Information Day 2021

Milk production from planted pastures

Outeniqua Research Farm: Directorates Plant and Animal Sciences

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Western Cape Government

Agriculture

INFORMATION DAY

OUTENIQUA RESEARCH FARM

MILK PRODUCTION FROM PLANTED PASTURE

Virtual information day streamed from Outeniqua Research Farm, George

Wednesday, 15 September 2021
Starting at 09:00

Presented by Directorates of Plant and Animal Sciences, Western Cape Department of Agriculture, Outeniqua Research Farm, George

Welcoming and opening	**Dr Ilse Trautmann**	10 min
Climate-smart dairy farming: opportunities for carbon mitigation and improved resource management	Dr Stephanie Midgley	15 min
An overview of ryegrass and tall fescue data of the 2020 evaluation trials	Sigrun Ammann	15 min
Changes in botanical composition of grass/forage herb mixtures over four years from a spring planting	Sigrun Ammann	15 min
The integration of forage herbs into systems: lessons learnt from farmlet studies	Janke van der Colf	15 min
Partial replacement of perennial ryegrass with plantain pasture when feeding a low or high level of concentrate to Jersey cows in spring	Prof Robin Meeske	15 min
Milk flocculation: Does feeding more phosphorous to cows improve milk protein stability?	Prof Robin Meeske	10 min

To register please send your E-mail to Janke van der Colf: JankeVdC@elsenburg.com

The link will be sent to registered persons.

For more information contact
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FOREWORD

And so another year of the COVID pandemic and associated challenges continued amidst our hopes to move closer to one another, socialize, de-mask and return to our normal lives.

Our research efforts continued despite COVID regulations and our teams were working according to new routines and schedules. The "not so normal" became normal, our walk and talks and information days became virtual days. The word "virtual" means "being on or simulated on a computer or computer network", but nothing about our research was "simulated". Our team was out there in the pastures and the dairy! It was only technology transfer in a new format, and the real research work was done despite the pandemic, resulting in advancements for dairy farmers at all levels.

In the past year the agricultural sector was challenged on many other levels as well, including climate change and farming in a climate smart way to ensure sustainability and resource optimisation. The research portfolio of the Western Cape Department is problem focused and farmer driven and we are committed to continue our support to our farmers, and in particular the farmers in the Southern Cape. We have also extended our impact with innovative tools like drone technology, spatial decision making tools and smart sensors, to name but a few. We are proud to announce that we could fill all our vacancies with skilled persons, the latest being two young animal scientists who joined the team of the Directorate Animal Sciences.

This year our well known Outeniqua information day is again virtually presented by a dedicated pasture and dairy research team who are not only experts in their respective fields, but who also know the researcher-farmer interface very well.

Please enjoy the day with us from a venue of your choice – be safe and be healthy!

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PLANT SCIENCES – A BRIEF OVERVIEW

Annelene Swanepoel

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Research in the Directorate has been organised into **various research programmes** in order to focus on specific disciplines. Sustainability, conservation agriculture, conservation of resources, environmental impact, and lower input cost are golden threads throughout the projects, and climate smart agriculture is incorporated as technologies develop.

Research on **veld and natural pastures** is currently focused on rehabilitation of degraded areas, management of invasive species, veld monitoring, as well as seed production of indigenous species for arid areas. We also support drought risk management with scientific inputs where required.

Sustainable production and crop rotation systems research is conducted mainly in the cropping areas of the Swartland and southern Cape. It is one of our flagship programmes and provides information on new cultivation practices and the biological and economical effects of these systems. It also creates opportunities for post graduate students and other researchers in agriculture (Universities, ARC, etc.) to do component/basic research within these systems trials and optimising the knowledge gained from these trials. New research focuses specifically on Conservation Agriculture (CA) production systems, with attention to specific knowledge gaps within these production systems for farm level efficiency. We also provide the secretariat for the association "Conservation Agriculture Western Cape".

Pasture systems research, including evaluation and introduction of new species and varieties and also pasture system management, is mainly focused on irrigated pasture systems for dairy and, to a lesser degree on dry-land pastures for the cropping areas of the Swartland and southern Cape. The driving force for sustainable dairy production from irrigated pastures is the research group at Outeniqua Research Farm at George, where the only research of its kind in the country is executed. They focus on the development of sustainable dairy production systems, from soil to pasture crops to grazing management and milk yield and quality, within sustainability and economic parameters. The Plant Sciences group is responsible for the soil and plant sciences part of the research, with collaboration on grazing management research, from the Animal Sciences directorate. This group also present pasture courses to farmers and advisors in the dairy and seed industries.

Grain, oil- and protein seed crops form the basis of small grain cropping enterprises and this programme focuses on evaluation of suitable varieties for our province, as well as the best cultivation and management practices for these crops, whether it is a cash crop or a cover crop.

Research on **soil, plant and water management** has been expanded, specifically pertaining to the biological component of the soil. Conservation agriculture practices have also demanded new research around fertiliser norms and extensive long-term trials on soil fertility, fertiliser requirements and tillage practices are being executed.

Priority areas that are also currently being expanded




are **Alternative crops,** in view of the expected impact of climate change and **Vegetables**, particularly pertaining to the subsistence- and smallholder farmers in our province. This is crucial in addressing food security in the province, as well as maximising outputs and profit for producers on small areas of land.

Supporting all these programmes as set out above, is expertise in the fields of **entomology, plant pathology and weed science,** as well as our **analytical laboratory** for soil, plant and water analyses and our **diagnostic laboratory** for plant diseases. These programmes support and enhance all research within the Directorate, from veld, pastures, crops and alternative crops to vegetables, addressing areas of expertise that is not limited only to specific crops, but integrated through the various production systems. Extensive research is being done on a range of crops and within various systems trials to address pertinent production issues, including international collaboration, in particular in the field of plant pathology. Also, the **analytical and diagnostic laboratories** offer analytical **services to the public**, who can request analyses of soil, plant and water samples at a reasonable cost.

Recently, we have also started developing new technology around remote sensing and crop management and aim to develop those into useful support systems for our producers in order to continue to **grow agriculture in the Western Cape.**

ANIMAL SCIENCES – A BRIEF OVERVIEW

Dr Chris de Brouwer

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The Animal Science Directorate has the mandate to research livestock production in the Western Cape. The purpose of the Directorate is to address industry challenges through needs-based animal production research. Needs identification happens through industry engagement and linkages with the Programe Agricultural Producers' Support and Developments in the department.

In terms of research resources the Directorate is conducting research on 6 research farms that are spread over the province. They are Elsenburg (Stellenbosch), Langgewens (Moorreesburg), Nortier (Lamberts Bay), Tygerhoek (Riviersonderend), Outeniqua (George) and Oudsthoorn.

The focus is divided into nutrition/products and breeding/genetics research.

The research commodities are:

1. ***Small stock including Merino, SAMM, Dormer and indigenous (Namakwa Afrikaner) and composites breeds (Dorper and Meatmaster).***
    - Wool
    - Meat – mutton and lamb
    - Nutrition
    - Growth modelling
    - Ideal slaughter weight
    - Genetics and genomics
2. ***Dairy cattle in total mixed ration (Holstein) and pasture-based systems (Jersey),***
    - Milk yield
    - Milk quality (butterfat, protein, etc.)
    - Feed cost saving, both in TMR and grazing systems
    - Improved feed utilisation, and
3. ***Ostriches (SA Black, Zimbabwe Blue and Kenyan Red).***
    - Breeding and crossbreeding,
    - Development of breeding values for important production parameters,
    - Hatchability and chick survival,
    - Value add through heavier carcasses, sought after leather traits
    - Improved growth performance

A team of nine researchers who work in tandem with eleven research technicians, with support, in turn, from foremen, auxiliary officers and farm aids conducts the research.

The research portfolio comprises an average of 38 projects at any given time. The projects investigate all aspects of animal production regarding nutrition, products, breeding and genetics in the commodities mentioned.

Climate-smart dairy farming: opportunities for carbon mitigation and improved resource management

Prof Stephanie J.E. Midgley

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Introduction

The agricultural sector of South Africa and of the Western Cape Province is already experiencing the impacts of human-driven climate change (Midgley et al., 2016a). These impacts are placing pressure on dairy farming in interaction with rising economic and social pressures, pressures arising from the degradation of the natural resources base in many regions, and the deterioration of air and water quality. Across the globe and in all sectors, there is a heightened urgency to intervene in order to limit the extent and impact of future climatic changes by rapidly reducing the sources and enhancing the sinks of greenhouse gases (GHGs) (termed climate change mitigation) (IPCC, 2021). A sink can be any activity or mechanism that removes GHGs from the atmosphere, such as the fixing of atmospheric carbon dioxide (CO_2) by plants through photosynthesis and its long-term storage in the soil carbon pool, termed carbon sequestration. Pasture-based dairy production has a significant footprint resulting from intensive energy, water and fertiliser use. Nevertheless, it offers several opportunities for cost-effective reductions in emissions of key GHGs, and for meaningful and even profitable carbon sequestration interventions.

Simultaneously, climate change will have disproportionately high negative impacts on pastures that are in a degraded state, and where soil and water resources are poorly or sub-optimally managed. Across South Africa and the Western Cape, water is a scarce and precious resource, and climate change is projected to lead to changes in rainfall amounts and seasonal rainfall patterns, which, together with rising temperatures, will reduce the water supply available to agriculture, and increase the rate of soil drying between rainfall/ irrigation events (DEFF, 2019). Excessive applications of nutrients and poor manure management, degraded river and wetland systems, and other factors in the dairy value chain, can impair the quality of downstream and ground water resources (Botha, 2011/2012). An array of adaptive strategies and better practices is available for addressing the actual or expected climate effects on water resources while in many instances reducing input costs.

One of the manifestations of climate change that has recently become highly visible both globally and locally is the increasing frequency, intensity and duration of extreme rainfall events such as droughts and floods (Otto et al., 2018; CSIR 2021 https://greenbook.co.za/). Managed pastures are highly vulnerable to these extremes, particularly in areas without sufficient water storage or well designed drainage infrastructure. This is an area of concern that has not received the same level of interest from the dairy sector as GHG emissions and environmental sustainability. Mitigation of disaster risk is needed to lessen the potential adverse impacts on farms and regions.

This paper focuses on the farm level, with emphasis on pasture management, notwithstanding the important impacts on, and role of the cows and the whole dairy value chain. These have been discussed in several previous publications (Botha, 2011/2012; Midgley, 2015). The aim here is to provide a science-based summary of the following considerations, in the context of three dairy regions of the Western Cape. Recommendations for further research are provided.

1. Overview of climate change trends and projections
2. Opportunities to reduce GHG (CO_2, nitrous oxide [N_2O]) emissions from pasture-based dairy farming (excluding the role of enteric fermentation and methane [CH_4] emissions);
3. Opportunities to sequester carbon in pasture soils;
4. Protection and efficient use of water resources.

Overview of climate change trends and projections

Three major dairy production regions of the Western Cape will be assessed: the western region, Overberg, and southern Cape (Fig. 1). These coastal regions are characterised by lower annual rainfall in the Western and Overberg regions and higher rainfall in the southern Cape (Fig. 2 top left), a west-east shift in rainfall seasonality from winter rainfall to all-year rainfall (Fig. 2 top right), a relatively similar mean annual temperature (16-18°C, Fig. 2 bottom) and cool winters, but hotter summer days in most of the western region compared to the Overberg and southern Cape. This diversity results in a matrix of expected future climates once the modelled climate change projections are overlaid. It is important to note that dairy production occurs in widely differing environments and production systems, so that climate change will affect farms in various ways depending on the local context, and responses must be tailored to each situation to ensure environmental sustainability and economic viability of the enterprise (Midgley et al., 2016b).

Figure 1. Three main dairy production regions of the Western Cape: Western, Overberg and southern Cape. Background map: Agro-ecological Zones of the Western Cape (M. Wallace, Western Cape Department of Agriculture).

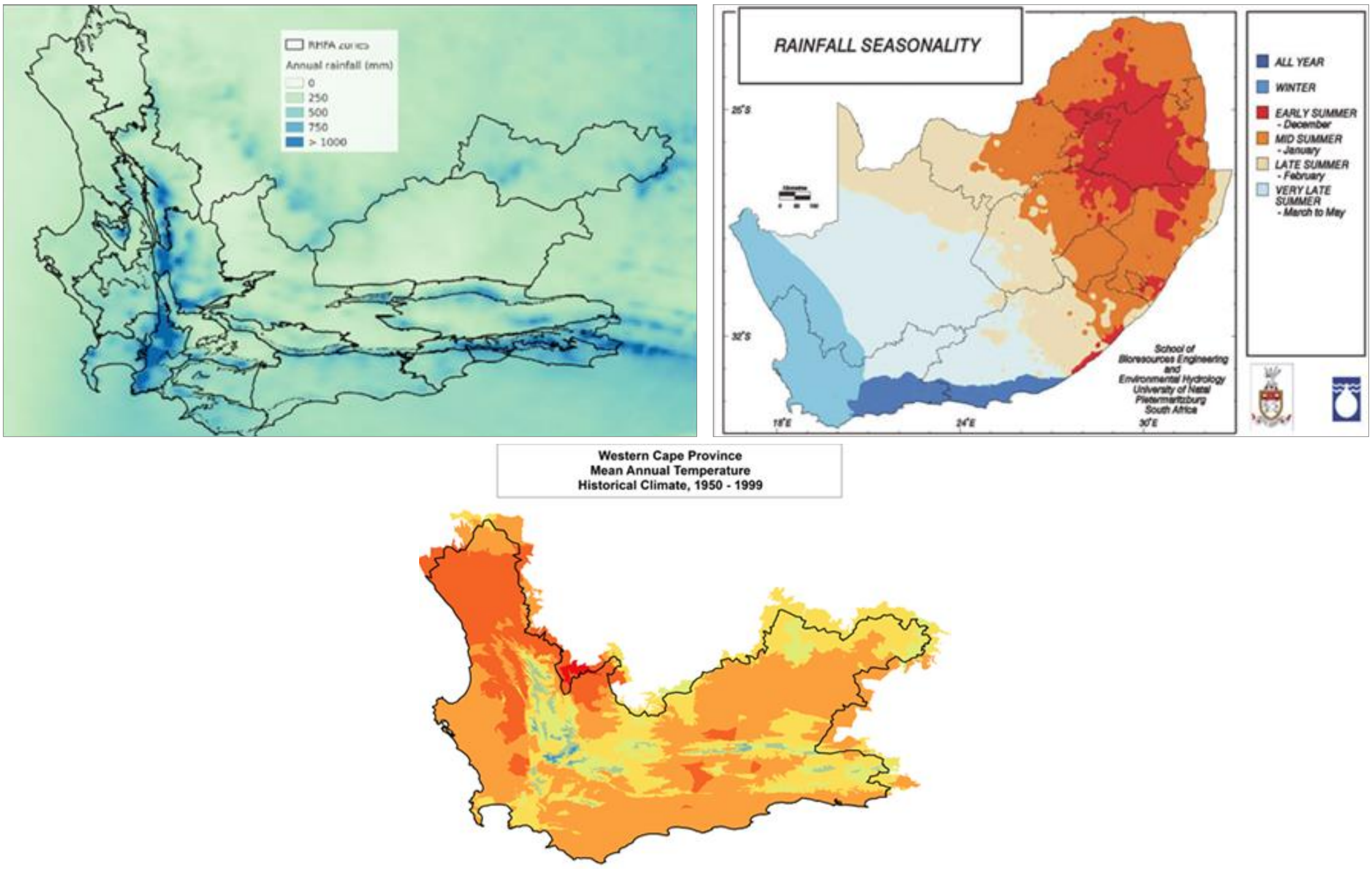

Figure 2. Top left: Mean annual precipitation of the Western Cape overlaid on the Agro-ecological Zones. Source: Midgley et al. (2016a). Top right: Rainfall seasonality of South Africa. Source: Schulze and Maharaj (2008). Bottom: Mean annual temperature of the Western Cape. Source: Midgley et al. (2021).

Across the Western Cape, the climate is already changing through increasingly variable and unpredictable weather, significant rates of warming, and more frequent climate-related extremes and disasters (Midgley et al., 2016a; DEA, 2018). Temperatures have increased by more than 1.1°C on average over the last eighty years, and this trend is especially significant in the western region. Daily maximum temperatures and the number of hot days are rising. Data indicates an increase in the probability of heavy rainfall events, but fewer rain days in late summer to autumn, and more rain days in November-December in the west. No significant trends in total annual rainfall can yet be discerned, except for a moderate long-term positive trend in the Little Karoo (in the northernmost part of the southern Cape region) associated with summer rainfall.

Climatologists are in agreement that shifts in climate systems are expected over the next few decades. Importantly for the coastal dairy regions, a southward (poleward) shift of the westerly winds will increasingly block the movement of rain-bringing cold fronts making landfall (DEA, 2018). In the shorter term (20-30 years), these shifts will emerge as increasing inter- and intra-annual rainfall variability. Although the projected changes in rainfall are more uncertain than those for temperature, there is scientific consensus that the Western Cape will become relatively drier in the longer term as the climate system adjusts (DEA, 2018; IPCC, 2021). Reductions in winter rainfall are projected for most parts of the province, but with greater certainty in the western core winter rainfall region (Fig. 3). The recently published first part of the sixth assessment report on climate change of the Intergovernmental Panel on Climate Change (IPCC, 2021) reports with increased scientific confidence that the Mediterranean-type climate regions of the world will experience reductions in winter rainfall. These regions are amongst those expected to experience increasing aridity and agricultural and ecological droughts under future warming (Fig. 4). In the Western Cape, local topography is likely to moderate this, and there is a possibility that more rain could fall on windward mountain slopes in autumn and spring, at least in the short term future, and especially for future scenarios where global GHG emissions are rapidly reduced (Midgley et al., 2016a). The models also project that the current trend towards fewer rain days and more intense rainfall events will continue.

The global climate models are in high agreement that warming will continue into the future, with absolute increases depending on how successfully the nations can achieve zero net carbon emissions. For the Western Cape (Midgley et al., 2016a), the projections indicate a warming of 1.5°C - 3°C by the mid-century (Fig. 5). The lower range of warming (1.5 - 2.1°C) is expected along coast from Cape Town eastwards, but a mid-range warming (2.1 - 2.4°C) is expected along the west coast. In all regions, there will be more hot days and nights, and fewer cold days and nights.

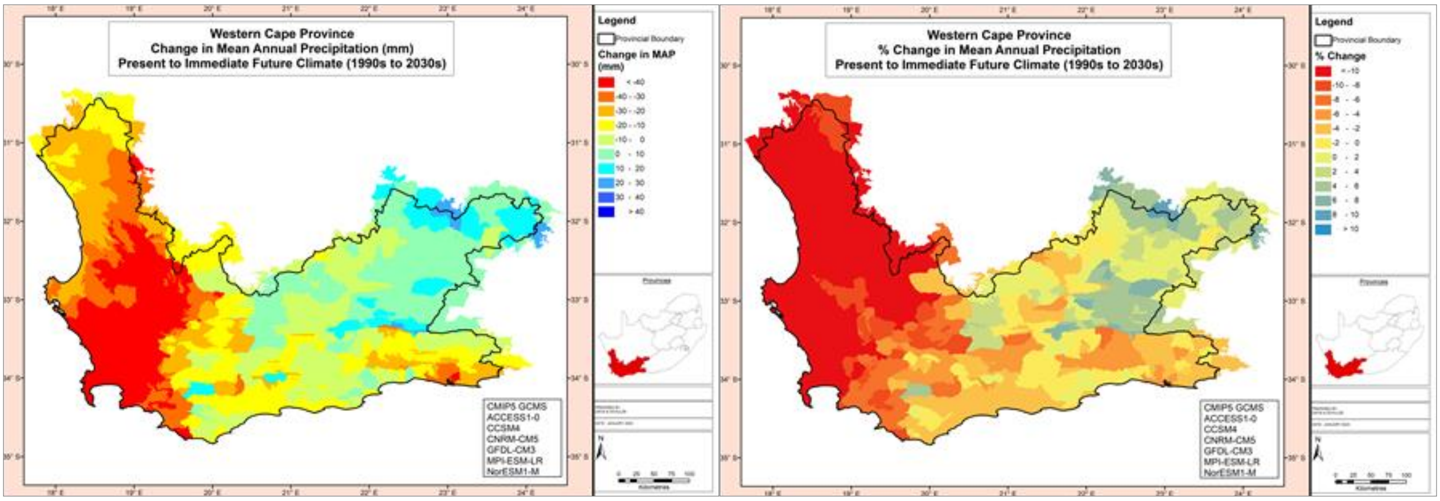

Figure 3. Projected (modelled) changes in mean annual precipitation in the Western Cape expressed in mm (left) and as a percentage (right) between the period 1990s and the period 2030s. The maps are derived from as yet unpublished outputs of seven bias-corrected CMIP5 GCMs (CWWR, 2021; unpublished). Source: Midgley et al. (2021).

Figure 4. Schematic map highlighting in brown the regions where droughts are expected to become worse as a result of climate change. This pattern is similar regardless of the emissions scenario; however, the magnitude of change increases under higher emissions. Source: IPCC AR6 WGI FAQ 8.3, Figure 1 (IPCC, 2021).

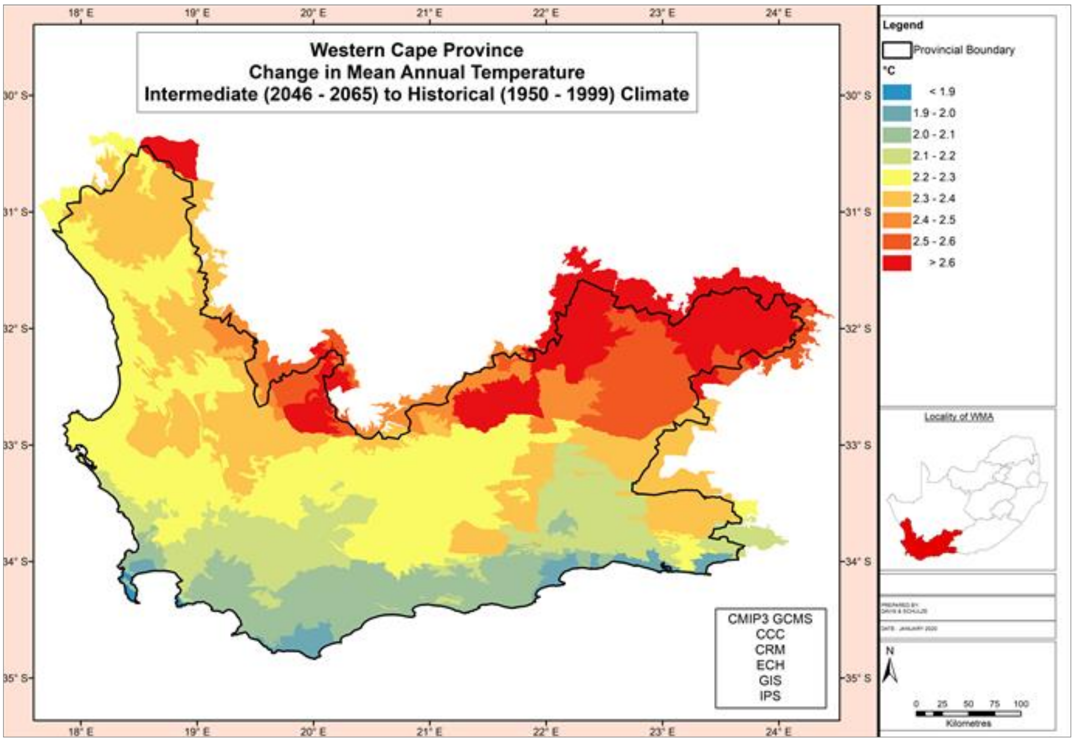

Figure 5. Projected (modelled) changes in mean annual temperature (in °C) from the historical climatic conditions (1950-1999) to the intermediate future (2046-2065) in the Western Cape. The results are derived from six CMIP3 GCMs. Source: Midgley et al. (2021); (original research: Schulze, 2011).

A picture thus emerges of the following likely future conditions in the three dairy regions:

Table 1. Summary of projected likely future climate conditions in the three dairy regions of the Western Cape.

Region	Temperature	Rainfall	General
Western	Stronger warming and more very hot days	Drying; reductions in winter rainfall across the region	Increases in aridity, agricultural and ecological drought; increases in wind speeds; increases in fire weather conditions
Overberg	Moderate warming and more hot days	Drying; linked to reductions in winter rainfall (more so in the west) and warming, but uncertainty about shifts in total annual and seasonal rainfall in the east	Increases in aridity, agricultural and ecological drought; increases in wind speeds; increases in fire weather conditions
Southern Cape	Moderate warming and more hot days	Drying linked to variable rainfall and warming, but uncertainty about shifts in total annual and seasonal rainfall; some models indicate possible minor wetting in the shorter term in the west	Increases in aridity, agricultural and ecological drought; increases in heavy rainfall and flash flooding; increases in wind speeds; increases in fire weather conditions

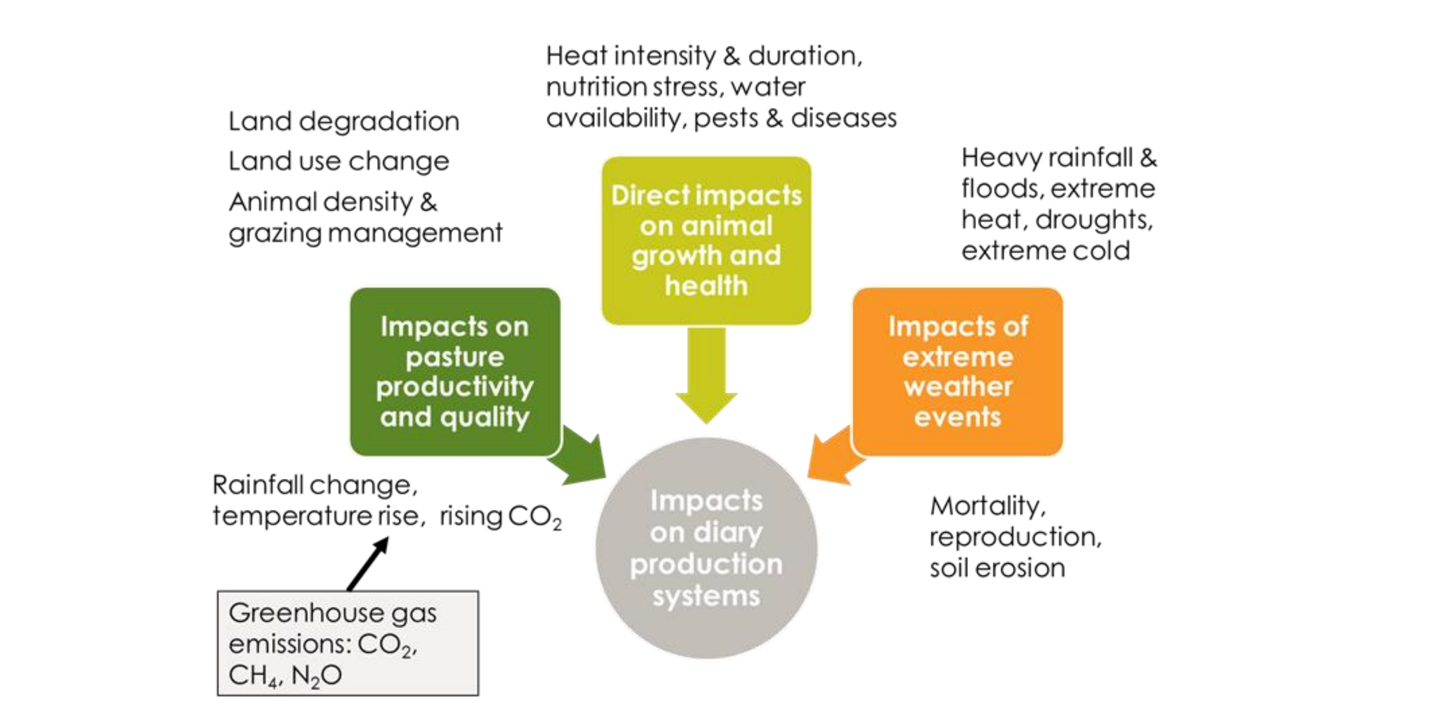

Figure 6. Schematic of pathways of climate change impacts on dairy production systems. Source: Author.

The impacts of these changes on pasture-based dairy production systems will manifest via three main pathways (Fig. 6):

1. Impacts on pasture productivity and quality;
2. Direct impacts on animal growth, milk production and health; and
3. Impacts of extreme weather events.

While research has significantly increased our understanding of some of these impacts, notably heat and nutrition stress effects on cows (Nesamvuni et al., 2012; Du Preez, 2014), many questions remain in other impact areas e.g. long-term shifts in pasture production potential, changes in the length of the growing season for pastures, the effects of rising atmospheric CO_2 concentrations on pasture species, the rising water demand of pastures, impacts of soil warming on soil biological activity and GHG emissions, and the potential impacts of more severe droughts and floods. These require further targeted research. For now, this paper will highlight actions that can already be taken now based on the current knowledge base and available improved practices and technologies. Both adaptation (water resources) and mitigation (pasture-based GHG emissions reductions and carbon sequestration) will be covered.

Opportunities to reduce GHG emissions from pasture-based dairy farming

South Africa is the 15th-largest emitter of greenhouse gases per capita in the world. This calls for shared responsibility in addressing the crisis. Estimates of direct CH_4 and N_2O emissions of South African dairy and beef cattle were published by du Toit et al. (2013). The latest National GHG Inventory for South Africa (DEFF, 2020), based on data until 2017 and using the IPCC accounting methodology (IPCC, 2006), highlights the high contribution of livestock CH_4 emissions and N_2O emissions from managed soil (Table 2). The global warming potential of CH_4 is 28 times that of CO_2, and the warming potential of N_2O is 265 times that of CO_2 over 100 years. When converted to CO_2-equivalent units, CH_4 emissions from enteric fermentation by cattle rank as the 7th (3.76%) highest contributor to national emissions, and those from direct N_2O emissions from managed lands are the 8th highest (3.15%) (Table 2). The total contribution by agriculture, when all GHGs are expressed as CO_2-equivalents, is about 9% (Fig. 7 top left) and has been a relatively constant proportion since 2000. These figures do not include the emissions arising from the use of electricity and liquid fuel in the dairy value chain.

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Table 2. Top eight categories for South Africa for 2017 (excluding FOLU) determined by level (L1) assessment. Source: DEFF (2020). Emissions are expressed as gigatons of CO2-equivalents. The red block highlights the contributions of livestock methane emissions (cattle enteric fermentation) and direct nitrous oxide emissions from managed (fertilised) soils.

Key category number	IPCC code	IPCC category	GHG	2017 Emissions (Gg CO_2e)	% Contribution
Emissions excluding FOLU - Level assessment (2017)					
1	1A1a	Electricity and Heat Production (Solid fuel)	CO_2	218 959.2	38.10
2	1A3b	Road Transport (Liquid fuel)	CO_2	69 816.6	12.15
3	1A2	Manufacturing Industries and Construction (Solid fuel)	CO_2	31 855.1	5.54
4	1A1c	Manufacture of Solid Fuels and Other Energy Industries (Solid fuel)	CO_2	29 270.6	5.09
5	1A4b	Residential (Solid fuel)	CO_2	28 337.4	4.93
6	1B3	Other Emissions from Energy Production	CO_2	25 746.5	4.48
7	3A1a	Enteric fermentation – cattle	CH_4	21 589.7	3.76
8	3C4	Direct N2O emissions from managed soils	N_2O	18 081.0	3.15

Fig. 7 shows the breakdown of emissions between the sectors energy; industry (IPPU); AFOLU (Agriculture, Forestry and Other Land Uses) but excluding the FOLU component; and waste. The negligible CO_2 emissions from agriculture (0.3%) compared to energy (92%) is particularly noteworthy (Fig. 7 top right). CO_2 emissions in agriculture (excl. energy and fuel use) occur primarily through land-use change.

Regarding CH_4 emissions (Fig. 7 bottom left), enteric fermentation by livestock contributed around 52% to the national total in 2017, but the contribution from livestock declined by 11.0% from 2000 to 2017 due to a decline in livestock populations. The dairy cattle contribution to the overall enteric fermentation emissions stands at around 12%, and increased by 1.7% between 2000 and 2017.

National N_2O emissions are dominated by the contribution from agriculture (Fig. 7 bottom right), specifically managed soils and biomass burning (85% in 2017). This is a significant fraction of non-carbon emissions from agriculture. However, over the period 2000 to 2017, overall N_2O emissions declined by 10%. Livestock manure, urine and dung inputs to managed soils provided the largest N_2O contribution in the agriculture sector and the downward trend follows a similar pattern to the livestock population. However, the dairy cattle population has shown a slight uptick and thus its contribution to N_2O emissions has also risen slightly. Regarding N_2O emissions from managed land, these

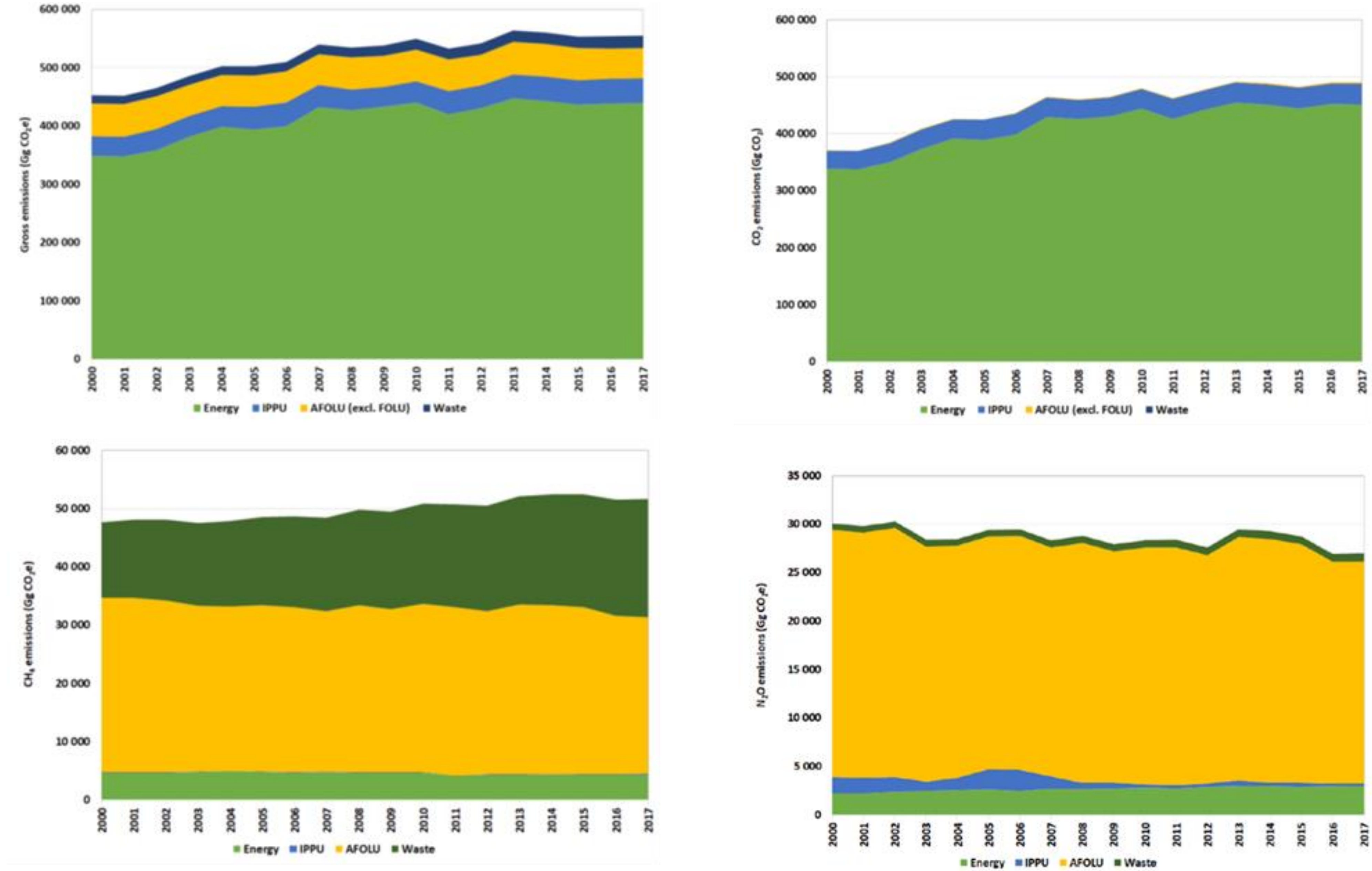

Figure 7. Sectoral contribution to the trend in the gross emissions (CO_2 equivalents) for South Africa, 2000 – 2017 (top left). Trend and sectoral contribution to CO2 emissions (top right), CH_4 emissions (bottom left) and N_2O emissions (bottom right) for the period 2000 – 2017. The agriculture sector (AFOLU excl. FOLU) is indicated in yellow. Source: DEFF (2020).

have decreased by around 10% (direct emissions, the dominant source) and by 9% (indirect emissions). N_2O emissions from land arise primarily from N-based fertilizer use in intensive cultivation.

The results of the National GHG Inventory for South Africa are, however, based on global emissions factors, and adjustments in the results can be expected as future updated inventory analyses use region-specific emission factors for dairy farming (Smit et al., 2020). Furthermore, different dairy production systems are associated with widely ranging GHG emissions (Reinecke and Casey, 2017) and this will affect regional estimates.

