish, freedom from rotting, cracks, skin blemish diseases, and shape and size distribution. Internal quality is determined on the basis of characteristics such as specific gravity, sugar content, internal blown spot, hollow hart, texture, and cooking qualities.

To grow the market for potatoes, the industry must be able to provide consumers and processors with the product they want. The climate in South Africa is generally not ideal for potato production, and although high yields are realised, the unfavourable climate often affects internal quality negatively.

A user-friendly method is available to determine the best cooking method for a specific batch of potatoes and is used by pre-packers, retail stores and consumers.

Knowledge of the relative tolerance of popular cultivars to internal defects is available and is used by farmers to make informed decisions.

Knowledge is available on the average weight loss of potatoes during the week after harvest.

Knowledge is available on the most important causes of weight loss, as well as the measures to limit weight loss.
### Soil Health

Soil health is the integration and optimisation of the physical, chemical and biological properties for specific soil types to improve productivity in a sustainable manner. Intensive agronomic crop production has contributed to the gradual deterioration of soil health, resulting in reduced yield and profitability. In addition to this, and to some extent as a result of this, soil-borne diseases are becoming more difficult to control. For some diseases there exist very little or no chemical control options. Soil-borne diseases that have become a major problem in potato production in South Africa include **powdery scab**, **common scab** and **root-knot nematode**. Current options are limited to broad-spectrum soil fumigants and these have proven to be inconsistent at best. In addition, these fumigants not only have a detrimental effect on soil ecology, but also adversely impact on air quality and may contribute broadly to environmental degradation. Such practices result in major ecological disturbances to the production system as a whole by sterilising the soil and destroying beneficial microorganisms. Pathogenic microorganisms that are introduced by planting material proliferate under these sterile conditions where no competition is offered by beneficial microorganisms. This is especially problematic for the potato industry, as potatoes are clonally propagated by planting whole seed tubers or seed pieces, which promote the spreading of pathogens from one area to another. A more sustainable approach needs to be investigated, ultimately demanding the development of a soil health strategy for potato production.

Soil health parameters that are tailor made for potato production have been developed.

Knowledge has been acquired of the success and feasibility of different cultural practices in potato production that are aimed at increasing soil health, i.e. conservation agriculture practices, minimum tillage, crop rotation, green manures, bio-fumigation, etc.

Knowledge has been acquired of the success and feasibility of increased soil health to suppress/control soil-borne diseases, including but not limited to common scab, powdery scab, blackleg, soft rot, root knot nematode, etc.

### Crop Rotation

Crop rotation is a key element of any integrated disease management strategy, in particular for soil-borne diseases. Knowledge regarding alternative host plants, survival of target pathogens in soil, soil type and history, water quality, climate etc., affects the development of IDM strategies. Farmers have identified common scab, powdery scab and root-knot nematode as the most threatening for soil health in potato production regions. Although the information mentioned above is incomplete, the development of region-specific rotation programmes needs urgent attention, as this requires long-term research, observation and adaptation.

Region-specific crop rotation programmes have been developed based on prevalent soil-borne diseases, other agricultural activities, soil condition, etc.

Information on how populations of soil bacteria and fungi are affected by different rotation crops is available.

Information on how different rotation crop affect nematode populations is available.

Information on how potato diseases are affected by rotation crops is available.
| Water usage and quality | Water is the most valuable resource in South Africa, on both a macro-economic and farm level. At the same time, maximum yield can be attained only if enough water is available to the potato crop. Research on water usage of potato plants under local conditions has been done in previous years, and this was followed by research on irrigation scheduling. The fact that new laws on water usage will place restrictions on water availability to farmers, together with increasing energy costs, necessitates irrigation scheduling by more potato farmers. Concerns about the quality of irrigation water in terms of both biological and chemical properties have been raised and need to be investigated. | A review of the quality of water in potato production regions is available. The review includes information on the effect of water quality on potato production. | B |

| Conservation practices | In the development of sustainable agricultural systems, the balance between management practices that support the conservation of natural resources, and practices that result in the degradation of those same resources, is dependent on numerous factors including soil type and climate. Both these factors can directly affect plant biomass production and consequently influence crop residue levels or live plant cover. The interaction between climate and soil, external inputs such as irrigation and the crop being produced influences the soil moisture regime, which in turn can affect the soil’s response to compaction forces, as well as wind and water erosion. Factors such as tillage practices and cover crop management to minimise the negative climatic impacts on a system and enhance the soil’s potential to support the production systems of concern must be developed within the context of specific soil types and climates. | Knowledge is available on the water use efficiency and leaching of the nitrogen in the water solution in potato production regions. | A |

| | Regular knowledge transfer sessions are being held on water usage and irrigation practices for potato. | | B |

| | Long-term projects have been initiated to evaluate the effect/influence of conservation farming practices on soil loss, potato yields, the physical, biological and chemical status of soil, and water use efficiency on potato production in different potato production regions, and the information gathered is being used to develop conservation farming guidelines for each potato production region where projects are being carried out. | | A |
### PRODUCT DEVELOPMENT

#### Research area 4. Cultivar development

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<tr>
<td>Cultivar evaluation</td>
<td>Yield potential is largely determined by the genetic potential of potato cultivars. The success of potato production in South Africa depends to a large extent on the availability of cultivars adapted to the local climate, and acceptable to the diverse but sophisticated market. Ten years ago, the dominant cultivars were of local origin, but currently the market is dominated by one foreign cultivar, namely Mondial, which has a high yield potential and is adapted to the diverse local production conditions. Many new cultivars are imported annually. Following screening by the licence holders, pre-commercial cultivars need to be evaluated for their potential for high yield, their adaptability, and possible risks and advantages. Farmers tend to grow one or a few cultivars and do not like to change, thus it is difficult to establish new cultivars in the market. An important aspect of cultivar trials is that they are performed on commercial farms in various potato production regions.</td>
<td>Potato workgroups carry out cultivar evaluation trials in most potato production regions to determine the yield potential and adaptability of cultivars in each specific region. From time to time, potato workgroups evaluate cultivars for specific purposes, such as short growing periods, processing and dual purpose. A user-friendly and cost-effective method to determine the cooking qualities of potatoes has been developed and is being used by retail stores to indicate the best use of each batch of potatoes.</td>
<td>A</td>
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