A forward-thinking and pre-emptive approach to climate change mitigation is required in the agricultural sector. There remains a window of opportunity for the dairy sector to establish farm-level emissions baselines and emissions reductions targets, supported by research and shifts to practices that yield rapid emissions reductions that are meaningful in the national emissions context and cost-effective at farm level. Measurable and verifiable emissions reductions will provide a bulwark against mounting pressure on agriculture, and livestock production systems in particular. Given the above figures, the two areas of greatest concern but also of greatest opportunity for the dairy sector are CH_4 and N_2O emissions. Farm-based research on coastal dairy farms confirms that CH_4 from enteric fermentation is the largest contributor of GHG emissions, followed by N_2O emissions from grazed pastures (Galloway, et al., 2018; Smit et al., 2021). Much research attention has focused on technologies and practices to reduce CH_4 emissions from enteric fermentation, and this will be not be discussed here.

Direct N_2O emissions result from several pathways of nitrogen inputs to agricultural soils (IPCC, 2006). The following two pathways relate to farming practices (other pathways include soil organic matter lost from mineral soils through land-use change, and organic soil that is drained or managed for agricultural purposes).

- Nitrogen inputs:
    - Synthetic nitrogen fertilizers;
    - Organic fertilizers (including animal manure, compost and sewage sludge);
    - Crop residue (including nitrogen fixing crops);
- Animal manure deposited on pastures, rangelands and paddocks.

Reducing emissions from the first pathway, and specifically purchased synthetic nitrogen fertilizers, is a relatively low-hanging fruit in most situations. Research conducted in the western part of the Eastern Cape found that excessive application of nitrogen-based fertilizer and low nitrogen-use efficiency (NUE, the percentage of N imported that is removed in milk or animals leaving the farm) is common in dairy farming (Galloway et al., 2018). The average on-farm NUE in this study was 29%, and an excess N of 284 kg/ha/year was generated. Mineral fertilizer was the largest source of imported N. Galloway et al. (2018) also reported a negative correlation between NUE and GHG emission intensity.

In a study of N_2O emissions from fertilized and irrigated dairy pastures in the southern Cape (Smit et al., 2020), an exponential relationship was reported between N_2O nitrogen losses and N input from fertilizer. Excessive fertilization of pastures with N raised N_2O emissions significantly, with no additional benefit to growth of the pasture herbage. Low rates of fertilizer application resulted in the lowest carbon footprint (Smit et al., 2021).

Raising and optimising NUE should thus be aimed for, using effective and affordable fertilization and feeding strategies. These could include, in conjunction with minimal N fertilizer application rates (from Galloway et al., 2018; Smit et al., 2020; Smit et al., 2021):

- Minimal use of purchased concentrates, and using those that lead to more efficient feed conversion;
- Milk production per hectare optimised for highest NUE;
- Stocking rates optimised for highest NUE;
- Rotational grazing management;
- Consider the contribution of excreta to the N balance and fertilization strategy;
- Optimal timing of fertilizer application;

- Incorporation of forage N-fixing legumes;
- Improved irrigation systems;
- Increased soil carbon levels (see next section).

Opportunities to sequester carbon in pasture soils

While reducing GHG emissions from dairy pastures using the above listed strategies, adapted pasture management practices aimed at building up soil carbon concentrations can also contribute substantially to reducing CO_2 levels in the atmosphere, as well as improving the soil health and water holding capacity (see next section). The uptake and capturing of CO_2 from the atmosphere through photosynthesis, followed by the long-term incorporation of carbon-rich compounds into the soil, is termed carbon sequestration. It can be accelerated through changes in agricultural practices. Soil carbon is positively correlated with NUE and negatively correlated with GHG emissions (Galloway et al., 2018). Building the soil carbon levels also leads to opportunities to reduce N fertilizer application rates. A managed dairy pasture in the southern Cape was found to sequester 850 – 1140 kg C/ha/year, representing an average reduction of 14% in the carbon footprint (Smit et al., 2021).

Several strategies are available for increasing soil organic carbon:

- Applying the principles of conservation agriculture (CA) to managed pastures, i.e.
    - Minimal soil disturbance, preferably using no-till, and leaving residues to be incorporated into the soil (no burning);
    - Keeping the soil surface covered with organic material at all times (this also reduces soil temperature which affects carbon losses);
    - Using forage rotations (see Loges et al., 2018) and a greater diversity of forage species including nitrogen-fixing legumes;
    - Including perennial grasses and other perennial forage species in the pasture species mix, including those with deep root systems, to increase the long-lived below ground biomass fraction and exudation of carbon compounds at greater depth;
- Optimise forage growth and biomass per hectare without excessive fertilizer applications or irrigation;
- Multi-paddock rotational grazing at a high stocking density with periods of rest to allow for regrowth (although the evidence is mixed, see Contosta et al., 2021).

A study by Kirschbaum et al. (2017) does, however, emphasise that building soil carbon is a complex outcome of several interacting factors, including carbon gain through higher primary production, carbon lost through grazing and eventual milk production, the stability of the various carbon fractions in the soil, and changes in SOC decomposition rates. These trade-offs are also significantly influenced by fertilizer rates, supplemental feed rates, soil water availability, root:shoot ratios and soil temperature.

Carbon offset programmes have become the focus of high interest in the agricultural community. The principle is that farmers receive a direct financial benefit in the form of carbon credit income, in return for long-term carbon fixation from the atmosphere and accumulation in farm soils. Such programmes have recently become available in South Africa and provide a sound opportunity for farmers to shift to climate-friendly practices and contribute further to GHG reductions. It must, however, be noted that interventions must be additional to existing practices and not business-as-usual, farmers must be able to provide existing soil data over several years, and the additionally fixed carbon must persist over the long term (many decades) and in a stable form that is protected from rapid decomposition. Dairy farmers are encouraged to investigate such opportunities, but are cautioned to use only programmes listed under an internationally recognised carbon standard.

Ultimately, the goal in agriculture is to strive towards "net zero carbon" or even a positive balance, where carbon sequestration is equal to or greater than total GHG emissions.

Protection and efficient use of water resources

In the section on climate change trends and projections, changes in rainfall together with warming and greater risks of droughts were discussed. The Western Cape already experiences high variability in rainfall, with regions like the southern Cape particularly prone to cycles of very dry and very wet weather (Midgley et al., 2016a). Climate change model outcomes send a strong message that rainfall variability and unpredictability are likely to worsen, and that the gap between water supply and water demand will grow. Surface water resources are under increasing pressure, and groundwater resources are increasingly being used for agriculture (especially since the 2015-2018 drought). Without improved monitoring and management, this resource is also facing future threats resulting from over-extraction and salinization.

Deteriorating water quality is a major risk to humans and agriculture. Various pathways exist through which climate change could worsen this problem. Intensively managed dairy pastures, especially those with a history of excessive fertilization and poor manure management, are sometimes part of this problem. Nitrogen and phosphorus leaching into surface and groundwater are especially challenging.

The three dairy farming regions do not benefit from large water storage capacity and irrigated pastures receive water mainly from smaller farm dams and rivers. Across the Western Cape, the engineered water infrastructure is reaching its limits. Adaptation to climate change must, therefore, focus on an increase in agricultural water use efficiency, and improved catchment and river management (Midgley et al., 2016b). Significant water resources can be released through the clearing of invasive alien plants and the restoration of sensitive wetlands that play a critical role in hydrological processes. This approach is based on utilizing ecological infrastructure, a much more cost-effective method compared to engineered solutions. Healthy ecological infrastructure, together with well designed on-farm drainage infrastructure, is also capable of mitigating the impacts of more frequent and intense rainfall and flash flooding, as expected in some regions in the future.

Irrigation in combination with fertilizers is used on pasture-based dairy farms to boost forage growth and yield, and milk production (Truter et al., 2016). Where rainfall is insufficient or during dry periods, supplemental irrigation is used, but many producers have permanent systems installed. However, above a certain optimum both inputs rapidly increase the N_2O emissions from the pasture (Smit et al., 2020). During the warm seasons, water inputs trigger high rates of N-mineralization, leading to large N_2O fluxes. From both an emissions and a water scarcity and water quality point of view, the implementation of best practices for nutrient and irrigation management is becoming increasingly important.

Irrigation strategies are an important component of climate-smart dairy farming. These can include:

- Reducing total irrigation water volumes but with shorter and more frequent application events;
- More water-efficient irrigation systems such as drip, sub-drip and even micro irrigation;
- Follow irrigation guidelines for the pasture mix, soil type and region (Truter et al., 2016);
- Where feasible use drought resilient species in the pasture mix and those with deeper root systems;
- Install soil moisture monitoring systems to guide irrigation scheduling; use remote precision irrigation tools e.g. FruitLook, drones;
- Aim to measure and increase the water productivity of milk production – in addition to Rand/liter milk and liters milk/hectare, also monitor Rand/liter water used and liters milk/ liter water used;
- Increase the soil water-holding capacity where this is sub-optimal (see section above on carbon sequestration) and reduce evaporation from soils through sufficient cover (CA principles);
- Protect the water resource from wasteful losses (e.g. leaking and faulty infrastructure) and pollution (e.g. effluent, excess nutrients);
- Install additional on-farm water storage capacity, where possible;
- Have access to more than one source of freshwater;
- Recycle and re-use waste water for irrigation;
- Clear invasive alien plants along watercourses and wetlands and maintain them alien-free;
- Maintain the proper buffer zones between managed pastures and watercourses/ wetlands;
- Ensure that drainage infrastructure is well-designed and fit for purpose under high rainfall.

Summary

This paper has addressed three of the key components of climate smart dairy production in the Western Cape and highlighted several opportunities. The cost-effectiveness of specific interventions is highly region- and farm-specific and requires investigation on a case-by-case basis. However, several of the interventions are linked to reductions in costly inputs rather than investments that require a return on income. Consideration should also be given to the long-term ramifications of possible future punitive measures taken by nations and markets (driven by consumer concerns) in their responses to the global climate crisis, with mounting pressure on sectors that are perceived to be high contributors. The dairy sector will ensure resilience and growth if it can proactively shift to practices with measurable environmental and climate benefits within the next 5-10 years.

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Tall Fescue and Festulolium cultivar evaluation results: the first 15 months 2020/21

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Introduction

The Elite evaluation trials are aimed at evaluating agronomic traits such as DM yield, disease tolerance and forage quality, and also provide data on interaction traits (seasonal yield distribution, flowering, growth form, persistence) for what can be mostly considered recent and high-end varieties or varieties with unique characteristics that may have a beneficial application for local pasture systems. This information provides local data for choice of pasture cultivars. The interaction traits can be used to assist in selecting varieties for pasture mixes. It is important to determine the genetic potential of varieties and in that way evaluate all varieties on equal terms in an unbiased way.

- Evaluate high-end varieties with modern genetics and special traits
- Characterize into types
- Determine agronomic and interaction traits to assist with choosing varieties for mixtures aiming at complementarity within the mixture

Parameters measured/assessed:

- DM yield (harvested according to leaf-stage)
- Seasonal yield patterns
- Dry matter (DM) content
- Disease incidence (mainly rust)
- Flowering behaviour (reproductive tillers)
- Persistence/ plant population (not applicable in the current report)
- Forage quality (not in the current report, refer to the 2019 booklet)
- General growth form (will be reported at the end of the trial)

Festuca species evaluated

The following Festuca species are evaluated

- *Festuca arundinacea* (tall fescue) – Continental (11 cultivars) and Mediterranean types (1 cultivar)
- *Festulolium* – tall fescue types: 6 cultivars
- The trial also contains one treatment which is a mixture of tall fescue and cocksfoot. However the cocksfoot component has been completely dominant with not much tall fescue evident in the plots.

Tall fescue (*Festuca arundinacea*) characteristics that are of interest:

- Perennial grass with deep root system with good persistence
- Relatively good forage quality, especially recent varieties that have softer leaves (lower tensile strength) and also related to appropriate grazing management (Donaghy et al 2008)
- Tolerates waterlogging
- Tolerates higher temperatures than ryegrass
- Tolerates low pH soils and salinity
- Has a high responsiveness to irrigation or rainfall and responds more quickly than perennial ryegrass (Lowe & Bondler 1995, Nie

et al 2008, Raeside et al 2012)

- Has a better water use efficiency than perennial ryegrass (Minnee et al 2010).
- ***Continental types***
  - Summer active growth
  - "intermediate types" with some winter growth activity
- ***Mediterranean types***
  - Winter active (summer dormant)
- Soil temperature at sowing should consistently be >12°C for rapid germination and consequently successful establishment (Dairy NZ 2010). Hence establishment should be done in early autumn or even late summer depending on the climate.

The aim of the cultivar evaluation trials is to determine the genetic potential for the various parameters. The *Festuca* trial is harvested when the first continental cultivars reach the 2 to 2.5 leaf stage or in spring at canopy closure if necessary. According to Chapman et al (2014), tall fescue carbohydrate reserves are replenished between the 2 and 4 leaf stage and maximum growth rate is achieved at the 2.5 leaf stage. Leaf appearance rate is determined mainly by temperature and hence most varieties reach the required leaf stage at a similar time. This harvest interval is used even though tall fescue is known to be a four-leaf plant, however with the larger root system, root growth recommencing almost immediately after defoliation and greater tolerance of higher temperatures, the plants tend to have sufficient storage carbohydrates to be harvested before the maximum leaf number is reached. Previous trials have shown no apparent adverse effects in terms of persistence when swards are harvested at the 2-leaf stage. There could however be an advantage in having a slightly longer defoliation interval at certain times of the year to allow for additional carbohydrate reserve accumulation. The advantage of tall fescue in terms of leaf stage is that there is greater flexibility than is the case of ryegrass since the sward can be grazed between the 2 and 4-leaf stage without leaf death. According to Donaghy et al (2008) forage quality is highest at the 2-leaf stage and lowest at the 4-leaf stage. Hence the compromise is sensible to graze between the two and three leaf stage.

Results are given below the trial named Fa2, which was planted on 3 March 2020 at the Outeniqua Research Farm. These are interim results for the first 15 months of the trial, which is expected to continue to a maximum of five years.

Total and seasonal yield (Table 1) gives an important overview of what to expect from different cultivars. This is especially important for tall fescue and festulolium since there are distinct types in terms of summer and winter active growth and fewer cultivars on the market as is the case for the ryegrasses. More recently there are continental types with improved winter growth activity. Tall fescue, more than the ryegrasses has more pronounced seasonal growth patterns which are important to quantify so that the species can be combined with other species either in a monoculture or mixtures for more optimal fodder flow or excess forage conserved as silage for feeding out in the lower producing season, typically winter. **Mean seasonal growth rates** are given in **Table 2.**

Individual harvests data is given in **Table 3** with **growth rates** in **Table 4** and shows the data for the first nine harvests of this trial up to May 2021. The trial is continuing.

Table 5 shows the **dry matter content** while **rust** and **flowering incidence** are given in **Tables 6 and 7**.

Leaf emergence rate is given in **Table 8**.

Table 1: Tall fescue and Festulolium (Festuca arundinaea), Fa 2, Elite Evaluation, Outeniqua Research Farm
Planted: 3 March 2020 **Seasonal Yield** (t DM/ha) TF-C = Continental, TF-M = Mediterranean, FL-Fa = Festulolium tall fescue type

Cultivars	Type	Autumn 2020	Rank	Winter 2020	Rank	Spring 2020	Rank	Summer 2020/21	Rank	Autumn 2021	Rank	Year 1 2020/21	Rank	15 months 2020/21	Rank
Bariane	TF-C	1.19 jghij	14	1.31 ghijk	16	2.96 k	20	4.40 efgh	15	2.77 cde	11	10.9 h	18	13.6 ij	19
Baroptima	TF-C	0.76 ij	19	1.08 jk	19	4.28 jk	19	4.66 defg	13	2.96 bcd	5	10.8 h	19	13.7 ij	18
Boschhoek	TF-C	**1.86 abcde**	7	1.91 cde	7	5.58 bcde	5	4.50 efgh	14	3.05 bc	3	13.9 bcde	7	16.9 bcd	6
Duramax	TF-C	**2.03 abc**	3	1.69 defg	8	5.42 cdef	6	4.79 bcdefg	9	2.58 cde	15	13.9 bcd	6	16.5 cde	8
Easton	TF-C	1.52 cdefgh	10	2.04 bcd	5	5.27 defg	8	4.97 bcdef	8	2.85 cde	8	13.8 bcde	8	16.7 bcd	7
Felina	FL-Fa	0.89 ij	18	1.02 k	20	4.60 hij	17	5.15 bcd	6	2.81 cde	10	11.6 gh	16	14.5 fghij	13
Fojtan	FL-Fa	1.16 ghij	15	1.12 ijk	18	4.42 ijk	18	3.94 h	20	2.31 e	20	10.6 h	20	12.9 j	20
Hipast	FL-Fa	1.29 efghi	12	1.55 fghi	12	4.66 hij	16	4.28 gh	18	2.45 de	17	11.8 fgh	15	14.2 ghij	16
Honak	FL-Fa	1.28 efghi	13	1.66 defgh	9	4.76 ghij	15	4.30 gh	17	2.38 de	19	12.0 fgh	13	14.4 fghij	14
Hummer	TF-C	1.69 bcdefg	9	1.56 fgh	11	4.85 fghij	12	1.73 cdefg	11	2.82 cde	9	12.8 defg	11	15.7 defgh	11
Hykor	FL-Fa	1.10 ghij	16	1.36 ghijk	15	4.99 efghi	10	4.79 bcdefg	10	2.66 cde	14	12.2 efgh	12	14.9 efghi	12
Jesup	TF-C	1.07 hij	17	1.24 hijk	17	4.97 fghi	11	4.35 fgh	16	2.41 de	18	11.6 gh	17	14.0 hij	17
Kora	TF-C	**1.79 abcdef**	8	1.59 efgh	10	4.83 fghij	13	5.15 bcd	5	2.67 cde	13	13.4 cdef	9	16.1 def	9
Mahulena	FL-Fa	0.63 j	20	1.37 ghijk	14	5.11 efgh	9	4.69 cdefg	12	2.52 cde	16	11.8 fgh	14	14.3 ghij	15
Paolo	TF-C	1.35 defghi	11	1.50 fghij	13	4.77 ghij	14	**5.34 abc**	3	2.87 cde	7	12.9 defg	10	15.8 defg	10
Quantico	TF-C	**1.99 abc**	4	2.19 bc	4	**5.72 abcd**	4	**5.40 ab**	2	**3.53 ab**	2	**15.3 ab**	4	**18.8 a**	3
Royal-Q	TF-C/M	**2.38 a**	1	2.46 b	2	**6.20 a**	1	5.04 bcde	7	2.98 bcd	4	**16.1 a**	1	**19.1 a**	1
Temora	TF-M	**2.13 ab**	2	**3.15 a**	1	5.35 cdefg	7	3.98 h	19	**3.68 a**	1	**14.6 abc**	5	**18.3 ab**	4
Tower	TF-C	**1.95 abcd**	5	2.22 bc	3	**5.93 abc**	3	**5.27 abcd**	4	2.68 cde	12	**15.4 ab**	3	**18.1 abc**	5
UltraSoft *	Mix	**1.94 abcd**	6	2.00 cde	6	**6.14 ab**	2	**5.84 a**	1	2.89 cde	6	**15.9 a**	2	**18.8 a**	2
LSD (0.05)		0.61		0.43		0.60		0.65		0.60		1.63		1.71	
CV %		24.4		15.4		7.14		8.25		13.0		7.57		6.54	

Shaded = highest yielding, **BOLD** = similar to highest. **Note: treatments with the same letter are similar i.e. not significantly different**
NS = non-significant *dominated by cocksfoot component

Table 2: Tall fescue and Festulolium (*Festuca arundinaea*), Fa 2, Elite Evaluation, Outeniqua Research Farm

Planted: 3 March 2020 **Mean seasonal growth rates** (kg DM/ha/day)

Cultivars	Type	Autumn 2020	Rank	Winter 2020	Rank	Spring 2020	Rank	Summer 2020/21	Rank	Autumn 2021	Rank
Bariane	TF-C	13.2 efgh	14	14.2 ghijk	16	43.5 k	20	48.9 fghi	15	30.8 cdef	11
Baroptima	TF-C	8.4 gh	19	11.7 jk	19	47.1 jk	19	51.7 defgh	13	32.9 bcde	5
Boschhoek	TF-C	**20.7 abcd**	7	20.8 defg	7	61.3 bcde	5	50.0 defgh	14	33.9 bc	3
Duramax	TF-C	**22.5 ab**	3	18.4 defg	8	59.6 cdef	6	53.2 bcdefgh	9	28.6 cdef	15
Easton	TF-C	17.0 bcdef	10	22.2 bcd	5	58.0 defg	8	55.2 bcdefg	8	31.7 cdef	8
Felina	FL-Fa	9.8 gh	18	11.1 k	20	50.6 hij	17	57.2 bcde	6	31.2 cdef	10
Fojtan	FL-Fa	12.8 efgh	15	12.2 ijk	18	48.6 ijk	18	43.7 i	20	25.7 f	20
Hipast	FL-Fa	14.3 defg	12	16.8 fghi	12	51.2 hij	16	47.6 hi	18	27.2 def	17
Honak	FL-Fa	14.2 defg	13	18.1 defgh	9	52.3 ghij	15	47.8 hi	17	26.4 ef	19
Hummer	TF-C	18.9 bcde	9	17.0 fgh	11	53.3 fghij	12	52.6 cdefgh	11	31.4 cdef	9
Hykor	FL-Fa	12.2 efgh	16	14.8 ghijk	15	54.9 efghi	10	53.2 bcdefgh	10	29.5 cdef	14
Jesup	TF-C	12.0 fgh	17	13.4 hijk	17	54.6 fghi	11	48.4 ghi	16	26.8 def	18
Kora	TF-C	**20.2 abcd**	8	17.3 efgh	10	53.1 fghij	13	57.2 bcde	5	29.6 cdef	13
Mahulena	FL-Fa	7.0 h	20	14.9 ghijk	14	56.2 efgh	9	52.1 cdefgh	12	28.0 cdef	16
Paolo	TF-C	15.0 cdefg	11	16.3 fghij	13	52.5 ghij	14	**59.3 abc**	3	31.9 cdef	7
Quantico	TF-C	**22.1 ab**	4	23.8 bc	4	**62.8 abcd**	4	**59.9 ab**	2	**39.1 ab**	2
Royal-Q	TF-C/M	**26.5 a**	1	26.6 b	2	**68.1 a**	1	56.0 bcdef	7	33.1 bcd	4
Temora	TF-M	**23.6 ab**	2	**34.2 a**	1	58.8 cdefg	7	44.2 i	19	**40.9 a**	1
Tower	TF-C	**21.7 ab**	5	24.2 bc	3	**65.2 abc**	3	**58.6 abcd**	4	29.8 cdef	12
UltraSoft *	Mix	**21.6 abc**	6	21.8 cde	6	**67.4 ab**	2	**64.8 a**	1	32.1 cdef	6
LSD (0.05)		6.73		4.71		6.62		7.24		6.66	
CV %		24.4		15.4		7.16		8.25		13.0	

Shaded = highest yielding, **BOLD** = similar to highest. **Note: treatments with the same letter are similar i.e. not significantly different**
NS = non-significant *dominated by cocksfoot component TF-C = Continental, TF-M = Mediterranean, FL-Fa = Festulolium tall fescue type

Table 3: Tall fescue and Festulolium (*Festuca arundinaea*), Fa 2, Elite Evaluation, Outeniqua Research Farm

Planted: 3 March 2020 **Yield** (t DM/ha) Individual harvests Trial is continuing

Cultivars	Type	Cut 1	Cut 2	Cut 3	Cut 4	Cut 5	Cut 6	Cut 7	Cut 8	Cut 9
		19/5/2020	8/7/2020	15/9/2020	23/10/2020	23/11/2020	4/1/2021	12/2/2021	8/4/2021	19/5/2021
Bariane	TF-C	0.91 efghi	1.19 cde	0.68 hij	1.55 g	2.14 def	2.14 ef	1.70 cde	**1.93 ab**	1.40 cdef
Baroptima	TF-C	0.53 hi	0.95 efg	0.59 ij	1.75 fg	2.30 cdef	2.22 cdef	1.80 bcde	**2.17 ab**	1.43 cdef
Boschhoek	TF-C	**1.57 abcd**	1.21 bcde	1.65 c	**2.65 ab**	2.28 cdef	2.19 def	1.71 cde	**2.08 ab**	1.58 bcd
Duramax	TF-C	**1.73 ab**	1.25 bcde	1.22 defg	2.52 bc	2.42 bcde	2.34 cdef	**1.89 abcd**	**1.91 ab**	1.23 fg
Easton	TF-C	1.17 bcdefg	**1.46 abc**	1.53 cd	2.44 bcd	2.34 cdef	2.43 bcde	**1.92 abcd**	**2.13 ab**	1.34 defg
Felina	FL-Fa	0.70 ghi	0.81g	0.67 hij	2.09 def	2.24 cdef	2.60 bcde	**1.94 abc**	**2.09 ab**	1.33 defg
Fojtan	FL-Fa	0.91 efghi	1.02 defg	0.57 j	1.99 ef	2.21 cdef	1.89 f	1.57 ef	1.66 b	1.13 g
Hipast	FL-Fa	1.01 defgh	1.16 cdef	1.10 fg	2.16 cdef	2.07 f	2.12 ef	1.65 cde	1.74 b	1.22 fg
Honak	FL-Fa	0.97 efghi	1.30 bcd	1.11 efg	2.09 def	2.24 cdef	2.10 ef	1.69 cde	1.76 b	1.13 g
Hummer	TF-C	1.39 bcdef	1.26 bcde	1.00 fghj	2.19 cde	2.26 cdef	2.51 bcde	1.65 cde	**1.95 ab**	1.44 cdef
Hykor	FL-Fa	0.84 fghi	1.10 defg	0.87 ghij	2.30 bcde	2.34 cdef	2.47 bcde	1.79 bcde	1.83 b	1.36 cdefg
Jesup	TF-C	0.88 efghi	0.83 fg	1.00 fghi	2.48 bcd	2.10 ef	2.22 cdef	1.62 de	1.73 b	1.18 fg
Kora	TF-C	**1.48 abcde**	1.32 bcd	0.97 fghij	2.00 ef	2.45 bcd	**2.73 abc**	**1.86 abcde**	**1.93 ab**	1.30 efg
Mahulena	FL-Fa	0.40 i	0.95 efg	1.07 fgh	2.54 bc	2.15 def	2.39 cdef	1.76 bcde	1.84 b	1.21 fg
Paolo	TF-C	1.09 cdefgh	1.08 defg	1.12 defg	1.98 ef	2.35 cdef	**2.71 abc**	**2.06 ab**	**1.95 ab**	1.49 cde
Quantico	TF-C	**1.63 abc**	**1.49 abc**	1.76 c	2.49 bcd	2.54 bc	**2.66 abcd**	**2.02 ab**	**2.48 a**	1.76 b
Royal-Q	TF-C/M	**2.03 a**	**1.49 abc**	2.18 b	**3.00 a**	2.34 cdef	2.34 cdef	**2.07 ab**	**2.18 ab**	1.43 cdef
Temora	TF-M	**1.71 ab**	**1.73 a**	**3.02 a**	2.14 cdef	2.01 f	2.11 ef	1.26 f	**2.12 ab**	**2.18 a**
Tower	TF-C	**1.54 abcd**	**1.71 a**	1.53 cde	**2.63 ab**	**2.70 ab**	**2.92 ab**	1.82 bcde	1.82 b	1.39 cdefg
UltraSoft *	Mix	**1.57 abcd**	**1.54 ab**	1.38 cdef	**2.66 ab**	**2.94 a**	**3.16 a**	**2.15 a**	1.81	1.61 bc
LSD (0.05)		0.57	0.34	0.42	0.42	0.34	0.52	0.30	0.60	0.26
CV %		28.7	16.6	20.2	11.0	9.01	12.9	10.2	18.6	11.2

Fa = *Festuca arundinacea* (Tall fescue), C = Continental type, M = Mediterranean type, FL = *Festulolium*, L = loloid, F = festucoid

Shaded = highest yielding, **BOLD** = similar to highest. **Note: treatments with the same letter are similar i.e. not significantly different**

Table 4: Tall fescue and Festulolium (*Festuca arundinacea*), Fa 2, Elite Evaluation, Outeniqua Research Farm

Planted: 3 March 2020 **Growth rates** (kg DM/ha/day) Individual harvests Trial is continuing

Cultivars	Type	Cut 1 19/5/2020	Cut 2 8/7/2020	Cut 3 15/9/2020	Cut 4 23/10/2020	Cut 5 23/11/2020	Cut 6 4/1/2021	Cut 7 12/2/2021	Cut 8 8/4/2021	Cut 9 19/5/2021
Bariane	TF-C	19.3 fghi	23.8 cde	17.8 hij	40.7 g	69.2 def	51.0 ef	43.6 cde	**35.1 ab**	34.2 cdef
Baroptima	TF-C	11.3 hi	19.0 efg	15.5 ij	46.0 fg	74.3 cdef	52.8 cdef	46.3 bcde	**39.4 ab**	34.8 cdef
Boschhoek	TF-C	**33.4 abcd**	24.1 bcde	43.2 c	**69.7 ab**	73.6 cdef	52.0 def	43.8 cde	**37.8 ab**	38.4 bcd
Duramax	TF-C	**36.7 ab**	25.0 bcde	32.2 defg	66.4 bc	78.0 bcde	55.8 cdef	**48.6 abcd**	**34.6 ab**	29.9 fg
Easton	TF-C	25.0 bcdefg	**29.2 abc**	40.3 cde	64.1 bcd	72.1 cdef	57.8 bcde	**49.1 abcd**	**38.8 ab**	32.6 defg
Felina	FL-Fa	14.7 ghi	16.1 g	17.8 hij	55.0 def	72.4 cdef	61.9 bcde	**49.8 abc**	**38.0 ab**	32.5 defg
Fojtan	FL-Fa	19.4 efghi	20.4 defg	15.1 j	52.4 ef	71.2 cdef	44.9 f	40.1 ef	30.2 b	27.7 g
Hipast	FL-Fa	21.5 defgh	23.2 cdef	29.0 fg	56.9 cdef	66.6 f	50.6 ef	42.3 cde	31.6 b	30.0 fg
Honak	FL-Fa	20.5 efghi	26.0 bcd	29.3 efg	54.9 def	72.1 cdef	49.9 ef	43.4 cde	32.0 b	27.6 g
Hummer	TF-C	29.6 bcdef	25.1 bcde	26.3 fghj	57.6 cde	72.9 cdef	59.8 bcde	42.4 cde	**35.4 ab**	35.1 cdef
Hykor	FL-Fa	17.8 fghi	21.9 defg	23.0 ghij	60.6 bcde	75.6 cdef	58.9 bcde	45.8 bcde	33.2 b	33.1 cdefg
Jesup	TF-C	18.6 efghi	16.6 fg	26.3 fghi	65.2 bcd	67.7 ef	52.9 cdef	41.6 de	31.5 b	28.8 fg
Kora	TF-C	**31.5 abcde**	26.4 bcd	25.5 fghij	52.7 ef	79.0 bcd	**64.9 abc**	**47.8 abcde**	**35.1 ab**	31.8 efg
Mahulena	FL-Fa	8.6 i	19.0 efg	28.1 fgh	66.8 bc	69.3 def	56.9 cdef	45.3 bcde	33.5 b	29.6 fg
Paolo	TF-C	23.1 cdefgh	21.6 defg	29.4 defg	52.1 ef	75.9 cdef	**64.6 abc**	**52.7 ab**	**35.4 ab**	36.4 cde
Quantico	TF-C	**34.7 abc**	**29.7 abc**	46.3 c	65.4 bcd	81.9 bc	**63.2 abcd**	**51.8 ab**	**45.1 a**	43.0 b
Royal-Q	TF-C/M	**43.1 a**	**29.8 abc**	57.4 b	**79.0 a**	75.4 cdef	55.7 cdef	**53.1 ab**	**39.7 ab**	34.8 cdef
Temora	TF-M	**36.4 ab**	**34.6 a**	**79.5 a**	56.4 cdef	65.0 f	50.1 ef	32.4 f	**38.5 ab**	**53.0 a**
Tower	TF-C	**1.54 abcd**	**34.2 a**	40.2 cde	**69.0 ab**	**87.2 ab**	**69.5 ab**	46.7 bcde	33.1 b	33.9 cdefg
UltraSoft *	Mix	**1.57 abcd**	**30.7 ab**	36.3 cdef	**69.9 ab**	**94.8 a**	**75.2 a**	**55.1 a**	32.8	39.3 bc
LSD (0.05)		12.1	6.81	11.0	10.9	11.2	12.2	7.82	10.9	6.35
CV %		28.7	16.6	20.3	11.0	9.04	12.9	10.3	18.6	11.2

Fa = *Festuca arundinacea* (Tall fescue), C = Continental type, M = Mediterranean type, FL = *Festulolium*, L = loloid, F = festucoid

Shaded = highest yielding, **BOLD** = similar to highest. **Note: treatments with the same letter are similar i.e. not significantly different**

Table 5: Tall fescue and Festulolium (*Festuca arundinaea*), Fa 2, Elite Evaluation, Outeniqua Research Farm

Planted: 3 March 2020 **Dry matter content** (DM%) Individual harvests Trial is continuing

Cultivars	Type	Cut 1	Cut 2	Cut 3	Cut 4	Cut 5	Cut 6	Cut 7	Cut 8	Cut 9
		19/5/2020	8/7/2020	15/9/2020	23/10/2020	23/11/2020	4/1/2021	12/2/2021	8/4/2021	19/5/2021
Bariane	TF-C	15.2 bc	16.9 cdefg	**24.8 abcd**	20.1 bcde	19.7 cde	22.7 c	18.3 e	**24.2 abcd**	17.8 defg
Baroptima	TF-C	**16.1 abc**	**18.1 abc**	**25.7 ab**	**20.8 abcd**	20.1 bcd	22.3 cd	20.0 cd	**23.6 abcd**	18.8 bcde
Boschhoek	TF-C	15.3 bc	**17.5 abcde**	22.7 defgh	**21.0 abcd**	20.0 bcd	22.9 c	20.1 cd	**23.6 abcd**	18.0 defg
Duramax	TF-C	**18.1 a**	**17.7 abcde**	23.9 bcdefg	**21.1 abcd**	**22.0 a**	23.0 c	**21.4 abc**	**25.1 ab**	**19.6 ab**
Easton	TF-C	14.3 bc	17.0 cdefgh	23.7 bcdefg	**20.5 abcde**	20.4 bc	23.4 bc	20.6 bcd	**24.9 abc**	18.7 bcdef
Felina	FL-Fa	14.3 bc	17.2 bcdef	**25.6 ab**	**21.0 abc**	19.7 cde	22.7 c	20.5 bcd	**24.2 abcd**	18.8 bcde
Fojtan	FL-Fa	15.4 bc	**17.9 abcd**	**27.0 a**	**21.6 a**	**21.5 ab**	**26.1 a**	**21.9 ab**	**25.4 a**	**20.2 a**
Hipast	FL-Fa	**15.9 abc**	**18.4 ab**	**25.1 abc**	**20.7 abcd**	20.1 bcd	22.5 c	19.6 de	**24.9 abc**	18.4 cdefg
Honak	FL-Fa	15.4 bc	17.2 bcdefg	24.0 bcdef	**20.3 abcde**	19.1 cde	22.3 cd	19.5 de	**24.2 abcd**	19.0 bcd
Hummer	TF-C	15.3 bc	16.6 efgh	24.7 bcde	19.9 bcde	18.7 de	23.2 c	20.6 bcd	23.0 cd	17.2 g
Hykor	FL-Fa	14.9 bc	**17.5 abcdef**	23.7 bcdefg	**20.5 abcde**	19.4 cde	23.4 bc	**20.7 abcd**	**24.2 abcd**	18.6 bcdef
Jesup	TF-C	**16.2 ab**	**18.1 abc**	23.2 cdefg	**21.8 a**	20.3 bc	23.2 c	**21.3 abc**	**24.1 abcd**	**19.4 abc**
Kora	TF-C	14.7 bc	**17.7 abcde**	**25.9 ab**	**21.1 abc**	19.3 cde	23.5 bc	19.1 de	**23.6 abcd**	18.0 defg
Mahulena	FL-Fa	15.1 bc	**18.5 a**	**25.6 ab**	**20.6 abcd**	20.0 bcd	**25.3 ab**	20.2 cd	**25.6 a**	**19.4 abc**
Paolo	TF-C	15.1 bc	16.7 defgh	23.9 bcde	**20.1 abcd**	19.1 cde	20.4 de	18.2 e	**23.6 abcd**	17.5 fg
Quantico	TF-C	14.9 bc	16.3 fghi	21.7 gh	19.2 e	18.2 e	22.3 cd	20.2 cd	**23.8 abcd**	17.7 efg
Royal-Q	TF-C/M	14.9 bc	15.8 hi	22.2 fgh	19.7 cde	19.3 cde	22.5 c	20.0 cd	23.2 bcd	18.7 bcdef
Temora	TF-M	13.6 c	14.2 j	22.5 efgh	**21.3 ab**	**21.4 ab**	**25.6 a**	**22.2 a**	22.5 d	17.7 efg
Tower	TF-C	14.2 bc	15.9 ghi	21.4 h	19.9 bcde	20.1 bcd	22.6 c	**20.7 abcd**	**23.7 abcd**	18.8 bcde
UltraSoft *	Mix	15.0 bc	15.0 ij	22.1 fgh	19.6 de	16.7 f	19.6 e	18.3 e	23.0 cd	17.2 g
LSD (0.05)		2.56	1.26	2.21	1.46	1.53	1.96	1.62	1.97	1.23
CV %		10.2	4.47	5.56	4.30	4.69	5.17	4.85	4.96	4.03

Fa = *Festuca arundinacea* (Tall fescue), C = Continental type, M = Mediterranean type, FL = *Festulolium*, L = loloid, F = festucoid

Shaded = higher than 18%, **BOLD** = highest and similar to highest. **Note: treatments with the same letter are similar i.e. not significantly different**

Table 6: Tall fescue and Festulolium (*Festuca arundinaea*), Fa 2, Elite Evaluation, Outeniqua Research Farm

Planted: 3 March 2020 **Leaf rust** (ratings based) Individual harvests Trial is continuing

	Type	Cut 1	Cut 2	Cut 3	Cut 4	Cut 5	Cut 6	Cut 7	Cut 8	Cut 9
Cultivars		19/5/2020	8/7/2020	15/9/2020	23/10/2020	23/11/2020	4/1/2021	12/2/2021	8/4/2021	19/5/2021
Bariane	TF-C	13	67	33	42	4	75	63	71	0
Baroptima	TF-C	8	33	29	21	17	63	54	63	4
Boschhoek	TF-C	13	50	17	13	8	79	63	71	0
Duramax	TF-C	8	42	17	4	8	63	67	54	0
Easton	TF-C	0	8	0	4	0	33	17	17	0
Felina	FL-Fa	8	79	33	21	8	67	46	67	4
Fojtan	FL-Fa	0	50	25	17	13	50	33	25	4
Hipast	FL-Fa	4	63	21	17	0	50	42	29	4
Honak	FL-Fa	0	46	17	13	8	58	50	54	13
Hummer	TF-C	13	75	25	29	17	83	79	79	8
Hykor	FL-Fa	17	67	42	29	4	71	46	58	8
Jesup	TF-C	4	67	13	17	13	67	54	58	4
Kora	TF-C	0	63	50	38	8	67	33	58	0
Mahulena	FL-Fa	4	75	29	21	17	88	71	79	17
Paolo	TF-C	8	8	8	0	0	29	25	46	4
Quantico	TF-C	0	0	4	0	0	75	83	58	0
Royal-Q	TF-C/M	0	0	4	0	0	58	17	29	0
Temora	TF-M	0	0	0	0	0	4	0	0	0
Tower	TF-C	0	13	17	4	0	33	17	25	0
UltraSoft *	Mix	0	0	0	0	0	0	0	0	0

Fa = *Festuca arundinacea* (Tall fescue), C = Continental type, M = Mediterranean type, FL = *Festulolium*, L = loloid, F = festucoid

Table 7: Tall fescue and Festulolium (*Festuca arundinaea*), Fa 2, Elite Evaluation, Outeniqua Research Farm
Planted: 3 March 2020 **Reproductive tillers/bolting** (ratings based) **Individual harvests** Trial is continuing

	Type	Cut 1	Cut 2	Cut 3	Cut 4	Cut 5	Cut 6	Cut 7	Cut 8	Cut 9
Cultivars		19/5/2020	8/7/2020	15/9/2020	23/10/2020	23/11/2020	4/1/2021	12/2/2021	8/4/2021	19/5/2021
Bariane	TF-C	0	0	0	13	17	0	0	0	0
Baroptima	TF-C	0	0	0	13	25	0	0	0	0
Boschhoek	TF-C	0	0	25	21	0	0	0	0	0
Duramax	TF-C	0	0	13	50	13	0	0	0	0
Easton	TF-C	0	0	8	13	0	0	0	0	0
Felina	FL-Fa	0	0	8	25	17	0	0	0	0
Fojtan	FL-Fa	0	0	0	25	33	0	0	0	0
Hipast	FL-Fa	0	0	0	4	8	0	0	0	0
Honak	FL-Fa	0	0	0	0	4	0	0	0	0
Hummer	TF-C	0	0	8	21	8	0	0	0	0
Hykor	FL-Fa	0	0	8	21	13	0	0	0	0
Jesup	TF-C	0	0	13	**58**	8	0	0	0	0
Kora	TF-C	0	0	0	8	13	0	0	0	0
Mahulena	FL-Fa	0	0	13	50	13	0	0	0	0
Paolo	TF-C	0	0	0	8	13	0	0	0	0
Quantico	TF-C	0	0	8	4	8	0	0	0	0
Royal-Q	TF-C/M	0	0	13	17	0	0	0	0	0
Temora	TF-M	0	0	**88**	8	4	0	0	0	0
Tower	TF-C	0	0	0	25	17	0	0	0	0
UltraSoft *	Mix	0	0	0	13	**67**	0	0	0	0

Fa = *Festuca arundinacea* (Tall fescue), C = Continental type, M = Mediterranean type, FL = *Festulolium*, L = loloid, F = festucoid

Table 8: Tall fescue and Festulolium (*Festuca arundinaea*), Fa 2, Elite Evaluation, Outeniqua Research Farm
Planted: 3 March 2020 **No. of days per leaf and projected harvest rotation based on 2 or 2.5-leaf stage**

	3 Mar 2020 to 19 May	19 May 2020 to 8 Jul	8 Jul 2020 to 15 Sep	15 Sep 2020 to 23 Oct	23 Oct 2020 to 23 Nov	23 Nov 2020 to 4 Jan 2021	4 Jan 2021 to 12 Feb	12 Feb 2021 to 8 Apr	8 Apr 2021 to 19 May
No. of days/leaf	12	22	13	19	18	17	18	22	21
Projected time to 2-leaf	24	44	26	38	36	34	36	44	42
2.5 leaf est.	30	55	33	48	45	43	45	55	53

Leaf emergence rate

The mean leaf stage at harvest for the first 9 harvests of this trial was 2.4 leaves.

According to Donaghy et al 2008, the minimum defoliation interval for tall fescue is at the 2-leaf stage although the maximum leaf number is 4 leaves and the plant will accumulate additional carbohydrate reserves if left to grow to the 4-leaf stage thus enabling greater persistence and regrowth potential in subsequent growth cycles. However at the 4-leaf stage the forage quality is lower than at the 2-leaf stage. Hence Donaghy et al (2008) suggest a compromise at around the 3-leaf stage. Alternatively one could consider allowing the pasture a recovery period for carbohydrate reserves by allowing a longer grazing cycle at certain times of the year if generally the 2-leaf stage is used for defoliation interval.

Summary of results for the 15 month period since establishment in March 2020

These results are preliminary in that the trial is still in progress but at least it gives an indication of the first year's data. Amongst the continental tall fescue cultivars, there are some cultivars with improved winter yield which make them more suitable for our dairy pasture systems.

Total yield over the first 15 months:

- Highest yielding: Royal Q100 (19.1 t DM/ha), Quantico (18.8 t DM/ha)
- Similar yield: Tower, Temora (Mediterranean type).

In comparison the best perennial ryegrass for the same time period was Viscount with 17.8 t DM/ha.

Total year 1 yield:

- Highest yielding: Royal Q100 (16.1 t DM/ha)
- Similar yield: Tower, Quantico, Temora

The best perennial ryegrass for the same period was Viscount with 14.4 t DM/ha

Winter yield:

- Highest: Temora (Mediterranean type) with 3.15 t DM/ha
- Best continental type: Royal Q100 (2.46 t DM/ha), similar yield: Tower, Quantico, Easton. The typical winter dormant continental types generally yielded less than 1.5 t DM/ha. This data, at least for the first year, clearly shows that there are continental types with competitive winter yield even though it is still less than perennial ryegrass.

For perennial ryegrass the best yield was Platform 3.66 t DM/ha and Legion 3.58 t DM/ha

Spring yield for both tall fescue and perennial ryegrass were very similar and generally a season were excess forage can be conserved.

Summer yield:

- Highest yielding: Quantico (5.40 t DM/ha)
- Similar yield: Paolo, Tower

In contrast the best perennial ryegrass cultivar in summer was Viscount with 3.71 t DM/ha.

Tall fescue thus provides an advantage in the summer months and may provide further opportunity to conserve excess forage as silage.

***Second autumn yield*:**

Highest yielding: Temora (M type) 3.68 t DM/ha, with similar yield from the continental type cultivar Quantico with 3.53 t DM/ha.

Perennial ryegrass cultivars that did best in the second autumn were Legion, Governor, Viscount and Platform with yields of 3.43 to 3.35 t DM/ha.

This data shows that tall fescue can have a roll in dairy pasture systems but it is important to understand the limitations and the differences in seasonal production compared to ryegrass as well as which combinations with other species will be most suitable in mixtures or pure stands. The deeper root system of tall fescue is a definite advantage over perennial ryegrass in water stressed environments as well as its higher temperature tolerances, the better water use efficiency and good response to rainfall and irrigation.

For pastures with tall fescue as the grass component it is of utmost importance to choose continental cultivars that also have some yielding capacity during the winter months. In addition it will be important to take advantage of the excess forage produced in winter and summer for silage to feed out in winter.

The tall fescue cultivars that show some winter activity also seem to have a more upright growth habit which could be an advantage in combination with other species such as forage herbs and lucerne.

It will be important to see how the yielding capacity of these cultivars continues into the second and third year.

Leaf rust incidence was generally high but some cultivars did have a lower rust incidence:

Lowest rust: Temora (Mediterranean type)

Lowest rust in continental types: Easton, followed by Tower, Paolo, Royal Q100.

Bolting incidence was generally low, especially compared to ryegrass with only the Mediterranean type cv. Temora having a typically high incidence of reproductive tillers at the end of winter/early spring.

For the continental types the highest flowering incidence was recorded for Jesup and Duramax, followed by Boschhoek, Tower and Paolo.

Forage quality data is not yet available for this trial but some values were reported for the previous trial (Fa 1) in the Outeniqua Information day 2019 booklet.

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Perennial ryegrass cultivar evaluation results for 2020/21

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Introduction

The perennial ryegrass (*Lolium perenne*) elite cultivar evaluation trial (Lp5) was planted on 5 March 2020 at the Outeniqua Research Farm. The aim of the trial is to evaluate the recent perennial ryegrass cultivars being used for intensive dairy pastures or ones that are about to enter the market together with cultivars that have shown promising results in the previous evaluation trial. This trial provides local data to assist farmers with choosing cultivars best adapted to the coastal region. Since all perennial ryegrass cultivars are imported, this data provides insight into the genetic potential and adaption for the southern Cape region. This data is specific for autumn 2020 (March) to May 2021 but the best cultivars are evaluated in successive trials, which means some have also been in previous trials. For previous data refer to the Outeniqua Information Day booklets for 2018, 2019 and 2020. The current trial, Lp5, of which the first 15 months data are reported here, is continuing to determine productivity for the second and third year.

Cultivars evaluated

The trial consists of 16 cultivars of which 11 are diploid and five are tetraploid types.

Diploid cultivars: 24Seven, 50Fifty, Boyne, Governor, Kimbuko, Kingsgate, Legion, Nui, One50, Platform, Tugela

Tetraploid cultivars: Base, Evans, Portique, Tanker, Viscount

Parameters reported in this article

- Total DM yield
- Seasonal DM yield
- DM content
- Flowering behaviour
- Persistence / sward density
- Disease incidence (mainly crown rust)

The diploids were sown at 25 kg/ha while the tetraploids were sown at 30kg/ha. The evaluation is done in small plot trials cut with a reciprocating mower at 5cm where material from the entire net plot is weighed and sampled. The trials are top-dressed with nitrogen and potassium fertilizer after each harvest to account for nutrient removal.

The harvest cycle is determined according to physiological stage being 3-leaf or in spring canopy closure. As the first cultivars reach these stages, the trial is harvested. Since leaf emergence rate is mainly driven by temperature, as well as radiation intensity, water and nutrient availability (Chapman 2016), most cultivars reach the 3-leaf stage at a similar time.

***Total yield* (Table 1)** is important, especially on farms that have the means to conserve the surplus as silage for later use. The establishment and input costs are also similar regardless of yield, hence the importance of choosing the cultivars with the best yield to get a better return on this establishment and input costs. The input costs being mainly fertilizer and irrigation. Total yield is given for both year 1 and for the first 15 months, as this trial is still in progress and these data provide an early snapshot of the results. At this stage of the trial yield stability over years cannot be reported on but it does give an indication of how strong the cultivars recover after the summer heat.

Seasonal yield data **(Table 1 and 2)** is of value for optimising fodder flow requirements especially for the more challenging seasons which are generally winter and summer/beginning of autumn. The question is whether there are cultivars with both good winter and summer yield. Alternatively it is advisable to plant paddocks to different cultivars to take advantage of different seasonal yield distributions and to spread risk. Alternatively other species like forage herbs can be used to boost summer production. A high yielding spring cultivar can for instance be considered for silage making of surplus production. Other options are mixed swards.

For perennial ryegrass it is also important to assess how the seasonal yield distribution changes over years i.e. is the seasonal yield distribution different in the second year compared to the first year. The seasons most affected by reduced yield in the second year are winter and summer. For this specific trial this comparison will on be possible once the trial has been completed. There is however already value in the data for the second autumn to give an indication on how well cultivars survive the summer and recover once the conditions become more favourable again for perennial ryegrass after the summer.

Individual harvest yields and ***growth rates*** are given in **Table 3 and 4.**

Dry matter (DM) content **(Table 5)** is a consideration especially early in the season when the DM content is generally low, since DM content in ryegrass can negatively influence voluntary intake if it is very low (Cabrera Estrada et al 2004, John & Ulyatt 1987, Leaver 1985, Minson 1990. The work by Vértité & Journet 1970 is also widely referenced where they investigated reduced intake with decreasing DM content. This can also be relevant when combined with other species in mixed pastures that also have a very low DM content such as forage herbs.

Rust incidence **(Table 6)** refers mainly to crown rust (*Puccinia coronata*). According to Clarke & Eagling (1994) crown rust causes yield loss as well as negative effects on root weight, tiller numbers and leaf area. Potter (2007) reported not only reduced yield but also reduced water-soluble carbohydrates and reduced digestibility. Hence there are advantages to cultivars which are resistant or have a low incidence only.

Flowering behaviour **(Table 7)** is important since it results in a higher stem component which implies a higher fibre content and thus lower nutritive value, but also increased bulk and sward height. The percentage of the sward that is reproductive varies significantly between cultivars as does the duration of reproductive tillers in the sward. Generally perennial ryegrass has a lower flowering incidence in the local climate than Italian ryegrass which is linked to its higher vernalization requirements. Cultivars that do have a high bolting percentage could for instance be used in mixed pastures. In mixtures with species that are very competitive and tall growing in summer it might be an advantage to have a ryegrass component with a higher bolting percentage as that results in taller plants to compete with the other tall components for example chicory or lucerne.

***Sward density* (Table 8) and plant population counts (Table 9)** gives an indication of persistence especially after the summer when a decrease in plant population often occurs from late February onwards. The cultivars that retain good sward density or plant population after the challenging summer conditions are desirable.

Leaf emergence rate for this trial up to July 2021 is given in **Table 10.**

Leaf emergence rate depends on leaf growth rate since leaves emerge consecutively, one after the other once the previous leaf is fully extended. Growth rate is mainly driven by temperature and soil moisture. If soil moisture is sufficient then the growth rate is mainly a function of temperature. Defoliation or harvest at the 3-leaf stage is optimal for the plant (carbohydrate reserves, root and tiller growth) and optimal for production since the first leaf dies once the fourth leaf emerges and yield reaches a plateau after the third leaf. The plants can at the earliest be defoliated at the 2.75-leaf stage when necessary. In spring when there is rapid growth and some reproductive tillers, the first criterion for defoliation should be canopy closure since a lack of light penetration into the base of the sward can reduce tillering which is important for persistence.

Leaf emergence rate can be used to give an approximate indication of grazing rotation length i.e. when the pasture will be ready for the next grazing, by counting the leaf number regularly as the pasture regrows and calculating the number of days it takes to grow a leaf. Since the process is driven mainly by temperature and soil moisture, one needs to also take weather predictions into account whether the growth rate will either increase or decrease during the regrowth cycle.

Table 1: Perennial ryegrass (*Lolium perenne*), Lp 5, Elite Evaluation, Outeniqua Research Farm
Planted: 5 March 2020 **Seasonal Yield** (t DM/ha) D = Diploid, T = Tetraploid

Cultivars	Type	Autumn 2020	Rank	Winter 2020	Rank	Spring 2020	Rank	Summer 2020/21	Rank	Autumn 2021	Rank	Year 1 2020/21	Rank	15 months 2020/21	Rank
24Seven	D	**2.01** ^{a}	4	2.88 ^{de}	10	**5.01** ^{abc}	13	2.68 ^{bc}	11	**2.78** ^{abc}	7	12.6 ^{bc}	10	15.3 ^{bcde}	7
50Fifty	D	**2.08** ^{a}	2	2.93 ^{cde}	8	**5.45** ^{abc}	4	**3.02** ^{abc}	4	**2.97** ^{ab}	5	**13.5** ^{abc}	4	**16.4** ^{abc}	5
Base	T	**1.64** ^{abc}	14	**3.37** ^{abc}	4	**5.21** ^{abc}	9	**3.05** ^{ab}	3	**2.75** ^{abc}	8	**13.3** ^{abc}	5	**16.0** ^{abcd}	6
Boyne	D	**1.72** ^{ab}	12	2.73 ^{efg}	12	**5.59** ^{abc}	3	2.50 ^{bc}	14	2.37 ^{bc}	14	12.6 ^{bc}	11	14.9 ^{cde}	11
Evans	T	1.31 ^{bc}	15	2.66 ^{efg}	13	**5.20** ^{abc}	11	2.87 ^{bc}	7	2.16 ^{c}	16	12.0 ^{cd}	13	14.2 ^{de}	15
Governor	D	**1.78** ^{ab}	11	3.10 ^{bcde}	6	**5.81** ^{ab}	2	**3.09** ^{ab}	2	**3.40** ^{a}	2	**13.8** ^{ab}	3	**17.2** ^{ab}	3
Kimbuko	D	**2.07** ^{a}	3	2.41 ^{fg}	14	**5.20** ^{abc}	10	2.74 ^{bc}	10	2.39 ^{bc}	13	12.4 ^{bc}	12	14.8 ^{cde}	13
Kingsgate	D	**1.82** ^{a}	8	2.81 ^{ef}	11	5.84 ^{c}	15	2.40 ^{bc}	15	**2.74** ^{abc}	9	11.9 ^{cd}	15	14.6 ^{cde}	14
Legion	D	**1.88** ^{a}	5	**3.58** ^{a}	2	4.93 ^{bc}	14	2.67 ^{bc}	12	**3.43** ^{a}	1	**13.1** ^{abc}	6	**16.5** ^{abc}	4
Nui (cont)	D	**1.69** ^{ab}	13	**3.32** ^{abcd}	5	**5.23** ^{abc}	8	2.82 ^{bc}	8	2.25 ^{bc}	15	**13.0** ^{abc}	7	15.3 ^{bcde}	10
One50	D	**1.86** ^{a}	6	**3.45** ^{ab}	3	**5.25** ^{abc}	7	2.31 ^{c}	16	2.44 ^{bc}	11	**12.8** ^{abc}	9	15.3 ^{bcde}	9
Platform	D	**2.09** ^{a}	1	**3.66** ^{a}	1	**5.29** ^{abc}	5	2.82 ^{bc}	9	**3.35** ^{a}	4	**13.9** ^{ab}	2	**17.2** ^{ab}	2
Portique	T	1.18 ^{c}	16	1.78 ^{h}	16	4.82 ^{c}	16	2.93 ^{bc}	5	2.56 ^{bc}	10	10.7 ^{d}	16	13.3 ^{e}	16
Tanker	T	**1.80** ^{ab}	10	2.91 ^{de}	9	**5.25** ^{abc}	6	2.93 ^{bc}	6	2.43 ^{bc}	12	**12.9** ^{abc}	8	15.3 ^{bcde}	8
Tugela	D	**1.86** ^{a}	7	2.34 ^{g}	15	**5.15** ^{abc}	12	2.53 ^{bc}	13	**2.95** ^{ab}	6	11.9 ^{cd}	14	14.8 ^{cde}	12
Viscount	T	**1.80** ^{ab}	9	3.07 ^{bcde}	7	**5.84** ^{a}	1	**3.71** ^{a}	1	**3.36** ^{a}	3	**14.4** ^{a}	1	**17.8** ^{a}	1
LSD (0.05)		0.50		0.46		0.90		0.77		0.72		1.68		2.16	
CV %		16.9		9.3		10.3		16.4		15.7		7.86		8.34	

Shaded = highest yielding, **BOLD** = similar to highest. **Note: treatments with the same letter are similar i.e. not significantly different**

Table 2: Perennial ryegrass (*Lolium perenne*), Lp 5, Elite Evaluation, Outeniqua Research Farm
Planted: 5 March 2020 **Mean seasonal growth rate over 3 months** (kg DM/ha/day) D = Diploid, T = Tetraploid

Cultivars	Type	Autumn 2020	Rank	Winter 2020	Rank	Spring 2020	Rank	Summer 2020/21	Rank	Autumn 2021	Rank
24Seven	D	**21.8 a**	4	31.3 de	10	**55.1 abc**	13	29.8 bc	11	**30.2 abc**	7
50Fifty	D	**22.6 a**	2	31.9 cde	8	**59.8 abc**	4	**33.6 abc**	4	**32.3 ab**	5
Base	T	**17.8 abc**	14	**36.6 abc**	4	**57.3 abc**	9	**33.9 ab**	3	**29.9 abc**	8
Boyne	D	**18.7** ab	12	29.7 efg	12	**61.5 abc**	3	27.8 bc	14	25.8 bc	14
Evans	T	14.3 bc	15	29.0 efg	13	**57.1 abc**	11	31.9 bc	7	23.5 c	16
Governor	D	**19.3 ab**	11	33.8 bcde	6	**63.8 ab**	2	**34.3 ab**	2	**36.9 a**	2
Kimbuko	D	**22.5 a**	3	26.2 fg	14	**57.1 abc**	10	30.4 bc	10	26.0 bc	13
Kingsgate	D	**19.9 a**	8	30.6 ef	11	53.1 c	15	26.6 bc	15	**29.8 abc**	9
Legion	D	**20.4 a**	5	**38.9 a**	2	54.2 bc	14	29.7 bc	12	**37.3 a**	1
Nui (cont)	D	**18.4 ab**	13	**36.1 abcd**	5	**57.4 abc**	8	31.3 bc	8	24.5 bc	15
One50	D	**20.2 a**	6	**37.5 ab**	3	**57.7 abc**	7	25.6 c	16	26.4 bc	11
Platform	D	**22.7 a**	1	**39.8 a**	1	**58.1 abc**	5	31.3 bc	9	**36.4 a**	4
Portique	T	12.8 c	16	19.4 h	16	53.0 c	16	32.6 bc	5	27.8 bc	10
Tanker	T	**19.5 ab**	10	31.6 de	9	**57.7 abc**	6	32.6 bc	6	26.4 bc	12
Tugela	D	**20.2 a**	7	25.4 g	15	**56.6 abc**	12	28.2 bc	13	**32.1 ab**	6
Viscount	T	**19.6 ab**	9	33.4 bcde	7	**64.2 a**	1	**41.3 a**	1	**36.5 a**	3
LSD (0.05)		5.46		4.96		9.85		8.58		7.87	
CV %		16.9		9.3		10.3		16.4		15.7	

Shaded = highest yielding, **BOLD** = similar to highest. **Note: treatments with the same letter are similar i.e. not significantly different**

Refer to Table 4 for growth rates on individual harvests for more detail for specific months of the year.

Table 3: Perennial ryegrass (*Lolium perenne*), Lp 5, Elite Evaluation, Outeniqua Research Farm

Planted: 5 March 2020 **Yield: Individual harvests** (t DM/ha) D = Diploid, T = Tetraploid

Cultivars	Type	Cut 1 18/5/2020	Cut 2 24/6/2020	Cut 3 3/8/2020	Cut 4 16/9/2020	Cut 5 21/10/2020	Cut 6 25/11/2020	Cut 7 22/12/2020
24Seven	D	**1.53 a**	**1.37 abc**	0.97 de	**1.61 abc**	2.10 a	**2.00 ab**	1.47 cde
50Fifty	D	**1.63 a**	1.27 bcd	1.06 cd	**1.65 abc**	2.29 a	**2.12 ab**	1.49 cde
Base	T	**1.18 abc**	1.31 bc	**1.33 abc**	**1.87 a**	2.14 a	**2.04 ab**	**1.55 abcde**
Boyne	D	**1.23 abc**	**1.39 abc**	0.93 de	1.42 bc	2.33 a	**2.41 ab**	1.49 cde
Evans	T	0.97 bc	0.97 ef	1.01 d	**1.60 abc**	2.34 a	1.96 b	1.42 e
Governor	D	**1.31 abc**	1.32 bc	1.18 bcd	**1.69 ab**	2.45 a	**2.34 ab**	**1.76 a**
Kimbuko	D	**1.61 a**	1.32 bc	0.89 de	1.04 de	2.12 a	**2.32 ab**	**1.65 abcd**
Kingsgate	D	**1.36 ab**	1.32 bc	1.10 bcd	1.34 cd	1.99 a	**2.06 ab**	1.32 e
Legion	D	**1.36 ab**	**1.46 ab**	**1.48 a**	**1.81 a**	2.03 a	1.91 b	1.45 de
Nui (cont)	D	**1.20 abc**	**1.38 abc**	**1.34 abc**	**1.69 ab**	2.12 a	**2.14 ab**	1.53 bcde
One50	D	**1.38 ab**	**1.37 abc**	**1.37 ab**	**1.87 a**	2.07 a	**2.17 ab**	1.44 de
Platform	D	**1.54 a**	**1.57 a**	**1.59 a**	**1.64 abc**	1.98 a	**2.38 ab**	1.46 de
Portique	T	0.86 c	0.90 f	0.57 f	0.99 e	1.98 a	**2.10 ab**	**1.68 abc**
Tanker	T	**1.34 abc**	1.30 bcd	1.03 d	**1.64 abc**	2.10 a	**2.23 ab**	1.47 cde
Tugela	D	**1.47 a**	1.11 de	0.73 ef	1.40 bc	2.34 a	**1.99 ab**	1.40 e
Viscount	T	**1.37 ab**	1.24 cd	1.16 bcd	**1.73 ab**	2.35 a	**2.47 a**	**1.73 ab**
LSD (0.05)		0.49	0.20	0.28	0.34	NS	0.51	0.22
CV %		22.1	9.54	15.3	13.0	13.5	14.0	8.85

Shaded = highest yielding, **BOLD** = similar to highest. **Note: treatments with the same letter are similar i.e. not significantly different**

Table 4: Perennial ryegrass (*Lolium perenne*), Lp 5, Elite Evaluation, Outeniqua Research Farm
Planted: 5 March 2020 **Growth rate: Individual harvests** (kg DM/ha/day) D = Diploid, T = Tetraploid

Cultivars	Type	Cut 1 18/5/2020	Cut 2 24/6/2020	Cut 3 3/8/2020	Cut 4 16/9/2020	Cut 5 21/10/2020	Cut 6 25/11/2020	Cut 7 22/12/2020
24Seven	D	**33.2** a	**37.0** abc	24.2 de	**36.6** abc	59.8 a	**57.2** ab	54.5 cde
50Fifty	D	**35.4** a	34.3 bcd	26.6 cd	**37.5** abc	65.3 a	**63.5** ab	55.2 cde
Base	T	**25.6** abc	35.5 bc	**33.2** abc	**42.5** a	61.2 a	**58.4** ab	**57.3** abcde
Boyne	D	**26.7** abc	**37.6** abc	23.3 de	32.2 bc	66.4 a	**68.9** ab	55.2 cde
Evans	T	21.1 bc	26.2 ef	25.4 d	**36.3** abc	66.7 a	55.8 b	52.5 e
Governor	D	**28.5** abc	35.7 bc	29.4 bcd	**38.4** ab	70.0 a	**66.9** ab	**65.0** a
Kimbuko	D	**35.0** a	35.6 bc	22.3 de	23.6 de	60.8 a	**66.3** ab	**61.0** abcd
Kingsgate	D	**29.6** ab	35.6 bc	27.6 bcd	30.4 cd	57.0 a	**58.8** ab	48.9 e
Legion	D	**29.6** ab	**39.4** ab	**37.1** a	**41.0** a	58.1 a	54.7 b	53.5 de
Nui (cont)	D	**26.1** abc	**37.4** abc	**33.6** abc	**38.5** ab	60.6 a	**61.2** ab	56.5 bcde
One50	D	**29.9** ab	**37.0** abc	**34.2** ab	**42.5** a	59.2 a	**62.0** ab	53.4 de
Platform	D	**33.4** a	**42.4** a	**39.8** a	**37.3** abc	56.6 a	**68.1** ab	53.8 de
Portique	T	18.8 c	24.3 f	14.2 f	22.6 e	56.5 a	**60.0** ab	**62.4** abc
Tanker	T	**29.1** abc	35.0 bcd	25.6 d	**37.1** abc	59.9 a	**63.7** ab	54.6 cde
Tugela	D	**31.9** a	29.9 de	18.2 ef	31.9 bc	66.7 a	**56.6** ab	51.9 e
Viscount	T	**29.8** ab	33.5 cd	29.1 bcd	**39.3** ab	67.1 a	**70.6** a	**64.2** ab
LSD (0.05)		10.6	5.51	7.10	7.66	NS	14.5	8.32
CV %		22.1	9.54	15.3	13.0	13.5	14.0	8.85

Shaded = highest yielding, **BOLD** = similar to highest **Note: treatments with the same letter are similar i.e. not significantly different.**
NS = non-significant, no difference between treatments

Table 4: Perennial ryegrass (*Lolium perenne*), Lp 5, Elite Evaluation, Outeniqua Research Farm
Planted: 5 March 2020 **Growth rate: Individual harvests** (kg DM/ha/day) D = Diploid, T = Tetraploid

Cultivars	Type	Cut 8 18/1/2021	Cut 9 25/2/2021	Cut 10 30/3/2021	Cut 11 3/5/2021	Cut 12 4/6/2021	Cut 13 7/7/2021
24Seven	D	32.9 bcde	**15.6 abcd**	27.1 bcde	**34.7 abc**	**23.9 abcd**	21.2 cd
50Fifty	D	37.1 bcde	**21.2 ab**	**30.5 abcd**	**33.1 abc**	**28.7 ab**	**26.2 abc**
Base	T	**42.5 ab**	**16.9 abcd**	26.7 bcde	**35.3 abc**	22.5 bcd	**28.9 ab**
Boyne	D	34.4 bcde	9.4 cd	21.7 de	26.0 c	**27.4 abcd**	**22.6 abcd**
Evans	T	**41.3 ab**	**15.8 abcd**	17.8 e	27.6 c	21.7 d	**24.7 abcd**
Governor	D	35.3 bcde	**18.6 abc**	**34.2 abc**	**40.8 a**	**30.0 a**	**24.7 abcd**
Kimbuko	D	30.1 cde	**15.4 abcd**	24.8 cde	27.9 c	21.4 d	22.4 bcd
Kingsgate	D	26.3 e	**16.0 abcd**	**29.4 abcd**	**31.3 abc**	**24.2 abcd**	**24.1 abcd**
Legion	D	31.9 bcde	**16.6 abcd**	**39.3 a**	**39.1 a**	**27.3 abcd**	**29.0 a**
Nui (cont)	D	**41.1 abc**	12.2 bcd	22.0 de	26.1 c	22.0 cd	**22.7 abcd**
One50	D	33.0 bcde	6.3 d	23.7 cde	**30.5 abc**	20.9 d	**23.3 abcd**
Platform	D	35.2 bcde	**18.0 abc**	**38.2 a**	**39.1 ab**	**25.8 abcd**	**23.0 abcd**
Portique	T	35.2 bcde	**16.2 abcd**	21.6 de	**31.6 abc**	**26.4 abcd**	21.9 cd
Tanker	T	**38.9 abcd**	**17.9 abc**	24.5 cde	28.8 bc	22.0 cd	20.8 cd
Tugela	D	29.3 de	**15.9 abcd**	**30.6 abcd**	**35.4 abc**	**25.0 abcd**	19.0 d
Viscount	T	**48.6 a**	**26.0 a**	**36.5 ab**	**38.9 ab**	**28.2 abc**	**27.0 abc**
LSD (0.05)		11.2	11.5	10.6	10.4	6.4	6.4
CV %		18.8	42.7	22.7	18.9	15.5	29.8

Shaded = highest GR, **BOLD** = similar to highest **Note: treatments with the same letter are similar i.e. not significantly different**

Table 5: Perennial ryegrass (*Lolium perenne*), Lp 5, Elite Evaluation, Outeniqua Research Farm
Planted: 5 March 2020 **Dry matter content (%)** D = Diploid, T = Tetraploid

Cultivars	Type	Cut 1 18/5/2020	Cut 2 24/6/2020	Cut 3 3/8/2020	Cut 4 16/9/2020	Cut 5 21/10/2020	Cut 6 25/11/2020	Cut 7 22/12/2020
24Seven	D	***15.8 ab***	***15.7 abc***	***18.2 abc***	***18.5 abc***	**23.2 a**	***21.5 abc***	***20.5 abc***
50Fifty	D	14.3 bcd	***16.4 ab***	***18.3 abc***	**20.0 a**	**23.2 a**	***21.8 ab***	***20.7 abc***
Base	T	13.1 d	14.0 de	15.4 fg	17.1 cd	20.6 cd	19.2 cdef	18.3 de
Boyne	D	***14.5 abcd***	**16.9 a**	**19.4 a**	**20.1 a**	***21.7 abc***	***22.2 ab***	21.3 ab
Evans	T	13.3 cd	15.2 bcde	15.8 fg	16.2 d	19.0 d	18.9 def	17.6 e
Governor	D	14.0 bcd	15.4 abcde	17.5 bcde	***18.5 abc***	***21.5 abc***	***21.3 abcd***	***20.0 abcd***
Kimbuko	D	13.1 d	15.0 bcde	**19.5 a**	***19.5 ab***	***22.7 ab***	20.8 bcde	***21.0 abc***
Kingsgate	D	13.7 cd	***15.6 abcd***	***18.1 abc***	**20.0 a**	**23.1 a**	***22.6 ab***	***21.2 ab***
Legion	D	14.1 bcd	14.4 cde	16.9 cdef	***18.6 abc***	20.6 bcd	***21.4 abc***	19.6 bcd
Nui (cont)	D	13.8 bcd	***15.6 abcd***	17.5 bcde	***19.4 ab***	***21.9 abc***	***22.1 ab***	19.8 bcd
One50	D	**16.4 a**	14.9 bcde	17.8 bcd	***18.9 ab***	**23.1 a**	***21.8 ab***	**21.9 a**
Platform	D	13.1 d	13.9 e	16.2 ef	***19.0 ab***	***22.0 abc***	***21.9 ab***	19.2 cde
Portique	T	13.2 cd	***16.3 ab***	***18.6 ab***	***19.5 ab***	20.5 cd	19.3 cdef	18.5 de
Tanker	T	12.6 d	14.0 de	16.4 def	17.9 bc	18.8 d	18.1 f	18.3 de
Tugela	D	***15.1 abc***	***16.5 ab***	***18.8 ab***	**19.9 a**	***22.4 abc***	**23.4 a**	***20.8 abc***
Viscount	T	14.4 bcd	14.0 de	14.5 g	17.0 cd	18.8 d	18.6 ef	17.3 e
LSD (0.05)		1.98	1.66	1.56	1.67	2.07	2.43	1.92
CV %		8.47	6.53	5.37	5.34	5.79	6.97	5.84

Shaded = above 18% , **BOLD** = highest DM, ***BOLD Italics*** = similar to the highest. **Note: treatments with the same letter are similar i.e. not significantly different.**
NS = non-significant, no difference between treatments

Table 5: Perennial ryegrass (*Lolium perenne*), Lp 5, Elite Evaluation, Outeniqua Research Farm
Planted: 5 March 2020 **Dry matter content (%)** D = Diploid, T = Tetraploid

Cultivars	Type	Cut 8 18/1/2021	Cut 9 25/2/2021	Cut 10 30/3/2021	Cut 11 3/5/2021	Cut 12 4/6/2021	Cut 13 7/7/2021
24Seven	D	***23.1*** ab	***23.6*** abcd	***21.6*** abcd	***18.5*** abc	***15.0*** abc	16.5
50Fifty	D	***23.0*** abc	***22.6*** abcde	***21.9*** abcd	***18.3*** abc	***15.3*** abc	17.6
Base	T	***21.5*** bcd	***24.1*** abc	20.8 cd	16.1 e	13.9 c	15.7
Boyne	D	***23.2*** ab	20.4 e	***23.8*** ab	**19.7** a	**16.0** a	17.9
Evans	T	20.5 d	22.0 bcde	21.0 cd	15.9 e	14.1 c	15.5
Governor	D	**24.2** a	***24.2*** abc	21.3 bcd	17.9 bcd	**16.2** a	16.1
Kimbuko	D	**24.2** a	21.2 de	**23.9** a	***19.2*** abc	***15.7*** ab	16.7
Kingsgate	D	**24.2** a	***22.6*** abcde	***22.7*** abc	17.9 bcd	***15.0*** abc	15.8
Legion	D	**24.5** a	**25.2** a	***22.2*** abcd	17.7 cd	***14.6*** abc	15.7
Nui (cont)	D	**23.6** a	22.3 bcde	***23.8*** ab	***18.6*** abc	***15.5*** abc	16.5
One50	D	***23.3*** ab	***22.8*** abcde	***22.6*** abc	***19.3*** ab	***15.2*** abc	16.1
Platform	D	**23.9** a	***23.5*** abcd	***21.7*** abcd	***18.8*** abc	***14.7*** abc	16.1
Portique	T	21.1 cd	21.6 cde	20.9 cd	17.9 bcd	***15.1*** abc	16.0
Tanker	T	20.1 d	21.8 cde	20.5 cd	16.5 de	***14.9*** abc	15.1
Tugela	D	**24.8** a	***24.7*** ab	***22.0*** abcd	**19.6** a	**16.1** a	17.2
Viscount	T	20.1 d	21.7 cde	19.7 d	16.6 de	14.1 bc	13.6
LSD (0.05)		1.96	2.75	2.53	1.55	1.65	
CV %		5.15	7.23	6.92	5.16	6.56	

Shaded = above 18%, **BOLD** = highest DM, **BOLD *Italics*** = similar to the highest. **Note: treatments with the same letter are similar i.e. not significantly different.**
NS = non-significant, no difference between treatments

Table 6: Perennial ryegrass (*Lolium perenne*), Lp 5, Elite Evaluation, Outeniqua Research Farm
Planted: 5 March 2020 **Leaf rust %** (rating based) D = Diploid, T = Tetraploid

Cultivars	Type	Cut 1 18/5/2020	Cut 2 24/6/2020	Cut 3 3/8/2020	Cut 4 16/9/2020	Cut 5 21/10/2020	Cut 6 25/11/2020	Cut 7 22/12/2020
24Seven	D	4	0	4	12.5	12.5	33	12.5
50Fifty	D	4	0	4	8	33	33	8
Base	T	8	0	4	17	50	50	12.5
Boyne	D	0	0	4	8	21	21	17
Evans	T	0	0	8	12.5	25	**54**	21
Governor	D	0	0	0	0	8	12.5	4
Kimbuko	D	0	0	0	0	0	4	0
Kingsgate	D	0	0	0	12.5	21	46	21
Legion	D	0	0	0	0	0	17	12.5
Nui (cont)	D	0	0	4	12.5	**58**	**79**	25
One50	D	0	0	8	8	17	33	4
Platform	D	0	0	0	0	8	21	12.5
Portique	T	0	0	0	0	0	17	4
Tanker	T	4	0	0	12.5	33	33	8
Tugela	D	4	0	12,5	8	42	42	12.5
Viscount	T	0	0	0	0	4	17	8

Table 6: Perennial ryegrass (*Lolium perenne*), Lp 5, Elite Evaluation, Outeniqua Research Farm
Planted: 5 March 2020 **Leaf rust %** (ratings based) D = Diploid, T = Tetraploid

Cultivars	Type	Cut 8 18/1/2021	Cut 9 25/2/2021	Cut 10 30/3/2021	Cut 11 3/5/2021	Cut 12 4/6/2021	Cut 13 7/7/2021
24Seven	D	17	21	8	12.5	0	0
50Fifty	D	4	25	4	4	0	0
Base	T	17	**62.5**	12.5	12.5	0	0
Boyne	D	25	46	4	37.5	0	0
Evans	T	42	**75**	4	29	0	0
Governor	D	0	0	0	0	0	0
Kimbuko	D	0	4	4	0	0	0
Kingsgate	D	25	21	0	8	0	0
Legion	D	4	8	0	0	0	0
Nui (cont)	D	46	**54**	21	25	0	4
One50	D	8	33	8	21	0	4
Platform	D	0	4	0	0	0	0
Portique	T	8	42	4	21	0	0
Tanker	T	4	29	17	12.5	0	0
Tugela	D	33	12.5	4	8	0	4
Viscount	T	8	21	12.5	8	0	0

Table 7: Perennial ryegrass (*Lolium perenne*), Lp 5, Elite Evaluation, Outeniqua Research Farm

Planted: 5 March 2020 **Reproductive tillers/ Bolting %** (rating based) D = Diploid, T = Tetraploid

Cultivars	Type	Cut 1 18/5/2020	Cut 2 24/6/2020	Cut 3 3/8/2020	Cut 4 16/9/2020	Cut 5 21/10/2020	Cut 6 25/11/2020	Cut 7 22/12/2020	Cut 8 18/1/2021	Cut 9 25/2/2021
					Early piping	Piping	Piping + heading	Heading	Heading	
24Seven	D	0	0	0	8	13	25	17	17	0
50Fifty	D	0	0	0	0	17	21	8	13	0
Base	T	0	0	0	0	29	33	21	17	0
Boyne	D	0	0	0	0	17	17	4	0	0
Evans	T	0	0	0	13	**54**	**50**	21	13	0
Governor	D	0	0	0	8	21	17	0	13	0
Kimbuko	D	0	0	0	0	0	0	0	0	0
Kingsgate	D	0	0	0	0	25	25	4	0	0
Legion	D	0	0	0	4	13	17	0	0	0
Nui (cont)	D	0	0	0	0	25	25	13	4	0
One50	D	0	0	0	13	21	21	17	13	0
Platform	D	0	0	0	0	17	17	4	0	0
Portique	T	0	0	0	0	0	0	0	0	0
Tanker	T	0	0	0	0	33	**63**	29	25	0
Tugela	D	0	0	0	0	13	13	8	8	0
Viscount	T	0	0	0	8	33	**46**	4	21	0

Table 8: Perennial ryegrass (*Lolium perenne*), Lp 5, Elite Evaluation, Outeniqua Research Farm
Planted: 5 March 2020 **Sward density %** (ratings based) D = Diploid, T = Tetraploid

Cultivars	Type	Cut 8 18/1/2021	Cut 9 25/2/2021	Cut 10 30/3/2021	Cut 11 3/5/2021	Cut 12 4/6/2021	Cut 13 7/7/2021
24Seven	D	100	83	88	100	100	100
50Fifty	D	100	83	88	100	100	100
Base	T	100	83	83	100	100	100
Boyne	D	100	46	67	83	92	92
Evans	T	100	63	58	96	92	92
Governor	D	100	96	96	100	100	100
Kimbuko	D	100	75	79	96	96	96
Kingsgate	D	100	79	88	100	96	100
Legion	D	100	96	100	100	100	100
Nui (cont)	D	100	67	71	92	88	92
One50	D	100	46	79	100	100	100
Platform	D	100	100	100	100	100	100
Portique	T	100	79	79	100	96	100
Tanker	T	100	83	83	100	96	100
Tugela	D	100	92	96	100	100	100
Viscount	T	100	96	100	100	100	100

Table 9: Perennial ryegrass (*Lolium perenne*), Lp 5, Elite Evaluation, Outeniqua Research Farm
Planted: 5 March 2020 **Plant counts** (4x10-point, within row) D = Diploid, T = Tetraploid

Cultivars	Type	Cut 8 18/1/2021	Cut 9 25/2/2021	Cut 10 30/3/2021	Cut 11 3/5/2021	Cut 12 4/6/2021	Cut 13 7/7/2021
24Seven	D	100	83	88	100	100	100
50Fifty	D	100	83	88	100	100	100
Base	T	100	83	83	100	100	100
Boyne	D	100	46	67	83	92	92
Evans	T	100	63	58	96	92	92
Governor	D	100	96	96	100	100	100
Kimbuko	D	100	75	79	96	96	96
Kingsgate	D	100	79	88	100	96	100
Legion	D	100	96	100	100	100	100
Nui (cont)	D	100	67	71	92	88	92
One50	D	100	46	79	100	100	100
Platform	D	100	100	100	100	100	100
Portique	T	100	79	79	100	96	100
Tanker	T	100	83	83	100	96	100
Tugela	D	100	92	96	100	100	100
Viscount	T	100	96	100	100	100	100

Table 9: Perennial ryegrass (*Lolium perenne*), Lp 5, Elite Evaluation, Outeniqua Research Farm
Planted: 5 March 2020 **Plant counts** (4x10-point, within row) D = Diploid, T = Tetraploid

Cultivars	Type	1st count Aug 2020 (%)	2nd count Apr 2021 (%)	Apr 2021 vs Aug 2020 (%)	Row width Apr 2021 (cm)
24Seven	D	90	79	**88**	10
50Fifty	D	80	80	**100**	10
Base	T	81	83	**102**	5
Boyne	D	84	75	**89**	10
Evans	T	79	67	**84**	5
Governor	D	87	78	**89**	8
Kimbuko	D	82	70	**86**	10
Kingsgate	D	86	73	**85**	10
Legion	D	84	78	**93**	7
Nui (cont)	D	74	62	**83**	5
One50	D	78	71	**91**	10
Platform	D	88	90	**103**	10
Portique	T	82	74	**91**	10
Tanker	T	79	68	**85**	5
Tugela	D	84	90	**107**	10
Viscount	T	68	75	**110**	5

Leaf emergence rate

Table 10: Perennial ryegrass (*Lolium perenne*), Lp 5, Elite Evaluation, Outeniqua Research Farm
Planted: 5 March 2020 **No. of days per leaf and projected harvest rotation based on 3-leaf stage**

Parameter	5 Mar to 18 May 2020	18 May to 24 Jun 2020	24 Jun to 3 Aug 2020	3 Aug to 16 Sep 2020	16 Sep to 21 Oct 2020	21 Oct to 25 Nov 2020	25 Nov to 22 Dec 2020
No. of days	13.1	13.5	16	13.5	11.7	11.7	12
Projected time to 3-leaf	39	41	48	41	35	35	36
2.75-leaf Shortest cycle	36	37	44	37	32	32	33
Parameter	**22 Dec 2020 to 18 Jan 2021**	**18 Jan to 25 Feb 2021**	**25 Feb to 30 Mar 2021**	**30 Mar to 3 May 2021**	**3 May to 4 Jun 2021**	**4 Jun to 7 Jul 2021**	
No. of days	12	9.8	10.2	10	11.6	12	
Projected time to 3-leaf	36	29	31	30	35	36	
2.75-leaf Shortest cycle	33	27	28	28	32	33	

Leaf emergence rate depends on leaf growth rate since leaves emerge consecutively, one after the other once the previous leaf is fully extended. Growth rate is mainly dependent on temperature and soil moisture. If soil moisture is sufficient, then the growth rate is mainly a function of temperature. Defoliation or harvest at the 3-leaf stage is optimal for the plant (carbohydrate reserves, root and tiller growth) and optimal for production since the first leaf dies once the fourth leaf emerges and yield reaches a plateau after the third leaf. The plants can at the earliest be defoliated at the 2.75-leaf stage when necessary.

Summary

(trial results for first 15 months; the trial is continuing)

Total yield for the first year (Year 1)

- Highest yielding cultivar: Viscount
- Similar to the highest yielding: Platform, Governor, 50Fifty, Base, Legion, Nui, Tanker, One50

Total yield 15 months (incl. second autumn)

- Highest yielding cultivar: Viscount
- Similar yield: Platform, Governor, Legion, 50Fifty, Base

This shows which cultivars continued strongly beyond the summer.

Establishment and autumn 2020

- Only two cultivars were significantly slower than the rest as reflected in the autumn yield (Evans, Portique). All other cultivars had a similar yield.

Winter yield 2020

- Highest yielding: Platform, Legion
- Similar yield: One50, Base, Nui

Spring 2020

- As expected in spring, most cultivars produce well and is the season of least concern.

Summer yield 2020/21

- Highest yielding: Viscount
- Similar yield: Governor, Base, 50Fifty

Second autumn (2021)

- Highest yielding: Legion, Governor, Viscount, Platform
- Similar yield: 50Fifty, Tugela, 24Seven, Base, Kingsgate

Lowest rust incidence (mainly October to February but some cultivars September to May)

17% or less throughout:

- Kimbuko, Governor, Legion
- 33% or less
- Platform, Viscount

Reproductive tillers/bolting

- No bolting: Kimbuko, Portique
- Highest bolting incidence: Evans, Tanker, Viscount
- Followed by: Base, Kingsgate, Nui

Table 7 also shows the length of the flowering window.

- Low bolting and relatively short flowering window: Boyne, Legion, Platform

Sward density after the first summer Feb 2021: lowest values recorded in February with density increasing again as conditions become more favourable.

- 100%: Platform
- 90-100%: Governor, Legion, Viscount, Tugela
- 80 – 89% : 24Seven, 50Fifty, Base, Tanker
- 75 – 79%: Kimbuko, Kingsgate, Portique

Plant counts comparing April 2021 to August 2020 using the 10-point/m x4 method :

Increased count (increased sward density): Viscount, Tugela, Platform, Base

Unchanged: 50Fifty

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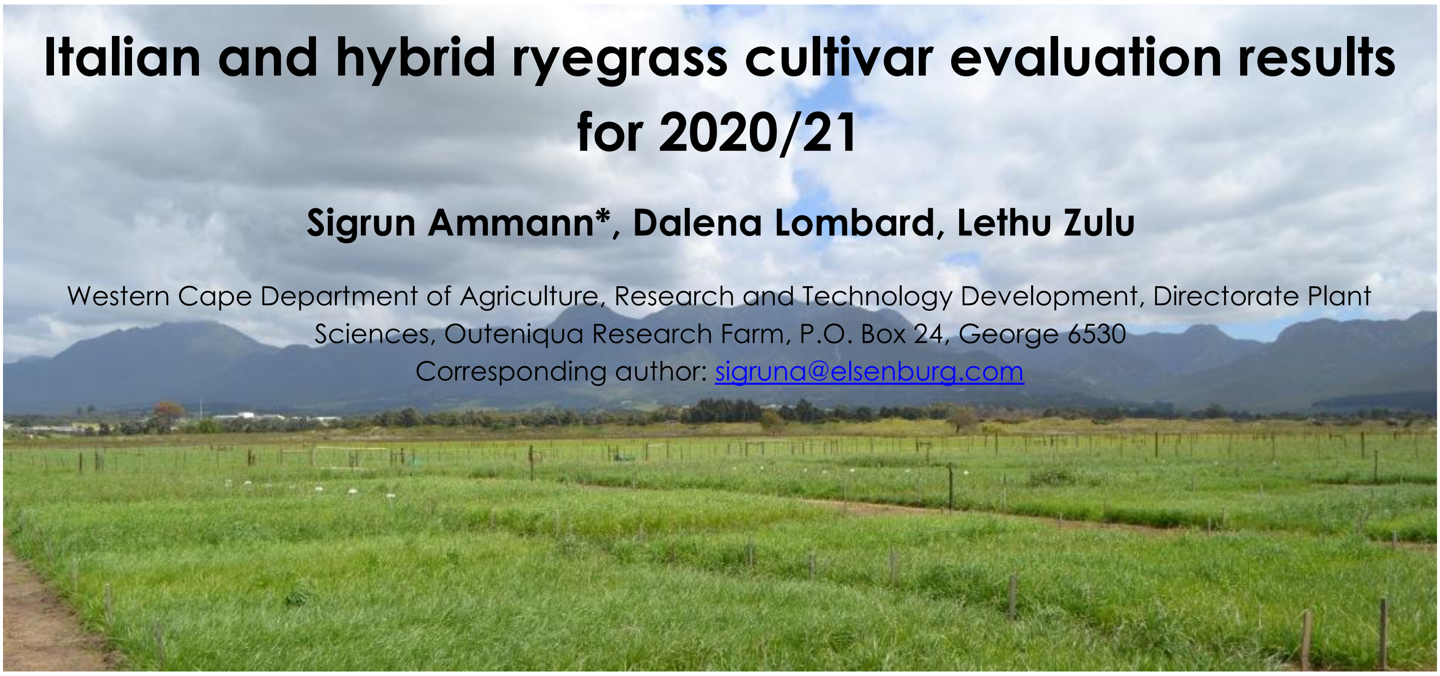

Italian and hybrid ryegrass cultivar evaluation results for 2020/21

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Introduction

The Italian and hybrid ryegrass (*Lolium multiflorum* and *L. hybridum*) elite cultivar evaluation trial 2020/21 was planted on 4 March 2020 at the Outeniqua Research Farm. The aim of the trial is to evaluate the recent Italian and hybrid ryegrass cultivars being used for intensive dairy pastures or ones that are about to enter the market. This trial provides local data to assist farmers with choosing cultivars best suited to the region and to their specific use of pastures. Preferably the cultivars evaluated in this trial should be ones that persist for at least a 12-month period, preferably 15 months. There is however also a use for the shorter duration cultivars in combination with other species or cultivars to fill certain gaps. Since most ryegrass cultivars are imported, this data provides insight into the genetic potential and adaption for the southern Cape coastal region. This data is specific for 2020/21 but the best cultivars are evaluated in successive trials. For previous data refer to the Outeniqua Information Day booklets for 2018, 2019 and 2020 which will give an indication of how cultivars perform in different years of establishment.

Cultivars evaluated

The trial consists of 20 cultivars of which 18 are Italian and two are hybrid ryegrass. Of the Italian cultivars 14 are diploid and four are tetraploid, while the hybrid cultivars are both tetraploid.

- ***Italian diploid***: AgriBoost, Belluci, Bond, Davinci, Fox, Icon, Jackpot, Knight, Podium, Sukari, SupremeQ, Surge, Tabu+, Yolande
- ***Italian tetraploid***: Barmultra II, Elvis, Firkin, Impact (synonym Udine),
- ***Hybrid tetraploid***: Green Spirit, Shogun

Parameters reported in this article

- Total DM yield
- Seasonal DM yield
- DM content
- Flowering behaviour (autumn and spring)
- Persistence / sward density

The diploids were sown at 25 kg/ha while the tetraploids were sown at 30kg/ha. The evaluation was done in small plot trials cut with a reciprocating mower at 5cm where material from the entire net plot was weighed and sampled. The trials were top-dressed with nitrogen fertilizer after each harvest, and potassium fertilizer when necessary to account for nutrient removal.

The harvest cycle is determined according to physiological stage being 3-leaf or in spring canopy closure. As the first cultivars reach these stages, the trial is harvested. Since leaf emergence rate is mainly driven by temperature as well as radiation intensity, water and nutrient availability (Chapman 2016), most cultivars reach the 3-leaf stage at a similar time.

Total yield **(Table 1)** is important, especially on farms that have the means to conserve the surplus as silage for later use. The establishment and input costs are also similar regardless of yield, hence the importance of choosing the cultivars with the best yield.

Seasonal yield data **(Table 1)** is of value for optimising fodder flow requirements especially for the more challenging seasons which are generally winter and summer as well as autumn. The question is whether there are cultivars with both good winter and summer yield. Alternatively it is advisable to plant paddocks to different cultivars to take advantage of different seasonal yield distributions and also to spread risk. A high yielding spring cultivar can for instance be considered for silage making of surplus production. Other consideration are for mixed pastures and how the seasonal yield can best be matched with the yield of the other species in the mixture.

Individual harvest yields and ***growth rates*** are given in **Table 3 and 4.**

Dry matter (DM) content **(Table 5)** is a consideration especially early in the season when the DM content is generally low, since DM content in ryegrass can negatively influence voluntary intake if it is very low (Cabrera Estrada et al 2004, John & Ulyatt 1987, Leaver 1985, Minson 1990. The work by Vértité & Journet 1970 is also widely referenced where they investigated reduced intake with decreasing DM content. In mixtures with other species that have a very low DM content tis can be taken into account.

Leaf rust incidence **(Table 6)** refers mainly to crown rust (*Puccinia coronata*). According to Clarke & Eagling (1994) and Webb et al (2019) crown rust causes yield loss as well as negative effects on root weight and rooting depth, tiller numbers and leaf area or photosynthetic area. Potter (2007) reported not only reduced yield but also reduced water-soluble carbohydrates and reduced digestibility. Plummer et al (1990) also refers to reduced tiller density and increased tiller death. Carr 1975 report rust to be a water soluble carbohydrate (WSC) sink that reduces growth and forage quality. Additionally he estimates that 10% leaf rust infection could cause up to 50% decline in WSC concentration. Hence there are advantages to cultivars which are resistant or have a low incidence only.

Rust can be more severe under nutrient deficiency conditions or if growth cycles are allowed to continue beyond the 3-leaf stage. Increased dead leaf matter may also increase facial eczema (McKenzie 1971).

Sward density **(Table 7)** gives an indication of persistence especially in the summer months. The cultivars that retain good sward density or plant population throughout the summer are desirable.

Italian ryegrass can also be used for ***spring-planting***. However only the cultivars with a low flowering incidence are suitable for spring-planting since early bolting will negatively affect such a planting. For these results refer to the 2020 booklet. The next evaluation is planned for spring 2021.

Flowering behaviour **(Table 8)** is important since it results in a higher stem component which implies a higher fibre content and thus lower nutritive value. The percentage of the sward that is reproductive varies significantly between cultivars as does the duration of reproductive tillers in the sward. Cultivars that do have a high bolting percentage could for instance be used for paddocks that will be cut for silage although it would also affect the silage quality as opposed to cutting a non-reproductive sward that is leafy. In mixtures with species that are very competitive and tall growing in summer it might be an advantage to have a ryegrass component with a higher bolting percentage as that results in taller plants to compete with the other tall components for example chicory or lucerne.

The majority of Italian ryegrass cultivars that are available have the ability to produce new vegetative daughter tillers after the flowering phase. These are then referred to as Italian ryegrasses with a long growth duration. There are also cultivars that do not produce vegetative tillers after the flowering phase and thus end after the bolting phase. In the current trial there are two such cultivars, AgriBoost and SupremeQ.

Plant counts **(Table 9)** were done twice, in June 2020 after successful establishment of the trial and again in April 2021 representing recovery after the summer months. The 10-point method was used for these counts. It consists of 10 pins on a wooden bar that are spaced 10cm apart. The bar is placed randomly within four rows within the plot and the number of strikes are counted i.e. how many spikes are in contact with a plant. Thus the number of strikes out of 40 are then used to calculate a percentage. The table gives the percentage decrease in plant over the 10 month period giving an indication of persistence into the second autumn.

Leaf emergence rate **(Table 10)** depends on leaf growth rate since leaves emerge consecutively, one after the other once the previous leaf is fully extended. Growth rate is mainly dependent on temperature and soil moisture. If soil moisture is sufficient, then the growth rate is mainly a function of temperature. Defoliation or harvest at the 3-leaf stage is optimal for the plant (carbohydrate reserves, root and tiller growth) and optimal for production since the first leaf dies once the fourth leaf emerges and yield reaches a plateau after the third leaf. The plants can at the earliest be defoliated at the 2.75-leaf stage when necessary. In spring canopy closure should be used as primary criterion to decide on the optimal defoliation time since limiting light penetration into the base of the sward can reduce daughter tiller initiation.

Table 1: Italian and hybrid ryegrass (*Lolium multiflorum* & *L. hybridum*), Lm 10, Elite Evaluation, Outeniqua Research Farm
Planted: 4 March 2020 **Seasonal Yield** (t DM/ha) D = Diploid, T = Tetraploid, I = Italian, H = Hybrid

Cultivars	Type	Autumn 2020	Rank	Winter 2020	Rank	Spring 2020	Rank	Summer 2020/21	Rank	Autumn 2021	Rank	Total Year 1	Rank	Total 15 months	Rank
AgriBoost	DI	2.51	1	2.30 ^{cde}	15	3.28 ^{h}	19	-		-		8.07 ^{h}	20	8.07 ^{k}	20
Barmultra II	TI	2.36	4	**2.56** ^{abcde}	10	**5.70** ^{a}	1	2.56 ^{defg}	9	**3.32** ^{abc}	3	**13.2** ^{abc}	3	**16.5** ^{abc}	3
Belluci	DI	2.34	6	**2.71** ^{abcd}	7	**5.62** ^{a}	2	**3.52** ^{ab}	2	**3.74** ^{a}	1	**14.2** ^{a}	1	**17.9** ^{a}	1
Bond	DI	2.16	8	**2.64** ^{abcde}	8	**5.24** ^{abcd}	6	**2.90** ^{abcde}	5	3.02 ^{bcdef}	9	**12.9** ^{abcd}	4	16.0 ^{bcd}	5
Davinci	DI	1.71	19	2.15 ^{e}	19	**5.37** ^{abc}	4	2.76 ^{cdef}	7	**3.29** ^{abcd}	4	12.0 ^{bcde}	10	15.3 ^{bcdef}	8
Elvis	TI	2.16	9	2.23 ^{de}	18	**5.27** ^{abcd}	5	2.53 ^{defgh}	10	3.02 ^{bcdef}	10	12.2 ^{bcd}	9	15.2 ^{bcdef}	10
Firkin	TI	1.62	20	2.25 ^{de}	16	4.68 ^{efg}	13	1.86 ^{ghi}	16	2.60 ^{efg}	14	10.4 ^{efg}	17	13.0 ^{ghi}	16
Fox	DI	1.94	16	**2.48** ^{abcde}	12	**5.47** ^{ab}	3	**3.60** ^{a}	1	3.22 ^{bcd}	6	**13.5** ^{ab}	2	**16.7** ^{ab}	2
Green Spirit	T Mix	2.04	13	**2.55** ^{abcde}	11	**5.16** ^{abcde}	7	2.72 ^{cdef}	8	**3.27** ^{abcd}	5	12.5 ^{bcd}	8	15.7 ^{bcde}	6
Icon	DI	2.00	15	2.13 ^{e}	20	4.74 ^{defg}	12	2.78 ^{bcdef}	6	3.19 ^{bcd}	7	11.6 ^{cdef}	14	14.9 ^{cdef}	12
Impact/ Udine	TI	1.91	17	**2.94** ^{a}	1	3.23 ^{h}	20	1.29 ^{ij}	18	2.53 ^{fg}	15	9.33 ^{gh}	19	11.9 ^{ij}	18
Jackpot	DI	2.35	5	**2.81** ^{abc}	4	4.27 ^{g}	17	2.39 ^{efgh}	13	1.97 ^{h}	17	11.8 ^{cde}	13	13.8 ^{fgh}	15
Knight	DI	2.03	14	**2.80** ^{abc}	5	4.25 ^{g}	18	2.51 ^{defgh}	12	2.50 ^{g}	16	11.6 ^{def}	15	14.1 ^{efgh}	14
Podium	DI	2.10	11	2.31 ^{cde}	14	4.87 ^{cdef}	11	2.52 ^{defgh}	11	3.08 ^{bcde}	8	11.8 ^{cde}	12	14.9 ^{cdef}	11
Shogun	TH	1.71	18	**2.88** ^{ab}	3	4.89 ^{cdef}	10	**3.39** ^{abc}	3	2.85 ^{cdefg}	11	**12.9** ^{abcd}	5	15.7 ^{bcde}	7
Sukari	DI	2.45	2	**2.93** ^{a}	2	5.01 ^{bcde}	9	2.11 ^{fgh}	15	2.79 ^{defg}	12	12.5 ^{bcd}	7	15.3 ^{bcdef}	9
Supreme Q	DI	2.15	10	**2.79** ^{abc}	6	4.39 ^{fg}	15	0.82 ^{j}	19	-		10.1 ^{fg}	18	10.1 ^{j}	19
Surge	DI	2.22	7	2.23 ^{de}	17	4.29 ^{g}	16	1.79 ^{hi}	17	1.88 ^{h}	18	10.5 ^{efg}	16	12.4 ^{hi}	17
Tabu +	DI	2.38	3	**2.57** ^{abcde}	9	4.65 ^{efg}	14	2.22 ^{efgh}	14	2.64 ^{efg}	13	11.8 ^{cde}	11	14.4 ^{defg}	13
Yolande	DI	2.08	12	2.37 ^{bcde}	13	5.05 ^{bcde}	8	**3.15** ^{abcd}	4	**3.40** ^{ab}	2	**12.6** ^{abcd}	6	16.0 ^{bcd}	4
LSD (0.05)		NS		0.53		0.54		0.75		0.50		1.58		1.78	
CV %		31.0		12.6		6.91		18.0		10.3		8.10		7.49	

Shaded = highest yielding, **BOLD** = similar to highest. **Note: treatments with the same letter are similar i.e. not significantly different**
NS = non-significant

Table 2: Italian and hybrid ryegrass (*Lolium multiflorum* & *L. hybridum*), Lm 10, Elite Evaluation, Outeniqua Research Farm
Planted: 4 March 2020 **Mean seasonal growth rate** (kg DM/ha/day) D = Diploid, T = Tetraploid, I = Italian, H = Hybrid

Cultivars	Type	Autumn 2020	Rank	Winter 2020	Rank	Spring 2020	Rank	Summer 2020/21	Rank	Autumn 2021	Rank
AgriBoost	DI	27.3	1	25.0 cde	15	36.0 h	18	-		-	
Barmultra II	TI	25.7	4	**27.9 abcde**	10	**62.6 a**	1	28.5 defg	9	**36.1 abc**	3
Belluci	DI	25.4	6	**29.4 abcd**	7	**61.7 a**	2	**39.2 ab**	2	**40.6 a**	1
Bond	DI	23.5	8	**28.7 abcde**	8	**57.6 abcd**	6	**32.3 abcd**	5	32.8 bcdef	9
Davinci	DI	18.6	18	23.3 e	19	**59.1 abc**	4	30.7 cdef	7	**35.7 abc**	4
Elvis	TI	23.5	9	24.3 de	18	**57.9 abcd**	5	28.1 defgh	10	32.8 bcdef	10
Firkin	TI	17.6	20	24.4 de	16	51.5 efg	13	20.7 ghi	16	28.3 efg	14
Fox	DI	21.1	16	**27.0 abcde**	12	**60.1 ab**	3	**40.0 a**	1	35.1 bcd	6
Green Spirit	T Mix	22.2	13	**27.7 abcde**	11	**56.7 abcde**	7	30.2 cdef	8	**35.5 abcd**	5
Icon	DI	21.8	15	23.2 e	20	52.1 defg	12	30.9 bcdef	6	34.6 bcd	7
Impact/Udine	TI	20.8	17	**31.9 a**	1	35.4 h	20	14.4 i	18	27.5 fg	15
Jackpot	DI	25.5	5	**30.5 abc**	4	47.0 g	17	26.5 efgh	13	21.3 h	17
Knight	DI	22.1	14	**30.4 abc**	5	46.8 g	18	27.9 defgh	12	27.1 g	16
Podium	DI	22.8	11	25.2 cde	14	53.6 cdef	11	28.0 defgh	11	33.4 bcde	8
Shogun	TH	18.5	18	**31.3 ab**	3	53.7 cdef	10	**37.7 abc**	3	31.0 cdefg	11
Sukari	DI	26.8	2	**31.8 a**	2	55.0 bcde	9	23.4 fgh	15	30.3 defg	12
Supreme Q	DI	23.4	10	**30.4 abc**	6	48.2 fg	15	-		-	
Surge	DI	24.1	7	24.3 de	17	47.1 g	16	19.9 hi	17	20.5 h	18
Tabu +	DI	25.8	3	**28.0 abcde**	9	51.0 efg	14	24.7 efgh	14	28.7 efg	13
Yolande	DI	22.6	12	25.7 bcde	13	55.5 bcde	8	**35.0 abcd**	4	**36.9 ab**	2
LSD (0.05)		NS		5.74		5.99		8.45		5.41	
CV %		31.0		12.6		6.91		17.7		10.3	

Shaded = highest yielding, **BOLD** = similar to highest. **Note: treatments with the same letter are similar i.e. not significantly different**
NS = non-significant **More detailed growth rates are given in Table 4**

Table 3: Italian and hybrid ryegrass (*Lolium multiflorum* & *L. hybridum*), Lm 10, Elite Evaluation, Outeniqua Research Farm

Planted: 4 March 2020 **Yield** (t DM/ha) **Individual harvests** D = Diploid, T = Tetraploid, I = Italian, H = Hybrid

Cultivars	Type	Cut 1 12/5/2020	Cut 2 12/6/2020	Cut 3 29/7/2020	Cut 4 8/9/2020	Cut 5 7/10/2020	Cut 6 2/11/2020	Cut 7 26/11/2020
AgriBoost	DI	1.92	0.97 bc	0.77 cde	1.43 bcde	1.52 g	0.77 i	0.72 i
Barmultra II	TI	1.70	**1.08 abc**	0.87 bcde	**1.59 abcde**	**2.19 ab**	**1.95 ab**	**1.25 abc**
Belluci	DI	1.62	**1.18 abc**	**1.12 ab**	1.41 bcde	**2.11 abc**	**2.03 a**	**1.21 abc**
Bond	DI	1.41	**1.22 ab**	**0.91 abcde**	**1.57 abcde**	**2.02 abcd**	1.73 bcde	**1.18 abcd**
Davinci	DI	1.13	0.94 c	0.67 e	1.39 cde	**2.18 ab**	**1.83 abc**	1.09 cdef
Elvis	TI	1.49	**1.10 abc**	0.84 bcde	1.20 e	1.82 def	**1.88 ab**	**1.34 a**
Firkin	TI	1.04	0.95 c	0.73 de	1.44 bcde	**2.00 abcd**	1.51 efg	0.89 ghi
Fox	DI	1.26	**1.11 abc**	0.84 bcde	**1.51 abcde**	**2.27 a**	1.72 bcde	**1.19 abcd**
Green Spirit	T Mix	1.37	**1.09 abc**	**1.04 abc**	1.34 cde	**2.04 abcd**	1.72 bcde	**1.14 abcde**
Icon	DI	1.31	**1.13 abc**	0.72 de	1.21 e	1.94 bcd	1.61 cdef	0.96 efgh
Impact/Udine	TI	1.23	**1.10 abc**	**0.98 abcd**	**1.90 a**	1.16 h	0.84 i	0.86 hi
Jackpot	DI	1.64	**1.16 abc**	**0.99 abcd**	**1.69 abc**	1.80 def	1.19 h	0.95 efgh
Knight	DI	1.36	**1.10 abc**	**1.01 abcd**	**1.69 abc**	1.65 efg	1.20 h	1.07 cdefg
Podium	DI	1.41	**1.13 abc**	0.73 de	1.43 bcde	**2.05 abcd**	1.59 def	0.96 efgh
Shogun	TH	1.00	**1.14 abc**	**1.19 a**	**1.55 abcde**	1.80 def	1.47 fg	**1.31 ab**
Sukari	DI	1.71	**1.23 a**	**0.96 abcde**	**1.86 ab**	**2.18 ab**	1.34 gh	1.12 bcdef
Supreme Q	DI	1.43	**1.17 abc**	**0.99 abcd**	**1.68 abcd**	1.89 cde	1.19 h	0.97 efgh
Surge	DI	1.55	**1.08 abc**	0.81 cde	1.24 de	1.61 fg	1.51 efg	0.92 fgh
Tabu +	DI	1.67	**1.16 abc**	**1.01 abcd**	1.38 cde	1.97 bcd	1.43 gh	0.99 defgh
Yolande	DI	1.42	**1.08 abc**	**0.92 abcde**	1.28 cde	1.87 cdef	**1.82 abcd**	1.11 bcdef
LSD (0.05)		NS	0.25	0.29	0.45	0.28	0.24	0.20
CV %		41.9	13.7	19.7	18.2	8.85	9.70	11.7

Shaded = highest yielding, **BOLD** = similar to highest. **Note: treatments with the same letter are similar i.e. not significantly different.**

Table 3: Italian and hybrid ryegrass (*Lolium multiflorum* & *L. hybridum*), Lm 10, Elite Evaluation, Outeniqua Research Farm

Planted: 4 March 2020 **Yield** (t DM/ha) **Individual harvests** D = Diploid, T = Tetraploid, I = Italian, H = Hybrid

Cultivars	Type	Cut 8 17/12/2020	Cut 9 12/1/2021	Cut 10 * 10/2/2021	Cut 11 5/3/2021	Cut 12 7/4/2021	Cut 13 5/5/2021	Cut 14 7/6/2021
AgriBoost	DI	-	-	-	-	-	-	-
Barmultra II	TI	**1.11** abcd	0.76 de	0.27 bcde	**0.55** abc	**1.25** abcd	1.19 bcd	**0.97** a
Belluci	DI	**1.30** a	**1.08** abc	**0.59** ab	**0.72** ab	**1.47** a	**1.40** a	**0.90** ab
Bond	DI	1.06 bcd	**0.96** abcde	**0.41** abcd	**0.62** ab	1.10 bcde	1.04 def	**0.95** a
Davinci	DI	0.96 cde	0.92 bcde	**0.42** abcd	**0.59** ab	**1.27** abc	1.18 bcd	**0.90** ab
Elvis	TI	**1.17** abc	0.81 cde	0.25 cde	**0.39** abcd	**1.16** abcde	1.09 cde	**0.88** abcd
Firkin	TI	0.96 cde	0.74 de	0.09 e	0.09 cd	0.90 def	1.10 cd	0.74 defg
Fox	DI	**1.10** abcd	**1.24** a	**0.59** a	**0.86** a	**1.28** abc	1.10 cd	**0.84** abcde
Green Spirit	T Mix	**1.14** abcd	0.78 de	**0.36** abcde	**0.55** abc	**1.20** abcd	**1.24** abc	**0.90** abc
Icon	DI	**1.07** abcd	**1.00** abcd	**0.36** abcde	**0.47** abcd	**1.36** ab	1.17 bcd	0.72 efg
Impact/Udine	TI	0.93 de	0.15 f	0.08 e	0.26 bcd	0.83 ef	1.06 def	0.76 bcdefg
Jackpot	DI	1.03 bcde	0.92 bcde	0.18 de	**0.51** abcd	0.55 f	0.90 fg	0.56 h
Knight	DI	0.95 cde	**0.97** abcde	**0.28** abcde	**0.66** ab	0.99 cde	0.92 efg	0.64 gh
Podium	DI	0.99 bcde	0.84 cde	**0.36** abcde	**0.42** abcd	**1.22** abcd	1.14 bcd	0.79 bcdef
Shogun	TH	**1.22** ab	**1.16** ab	**0.54** abc	**0.62** ab	1.10 bcde	1.03 def	0.75 cdefg
Sukari	DI	0.92 de	0.83 cde	0.17 de	**0.38** abcd	1.05 bcde	1.10 cd	0.75 defg
Supreme Q	DI	0.82 e	-	-	-	-	-	-
Surge	DI	0.81 e	0.80 cde	0.15 de	0.06 d	0.59 f	0.84 g	0.55 h
Tabu +	DI	**1.11** abcd	0.71 e	0.15 de	0.32 bcd	1.02 bcde	1.04 def	0.65 fgh
Yolande	DI	**1.21** ab	**1.03** abcd	**0.47** abcd	**0.56** abc	**1.31** abc	**1.29** ab	**0.86** abcde
LSD (0.05)		0.24	0.29	0.32	0.49	0.37	0.17	0.15
CV %		13.6	20.5	61.5	55.6	20.4	9.3	11.4

Shaded = highest yielding, **BOLD** = similar to highest. **Note: treatments with the same letter are similar i.e. not significantly different.**
*** heat stress conditions the week before harvest**

Table 4 Italian and hybrid ryegrass (*Lolium multiflorum* & *L. hybridum*), Lm 10, Elite Evaluation, Outeniqua Research Farm

Planted: 4 March 2020 **Growth rates** (kg DM/ha/day) **Individual harvests** D = Diploid, T = Tetraploid, I = Italian, H = Hybrid

Cultivars	Type	Cut 1 12/5/2020	Cut 2 12/6/2020	Cut 3 29/7/2020	Cut 4 8/9/2020	Cut 5 7/10/2020	Cut 6 2/11/2020	Cut 7 26/11/2020
AgriBoost	DI	27.8	31.4 b	16.4 cde	35.0 bcde	52.4 g	29.4 h	29.8 i
Barmultra II	TI	24.7	**34.7 ab**	18.5 bcde	**38.7 abcde**	**75.5 ab**	**74.9 ab**	**52.1 abc**
Belluci	DI	23.4	**38.0 ab**	**23.8 ab**	34.4 bcde	**72.6 abc**	**77.9 a**	**50.5 abc**
Bond	DI	20.5	**39.5 a**	**19.3 abcde**	**38.2 abcde**	**69.5 abcd**	66.7 bcd	**49.2 abcd**
Davinci	DI	16.4	30.4 b	14.2 e	33.8 cde	**75.2 ab**	**70.5 abc**	45.5 bcdef
Elvis	TI	21.6	**35.4 ab**	17.9 bcde	29.2 e	62.9 def	**72.2 ab**	**55.8 a**
Firkin	TI	15.0	30.5 b	15.4 de	35.1 bcde	**69.0 abcd**	58.1 def	37.1 ghi
Fox	DI	18.2	**35.8 ab**	17.9 bcde	**36.8 abcde**	**78.2 a**	66.2 bcd	**49.5 abcd**
Green Spirit	T Mix	20.0	**35.2 ab**	**22.3 abc**	32.7 cde	**70.3 abcd**	66.1 bcd	**47.6 abcde**
Icon	DI	19.0	**36.5 ab**	15.3 de	29.5 e	66.7 bcd	61.8 cde	40.1 efgh
Impact/Udine	TI	17.9	**35.6 ab**	**20.9 abcd**	**46.3 a**	40.0 h	32.1 h	35.7 hi
Jackpot	DI	23.7	**37.5 ab**	**21.1 abcd**	**41.4 abc**	62.1 def	45.8 g	39.5 efgh
Knight	DI	19.7	**35.5 ab**	**21.5 abcd**	**41.2 abc**	57.1 efg	46.3 g	44.4 cdefg
Podium	DI	20.5	**36.3 ab**	15.6 de	34.8 bcde	**70.7 abcd**	61.2 cde	39.8 efgh
Shogun	TH	14.5	**36.9 ab**	**25.2 a**	**37.8 abcde**	62.2 def	56.8 ef	**54.5 ab**
Sukari	DI	24.8	**39.7 a**	**20.4 abcde**	**45.3 ab**	**75.3 ab**	51.5 fg	46.8 bcdef
Supreme Q	DI	20.7	**37.9 ab**	**20.9 abcd**	**41.1 abcd**	65.3 cde	45.9 g	40.6 efgh
Surge	DI	22.5	**35.0 ab**	17.2 cde	30.3 de	55.6 fg	58.0 def	38.5 fgh
Tabu +	DI	24.2	**37.4 ab**	**21.5 abcd**	33.7 cde	67.7 bcd	54.8 efg	41.1 defgh
Yolande	DI	20.5	**35.0 ab**	**19.5 abcde**	31.3 cde	64.3 cdef	**70.2 abc**	46.2 bcdef
LSD (0.05)		NS	8.09	6.26	10.9	9.62	9.33	8.58
CV %		41.9	13.7	19.7	18.2	8.85	9.70	11.7

Shaded = highest yielding, **BOLD** = similar to highest. **Note: treatments with the same letter are similar i.e. not significantly different.**

Table 4 Italian and hybrid ryegrass (*Lolium multiflorum* & *L. hybridum*), Lm 10, Elite Evaluation, Outeniqua Research Farm
Planted: 4 March 2020 **Growth rates** (kg DM/ha/day) **Individual harvests** D = Diploid, T = Tetraploid, I = Italian, H = Hybrid

Cultivars	Type	Cut 8 17/12/2020	Cut 9 12/1/2021	Cut 10 * 10/2/2021	Cut 11 5/3/2021	Cut 12 7/4/2021	Cut 13 5/5/2021	Cut 14 7/6/2021
AgriBoost	DI	-	-	-	-	-	-	-
Barmultra II	TI	**52.9 abcd**	29.1 de	9.2 bcd	**23.8 abc**	**37.8 abcd**	42.7 bcd	**29.3 a**
Belluci	DI	**61.7 a**	**41.4 abc**	**20.3 a**	**31.3 ab**	**44.4 a**	**50.1 a**	**27.4 ab**
Bond	DI	50.2 bcd	**37.0 abcde**	**14.1 abc**	**26.7 ab**	33.2 bcde	37.2 def	**28.8 a**
Davinci	DI	45.7 cde	35.5 bcde	**14.4 abc**	**25.7 ab**	**38.6 abc**	42.0 bcd	**27.3 ab**
Elvis	TI	**55.8 abc**	31.0 cde	8.7 bcd	**16.5 abcd**	**35.1 abcde**	38.8 cde	**26.6 abcd**
Firkin	TI	45.8 cde	28.5 de	2.9 d	4.1 cd	27.3 def	39.2 cd	22.4 defg
Fox	DI	**52.3 abcd**	**47.7 a**	**20.3 a**	**37.2 a**	**38.8 abc**	39.3 cd	**25.4 abcde**
Green Spirit	T Mix	**54.4 abcd**	30.0 cde	**12.6 abcd**	**24.0 abc**	**36.5 abcd**	**44.3 abc**	**27.1 abc**
Icon	DI	**50.8 abcd**	**38.6 abcde**	**12.2 abcd**	**19.8 abcd**	**41.0 ab**	41.7 bcd	21.8 efg
Impact/Udine	TI	44.2 de	6.0 f	2.6 d	11.2 bcd	25.2 ef	37.9 def	23.0 bcdefg
Jackpot	DI	48.9 bcde	35.2 bcde	6.2 cd	**22.0 abcd**	16.7 f	32.0 gf	17.1 h
Knight	DI	45.3 cde	**37.1 abcde**	**9.7 abcd**	**26.4 ab**	29.9 cde	32.8 efg	19.4 gh
Podium	DI	47.0 bcde	32.4 cde	**12.4 abcd**	**18.3 abcd**	**37.0 abcd**	40.8 bcd	24.1 bcdef
Shogun	TH	**57.9 ab**	**44.7 ab**	**18.7 ab**	**26.1 ab**	33.1 bcde	37.0 def	22.8 cdefg
Sukari	DI	43.7 de	31.8 cde	5.8 cd	**16.2 abcd**	31.7 bcde	39.3 cd	22.6 defg
Supreme Q	DI	38.9 e	-	-	-	-	-	-
Surge	DI	38.7 e	30.7 cde	5.2 cd	2.3 d	18.0 f	30.1 g	16.8 h
Tabu +	DI	**52.9 abcd**	27.5 e	5.1 cd	13.7 bcd	30.9 bcde	37.1 def	19.7 fgh
Yolande	DI	**57.9 ab**	**40.0 abcd**	**16.1 abc**	**24.3 abc**	**39.5 abc**	**46.2 ab**	**26.1 abcde**
LSD (0.05)		11.2	11.6	11.1	21.4	11.1	6.08	4.49
CV %		13.6	20.2	61.3	57.2	20.3	9.3	11.4

Shaded = highest yielding, **BOLD** = similar to highest. **Note: treatments with the same letter are similar i.e. not significantly different.**
*** heat stress conditions the week before harvest**

Table 5 Italian and hybrid ryegrass (*Lolium multiflorum* & *L. hybridum*), Lm 10, Elite Evaluation, Outeniqua Research Farm
Planted: 4 March 2020 **Dry matter content** (%) **Individual harvests** D = Diploid, T = Tetraploid, I = Italian, H = Hybrid

Cultivars	Type	Cut 1 12/5/2020	Cut 2 12/6/2020	Cut 3 29/7/2020	Cut 4 8/9/2020	Cut 5 7/10/2020	Cut 6 2/11/2020	Cut 7 26/11/2020
AgriBoost	DI	13.1 bcde	14.5 bcde	***21.0 ab***	***20.0 abc***	***17.6 abcd***	***20.9 abc***	**21.7 a**
Barmultra II	TI	13.2 bc	13.7 de	18.8 d	18.2 cdef	16.8 cd	16.9 j	16.1 i
Belluci	DI	11.6 ef	14.5 bcde	19.6 bcd	***20.0 abc***	***17.5 abcd***	18.5 ghi	17.7 defg
Bond	DI	**15.0 a**	15.1 bcde	***21.2 ab***	19.2 bcde	***18.0 abcd***	18.7 fghi	17.7 efgh
Davinci	DI	***13.7 ab***	***16.2 ab***	***20.8 abc***	***19.5 abcd***	***17.7 abcd***	19.6 cdefgh	18.7 cdef
Elvis	TI	12.6 bcdef	14.3 bcde	19.9 bcd	18.9 bcde	17.3 bcd	17.5 ij	16.5 hi
Firkin	TI	11.6 def	13.2 e	19.5 bcd	18.5 cde	17.1 bcd	18.1 hij	17.8 defg
Fox	DI	12.8 bcdef	15.4 bcd	***20.6 abcd***	***19.7 abc***	***17.7 abcd***	18.6 ghi	17.6 fgh
Green Spirit	T Mix	11.9 cdef	14.0 cde	18.8 d	18.8 bcde	17.5 bcd	16.9 j	16.9 ghi
Icon	DI	13.4 b	**17.9 a**	***21.1 ab***	***20.2 abc***	***17.7 abcd***	19.4 cdefgh	18.0 defg
Impact/Udine	TI	11.5 f	13.2 e	19.1 cd	16.8 def	16.4 d	19.1 efgh	18.7 cdef
Jackpot	DI	12.8 bcdef	14.3 bcde	18.8 d	18.4 cde	17.0 cd	20.2 bcdef	18.6 cdef
Knight	DI	13.2 bc	14.1 cde	19.8 bcd	16.5 ef	16.8 cd	19.2 defgh	18.5 cdef
Podium	DI	***13.6 ab***	15.7 bc	**22.0 a**	**22.0 a**	**19.1 a**	***20.5 abcde***	18.9 cde
Shogun	TH	13.1 bcd	14.7 bcde	19.0 cd	15.6 f	***17.8 abcd***	19.6 cdefgh	17.6 fgh
Sukari	DI	***14.0 ab***	15.8 bc	**22.3 a**	***21.3 ab***	***18.7 ab***	**21.8 a**	***20.6 ab***
Supreme Q	DI	13.3 bc	15.7 bc	***21.1 ab***	***20.1 abc***	***18.1 abc***	***21.5 ab***	19.6 bc
Surge	DI	12.5 bcdef	15.5 bcd	19.6 bcd	***19.5 abcd***	***17.6 abcd***	***20.7 abcd***	19.5 bc
Tabu +	DI	12.5 bcdef	15.2 bcd	19.4 bcd	***19.5 abcd***	17.3 bcd	19.7 cdefg	19.0 cd
Yolande	DI	13.1 bcde	14.4 bcde	***20.7 abc***	**21.9 a**	***18.3 abc***	19.4 cdefgh	18.7 cdef
LSD (0.05)		1.51	1.93	1.82	2.67	1.66	1.47	1.21
CV %		7.05	7.86	5.48	8.40	5.70	4.59	3.99

Shaded = above 18%, **BOLD** = highest DM, ***BOLD Italics*** = similar to the highest.. **Note: treatments with the same letter are similar i.e. not significantly different.**

Table 5 Italian and hybrid ryegrass (*Lolium multiflorum* & *L. hybridum*), Lm 10, Elite Evaluation, Outeniqua Research Farm
Planted: 4 March 2020 **Dry matter content** (%) **Individual harvests** D = Diploid, T = Tetraploid, I = Italian, H = Hybrid

Cultivars	Type	Cut 8 17/12/2020	Cut 9 12/1/2021	Cut 10 * 10/2/2021	Cut 11 5/3/2021	Cut 12 7/4/2021	Cut 13 5/5/2021	Cut 14 7/6/2021
AgriBoost	DI	-	-	-	-	-	-	-
Barmultra II	TI	14.7 i	16.0 d	***22.8 ab***	18.5 bcd	13.8 bcde	10.6 fghi	14.6 ij
Belluci	DI	17.3 cdefg	16.1 d	***23.3 ab***	17.3 cd	13.6 bcde	11.1 cdefg	15.9 cdefg
Bond	DI	18.1 bcde	***18.1 abc***	***25.7 ab***	***18.0 abc***	15.1 bc	10.9 defgh	16.6 bcd
Davinci	DI	17.8 bcdef	***17.7 abcd***	***25.6 ab***	18.9 bcd	15.0 bcd	12.0 b	16.7 bc
Elvis	TI	15.3 hi	16.7 bcd	***24.5 ab***	18.0 bcd	13.1 de	10.2 i	14.3 j
Firkin	TI	18.1 bcde	***17.5 abcd***	***24.6 ab***	18.2 bcd	13.8 bcde	10.5 hi	15.2 ghi
Fox	DI	17.4 cdefg	17.2 bcd	21.4 b	17.4 cd	14.1 bcde	11.3 cd	16.4 bcd
Green Spirit	T Mix	16.4 fgh	16.4 cd	***24.4 ab***	18.0 bcd	12.8 e	10.6 ghi	15.1 hij
Icon	DI	16.8 efgh	16.7 bcd	***25.5 ab***	18.9 bc	14.0 bcde	11.3 cde	16.2 bcdef
Impact/Udine	TI	16.2 ghi	16.4 cd	***23.0 ab***	19.0 bc	13.6 bcde	10.8 efghi	15.1 hij
Jackpot	DI	17.1 defg	***17.5 abcd***	***25.1 ab***	16.3 d	14.8 bcd	11.0 cdefgh	15.3 ghi
Knight	DI	18.0 bcde	***18.5 ab***	***27.8 ab***	17.3 cd	14.9 bcd	10.8 efghi	15.9 defg
Podium	DI	18.6 bcd	***17.6 abcd***	***23.9 ab***	***19.6 abc***	14.5 bcde	12.0 b	17.0 b
Shogun	TH	17.4 cdefg	16.1 d	***22.6 ab***	18.4 bcd	14.8 bcd	11.2 cdef	15.4 fgh
Sukari	DI	**20.3 a**	**19.1 a**	***26.6 ab***	**22.0 a**	15.4 b	**13.0 a**	**18.7 a**
Supreme Q	DI	***19.1 ab***	-	-	-	-	-	-
Surge	DI	18.3 bcd	***17.5 abcd***	**28.0 a**	***20.4 ab***	**17.6 a**	11.1 cdefgh	16.5 bcd
Tabu +	DI	18.7 bc	***18.1 abc***	**27.9 a**	17.9 bcd	14.6 bcde	11.5 bc	15.6 efgh
Yolande	DI	17.9 bcde	17.2 bcd	***25.3 ab***	***20.2 ab***	13.3 de	11.3 cde	16.3 bcde
LSD (0.05)		1.53	1.80	6.42	2.61	1.88	0.59	0.82
CV %		5.28	6.24	15.5	8.48	7.91	3.18	3.12

Shaded = above 18%, **BOLD** = highest DM, **BOLD *Italics*** = similar to the highest.. **Note: treatments with the same letter are similar i.e. not significantly different.**
*** heat stress conditions the week before harvest**

Table 6 Italian and hybrid ryegrass (*Lolium multiflorum* & *L. hybridum*), Lm 10, Elite Evaluation, Outeniqua Research Farm

Planted: 4 March 2020 **Leaf rust** (%) (rating based) **Individual harvests** D = Diploid, T = Tetraploid, I = Italian, H = Hybrid

Cultivars	Type	Cut 1 12/5/2020	Cut 2 12/6/2020	Cut 3 29/7/2020	Cut 4 8/9/2020	Cut 5 7/10/2020	Cut 6 2/11/2020	Cut 7 26/11/2020
AgriBoost	DI	25	4	4	0	0	0	0
Barmultra II	TI	25	12.5	33	8	0	0	0
Belluci	DI	21	0	0	0	0	0	0
Bond	DI	21	4	0	0	4	0	0
Davinci	DI	21	12.5	17	0	4	0	0
Elvis	TI	25	29	46	4	8	0	0
Firkin	TI	17	21	58	0	17	0	0
Fox	DI	21	0	8	4	0	0	4
Green Spirit	T Mix	21	8	33	4	8	0	0
Icon	DI	17	8	8	0	0	0	4
Impact/Udine	TI	0	0	0	0	0	0	0
Jackpot	DI	25	0	4	0	0	0	0
Knight	DI	4	0	0	0	0	0	0
Podium	DI	4	4	17	0	0	0	0
Shogun	TH	12.5	21	29	0	8	4	8
Sukari	DI	0	0	0	0	0	0	0
Supreme Q	DI	4	0	0	0	0	0	0
Surge	DI	21	0	0	0	0	0	0
Tabu +	DI	12.5	4	4	0	0	0	0
Yolande	DI	8	0	4	0	0	4	0

Table 6 Italian and hybrid ryegrass (*Lolium multiflorum* & *L. hybridum*), Lm 10, Elite Evaluation, Outeniqua Research Farm

Planted: 4 March 2020 **Leaf rust** (%) (rating based) **Individual harvests** D = Diploid, T = Tetraploid, I = Italian, H = Hybrid

Cultivars	Type	Cut 8 17/12/2020	Cut 9 12/1/2021	Cut 10 * 10/2/2021	Cut 11 5/3/2021	Cut 12 7/4/2021	Cut 13 5/5/2021	Cut 14 7/6/2021
AgriBoost	DI	0	-	-	-	-	-	-
Barmultra II	TI	0	25	0	4	12.5	0	0
Belluci	DI	0	0	4	0	4	0	0
Bond	DI	8	8	0	0	8	0	0
Davinci	DI	0	12.5	0	0	17	4	0
Elvis	TI	0	25	8	4	33	4	0
Firkin	TI	4	25	17	4	29	8	0
Fox	DI	0	17	4	0	21	0	0
Green Spirit	T Mix	0	4	4	0	12.5	4	0
Icon	DI	4	0	0	0	0	4	0
Impact/Udine	TI	0	0	4	0	12.5	0	0
Jackpot	DI	4	8	0	0	0	0	0
Knight	DI	4	8	4	4	0	0	0
Podium	DI	0	17	0	0	12.5	4	0
Shogun	TH	12.5	25	12.5	0	21	12.5	0
Sukari	DI	0	0	0	0	0	0	0
Supreme Q	DI	0	0	-	-	-	-	-
Surge	DI	0	0	0	0	0	4	0
Tabu +	DI	0	21	4	0	8	4	0
Yolande	DI	0	8	0	0	8	4	0

*** heat stress conditions the week before harvest**

Table 7 Italian and hybrid ryegrass (*Lolium multiflorum* & *L. hybridum*), Lm 10, Elite Evaluation, Outeniqua Research Farm
Planted: 4 March 2020 **Sward density** (%) (rating based)**Individual harvests** D = Diploid, T = Tetraploid, I = Italian, H = Hybrid

Cultivars	Type	Cut 1 12/5/2020	Cut 2 12/6/2020	Cut 3 29/7/2020	Cut 4 8/9/2020	Cut 5 7/10/2020	Cut 6 2/11/2020	Cut 7 26/11/2020
AgriBoost	DI	100	100	100	100	100 a	96 b	71 d
Barmultra II	TI	100	100	100	100	100 a	100 a	100 a
Belluci	DI	100	100	100	100	100 a	100 a	100 a
Bond	DI	100	100	100	100	100 a	100 a	100 a
Davinci	DI	100	100	100	100	100 a	100 a	100 a
Elvis	TI	100	100	100	100	100 a	100 a	100 a
Firkin	TI	100	100	100	100	100 a	100 a	92 bc
Fox	DI	100	100	100	100	100 a	100 a	100 a
Green Spirit	T Mix	100	100	100	100	100 a	100 a	100 a
Icon	DI	100	100	100	100	100 a	100 a	100 a
Impact/Udine	TI	100	100	100	100	88 b	96 b	75 d
Jackpot	DI	100	100	100	100	100 a	100 a	96 ab
Knight	DI	100	100	100	100	100 a	100 a	100 a
Podium	DI	100	100	100	100	100 a	100 a	100 a
Shogun	TH	100	100	100	100	100 a	100 a	100 a
Sukari	DI	100	100	100	100	100 a	100 a	100 a
Supreme Q	DI	100	100	100	100	100 a	100 a	88 c
Surge	DI	100	100	100	100	100 a	100 a	96 ab
Tabu +	DI	100	100	100	100	100 a	100 a	96 ab
Yolande	DI	100	100	100	100	100 a	100 a	100 a
LSD (0.05)		-	-	-	-	-	3.82	7.67
CV %		-	-	-	-	-	2.32	4.85

Note: treatments with the same letter are similar i.e. not significantly different.

Table 7 Italian and hybrid ryegrass (*Lolium multiflorum* & *L. hybridum*), Lm 10, Elite Evaluation, Outeniqua Research Farm
Planted: 4 March 2020 **Sward density** (%) (rating based) **Individual harvests** D = Diploid, T = Tetraploid, I = Italian, H = Hybrid

Cultivars	Type	Cut 8 17/12/2020	Cut 9 12/1/2021	Cut 10 * 10/2/2021	Cut 11 5/3/2021	Cut 12 7/4/2021	Cut 13 5/5/2021	Cut 14 7/6/2021
AgriBoost	DI	0	0	0	0	0	0	0
Barmultra II	TI	100 a	75 d	50 bcdef	54 abcde	79 abc	100 a	96 ab
Belluci	DI	100 a	100 a	83 a	88 a	96 a	100 a	100 a
Bond	DI	100 a	100 a	71 abc	67 abc	79 abc	96 ab	100 a
Davinci	DI	100 a	96 ab	71 abc	71 ab	87.5 abc	100 a	100 a
Elvis	TI	100 a	79 cd	33 efg	63 abc	79 abc	100 a	96 ab
Firkin	TI	100 a	83 bcd	33 efg	33 cde	71 cd	92 ab	96 ab
Fox	DI	100 a	96 ab	75 ab	79 ab	87.5 abc	100 a	100 a
Green Spirit	T Mix	100 a	75 d	54 abcdef	58 abcd	83 abc	100 a	100 a
Icon	DI	100 a	92 abc	58 abcde	58 abcd	83 abc	100 a	92 abc
Impact/Udine	TI	92 b	25 e	17 g	21 e	58 de	83 bc	83 cd
Jackpot	DI	100 a	79 cd	25 fg	50 bcde	50 e	67 d	79 d
Knight	DI	100 a	100 a	63 abcde	58 abcd	75 bcd	96 ab	88 bcd
Podium	DI	100 a	96 ab	67 abcd	62.5 abc	83 abc	100 a	96 ab
Shogun	TH	100 a	100 a	67 abcd	62.5 abc	83 abc	96 ab	92 abc
Sukari	DI	100 a	83 bcd	42 cdefg	33 cde	75 bcd	88 abc	92 abc
Supreme Q	DI	92 b	0	0	0	0	0	0
Surge	DI	100 a	96 ab	38 defg	25 de	46 e	75 cd	79 d
Tabu +	DI	100 a	79 cd	33 efg	63 abc	75 bcd	88 abc	92 abc
Yolande	DI	100 a	100 a	79 ab	79 ab	92 ab	100 a	96 ab
LSD (0.05)		6.06	12.7	32.3	35.9	20.7	15.3	11.9
CV %		3.69	9.3	36.6	37.4	16.3	9.86	7.72

Note: treatments with the same letter are similar i.e. not significantly different. * heat stress conditions the week before harvest

Table 8 Italian and hybrid ryegrass (*Lolium multiflorum* & *L. hybridum*), Lm 10, Elite Evaluation, Outeniqua Research Farm
Planted: 4 March 2020 **Reproductive tillers/bolting** (%) (rating based) D = Diploid, T = Tetraploid, I = Italian, H = Hybrid

Cultivars	Type	Cut 1 12/5/2020	Cut 2 12/6/2020	Cut 3 29/7/2020	Cut 4 8/9/2020	Cut 5 7/10/2020	Cut 6 2/11/2020	Cut 7 26/11/2020
AgriBoost	DI	0	0	0	25	83	83	88
Barmultra II	TI	0	0	0	21	79	83	63
Belluci	DI	0	0	0	0	17	29	13
Bond	DI	0	0	0	21	42	29	17
Davinci	DI	0	0	0	17	58	58	29
Elvis	TI	0	0	0	13	58	79	67
Firkin	TI	0	0	0	4	67	71	67
Fox	DI	0	0	0	21	71	42	29
Green Spirit	T Mix	0	0	0	8	46	88	63
Icon	DI	0	0	0	0	25	46	33
Impact/Udine	TI	0	0	29	88	88	88	67
Jackpot	DI	0	0	0	13	21	25	33
Knight	DI	0	0	0	21	42	33	38
Podium	DI	0	0	0	29	46	58	38
Shogun	TH	0	0	0	25	42	46	38
Sukari	DI	0	0	0	54	88	79	75
Supreme Q	DI	0	0	0	63	83	79	83
Surge	DI	0	0	0	0	13	21	13
Tabu +	DI	0	0	0	25	58	79	67
Yolande	DI	0	0	0	0	25	29	17

Table 8 Italian and hybrid ryegrass (*Lolium multiflorum* & *L. hybridum*), Lm 10, Elite Evaluation, Outeniqua Research Farm

Planted: 4 March 2020 **Reproductive tillers/bolting** (%) (rating based) D = Diploid, T = Tetraploid, I = Italian, H = Hybrid

Cultivars	Type	Cut 8 17/12/2020	Cut 9 12/1/2021	Cut 10 * 10/2/2021	Cut 11 5/3/2021	Cut 12 7/4/2021	Cut 13 5/5/2021	Cut 14 7/6/2021
AgriBoost	DI	-	-	-	-	-	-	-
Barmultra II	TI	67	42	4	0	0	0	0
Belluci	DI	13	0	0	0	0	0	0
Bond	DI	21	21	0	0	0	0	0
Davinci	DI	46	33	8	0	0	0	0
Elvis	TI	**75**	50	13	0	0	0	0
Firkin	TI	46	38	4	0	0	0	0
Fox	DI	52	25	0	0	0	0	0
Green Spirit	T Mix	58	42	0	0	0	0	0
Icon	DI	29	25	0	0	0	0	0
Impact/Udine	TI	**75**	**75**	8	0	0	0	0
Jackpot	DI	54	63	8	0	0	0	0
Knight	DI	33	38	0	0	0	0	0
Podium	DI	33	25	0	0	0	0	0
Shogun	TH	38	38	4	0	0	0	0
Sukari	DI	**83**	**79**	17	0	0	0	0
Supreme Q	DI	**83**	**100**	-	-	-	-	-
Surge	DI	13	13	0	0	0	0	0
Tabu +	DI	**75**	58	21	0	0	0	0
Yolande	DI	17	13	0	0	0	0	0

Table 9 Italian and hybrid ryegrass (*Lolium multiflorum* & *L. hybridum*), Lm 10, Elite Evaluation, Outeniqua Research Farm
Planted: 4 March 2020 **Plant counts** (%) (10-point x 4 method) D = Diploid, T = Tetraploid, I = Italian, H = Hybrid

Cultivars	Type	1st count Jul 2020 (%)	2nd count Apr 2021 (%)	% difference 2nd vs 1st	% reduction	Row Width cm
AgriBoost	DI	83	0	0	-100	
Barmultra II	TI	78	67	85	-15	5
Belluci	DI	79	77	97	-3	5
Bond	DI	80	68	85	-15	8
Davinci	DI	78	74	96	-4	8
Elvis	TI	67	61	91	-9	10
Firkin	TI	80	63	78	-22	7
Fox	DI	80	78	97	-3	7
Green Spirit	T Mix	78	63	82	-18	8
Icon	DI	86	67	78	-22	10
Impact/Udine	TI	83	39	48	-52	10
Jackpot	DI	77	54	71	-29	8
Knight	DI	86	59	69	-31	8
Podium	DI	79	68	85	-15	7
Shogun	TH	76	63	82	-18	5
Sukari	DI	84	68	81	-19	5
Supreme Q	DI	82	27	33	-67	5
Surge	DI	85	53	62	-38	8
Tabu +	DI	80	64	80	-20	8
Yolande	DI	75	70	93	-7	5

Table 10: Italian & hybrid ryegrass (*Lolium multiflorum, L. hybridum*), Lm 10, Elite Evaluation, Outeniqua Research Farm
Planted: 4 March 2020 **No. of days per leaf and projected harvest rotation based on 3-leaf stage**

	4 Mar 2020 To 12 May	12 May 2020 To 12 Jun	12 Jun 2020 To 29 Jul	29 Jul 2020 To 8 Aug	8 Aug 2020 To 7 Oct	7 Oct 2020 To 2 Nov	2 Nov 2020 To 26 Nov
No. of days/leaf	15	12	13	12	11.5	9.5	9
Projected time to 3-leaf	45	36	39	36	35	29	27
2.75-leaf Shortest cycle	41	33	36	33	32	26	25
	26 Nov 2020 To 17 Dec	**17 Dec 2020 To 12 Jan 2021**	**12 Jan 2021 To 10 Feb**	**10 Feb 2021 To 5 Mar**	**5 Mar 2021 To 7 Apr**	**7 Apr 2021 To 5 May**	**5 May 2021 To 7 Jun**
No. of days/leaf	10.5	9.5	10	8	8	8	10
Projected time to 3-leaf	32	29	30	24	24	24	30
2.75-leaf Shortest cycle	29	26	28	22	22	22	28

Leaf emergence rate

Leaf emergence rate depends on leaf growth rate since leaves emerge consecutively, one after the other once the previous leaf is fully extended. Growth rate is mainly dependent on temperature and soil moisture. If soil moisture is sufficient, then the growth rate is mainly a function of temperature. Defoliation or harvest at the 3-leaf stage is optimal for the plant (carbohydrate reserves, root and tiller growth) and optimal for production since the first leaf dies once the fourth leaf emerges and yield reaches a plateau after the third leaf. The plants can at the earliest be defoliated at the 2.75-leaf stage when necessary. In spring canopy closure should be used as primary criterion.

Summary

Total or annual yield

- Highest yielding cultivar: Belluci
- Cultivars similar to the highest yielding: Fox, Barmultra II, Bond, Shogun

Total yield over 15 months

- Highest yielding: Belluci
- Similar: Fox, Barmultra II

Winter yield

- Highest yielding cultivar: Impact (syn. Udine), Sukari
- Similar: Shogun, Jackpot, Knight, SupremeQ, Belluci, Bond, Tabu+, Barmultra II, Green Spirit, Fox.
- It is promising that 13 out of 20 cultivars did well during the winter months in this particular year and some were also the in the best group for summer yield.

Summer yield

- Highest yielding cultivars: Fox
- Similar yielding: Belluci, Shogun, Yolande, Bond
- Four of these cultivars are also in the best group of cultivars for winter yield.

Second autumn yield

- Highest yielding: Belluci
- Similar yielding: Yolande, Barmultra II, Davinci, Green Spirit.

Prolific flowering during summer with higher stem component for an extended period

- Impact, AgriBoost, SupremeQ, Sukari, Barmultra II, Tabu+

High yield and low flowering incidence

- E.g. Belluci, Yolande followed by Bond, Shogun

High yield and high sward density through summer

- E.g. Belluci, Fox, Yolande, Bond

Rust incidence: rust occurred throughout the duration of the trial with differences in cultivar susceptibility. Some cultivars had a higher incidence throughout while some had a very low incidence level indicated in Table 6.

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Forage herbs (Chicory and plantain) cultivar evaluation seasonal yield results for October 2018 to February 2021

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Introduction

The production potential of chicory (*Cichorium intybus*) and plantain (*Plantago lanceolata*) cultivars was assessed from a spring-planting in October 2018. Forage herbs are most productive in the warmers months of the year but the best cultivars yield equally well to ryegrass in the winter months. The advantage of chicory and plantain is this high productivity in spring, summer and going into autumn, which tend to be the more challenging months for temperate grasses. Additionally the criterion for suitable cultivars is that they are not winter dormant and should retain a good plant population for at least two years. The deep root system of both plantain and especially chicory is valuable in terms of accessing water and nutrients and providing carbon related to root growth into the deeper soil layers.

Both these species are commonly utilized in mixed pastures but can also be utilized in pure stands and then often alternately grazed with a grass pasture. Forage herbs are highly digestible, generally high in energy and should be used in combination with a high fibre concentrate, if concentrate is fed.

More detailed information about the species, basic management principles and the different types of cultivars is available in the 2017, 2018 and 2019 Outeniqua Information Day booklets.

The data reported on in this article is from the cultivar evaluation trial planted on the Outeniqua Research Farm on 10 October 2018 (Fh 5). The trial consists of 10 chicory and 5 plantain cultivars sown at 8 kg/ha. The first harvest was done after the cultivars had at least six fully extended leaves. Thereafter harvests were determined by sward height. Generally for plantain between 25 and 30 cm and chicory 30 to 35cm depending on the time of the year. Harvesting was done with a reciprocating mower at 5cm blade height with the entire net plot weighed and sampled.

Cultivars in the trial

- ***Chicory***: 501, Affila, Choice, Commander, Estero Quality, Forage Feast, Puna II, Spada
- ***Plantain***: Agritonic, Boston, Captain, Hercules, Tonic

Parameters reported in this article

- Total yield
- Seasonal yield
- Plant population counts

Total yield **(Table 1)** is important since the establishment and input costs are also similar regardless of yield, hence the importance of choosing the cultivars with the best yield. In mixed pastures that contain plantain it is also possible to make silage of surplus yield. Yield data of the previous cultivar evaluation trial (Fh1) are contained in the 2019 booklet.

Seasonal yield ***(Table 1)*** is important for fodder flow purposes and to choose the best cultivars for the seasons that are most challenging in terms of fodder flow needs. For chicory and plantain the yields in summer and autumn are valuable in relation to the yield challenges of ryegrass in summer and the over-sowing in autumn resulting in an extended grazing rotation on many paddocks on the farm.

Plant population counts ***(Figure 1)*** were done in January 2020, June 2020 and again January 2021. The counts show a significant decrease in population. For chicory this is mainly associated with plants that previously flowered and with plants that succumbed to Fusarium wilt. For plantain the plant population also decreased but was generally associated with an increase in plant size for the remaining plants resulting in the similar sward density especially for the winter-active cultivars. **Sward density** ratings are shown in **Figure 2**.

Summary comments

Comparing the annual yield of the first cultivar evaluation trial (Fh1), which was conducted from October 2016 to March 2019, with the annual yield of the second trial (Fh5), from October 2018 to February 2021, then we can generally conclude that the yields in year 2 were lower in the second trial than in the first trial. The winter yield is also very different in the two trials where, especially for plantain, the second winter of the Fh1 trial yielded higher than the first, whereas in Fh5 the second winter was significantly lower yielding than the first. This data deserves a closer look in terms of possible climatic effects.

Table 1: Forage herbs: *Plantago lanceolata, Cichorium intybus*, Fh 5, Evaluation Outeniqua Research Farm

Planted: 10 October 2018 **Seasonal Yield (t DM/ha)**

	Spring* 2018	Rank	Summer 2018/19	Rank	Autumn 2019	Rank	Winter 2019	Rank	Spring 2019	Rank	Summer 2019/20	Rank	Autumn 2020	Rank
Narrow-leaved plantain														
Agritonic	1.27	13	**8.70** abcd	4	**6.09** a	1	3.06 bc	3	**6.24** a	7	**6.62** a	1	**3.00 ab**	5
Boston	1.36	10	**9.19** a	1	4.03 c	14	0.15 e	15	**5.89** ab	12	**6.10** ab	4	1.48 cde	13
Captain	1.32	12	**9.07** ab	2	**6.04** a	4	**3.44** ab	2	**5.79** ab	13	**5.98** ab	7	**3.30 ab**	3
Hercules	1.74	8	**8.93** abc	3	3.97 c	15	0.16 e	14	**6.48** a	5	**6.10** ab	5	1.50 cde	12
Tonic	1.33	11	**8.48** abcde	6	**5.99** a	5	**3.55** a	1	**5.93** ab	11	**6.49** a	2	**3.77 a**	1
Forage chicory														
501	2.15	1	**8.25** abcde	8	**5.92** a	6	2.52 d	9	**6.59** a	1	**5.66** ab	12	2.51 bcd	11
Affila	2.10	2	**8.21** abcde	9	**5.83** a	8	2.61 cd	6	**6.49** a	4	**6.24** a	3	**2.98 ab**	6
Choice	1.87	5	8.00 bcde	11	**5.35** ab	12	2.22 d	12	5.21 b	14	4.88 bc	14	1.12 e	15
Commander (2016)	1.23	15	7.67 de	14	**5.63** ab	11	2.27 d	11	**6.03** ab	9	**5.54** abc	13	**2.72 ab**	9
Commander (2018)	1.77	6	**8.48** abcde	5	**6.07** a	2	2.49 d	10	**6.21** a	8	**5.85** ab	9	**3.09 ab**	4
Estero Quality	1.75	7	**8.23** abcde	7	**5.83** a	7	2.65 cd	4	**6.02** ab	10	**5.82** ab	10	**2.93 ab**	7
Forage Feast	1.24	14	7.42 e	15	4.91 b	13	0.41 e	13	2.59 c	15	4.45 c	15	1.45 de	14
Puna II	1.63	9	7.87 cde	12	**6.06** a	3	2.62 cd	5	**6.40** a	6	**5.87** ab	8	2.52 bc	10
Spada (2016)	1.91	4	**8.12** abcde	10	**5.73** a	9	2.59 cd	7	**6.56** a	2	**5.98** ab	6	**3.35 ab**	2
Spada (2018)	2.00	3	7.77 de	13	**5.68** a	10	2.57 cd	8	**6.56** a	3	**5.66** ab	11	**2.75 ab**	8
LSD (0.05)	NS		0.97		0.71		0.44		0.88		1.09		1.06	
CV %	39.6		6.94		7.65		11.9		8.84		11.2		24.8	

*includes establishment phase of 6 weeks

Shaded = highest yielding, **BOLD** = similar to highest. **Note: treatments with the same letter are similar i.e. not significantly different**

Table 1: Forage herbs: *Plantago lanceolata, Cichorium intybus*, Fh 5, Evaluation Outeniqua Research Farm

Planted: 10 October 2018 **Seasonal Yield (t DM/ha)**

	Winter 2020	Rank	Spring 2020	Rank	Summer 2020/21	Rank	Year 1* Dec 2018 - Nov 2019	Rank	Year 2 * Dec 2019 – Nov 2020	Rank	% De-crease	Total ** Oct 2018 – Feb 2021	Rank
Narrow-leaved plantain													
Agritonic	0.67 bc	9	**5.44 ab**	2	**3.53 ab**	2	**24.10 a**	2	**15.72 ab**	2	36	**44.62 ab**	2
Boston	0 d		3.29 c	13	**3.24 ab**	3	19.24 e	14	10.87 d	13	44	34.71 d	12
Captain	1.00 b	2	4.18 c	5	**2.73 ab**	4	**24.34 a**	1	14.45 bc	3	41	**42.85 abc**	3
Hercules	0 d		3.82 c	8	1.51 b	5	19.54 de	13	11.41 d	12	42	34.20 d	13
Tonic	**1.62 a**	1	**5.68 a**	1	**4.84 a**	1	**23.95 a**	3	**17.56 a**	1	27	**47.68 a**	1
Forage chicory													
501	0.53 c	11	3.70 c	10	0		**23.28 ab**	4	12.39 cd	11	47	37.81 cd	8
Affila	0.75 bc	5	3.76 c	9	0		**23.14 ab**	6	13.73 bcd	7	41	38.97 cd	5
Choice	0 d		0 e		0		20.77 cde	12	6.00 e	15	71	28.64 e	14
Commander (2016)	0.61 c	10	3.66 c	11	0		21.60 bcd	11	12.53 cd	10	42	35.37 d	11
Commander (2018)	0.77 bc	4	4.13 c	6	0		**23.25 ab**	5	13.84 bcd	6	40	38.85 cd	6
Estero Quality	0.71 bc	8	4.40 bc	3	0		**22.83 abc**	9	13.85 bcd	5	39	38.43 cd	7
Forage Feast	0 d		1.52 d	14	0		15.34 f	15	7.42 e	14	52	23.99 e	15
Puna II	0.77 bc	3	3.85 c	7	0		**22.96 abc**	8	13.0 bcd	8	43	37.59 cd	9
Spada (2016)	0.74 bc	7	4.32 bc	4	0		**22.98 abc**	7	14.40 bc	4	37	39.29 bcd	4
Spada (2018)	0.74 bc	6	3.65 c	12	0		**22.58 abc**	10	12.81 bcd	9	43	37.39 d	10
LSD (0.05)	0.33		1.22		2.16		2.13		2.97			5.34	
CV %	33.1		19.7		122.3		5.80		14.1			8.54	

*does not include the initial establishment phase of Oct/Nov 2018 ** includes the establishment phase (total trial duration = 29 months)

Shaded = highest yielding, **BOLD** = similar to highest. **Note: treatments with the same letter are similar i.e. not significantly different**

Figure 1: Forage herbs: *Plantago lanceolata, Cichorium intybus*, Fh 5, Evaluation Outeniqua Research Farm

Planted: 10 October 2018 **Plant population counts**

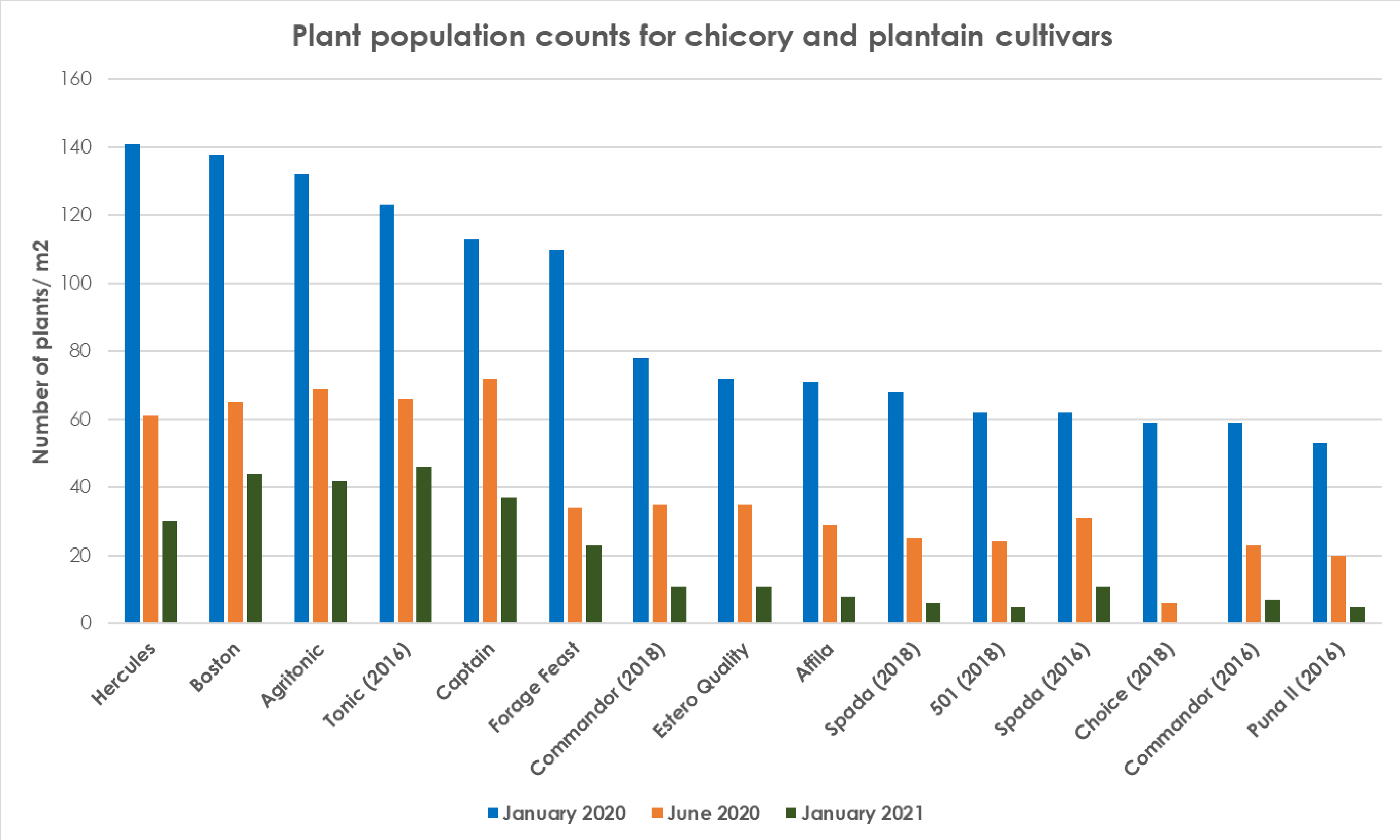
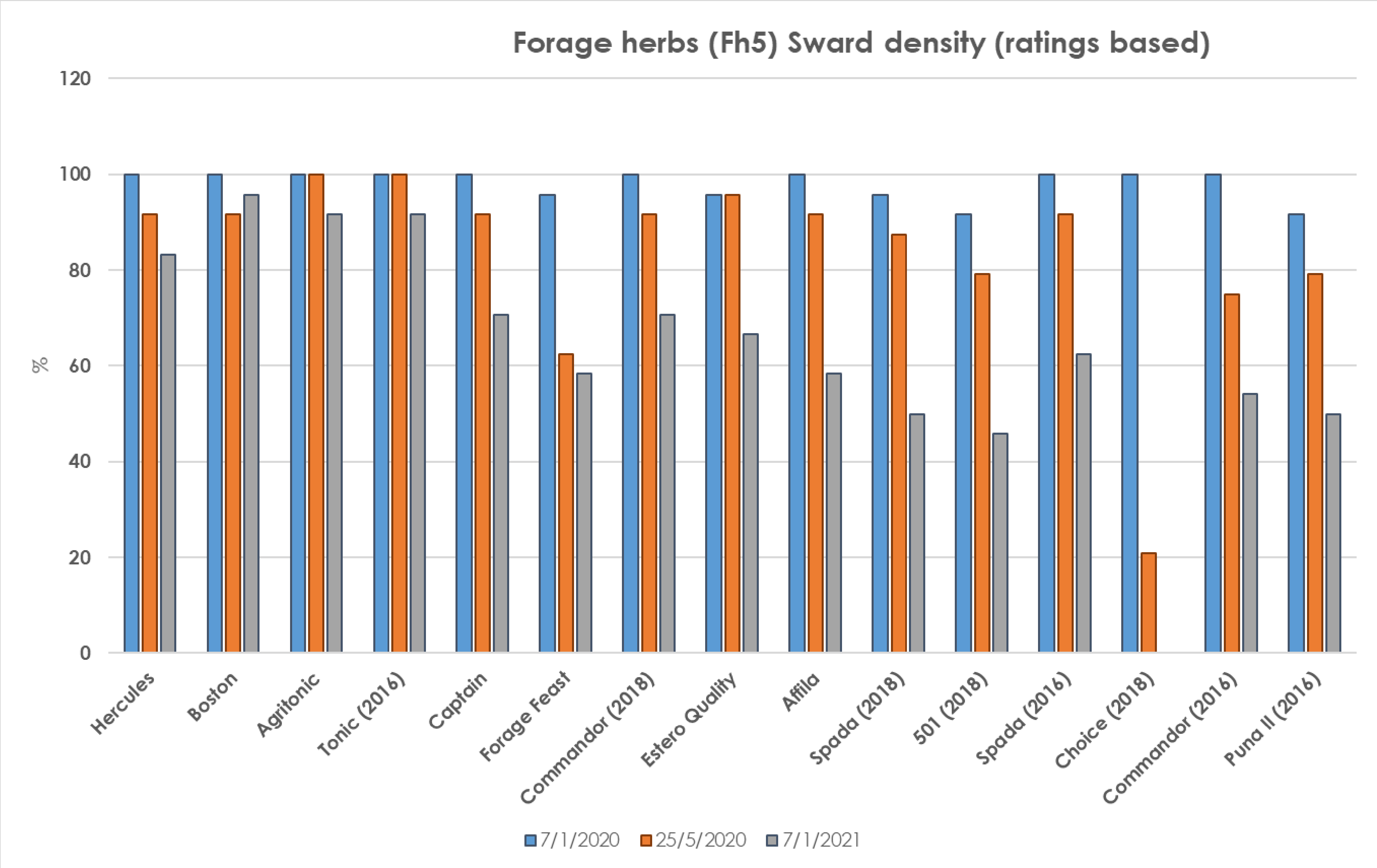
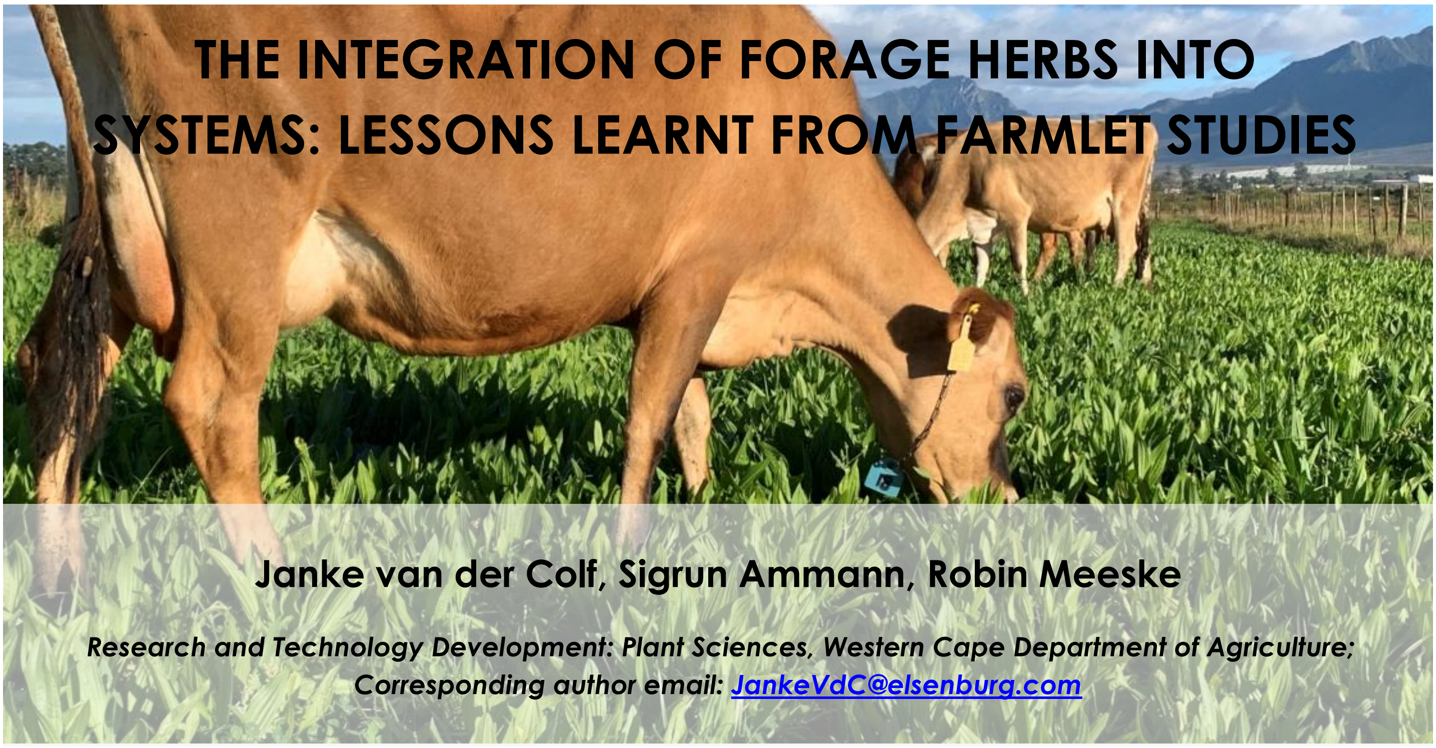


Figure 2: Forage herbs: *Plantago lanceolata, Cichorium intybus*, Fh 5, Evaluation Outeniqua Research Farm

Planted: 10 October 2018 **Sward density (ratings based) %**





THE INTEGRATION OF FORAGE HERBS INTO SYSTEMS: LESSONS LEARNT FROM FARMLET STUDIES

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Introduction

High stocking rates, poor persistence of pastures, an increase in weed ingression in no-till pastures and increasing input costs associated with irrigation and fertilisation, are putting a strain on the ability of pasture based dairy producers to maintain acceptable forage quality and pasture yields within their systems in the southern Cape. This in turn, threatens the continued sustainability of these systems. Research should thus focus on strategies that can improve the resilience and efficiency of pasture systems.

The inclusion of forage herbs, such as Plantain, into pastures, has been reported to hold various potential advantages for pasture based producers including (Moorhead and Piggot 2009, Cave et al. 2013, Totty et al. 2013, Woodward et al. 2013, Lee et al. 2015, Cheng et al. 2015, Box et al. 2016; Minee et al. 2017):

- an improvement or maintenance of milk yield compared to ryegrass during adverse climatic conditions,
- higher kg milk solids production per animal,
- lowered rates of N leaching,
- improved dry matter intake in animals,
- higher forage quality compared to perennial ryegrass-clover pastures,
- higher summer/autumn production than temperate grasses,
- a lower decline in plant population over years compared to ryegrass
- improved resilience to periods of drought.

In terms of an alternative grass component within dairy systems, Tall Fescue has been noted to be a potential species that can be included due to its improved drought tolerance, the resultant ability to more effectively utilise soil water and rainfall due to their deep root systems (Van Eekeren et al. 2010) and improved persistance over years (Lowe and Bowdler 1995, Nie et al. 2004).

However, before systems can be adapted for the inclusion of these alternative pasture species, the following needs to be evaluated and determined relative to current systems:

- The milk yield, pasture yield and forage quality should either be similar or higher than the accepted norm for current pasture systems.
- The effect that alternative species and mixtures will have on the seasonal distribution of dry matter production and the resultant impact on feed budgets, particularly as it relates to the need to buy in feed, needs to be determined.
- The potential of alternative species and pastures to be persistent and maintain yield over years needs to be evaluated.
- The rate of deterioration in pasture composition, indirectly associated with

persistence, but also related to the rate of weed ingression, over years needs to be characterised.

- The efficiency with which resources can be utilised by the pasture species and systems, particularly as it relates to water utilisation, nitrogen utilisation and feed conversion ratio should be quantified.
- The appropriate rate of inclusion of alternative pasture species and systems on a farm scale to ensure adequate returns needs to be determined. This includes an evaluation of whether monocultures, mixtures or both should be included in systems.

The aim of this study is thus to determine the whole system production potential and efficiency of three pasture systems based on the current system (Kikuyu -ryegrass), monocultures of alternative species (Tall fescue and plantain) and a pasture mixture that includes alternative species (Tall fescue, plantain and red clover). This paper will focus on the preliminary data collected during year one of the planned three year study, with data primarily presented in the form of index values for comparison purposes.

Site description

The study is being carried out on the Outeniqua Research Farm (altitude 210 m, 33°58'38" S and 22° 25'16"E) in the Western Cape Province of South Africa. The mean annual rainfall (30 year average) in this area is 725 mm, with mean minimum and maximum temperatures ranging between 7-15°C and 18-25°C respectively (ARC 2010).

Treatments, site selection and layout

The project is evaluating four pasture systems based on different pasture species and types. The first system, which will be referred to as "Unimproved" (UI), is based on kikuyu-ryegrass pasture, and is aimed at representing a typical long term no-till pasture in the region. The second system, or "Monoculture" (MC), consists of two separate areas, one planted to a monoculture of plantain (*Plantago lanceolata*) and the other to Tall Fescue (*Festuca arundinacea*). The third system is based on a diverse pasture mixture (DPM) consisting of Tall Fescue, plantain and red clover. The fourth system, which was added in year 2, is also based on a mixture, but consists of Lucerne, chicory, plantain and ryegrass. It will be referred to the complex pasture mixture (CPM).

The trial is being conducted in the form of a full farmlet study over a three year period. The premise behind a farmlet study is to apply systems to a large enough area and in such a manner that it resembles a practical farming unit (Murrison and Scott 2013). This presents a particular challenge when planning and implementing such a study, as the possibility of replication is largely constrained by the availability of both physical and financial resources. As such, the planned project will be based on the principles described by Scott et al. (2013a) for allocating areas to an un-replicated farmlet study, with sub-sampling implemented to over-come problems of estimating experimental error (Grima and Machodo 2013).

The area identified for the project has a negligible gradient in slope and as such, the primary criteria utilised to identify the research site(s) was soil type based on a soil survey map of Outeniqua Research Farm (Measured Agriculture, Greyton). Each farmlet is approximately 5 ha in size, with 60% allocated to a Katspruit soil type and the remaining to a Witfontein soil type.

To facilitate sub-sampling on each system, grazing strips (average size of 0.18 ha) within the respective paddocks were utilised as measurement units. A varying degree of sampling intensity was applied to strips based on the parameters being measured. For highly intensive measurements (for example botanical composition determination or weekly pasture measurement), paddocks were divided into approximate half hectare (0.50 ha) "blocks", each consisting of three pasture strips, with the centre strip functioning as a monitor strip for sampling purposes. For less intensive sampling (for example daily pasture allocation), sampling occurred on a grazing strip basis.

Pasture establishment

The plantain pasture was established in October 2018. Two applications of a non-selective contact herbicide (200 g/L Glufosinate ammonium applied at 6L ha^{-1}) were used to spray off the existing pasture approximately a month before establishment. The remaining residue was then mulched to ground level (1.6 meter Nobili with 24 blades) and the plantain planted utilising a modified Aitchison no-till seeder with press wheels.

The other pastures were established during March 2019. The area earmarked for the establishment of

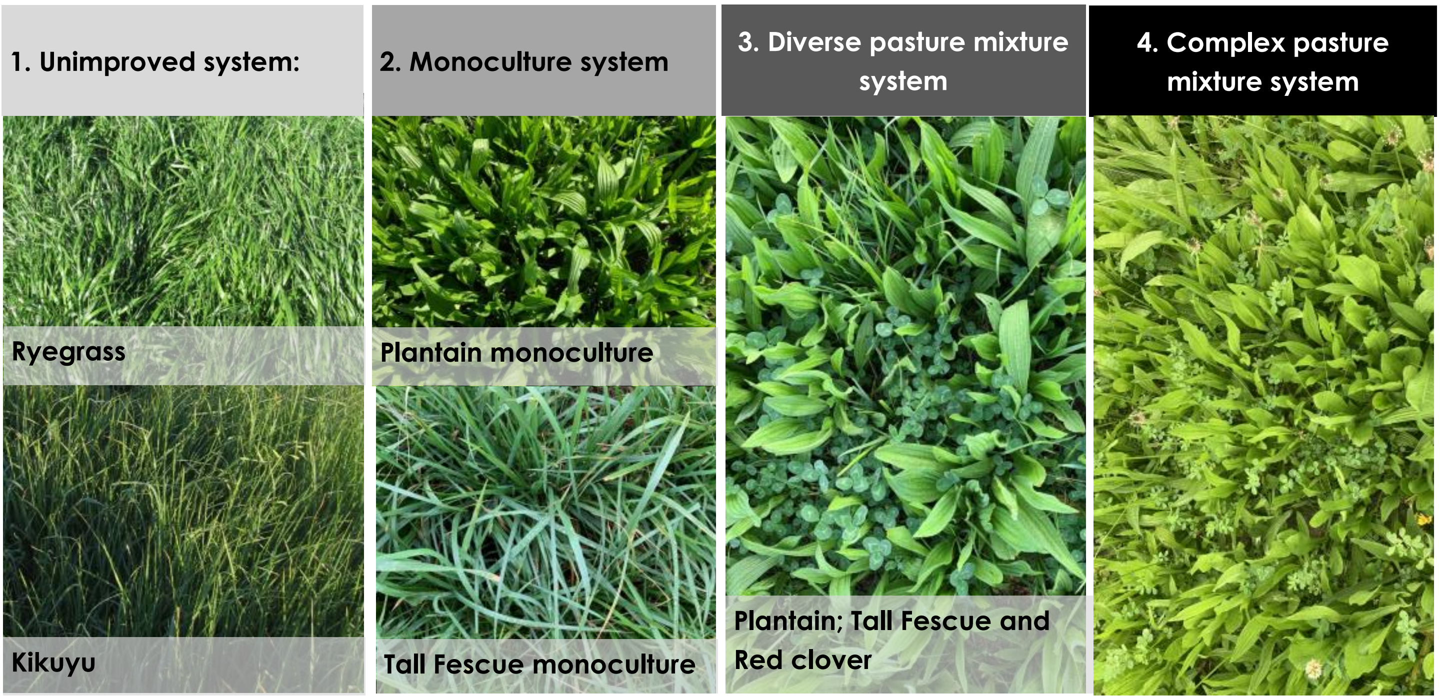
Table 1. Species, varieties and seeding rates for pastures during the study

System	Abbreviation	Species	Scientific name	Variety*	Seeding rate (kg ha^{-1})
Unimproved	**UI**	Kikuyu	*Pennisetum clandestinum*	Existing sward	-
		Perennial ryegrass	*Lolium perenne*	24Seven	25
Monoculture	**MC**	Tall Fescue	*Festuca arundinacea*	Easton	25
		Plantain	*Plantago lanceolata*	Tonic	8
Diverse pasture mixture	**DPM**	Tall fescue	*Festuca arundinacea*	Easton	20
		Plantain	*Plantago lanceolata*	Tonic	3
		Red clover	*Trifolium pratense*	Oregon red	3
Complex pasture mixture	**CPM**	Lucerne	Medicago sativa	WL414	6
		Chicory	Cichorium intybus	Commandor	2
		Plantain	Plantago lanceolata	Agritonic	3
		Hybrid ryegrass	Lolium	Shogun	25

Tall Fescue and the diverse pasture mixture was sprayed off with a non-selective contact herbicide (200 g/L Glufosinate ammonium applied at 6L ha^{-1}) during February 2019. Approximately 2 weeks after herbicide application, the remaining residue was mulched to ground level to facilitate breakdown and allow weed germination. A week prior to establishment, a follow up application of a non-selective contact herbicide (200g/L Paraquat at 4L ha^{-1}) was undertaken, with remaining residue mulched to ground level just prior to establishment. The mono-culture Tall Fescue, which initially made up 80% of the monoculture system area, was established using a standard planting method with a modified Aitchison no-till seeder with press wheels.

In the autumn of 2019, a further 20% of the monoculture area was converted to plantain by spraying of the Tall Fescue (200 g/L Glufosinate ammonium applied at 6L ha^{-1}) in January, a second time in February and then planting in March.

In order to facilitate the shallow planting depth required for the small seeded plantain and clover, this mixture site was "cross-planted". This entailed



planting the Tall Fescue parallel to the length of grazing strips (i.e. from front to back), followed by the plantain/red clover mixture perpendicular to this (right to left).

The perennial ryegrass on the kikuyu-ryegrass site was established by grazing the area down to a height of 50 mm, mulching the remaining stubble to ground level and planting the perennial ryegrass with a modified Aitchison no-till seeder with press wheels.

The kikuyu-ryegrass pasture was over-sown on an annual basis (2019 and 2020) as is common practice in the region, motivated by the poor persistence and resultant decline in yield of ryegrass that occurs from year 1 to year 2, even in pure swards under cutting (van der Colf et al. 2016). In addition, during the summer of year 1 (January 2020), 20% of the kikuyu-ryegrass platform was identified as severely degraded due to the ingression of *E. plana*. This area was sprayed of and planted to perennial ryegrass in March.

The fescue, plantain and mixture pastures were not over-sown during the autumn of year 1, as composition in terms of sown species was deemed to be acceptable. However, a decision was made to increase the plantain component within the monoculture system to 50% of the system area for year 2. The earmarked area was thus sprayed off and plantain planted using no-till methods in March 2019.

The complex pasture mixture was established in autumn of 2020. Establishment methods was similar to that of the DPM, with planting taking place from mid-April 2020.

Trial animals

Each system was allocated its own "mini-herd" of animals, selected to maintain days in milk (DIM) at approximately 150 and provide a constant flow of animals into and out of the system. Milk yield and milk composition form the previous lactation were used to block animals. Each system was allocated 24 animals in milk and 6 dry animals (25% of herd). As animals in the "milk herd" are dried off, they will be replaced by animals from the systems' "dry herd" as they calve. This may result in periods when the pasture area for each system is stocked below or above the 24 animals/system.

Pasture parameters

Pasture yield (kg DM ha-1)

Dry matter production of the pasture treatments was estimated using the rising plate meter (Stockdale 1984, Fulkerson 1997). Calibration equations were developed for each pasture type by cutting samples on monitor strips as per (t'Mannetjie 2000) to a height of 50 mm. Linear and curvilinear relationships between herbage mass and pasture height were determined and best fit equations used to calculate available herbage mass from pre-grazing height readings per grazing strip.

The estimated pre-grazing yield will also be used for pasture allocation purposes (see section on "Pasture allocation and conservation").

Botanical composition (%)

Botanical composition was estimated by placing three 0.098 m2 rings randomly within a sub-plot on

Table 2. Components into which botanical composition samples will be fractioned

System	Sown components	Volunteer/weed grasses	Broadleaf weeds	Volunteer legumes
UI	Kikuyu Ryegrass	*Paspalum urvillei** *Eragrostis plana** *Sporobolus africanus** *Bromus catharticus** *Poa pratensis** Other*	All	All
DPM	Tall Fescue Plantain Red clover	Same as above* (UI) Ryegrass	All	White clover Trefoil
CPM	Lucerne Plantain Chicory Ryegrass	Same as above* (UI)	All	White clover Trefoil
MC	Plantain site	Same as above* (UI) Ryegrass	All	White clover Trefoil
	Fescue site	Same as above* (UI) Ryegrass	All	All

monitor strips before grazing/cutting and cutting samples to a height of 50 mm above ground during each grazing cycle. The three samples were pooled, thoroughly mixed; a grab sample of approximately 500 g taken and then separated into the relevant fractions for each pasture type as described in Table 2.

Animal parameters

Cows were milked twice daily at, 07:00 and 15:00, utilising a 20 Point Waikato/Afikim swing over milking machine with electronic meters. The machine is fully automated with weigh-all electronic milk meters that will allow daily milk production of each individual cow to be measured.

Milk composition was determined on an approximately monthly basis from a 24 mL composite morning and afternoon milk sample of 16 mL and 8 mL, respectively. Samples will be analysed for butterfat (BF), lactose and milk urea nitrogen (MUN) content (Milkoscan FT 6000 analyzer; Foss Electric, Denmark) by Merieux Nutriscience Pty (Ltd) (Stellenryk Building, Constantia Square Office Park, 526 16th Street, Randjespark, Midrand, 1685). In addition, daily milk composition in terms of milk protein, lactose and fat will be available as determined by the Afimilk milking system.

Pasture and grazing management

Pasture allocation

Each system was managed as a self-sustaining, closed system, with pasture allocated to each group following the morning and afternoon milking according to available pasture biomass (kg DM ha^{-1}). Pasture biomass available above 50 mm was determined per sub-plot from RPM readings and calibrations determined during the study for each sward type. Pasture was allocated at a rate of 10 kg DM cow^{-1} day^{-1} (approximately 2% of body weight), with a fresh piece of pasture provided at a rate of 5 kg DM cow^{-1} after each milking. On the MC system, animals will be allocated plantain according to the proportional availability of the pasture within a period, with the rest of the intake allocated to Tall Fescue. Cows receive 2 kg of dairy concentrate at each milking, equating to a total of 4kg cow^{-1} day^{-1}.

Weekly farm walks and fodder flow management

In order to facilitate ease of management of fodder flow within the respective systems, pasture will be measured on a weekly basis for the entire study site. For this purpose, grazing strips were allocated to 0.5 ha monitoring blocks on which average leaf number and pasture height will be determined using a RPM. Based dry matter yield on a farmlet scale and the estimated pasture requirement for animals, it was determined whether pasture availability on the pasture platform was in excess of animal requirements (surplus) or lower than requirements (shortfall). The following strategies were followed under these circumstances:

- ***Shortfall in winter of year 1:*** Animals will be supplemented with bought in feed in the form of lucerne hay.
- ***Shortfall in year 2 and 3:*** Grass silage from system fed to cow groups in isolation. Any shortfall beyond silage will be met by Lucerne.
- ***Surplus:*** Area will be cut to make wrapped grass silage. Plantain will not be cut for silage, with allocation rate (% of intake) adjusted upwards as yield increases.

The data collected on the above parameters (silage made, bales fed and feed bought in) will allow for the determination of fodderflow dynamics within the tree systems.

Fertilisation

Corrective fertilisation application for the entire project site will be based on annual soil sample analysis results for the 0-100 mm soil depth and the recommend soil nutrient levels as per Beyers (1973).

Based on literature studies and experiences from current small plot cutting trials on Outeniqua with pure forage herb and grass/herb swards, nitrogen was applied at 30 kg N/ha after each grazing.

Results and Discussion

Pasture yield

The total seasonal pasture yield during year 1 and year 2 of the pasture systems is shown in Table 3. Due to the lack of replication of farmlets, data cannot be statistically compared. However, the data does show that the DPM had the highest pasture yield during year 1, likely due to it also achieving the highest seasonal pasture yield from winter to summer. The highest total annual yield during year 2 was for the KIK-RYE system, driven by high summer and autumn yields. Consideration should, however, be given to the trend of forage quality decline often observed in kikuyu pastures during late summer and autumn. This could thus offset the advantages of high pasture yields in terms of milk production.

Grazing capacity

The mean monthly grazing capacity of the four systems during year 1 and year 2 are shown in Figure 1 and Figure 2, respectively.

Grazing capacity showed strong seasonal trends. In terms of winter grazing capacity during year 1, all systems had a relatively low, but similar grazing capacity. However, from mid-spring to early summer, the DPM system had a higher grazing capacity than the other systems. The KIK-RYE system had a higher grazing capacity from the middle of summer to autumn in year 1.

During year 2, the grazing capacity of the KIK-RYE

Table 3. Total seasonal and annual pasture yield (kg DM/ha) for different pasture systems

Season		Winter	Spring	Summer	Autumn	Annual
Year 1	MC	3984	4367	3434	2837	**14622**
	DPM	4017*	5435*	4340*	3140	**16932**
	CPM					
	KIK_RYE	3070	4003	3695	3846*	**14207**
Year 2	MC	2519	3535	3718	3451	**13224**
	DPM	2849	3883	4253	3080	**14064**
	CPM	2434	6851	4138	3997	**17420**
	KIK_RYE	2967	4470	6393	4641	**18470**

MC: Monoculture (Fescue + Plantain) **DPM:** Diverse pasture mixture (Fescue/plantain/red clover) **CPM:** Complex pasture mixture (Lucerne/plantain/chicory/ryegrass)

Table 4. Total seasonal and annual milk yield per ha (kg milk/ha) for different pasture systems

Season		Winter	Spring	Summer	Autumn	Annual
Year 1	MC	3204	7621	6904	3472	**21201**
	DPM	2462	8182	7992	4459	**23095**
	CPM					
	KIK_RYE	3050	6820	7058	4079	**21007**
Year 2	MC	3089	6461	5331	3477	**18358**
	DPM	3447	7489	7684	4687	**23307**
	CPM	2247	7816	6699	5301	**22064**
	KIK_RYE	3309	8538	9905	4862	**26613**

MC: Monoculture (Fescue + Plantain) **DPM:** Diverse pasture mixture (Fescue/plantain/red clover) **CPM:** Complex pasture mixture (Lucerne/plantain/chicory/ryegrass)

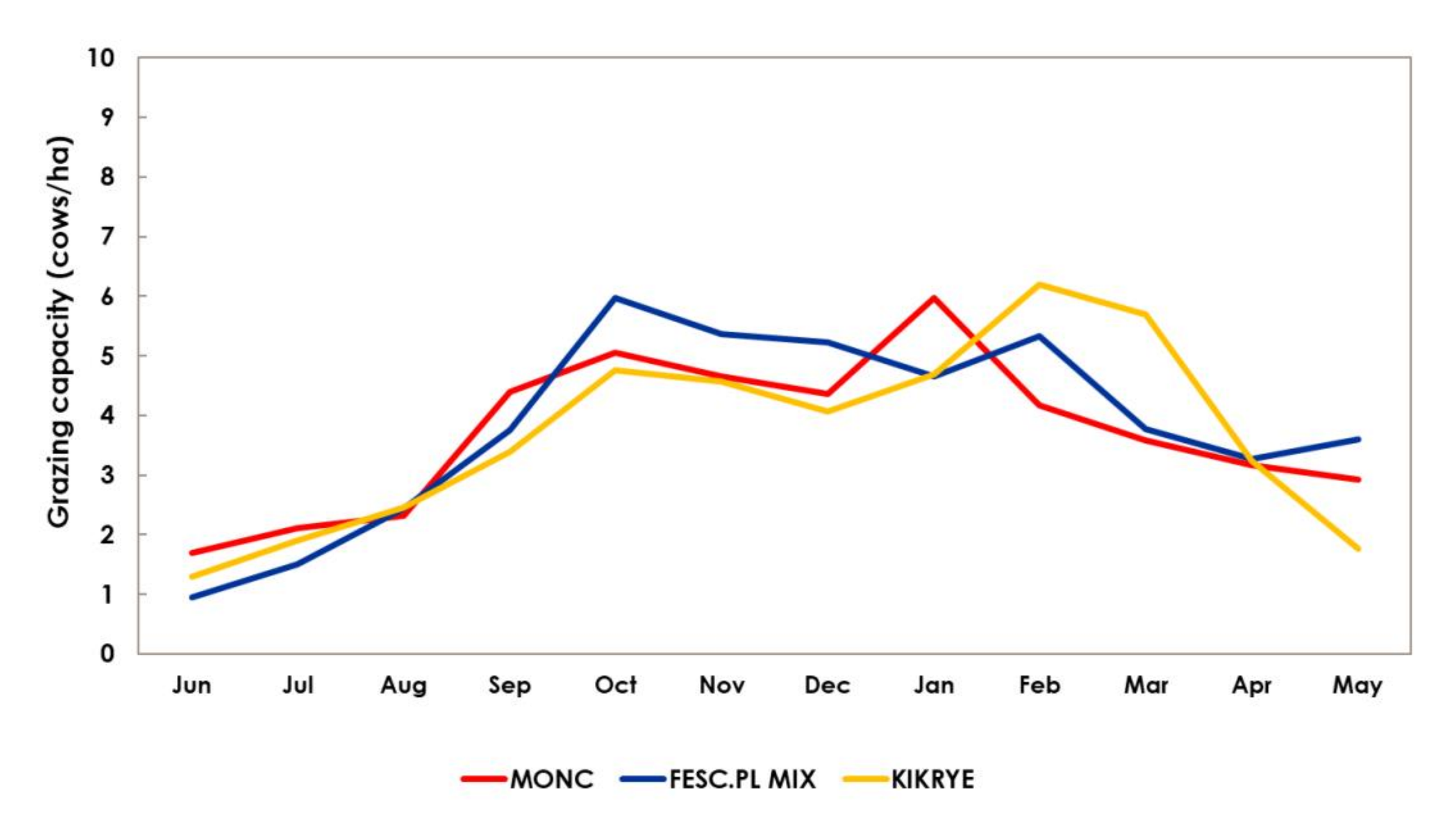


Figure 1. Monthly grazing capacity of the diverse pasture mixture, monoculture, kikuyu-ryegrass s and complex pasture mixture systems during year 1

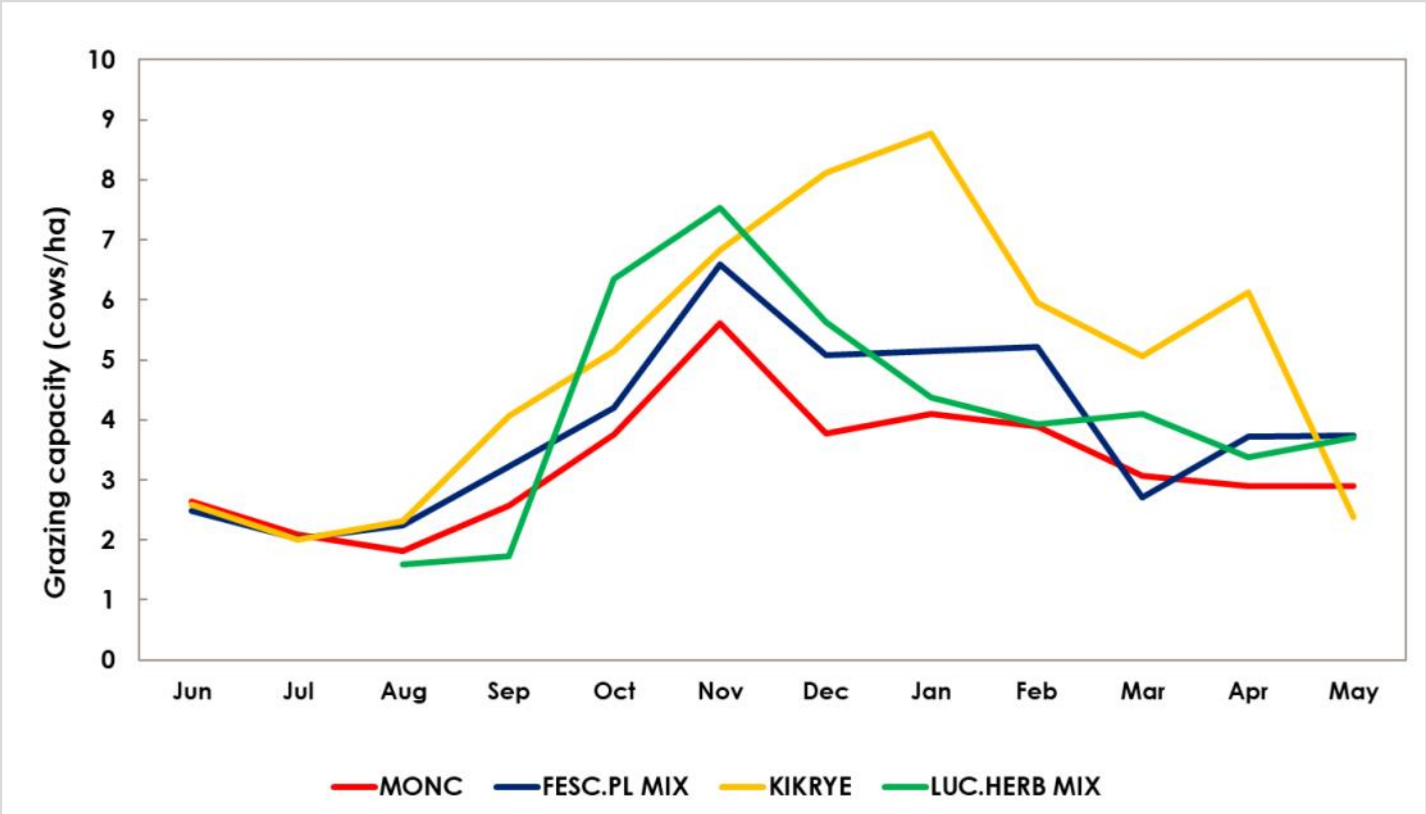


Figure 2. Monthly grazing capacity of the diverse pasture mixture, monoculture, kikuyu-ryegrass s and complex pasture mixture systems during year 2

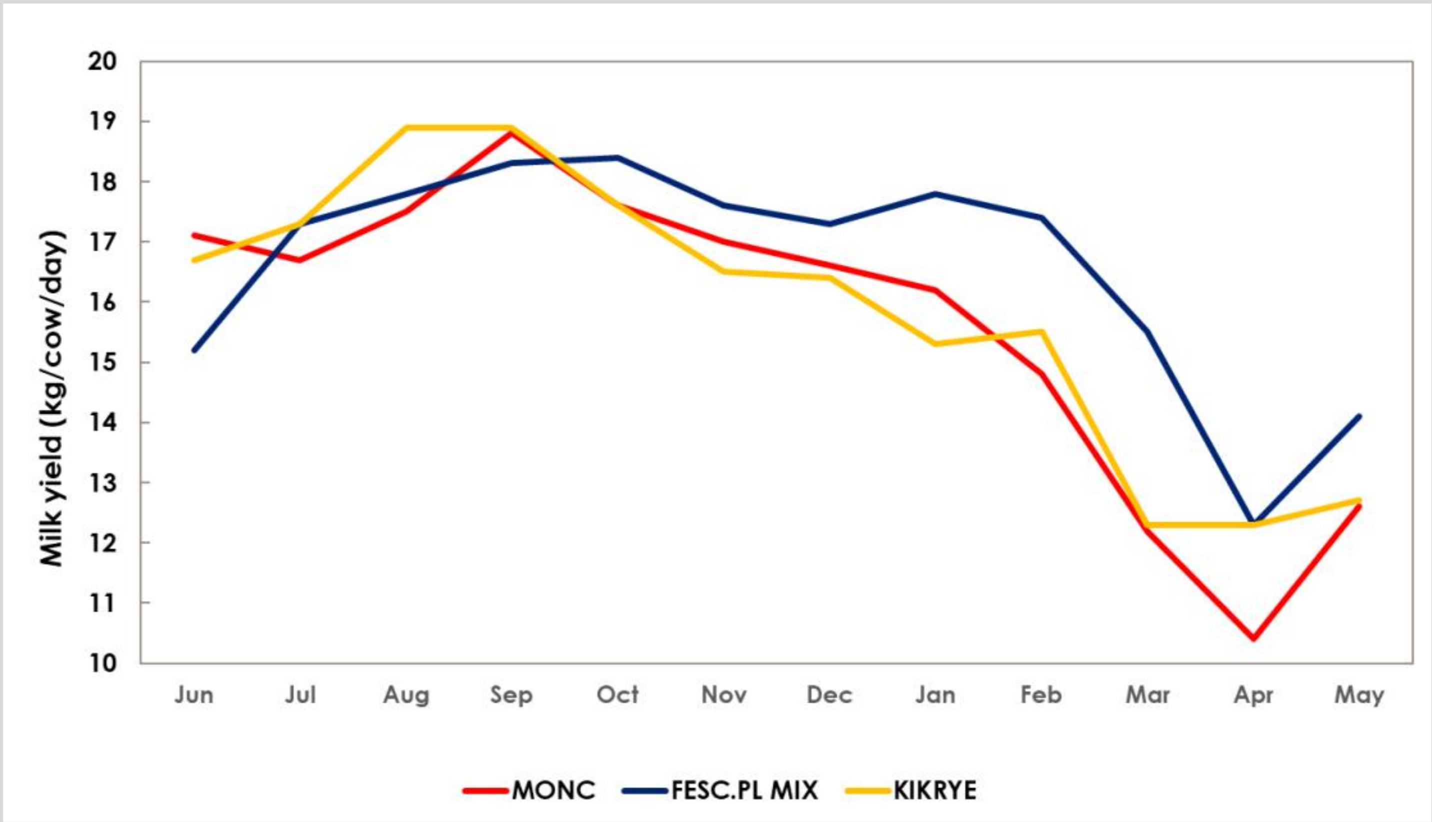


Figure 3. Monthly milk yield per cow (kg/cow/day) of the mixture, monoculture and kikuyu-ryegrass systems during year 1

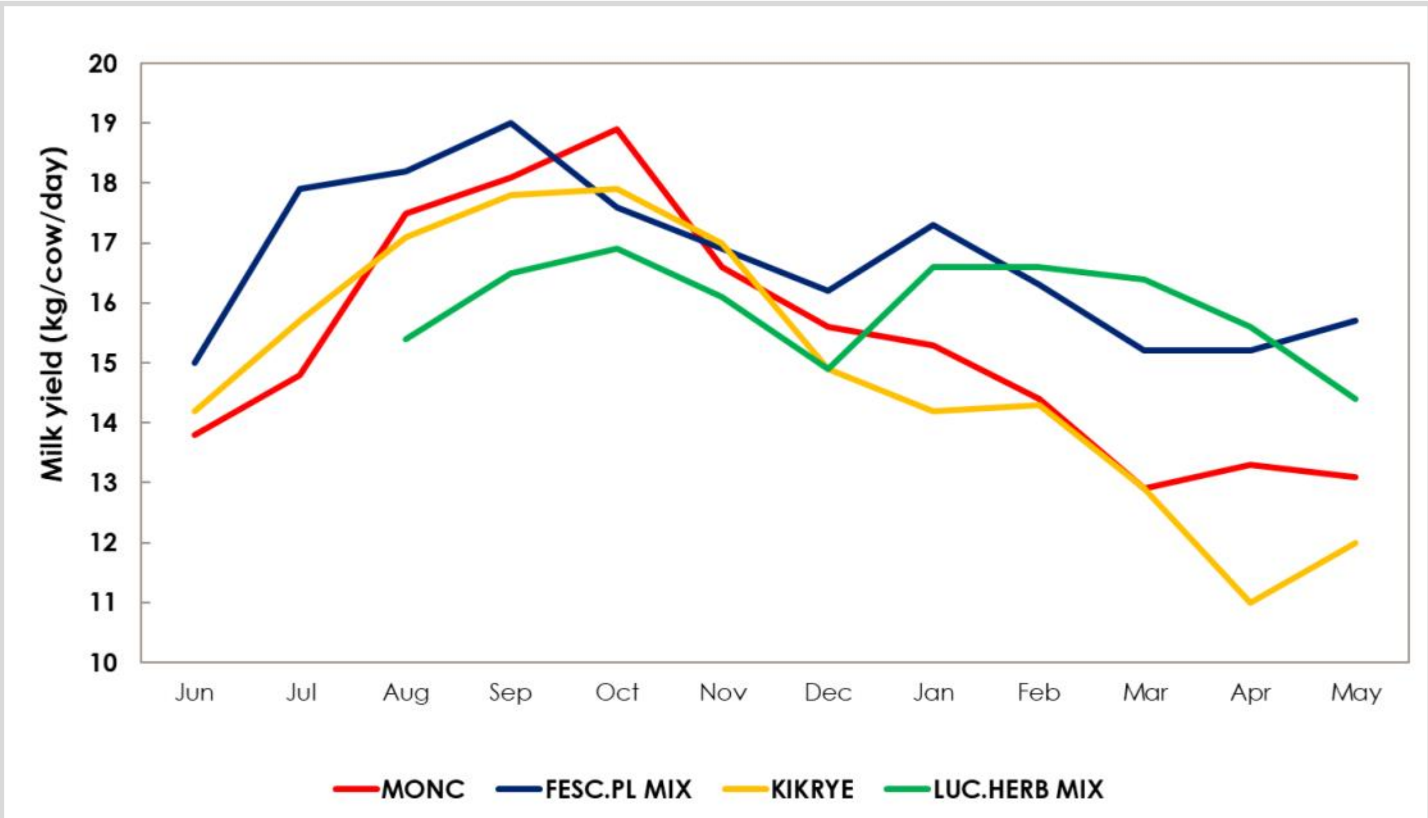


Figure 4. Monthly milk yield per cow (kg/cow/day) of the diverse mixture, monoculture, kikuyu-ryegrass and complex pasture mix systems during year 2

system was higher than the other systems from spring through to autumn. This data clearly shows that grazing capacity can be highly variable over seasons and years, driven by variable growth rates,. In turn, growth rates may not only be system dependant, but also driven by climatic and management factors.

Milk yield

The mean milk yield per cow (kg/cow/day) for the pasture systems during year 1 and year 2 is shown in Figure 3 and 4, respectively.

During year 1, the milk yield per cow was higher for the cows grazing the DPM system from October to May. During year 2, the highest yielding system was more varied over months, but both the DPM and CPM had a higher milk yield per cow from January to May than the KIK-RYE and MC systems. Thus, it appears that the inclusion of a legume and forage herb in a pasture mixture could improve milk yield per cow during summer and autumn compared to kikuyu-ryegrass pastures.

The total seasonal and annual milk yield of the pasture systems is shown in Table 4. As expected, milk yield per ha during the first two years, was driven strongly by pasture yield, and in turn by grazing capacity. As result, the highest annual milk yield per ha was for the DPM system in year 1 and the KIK-RYE system in year 2.

Farm simulation

The challenge with the data presented up to this point, such as milk yield per ha, is that it does not take into consideration that farms are often stocked at a constant rate. As such it neglects to show how a system may impact:

- pasture and milk yield at a average grazing capacity for the system (i.e. fixed stocking rate)
- Fodder-flow dynamics
- Efficiency parameters related to concentrate (g concentrate/kg milk) and nitrogen (kg DM/ kg N) utilisation, which in turn is affected by average grazing capacity of the system over a year

On this premise, a farm simulation was done to determine farm productivity for the three systems.

Assumptions for the simulation analysis were:

- Each farm was 300 ha in size (dairy platform)
- The whole farm was planted to the same system
- Farms would be stocked at the average annual grazing capacity determined over the two years of the farmlet study (Table 4)
- Animals would receive a constant rate of concentrate of 4 kg concentrate/cow/day
- throughout the year Pastures would be fertilised at 33 kg N/ha after each grazing

In addition, to determine whether a combination of systems, rather than just one system applied across the entire farm, could improve whole farm productivity, a fourth "farm", referred to as "COMBINED" was analysed. This farm was divided into three, and a 1/3 of the farm allocated to each of the systems.

Figure 5 shows ow the data from the farmlet study was used to to calculate the parameters for the farm simulation.

The results from this analysis is shown in Table 5. As can be seen, different systems performed well for

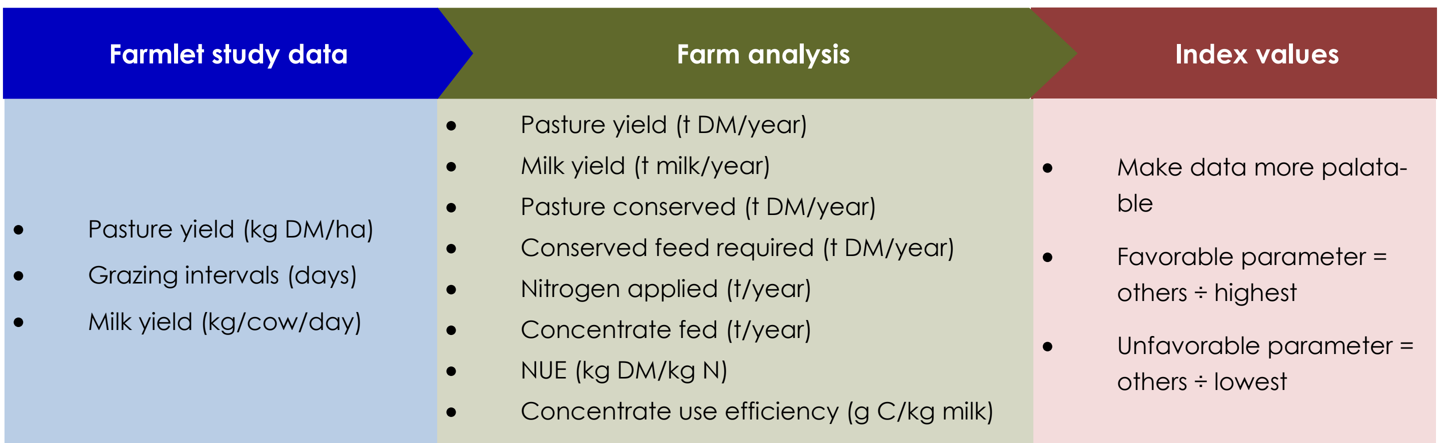


Figure 4. Methodology used to do whole farm analysis and construct index values

Table 4. Whole farm simulation based on farmlet study data for three pasture systems on a 300 ha farm

	Parameter	Units	MONOC	FESC.PL MIX	KIK.RYE	COMBINED
	Grazing capacity	**Cows/ha**	3.58	3.84	4.93	3.90
	Milk cows in herd		1074	1152	1318	1171
	Concentrate/cow/day	**kg/cow/day**	4	4	4	4
	Nitrogen after grazing	**kg/ha**	33	33	33	33
Year 1	**Pasture yield**	t /year	3558	**3639**	3156	3451
	Milk yield	t/year	6128	6974	**7632**	6844
	Conserved feed req.	t/year	**528**	640	1408	878
	Pasture Conserved	t/year	**677**	574	172	486
	Nitrogen applied	t/year	91	**87**	**87**	88
	Concentrate fed	t/year	**1568**	1683	1924	1708
	NUE	kg DM/kg N	39	**42**	36	39
	CUE	g C/kg milk	256	**241**	252	250
Year 2	**Pasture yield**	t /year	**4668**	3715	4227	4203
	Milk yield	t/year	6023	7028	**7168**	6687
	Conserved feed req.	t/year	**272**	456	854	590
	Pasture Conserved	t/year	767	544	**1022**	798
	Nitrogen applied	t/year	98	105	**90**	97
	Concentrate fed	t/year	**1568**	1683	1924	1708
	NUE	kg DM/kg N	**48**	35	47	43
	CUE	g C/kg milk	260	**239**	268	255

NUE: Nitrogen use efficiency **CUE: Concentrate use efficiency** **SHADED = MOST FAVOURABLE VALUE**

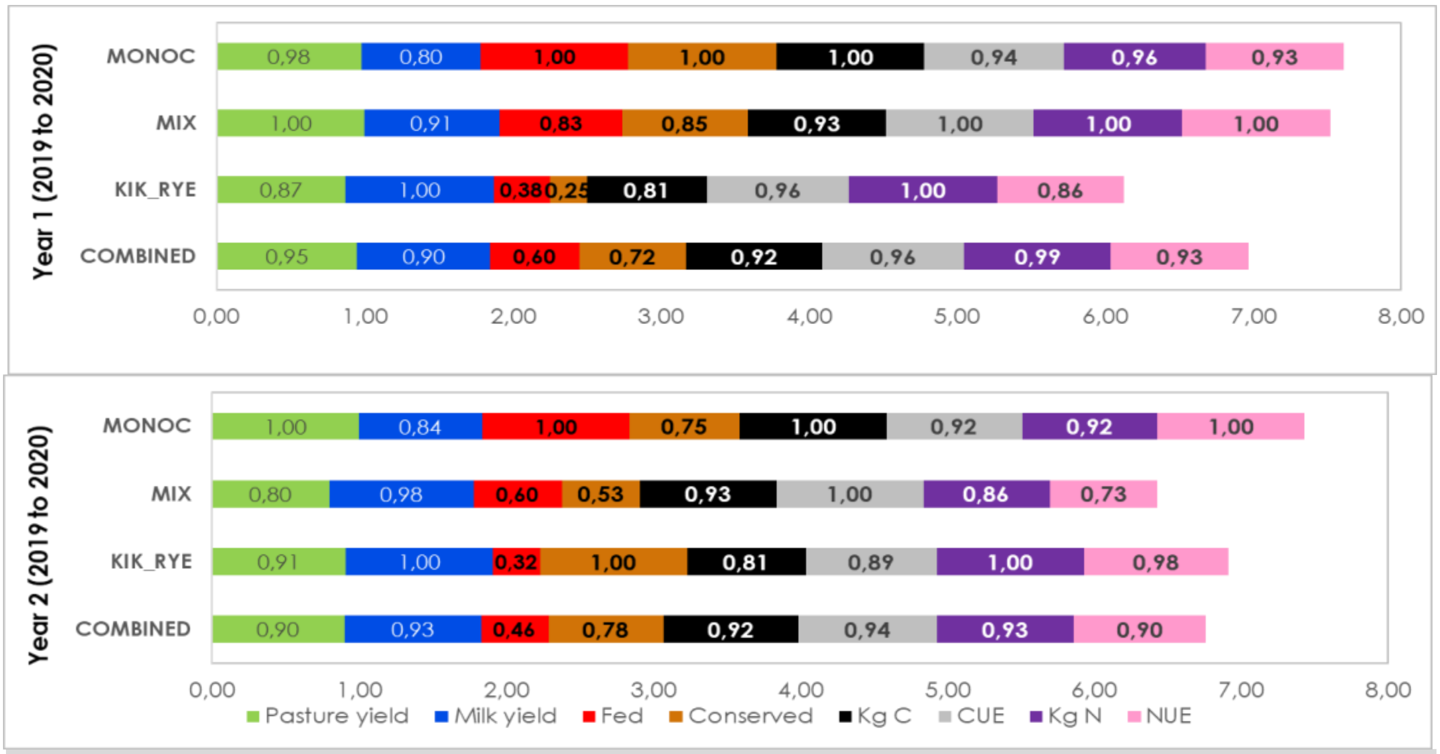


Table 4. Index values for whole farm simulation based on farmlet study data for three pasture systems on a 300 ha farm

different parameters and it becomes difficult to determine which would do well overall. In order to simplify the analysis further, the data was normalised to draw up index values. When interpreting index values, the following should be kept in mind:

- Index values do not have units, and function solely to compare parameters relative to each other
- For this paper, a higher index value indicates a more favourable performance for a specific parameter

During year one, the total index value (individual values summed) of the monoculture and diverse pasture mixture farm was the highest. This was primarily a result of both systems having high index values for conserved feed required (so less feed is required to supplement pasture) and the amount of fodder conserved (so more pasture could be cut for silage) on farm. A similar trend was observed in year 2, when the highest index value was again for the monoculture system. This is an interesting observation, since total annual pasture yield (kg DM/ha) showed that the mixture system was highest yielding in year 1 and the kikuyu-ryegrass system in year 2. Thus, high yielding systems, stocked at grazing capacities, could result in poor fodderflow dynamics on a farm, leading to more conserved forage having to be bought in during winter months.

In terms of efficiency index values, concentrate use efficiency was highest for the mixture farm in both years. This indicates that the pasture itself on the mixture system (Fescue, plantain and red clover) is supporting higher milk yields than on the other pasture types. In this case, forage quality, rather than quantity is likely driving the productivity of the system.

One aspect missing from this analysis is the economic comparison of systems, particularly as it relates to aspects like pasture renovation costs (annual vs strategic), concentrate costs (higher costs at higher stocking rates) and nitrogen costs (which in this case would be affected by grazing interval, since rates were constant per grazing incident).

Conclusion

Results reported in this paper are still very preliminary, but do indicate that the inclusion of plantain, chicory, lucerne and Tall Fescue, whether in a mixture or as a monoculture, holds the potential to yield similar or even higher pasture and milk per ha when compared to kikuyu-ryegrass. The inclusion of forage herbs and legumes, in particular, could improve milk yield per cow from spring to autumn.

However, the whole farm analysis highlights the need to consider other factors, such as fodderflow and efficiency parameters, when deciding on what system would suit a particular farming system.

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The effect of partial replacement of perennial ryegrass with plantain pasture and concentrate level on milk production and milk composition of Jersey cows in spring

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Introduction

Kikuyu/ryegrass pasture under irrigation is commonly used as forage for dairy cows in the southern Cape. Plantain however has become more popular and is planted in pure stands or as part of a pasture mix. Plantain has a high production potential, low fibre content and high feeding value, but is low in effective fibre. This may result in less rumination and lower rumen pH levels. The response on concentrate feeding is expected to change depending on level of concentrate feeding and the proportion of ryegrass and plantain in the total diet. Concentrates are relatively expensive compared to pasture and often contain 50-80% maize. As the level of concentrate feeding to cows increases the rumen pH is expected to be lower. When rumen pH gets below 5.8, fibre digestion may be compromised. Most research on plantain has been done in New Zealand where concentrate supplementation to cows is not common. Very limited research is available on effective concentrate supplementation to cows that consume plantain as 50% of their forage intake.

Aim

The aim of the study was to determine the effect of partial replacement of ryegrass pasture with plantain pasture during spring on milk production and milk composition at a low and a high level of concentrate feeding.

Materials and methods

The study was conducted during spring 2020 (September/October) at the Outeniqua Research Farm, situated near George in the Western Cape province of South Africa (22º 25´ 16´´E and 33˚ 58´ 38´´S). Nine hectares kikuyu/ryegrass pasture under permanent irrigation was over-sown with perennial ryegrass (*Lolium multiflorum)* cv. Base at 20kg/ha in May 2020. Plantain (cv. Agritonic) was planted at 9kg/ha on five hectare under irrigation during April 2019 and another 3 ha was planted in March 2020. The study took place during September/ October 2020 and consisted of a 14 day adaptation and 44 day measurement period. Fertilizer was applied at 42kg N after each grazing (150kg/ha limestone ammonium nitrate (LAN) containing 28% nitrogen). Pasture was irrigated according to soil moisture probe readings. The grazing cycle varied from 21 to 25 days depending on pasture growth rate. Sixty Jersey cows from the Outeniqua Research Farm were used in a randomized block design with four treatments (15 cows/treatment). The cows were blocked according to milk production (of the previous three weeks, 20.7±1.76 kg), lactation number (4.1±1.78) and days in milk (98±43.5 DIM) and were randomly allocated to one of four treatments:

1. Cows grazed kikuyu/ryegrass pasture day and night with supplementation of 3.5kg concentrate (RGRG 3.5).
2. Cows grazed kikuyu/ryegrass pasture day and night with supplementation of 7kg concentrate (RGRG 7).
3. Cows grazed plantain pasture during the day and kikuyu/ryegrass pasture during the night with supplementation of 3.5kg concentrate (RGPL 3.5).

Cows grazed plantain pasture during the day and kikuyu/ryegrass pasture during the night with supplementation of 7kg of concentrate (RGPL 7).

The dairy concentrate (DM 89%, 11MJ ME/kg, CP 12%, Ca 1% and P 0.4% on as is basis) was fed in the dairy parlour during milking at either 3.5kg/cow/day or 7kg/cow/day divided in equal portions between the two milkings. Cows on the plantain treatments were drafted after morning milking using a drafting gate to separate them from cows on ryegrass treatments. These cows strip grazed plantain pasture during the day while the other cows grazed kikuyu/ ryegrass pasture. All cows strip grazed kikuyu/ ryegrass pasture as one group during the night.

Cows were milked at 06h00 and 14h30 and grazed 24 hours per day (except for milking times). Clean water was provided (*ad Libitum*). Cows were marked with a coloured tag and light chain hanging from the neck indicating the specific treatment. Pasture (plantain and kikuyu/ryegrass) and concentrate samples were collected weekly. Concentrate samples were pooled for every two weeks resulting in 4 concentrate samples. Pasture samples were collected weekly by randomly cutting four circles of 35.4 cm in diameter at a height of 3 cm above the ground. Samples were dried at 60°C for 72 hours to determine the % DM and pooled for every two weeks resulting in four ryegrass and four plantain samples. All samples were milled though a 1mm screen with a Retsch GmbH5657 Laboratory mill (Retch GmbH 5657 Haan, West Germany) and stored pending analysis. The concentrate and pasture samples were analysed for DM, ash, crude protein, metabolisable energy, NDF, ADF, Ca, P, Mg, K, Na, Fe, Zn, Cu and Mn.

The pasture height was determined by using the rising plate meter (**RPM**) (Filip's folding plate pasture meter, Jenquip, Rd 5, Fielding, New Zealand). The pasture height of each grazing strip was determined by taking 100 RPM readings before and after grazing. Pasture was allocated at 12-14 kg DM/ cow/day. An after grazing pasture height of 10-12 on the RPM was targeted to ensure that pasture was not limiting.

Cows were weighed and body condition scored at the beginning and at the end of the study on two consecutive days before afternoon milking. Body condition score (BCS) of cows was determined on a scale of 1 to 5, where 1 is thin and 5 is fat. Cows were milked using a 20 Point Waikato/Afikim swing over milking machine with electronic meters. Milk production was recorded during each milking with the Afikim milk meter and management system. Composite milk samples (Ratio 8 ml: 16 ml, afternoon: morning milking) (06h00 and 14h30) were collected every two weeks. Milk samples were analysed for fat, protein, lactose, somatic cell count (SCC) and MUN using a Milkoscan FT 6000 machine (Foss Electric, Denmark).

Results and discussion

The chemical composition of ryegrass, plantain and concentrate fed to cows is presented in Table 1. The crude protein content of the plantain was lower and the NDF content higher than expected. Plantain did contain a higher level of Ca and lower level of K than ryegrass. The energy value of ryegrass and plantain was similar. The RPM height before and after grazing was 32.7±7.60 and 10.7±2.40 for ryegrass and 29.7±7.17 and 9.53±3.05 for plantain respectively.

Milk production, milk composition and live weight gain of cows is presented in Table 2. The average live weight of cows was 399 ± 36.5kg at the start of the study.

No significant interaction (P>0.05) was found between pasture and concentrate treatments for any of the parameters and therefor the main effects of pasture and concentrate were presented. Milk production of cows grazing ryegrass or ryegrass and plantain was similar (p = 0.19) at 18.8 and 19.4 kg milk per day respectively. Four percent fat

Table 1. Composition (% of DM) of ryegrass pasture, plantain pasture and concentrate fed to cows during spring.

Composition (% of DM)	Ryegrass pasture	Plantain pasture	Concentrate
DM%	12.6	12.4	88.9
Crude protein%	19.8	13.6	11.5
ME MJ/kg	10.7	10.8	12.7
NDF %	47.9	38.5	14.8
ADF%	30.1	33.2	6.66
Ca%	0.52	1.38	1.40
P%	0.53	0.32	0.50
Mg%	0.38	0.39	0.32
K%	3.68	2.18	1.06
Na %	1.43	2.51	0.23
Mn ppm	47.2	33.4	198
Cu ppm	7.24	8.02	19.4
Fe ppm	228	154	136
Zn ppm	41.3	44.7	201

Table 2: Milk production, milk composition and live weight gain of Jersey cows grazing ryegrass or ryegrass and plantain in spring supplemented with 3.5 or 7kg concentrate/cow/day.

	Pasture Treatment			Concentrate Treatment			
Parameter	RGRG	RGPL	P-value	3.5kg	7.0kg	P-value	SEM
Milk production (kg/cow/day)	18.8	19.4	0.19	18.4	19.8	0.001	0.30
FCM 4% (kg/cow/day)	21.4	21.7	0.63	20.8	22.2	0.01	0.39
Milk fat %	4.93	4.80	0.30	4.89	4.84	0.66	0.090
Milk protein %	3.79	3.72	0.19	3.75	3.76	0.77	0.040
Milk lactose %	4.65	4.66	0.87	4.63	4.69	0.12	0.025
MUN mg/dl	9.11	5.81	<0.001	8.13	6.79	0.006	0.343
Live weight gain (kg)	21.4	22.6	0.68	21.3	22.7	0.61	1.90

FCM= Fat corrected milk; MUN= milk urea nitrogen; RGRG = cows grazed ryegrass day and night; RGPL= cows grazed ryegrass at night and plantain during the day.

Table 3. Economic implications of level of concentrate feeding for cows grazing high quality pasture during spring.

Parameter	3.5 kg Concentrate	7 kg of concentrate
Milk production kg/cow/day	18.4	19.8
Milk income R/cow/day	R114.08	R122.76
Cost of concentrate	R20.30	R40.60
Pasture intake kg/cow/day (estimation)	10	8
Cost of pasture R/cow/day	R15.00	R12.00
Margin over feed cost R/cow/day	R83.78	R74.16
Increase in margin/cow/day feeding less concentrate	R9.62	
Increase in margin R/month for 400 cows	R115 440.00	

Assumptions: Cost of pasture R1.50/kg, Concentrate R5.80, Milk price R6.20

corrected milk did not differ ($p = 0.69$) and was 21.4 and 21.7 kg per cow per day for RGRG and RGPL pasture treatments. Milk production and 4 % fat corrected milk (FCM) increased significantly due to higher concentrate feeding and was 18.4 and 19.8 kg milk/cow/day ($p = 0.001$) and 20.8 and 22.2 kg FCM/cow/day ($p = 0.01$) for cows fed 3.5 or 7 kg/day. The response on concentrate feeding was low at only 0.40 kg milk per kg concentrate fed as concentrate feeding increased from 3.5 to 7 kg/cow/day. Milk composition was not significantly ($p > 0.05$) affected by pasture or concentrate treatments.

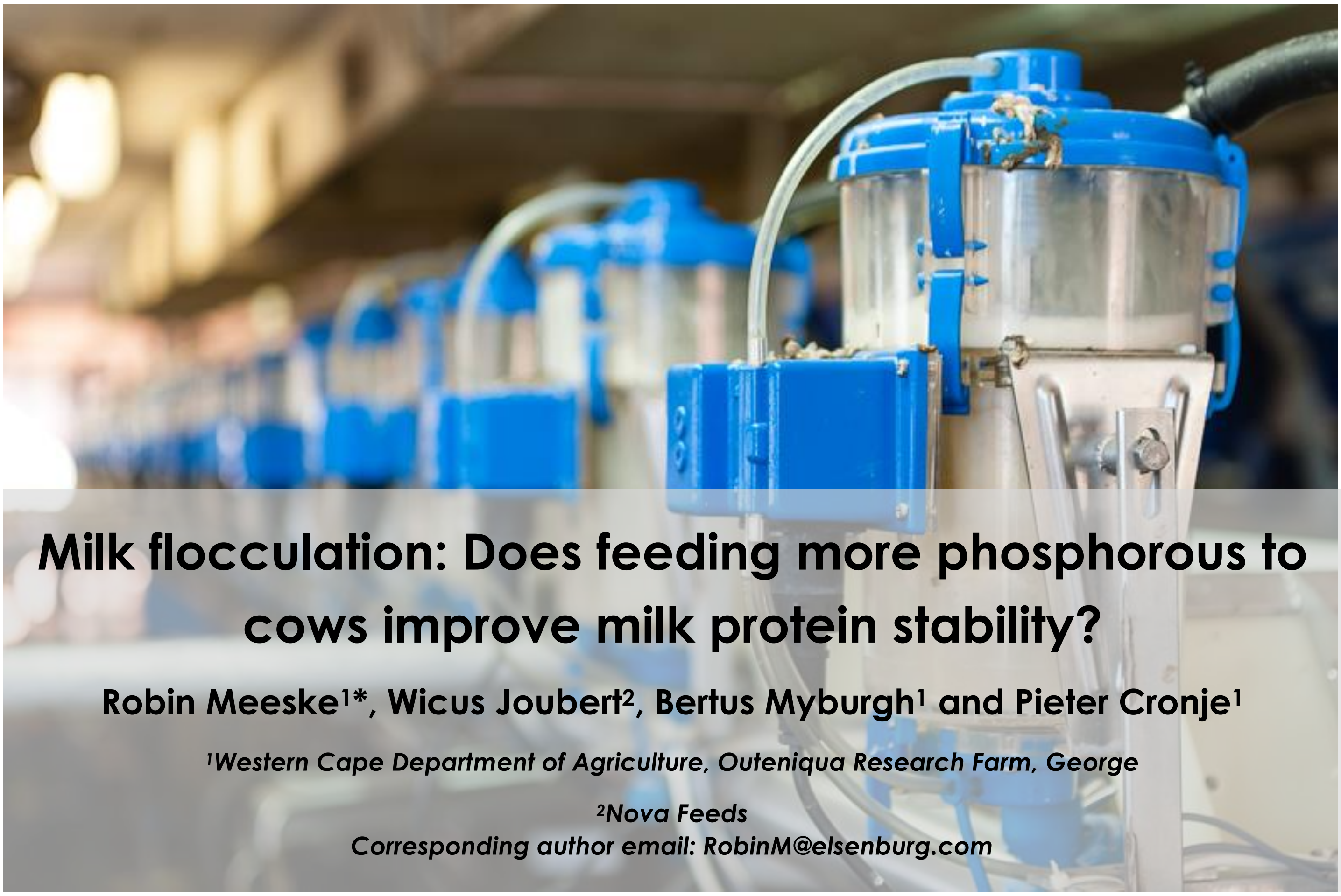
Economic implications

Economic implications of level of concentrate feeding during spring is presented in Table 3. When pasture quality and availability is high, response on concentrate feeding will be lower and feeding less concentrate may be more profitable.

Farmers should approach level of concentrate feeding to cows in balance with pasture quality and availability. Feeding less concentrate when pasture quality is high and more concentrate when pasture quality is low may result in improved profitability.

Conclusions

Partial replacement of ryegrass with plantain during spring, when pasture quality is high, did not increase milk production. Farmers should though consider feeding lower levels of concentrate to cows during spring when pasture quality and availability is high. In our study the return of only 0.4kg milk per kg of concentrate when increasing concentrate feeding from 3.5 to 7kg/cow/day resulted in lower profit.



Milk flocculation: Does feeding more phosphorous to cows improve milk protein stability?

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Introduction

The processing of milk as UHT or long life milk is continuously increasing. According to Milk SA, UHT and Steri Milk comprised 43% of the South African liquid products market compared to 34% for pasteurised milk in 2018 (Lactodata, 2020). With a total milk production of 3 411000 tons in 2018 of which 62% was processed for the liquid market the annual production of UHT milk was 909000 tons with a retail value of approximately R10.9 billion. It is expected that the demand for UHT milk will grow in future. During the processing of long life milk or UHT milk, the milk is subjected to heat treatment. The casein complex in milk must withstand the heat treatment and sustain its integrity. If UHT milk is not stable, protein will precipitate, flocculation occurs and shelf life of milk is compromised. This is not acceptable for consumers and milk is rejected resulting in major financial losses for milk processors. The alizarol test is used to estimate the heat stability of milk. Milk has to pass the 76 % alizarol test to be suitable for processing as UHT milk. The biggest challenge with unstable milk occurs during the late summer and autumn when pasture quality is lower and cows also experience heat stress. Phosphorous plays a key role in stability of protein micelles in milk. Sanchez et al. (1994) showed that phosphorous supply to the udder was reduced by 50% during heat stress. This may partially explain why the problem of unstable milk is more prominent from February to April. Fagnani et al. (2014) reported lower levels of phosphorous in unstable milk compared to stable milk. This was also found in a previous study at Outeniqua Research farm. Forar et al. (1982) found that inorganic phosphate in milk was lower during summer compared to winter. The mineral content of milk plays an important role in the stability of the milk protein and more specific the casein micelle (Tsioulpas et al., 2007). Supplementing mono calcium phosphate at 80 g/cow/day has improved protein stability of milk on some farms in the Tsitsikamma in the past.

Aim

To determine if changing the Ca:P ratio in the diet of cows grazing kikuyu pasture in late summer from 2:1 tot 1:1 will increase phosphorous content of milk and improve protein stability.

Material and Methods

The study was conducted during February/March 2021 on the Outeniqua Research Farm, situated near George in the Western Cape province of South Africa (22° 25´ 16´´E and 33˚ 58´ 38´´S). Twenty hectares irrigated kikuyu/ryegrass pasture was used in the study. Fertilizer was applied at 33kg N after each grazing (150kg/ha 1:0:1 containing 22% nitrogen). Pasture height was measured with a rising plate meter (RPM) and pasture was allocated at 12kgDM/cow/day. A pasture height before and after grazing on the RPM of 25 and 12 respectively was targeted to ensure proper pasture utilization as well as sufficient pasture allocation.

Eighty multiparous Jersey cows of the Outeniqua Jersey herd were be randomly allocated to one of two treatments:

1. Dietary Ca:P ratio of 2:1
2. Dietary Ca:P ratio of 1:1

The study was a cross-over design with two treatments and two periods (40 cows per treatment during each period). The different Ca:P ratios were achieved by feeding two different dairy concentrates as shown in Table1.

Concentrates were mixed and pelleted by Nova Feeds, George and delivered in bulk into two silos. The Ca and P content of pasture was expected to be the same at 0.4%. With supplementation of 6kg of concentrate, the Ca:P ratio of the total diet should be 2:1 and 1:1 for the control and high P treatment respectively. Cows were adapted to diets for 14 days followed by a measurement period of 7 days in period, after which treatments were switched for period 2. Concentrates were fed in the dairy parlour during milking at 6kg/cow/day divided between the morning and afternoon milking. Composite morning and afternoon milk samples were collected on day 1, 3 and 5 of each measurement period. Milk production was recorded daily and cows were weighed and condition scored at the start and end of each period. Milk samples were analysed for fat, protein, lactose, MUN, SCC, Ca, P and Alizarol level passed (72, 74, 76, 78 and 80%) as well as Ca, P, Mg, K and Na content. Pasture and concentrate samples were collected during each measurement period on day 1, 3 and 5. A total of 6 pasture samples (2 per sampling day) and 6 concentrate samples (3 for Control and 3 for high P treatment) were analysed per period for DM, OM, IVOMD, CP, Ca, P, Mg, K, Na, Zn, Cu, Mn, Fe. Milk samples taken were 240 (80 cows X3 samples) for each measurement period resulting in a total of 480 milk samples collected and analysed during the study.

Table 1. Concentrates differing in P content fed to cows grazing kikuyu/ryegrass

Ingredient	Control	High P
Hominy chop	10	10
Maize grain	59.9	59.9
Wheaten bran	10	8,2
Soybean oilcake	12	12
Molasses syrup	4	4
Feed lime	2.9	1.25
Mono-CaP	0	3.35
MgO	0.3	0.3
Salt	0.5	0.5
Urea	0.3	0.4
Premix	0.1	0.1
Total	100	100
Composition		
ME MJ/kg	12.1	12.0
Crude Protein %	15.0	15.2
NDF %	16.5	16.3
Ca %	1.21	1.21
P %	0.49	1.18

Results and discussion

The composition of the concentrates supplemented at 6kg/cow/day and pasture offered to Jersey cows is presented in Table 2. The high P concentrate contained 1.22% P compared to 0.43% P of the control concentrate. The estimated Ca:P ratio in the total diet was 1.8:1 and 1:1 for the control and high P treatment respectively. The intake of P was 43g/cow/day higher on the high P treatment compared to the control. We thus succeeded in substantially increasing P intake by cows on the high P treatment.

The % of cows that failed the 72 to 80% alizarol test is presented in Table 3. The incidence of flocculation did not differ between the control and high P treatment at any of the alizarol levels tested. It is interesting to note that 33% and 35% of cows failed the 76% alizarol test on the control and high P treatment respectively. The incidence of flocculation was therefore substantial in both the control and the high P treatment.

During the study we did not experience very high ambient temperatures and cows were not subjected to any nutritional stress. The pasture was of good quality (Table 2) and availability of pasture was sufficient as indicated by the rising plate meter reading of 27±5.1 and 9.14±1.02 before and after grazing respectively.

Table 2. Composition of concentrates supplemented and pasture offered to Jersey cows

Parameter (% of DM)	Control concentrate n=6	High P concentrate n=6	Pasture n=12
DM%	89.8±0.20	90.4±0.28	13.0±2.32
Ash%	7.0±0.16	7.8±0.33	12.2±1.18
Crude protein%	13.6±0.62	14.4±0.43	22.7±3013
ME MJ/kg	12.4±0.03	12.4±0.02	10.4±0.19
NDF%	11.9±0.53	10.5±0.54	51.2±2.88
ADF%	4.92±0.05	4.29±0.07	28.1±1.75
Ca%	1.39±0.064	1.30±0.064	0.44±0.050
P%	0.43±0.017	1.22±0.019	0.49±0.051
Mg%	0.41±0.024	0.42±0.050	0.43±0.044
K%	1.30±0.058	1.37±0.027	4.09±0.472
Na%	0.25±0.024	0.26±0.005	0.27±0.135
Mn ppm	215±11.0	214±9.2	47.9±18.5
Cu ppm	9.54±1.69	10.3±1.29	3.99±0.544
Fe ppm	165±25.7	272±17.9	194±38
Zn ppm	103±3.2	104±2.4	23.6±1.82

Table 3. The % of cows that failed the 72, 74, 76, 78 and 80% alizarol test when fed the control or high P concentrate, n=80.

% Alizarol tested	Control	High P	P-value
72	12.2	9.9	0.41
74	20.9	21.5	0.88
76	33.0	35.2	0.65
78	42.4	46.3	0.44
80	56.6	62.4	0.23

Table 4. Milk production and milk composition of cows grazing kikuyu/ryegrass pasture during autumn supplemented with control and high P concentrate.

Parameter	Control	High P	P-value
Milk production kg/cow/day	16.6	16.7	0.40
4% Fat corrected milk kg/cow/day	19.0	19.1	0.82
Milk fat %	5.03	5.00	0.43
Milk protein %	3.93	3.96	0.012
Milk lactose %	4.56	4.54	0.005
MUN mg/dl	16.9	17.0	0.46
Somatic cell count X 1000	127	136	0.96
Milk pH	6.65	6.67	0.27
Average Alizarol % passed	76.5	76.4	0.65
Milk mineral content			
Ca mg/100ml	142	141	0.52
P mg/100ml	77.4	76.9	0.42
Mg mg/100ml	12.8	12.8	0.99
Na mg/100ml	38.4	38.8	0.43
K mg/100ml	136	136	0.95

Milk production and milk composition of cows fed control or high P concentrate is presented in Table 4. Milk production or milk composition was not affected by increasing the level of P in the diet. The statistical significant differences in milk protein and lactose between treatments were very small and not of any biological significance. The MUN levels were high indicating that protein feeding was sufficient.

The average alizarol level passed was not improved by feeding more phosphorous to cows and the mineral content of milk was not affected. The P level in milk compared well with values reported by Fagnani et al. (2014) on milk with high protein stability. Mineral content of milk in our study compared well with values reported by Tsioulpas et al. (2007) of Ca 129mg/100ml, P 84 mg/100ml, Mg 9.7mg/100ml, Na 54mg/100ml and K 148mg/100ml.

Conclusions

Increasing phosphorous in the diet did not improve the protein stability of milk in this study. Milk production and milk composition was not affected. A third of the cows in the study produced milk that did not pass the 76% alizarol test and was therefore not suitable to process as UHT milk on both the control and high P treatments. Protein stability of milk is complex as it is affected by both environmental and nutritional stress as well as the genetics of the cow.

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Weather data: Outeniqua Research Farm 2019 to 2021

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	2019											
	January	February	March	April	May	June	July	August	September	October	November	December
Min T	15.8	17.2	15.8	13.4	11.7	9.3	7.7	9.6	11.8	11.9	14.6	15.0
Max T	22.7	21.5	22.0	20.1	26.8	23.2	16.9	17.7	28.4	19.2	20.2	21.4
Mean T	19.0	19.8	19.0	16.3	15.7	14.3	13.4	12.9	16.0	15.8	17.3	18.0
RF	24	75	56	36	41	29	30	3	58	35	60	32
PAR	204	215	187	141	109	104	125	155	160	200	256	216

	2020											
	January	February	March	April	May	June	July	August	September	October	November	December
Min T	15.7	16.0	13.3	12.5	8.6	9.8	8.4	7.2	10.1	10.0	13.2	14.3
Max T	24.8	26.8	25.8	26.6	22.5	20.7	21.2	18.3	22.8	20.0	26.4	21.9
Mean T	19.5	20.1	18.4	16.9	15.3	15.1	13.9	12.4	14.4	15.1	17.3	18.9
RF	134	37	33	34	53	18	14	51	68	101	68	31
PAR	187	202	168	164	118	101	119	119	175	194	188	199

	2021				
	January	February	March	April	May
Min T	16.9	17.7	15.2	13.8	11.3
Max T	24.6	25.0	27.0	24.0	22.3
Mean T	20.3	20.1	19.5	17.6	15.5
RF	38	30	64	42	85
PAR	207	208	165	153	114

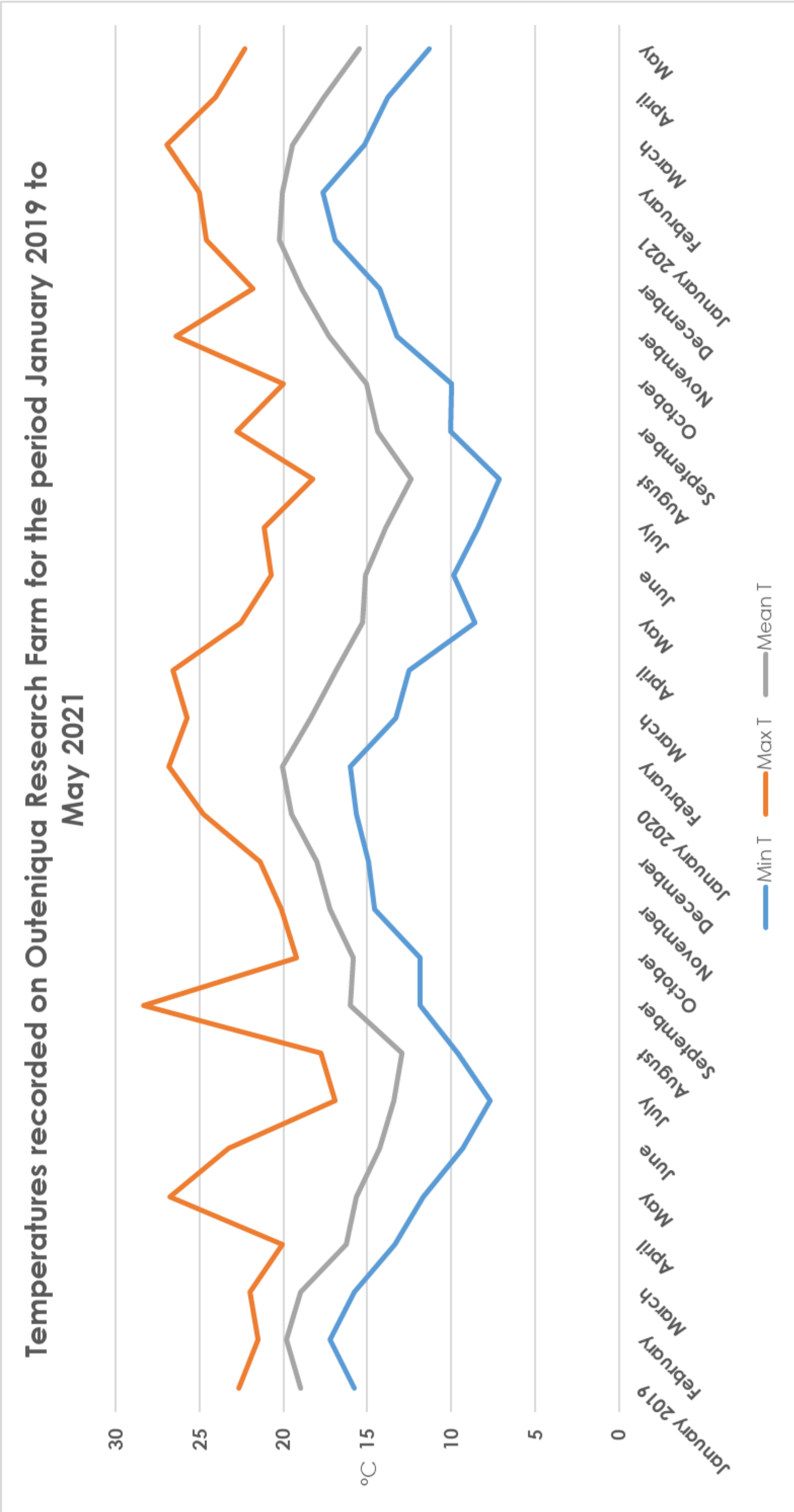
Min T = Minimum temperature (°C) recorded in specific month

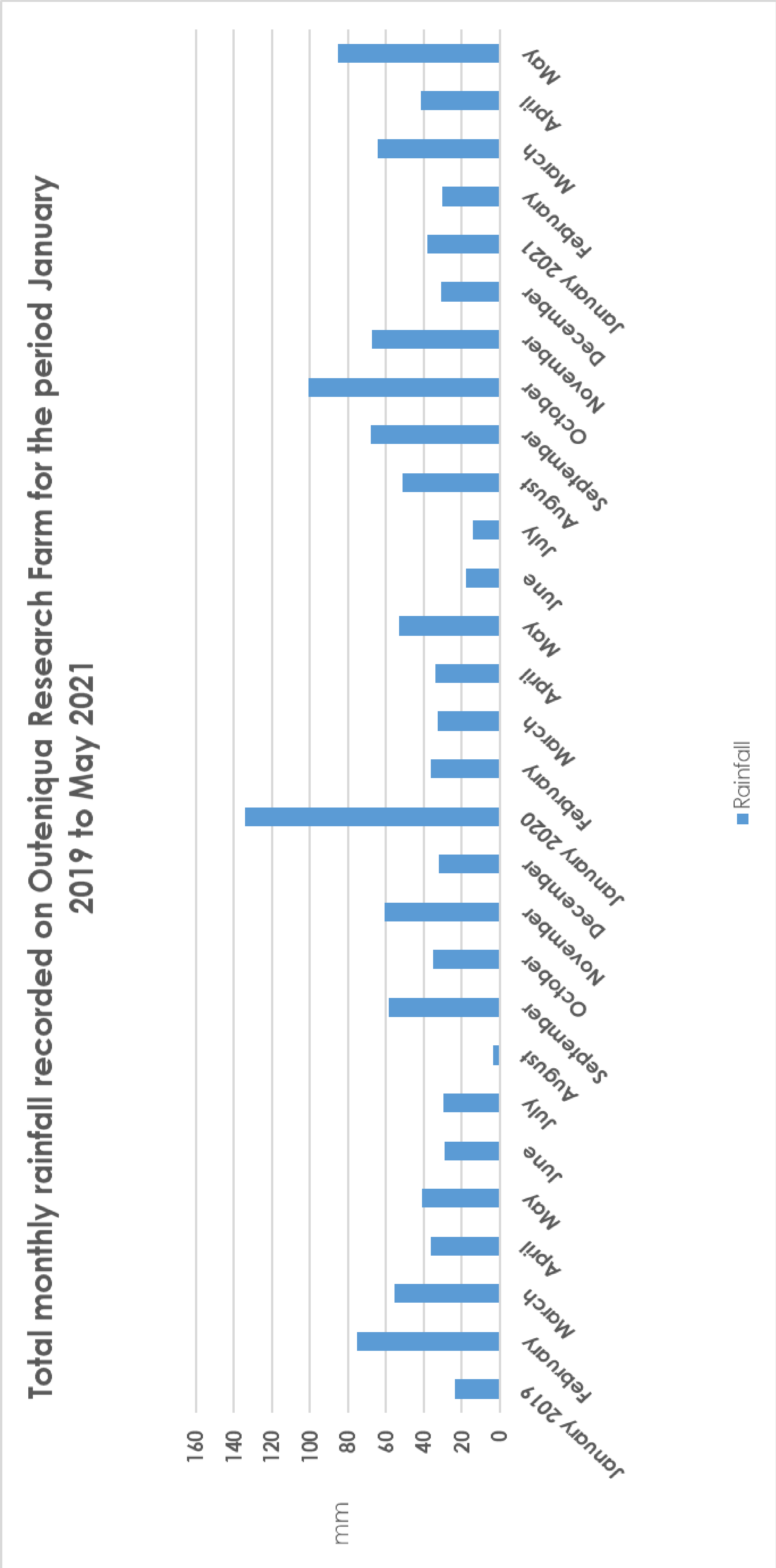
Max T = Maximum temperature (°C) recorded in specific month

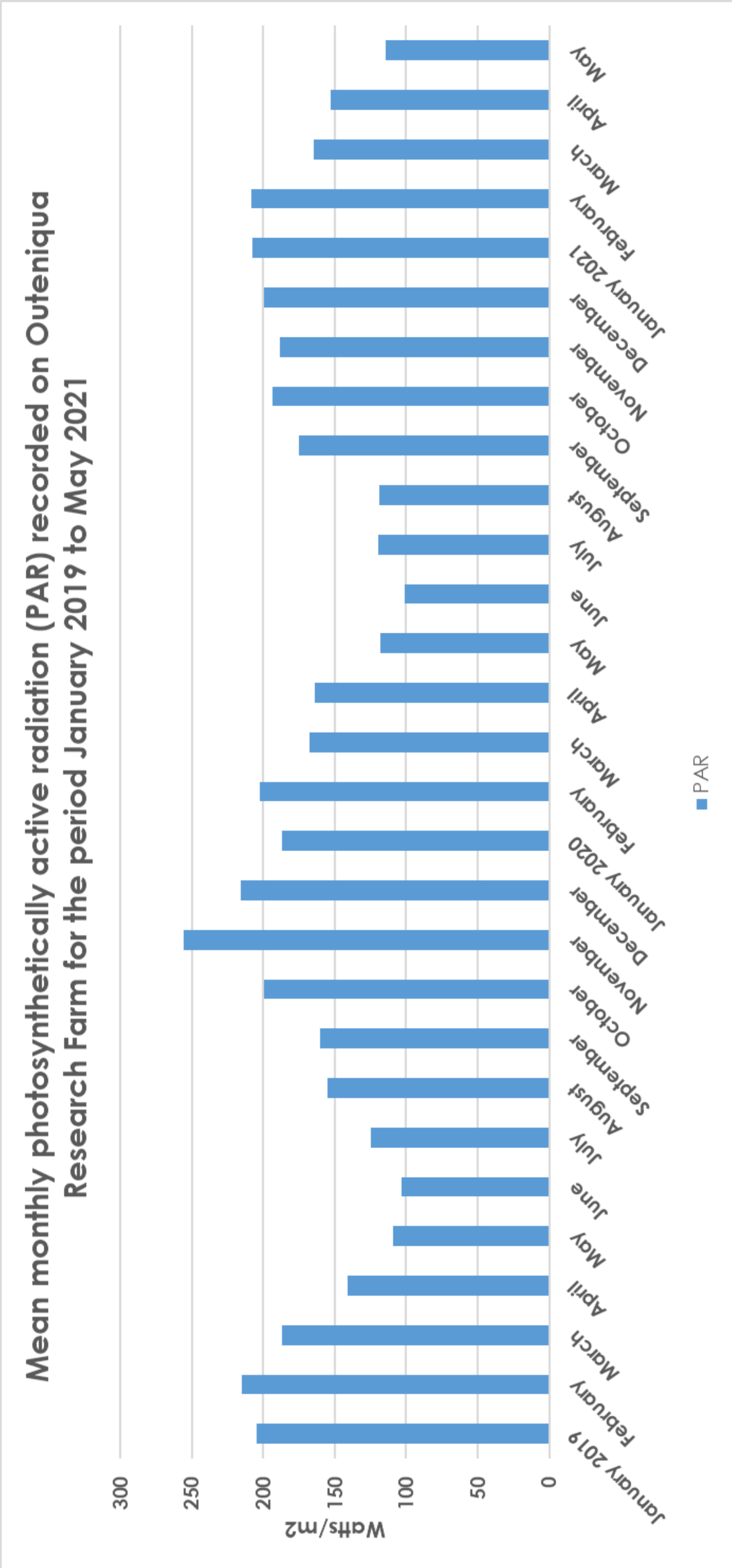
Mean T = Mean temperature (°C) of specific month

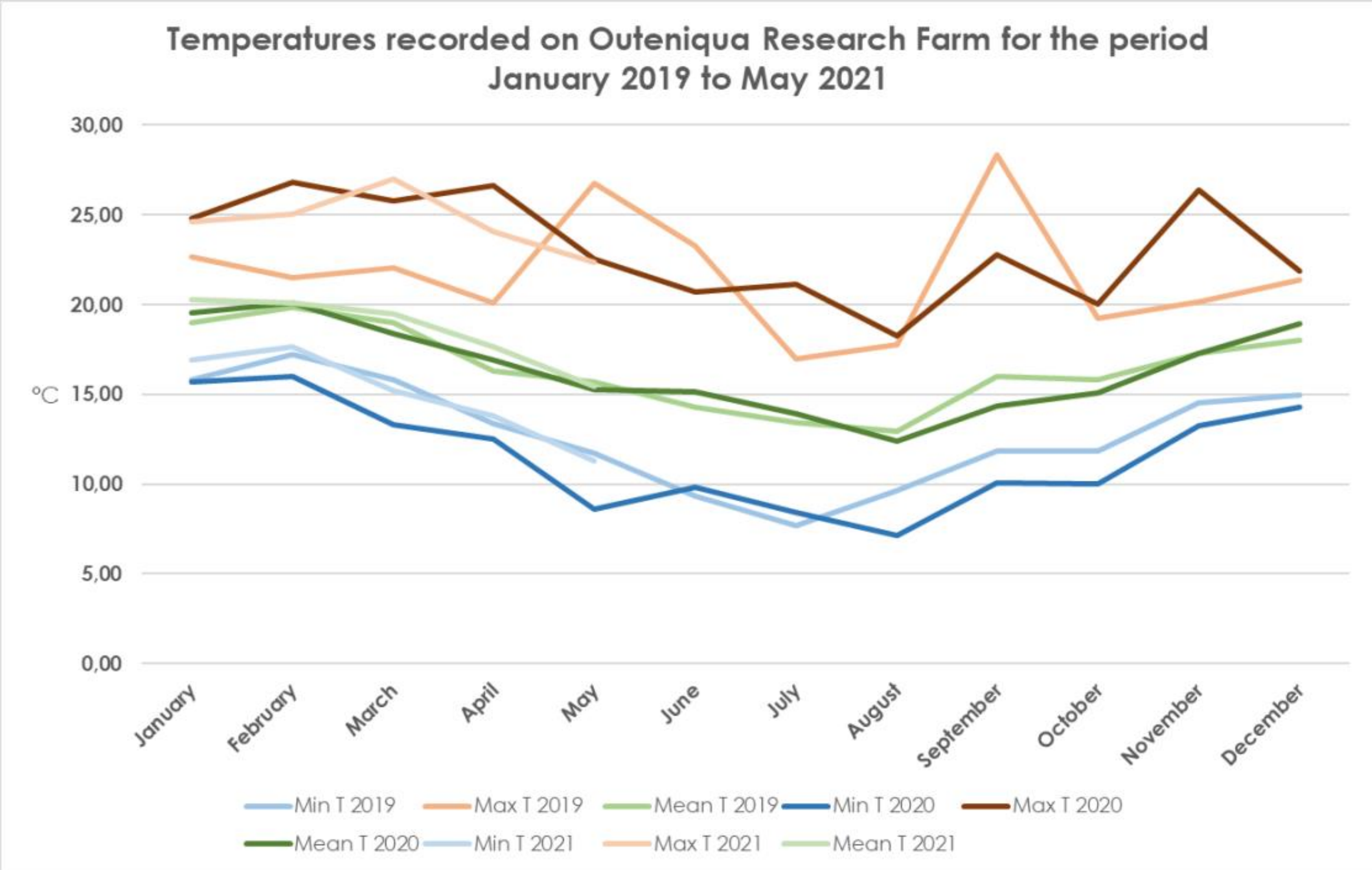
RF = Total Rainfall (mm) recorded in specific month

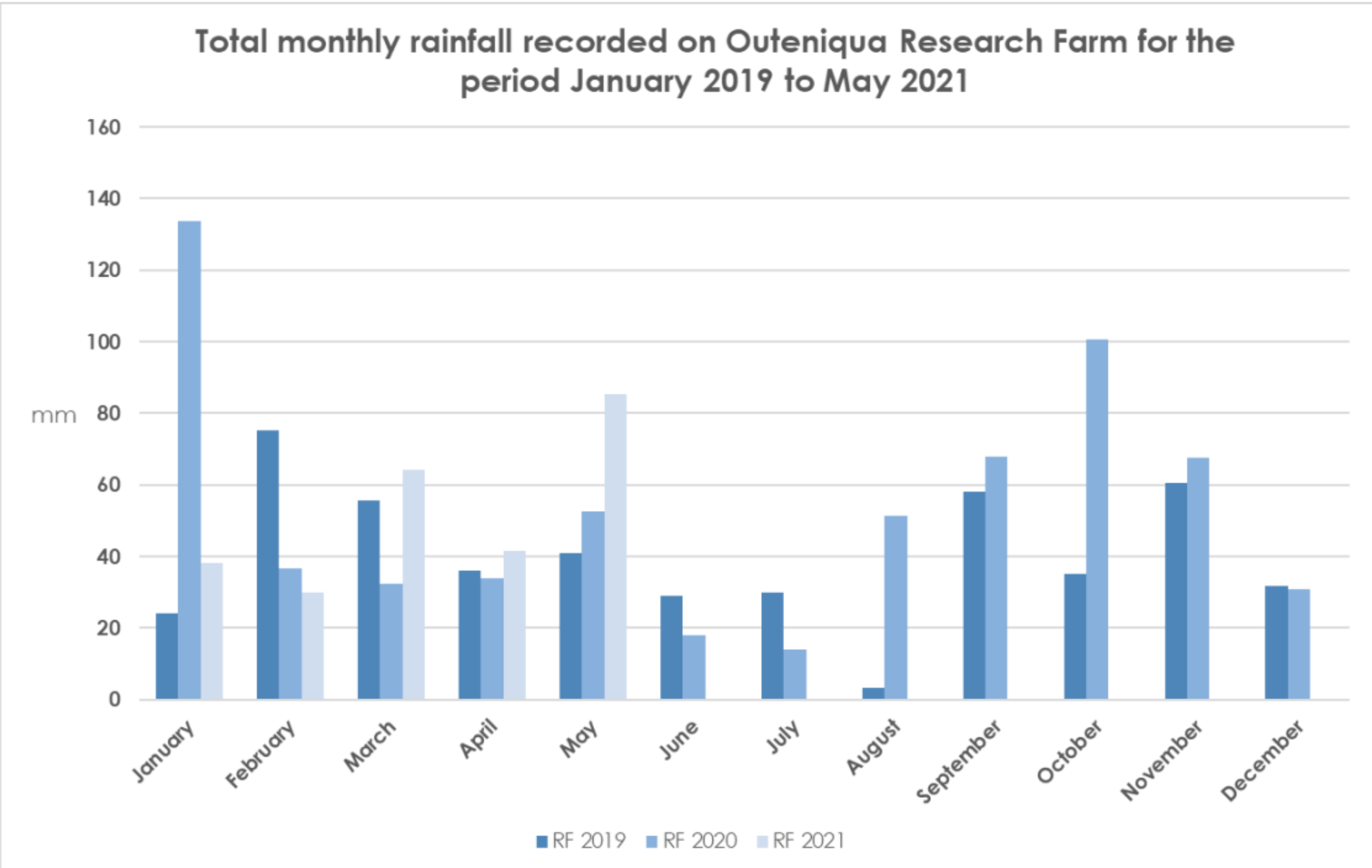
PAR = Mean photosynthetically active radiaton reading (Watts/m^2) of specific month

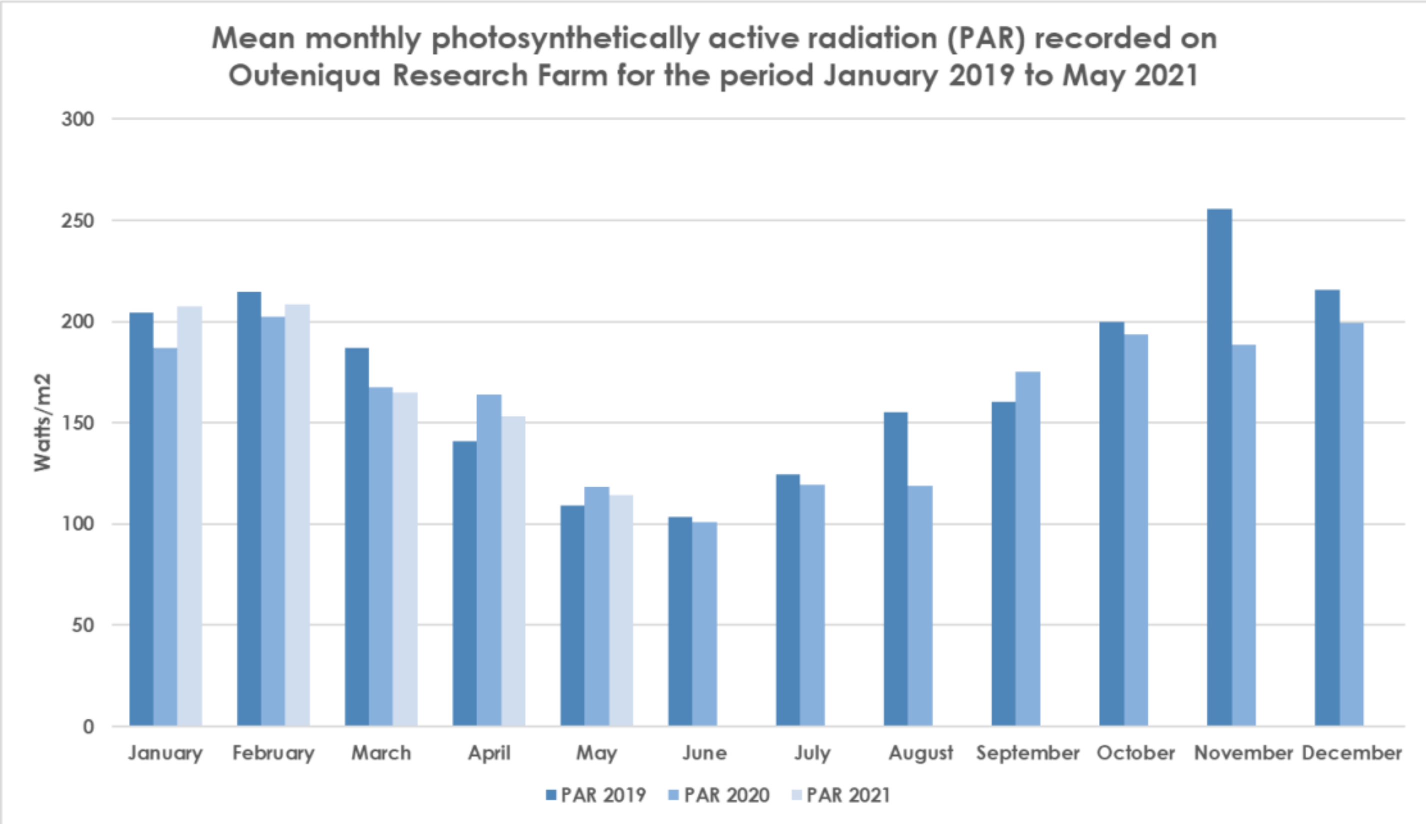

Temperatures recorded on Outeniqua Research Farm for the period January 2019 to May 2021
°C
0
5
10
15
20
25
30
January 2019
February
March
April
May
June
July
August
September
October
November
December
January 2020
February
March
April
May
June
July
August
September
October
November
December
January 2021
February
March
April
May
Min T
Max T
Mean T


Total monthly rainfall recorded on Outeniqua Research Farm for the period January 2019 to May 2021
mm
160
140
120
100
80
60
40
20
0
January 2019
February
March
April
May
June
July
August
September
October
November
December
January 2020
February
March
April
May
June
July
August
September
October
November
December
January 2021
February
March
April
May
Rainfall


Mean monthly photosynthetically active radiation (PAR) recorded on Outeniqua Research Farm for the period January 2019 to May 2021
Watts/m2
0
50
100
150
200
250
300
January 2019
February
March
April
May
June
July
August
September
October
November
December
January 2020
February
March
April
May
June
July
August
September
October
November
December
January 2021
February
March
April
May
PAR


Temperatures recorded on Outeniqua Research Farm for the period January 2019 to May 2021
30,00
25,00
20,00
15,00
10,00
5,00
0,00
°C
January
February
March
April
May
June
July
August
September
October
November
December
Min T 2019
Max T 2019
Mean T 2019
Min T 2020
Max T 2020
Mean T 2020
Min T 2021
Max T 2021
Mean T 2021


Total monthly rainfall recorded on Outeniqua Research Farm for the period January 2019 to May 2021
160
140
120
100
80
60
40
20
0
mm
January
February
March
April
May
June
July
August
September
October
November
December
RF 2019
RF 2020
RF 2021



Mean monthly photosynthetically active radiation (PAR) recorded on Outeniqua Research Farm for the period January 2019 to May 2021
Watts/m2
300
250
200
150
100
50
0
January
February
March
April
May
June
July
August
September
October
November
December
PAR 2019
PAR 2020
PAR 2021