Gross margin analysis of crop and pasture production systems within the longterm crop rotation trial at the Tygerhoek Agricultural Research Farm - 2002 to 2010

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Department of Agriculture: Western Cape

Institute for Plant Production

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Interim Report

Gross margin analysis of crop and pasture production systems within the long-term crop rotation trial at the Tygerhoek Agricultural Research Farm - 2002 to 2010

A component of the project entitled:

Economic sustainability of short- and long- rotation crop/pasture production systems in the southern Cape

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Contents

Volume 2: Figures, Tables and Appendixes

Executive summary

Report title: **Gross margin analysis of crop and pasture production systems within the long-term crop rotation trial at the Tygerhoek Agricultural Research Farm (2002 to 2010)**

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The interim report provides detailed gross margin analyses towards meeting one of the major aims of the long-term crop rotation project located at the Tygerhoek research farm in the southern Cape. This project aims to determine the effect of selected crop rotation systems on economically sustainable crop and crop/pasture production systems for this important grain producing region of the Western Cape. The identified needs that were to be addressed in the project included, improving crop yield, improving margins in the production system, increasing protein and oil seed production, increasing diversification of the farm unit for greater financial stability, and reducing input costs.

A conservation farming approach was applied to the management of all treatments that includes minimum- and no-till land preparation and planting, and retention of crop residues following harvesting (although crop residues were available to the sheep during the dry summer months in those systems that include a pasture phase). Data from the 2002 to 2010 seasons were included in the gross margin analysis. Five main rotations were used and included, Rotation System 1 - a 100% lucerne pasture, Rotation System 2 - 67% annual legume pasture/ 33% crops (with 4 different crop sequences), Rotation System 3 - 50% annual legume pastures/ 50% crops (alternative years of crops and pastures with 5 different crop sequences), Rotation System 4 - 50% annual legume pastures/ 50% crops (two consecutive years of crops followed by two consecutive years of pastures with 4 different crop sequences), Rotation System 5 - 100% crops (with 2 different continuous crop sequences).

Increasing crop yields

Climatic conditions had an overriding effect on the production all crops and pastures in the trial. Crop sequence did not have a major effect on yields of individual crops although some weak trends were apparent. The average wheat yield (over all 9 seasons) following a single pasture was the highest (3 412 kg/ha), followed by: wheat after canola (3 311 kg/ha), wheat after two years of pasture (3 297 kg/ha), and wheat after lupin or oats (3 249 kg/ha). The low wheat yield after lupin was unexpected but could have been due, in part, to the soil type that one of the replicates in which lupins were planted. Where wheat followed wheat in the sequence the average yield was 3 095 kg/ha. The average for wheat in all crop sequences with pastures was 3 347 kg/ha compared to the average of wheat in the cash crop systems of 3 247 kg/ha.

Crop sequence does not appear to have had a major effect on the yield of lupins. Canola production in the continuous crop rotation of WBLWBC tended to be higher than for canola in any other crop sequence. Average barley production was highest in the 6-year continuous crop rotation.

Improving margins

In the short term, gross margins realised differ among rotation systems both within and between years. This was, in part, due to large variations in allocatable variable costs, commodity prices and crop yields. The inherent variability in the production potential of soils across the study site also contributed to variability in the data set although the experimental design accounted for much of that variation.

From the data it is clear that the continuous lucerne system provided the most consistent gross margins across seasons, followed by the 6 year (WBLWBC) continuous cropping system. All crop rotation systems which included annual legume pastures varied according to each seasons' specific environmental conditions. The trial data and gross margin analysis strongly support the farming system of 5-6 years of lucerne pasture followed by 5-6 years of cash crop production that is commonly applied in the southern Cape.

<u>Increasing protein and oil seed production</u>

One of the important results from the analyses was that, whilst the gross margins achieved for canola and lupins were sometimes negative, the inclusion of one or both of these crops into the production system did not negatively influence the gross margins realised among the rotation systems being tested. The results therefore suggest that the area allocated to canola and lupin production in the southern Cape could be significantly increased without compromising, and would potentially improve, gross margins on farm, resulting in increased oil and protein seed production from the southern Cape grain production region.

<u>Increasing diversification of the farm for greater financial stability</u>

Reducing the proportion of land planted to wheat and barley while diversifying production systems by including crops, such as canola, lupins and oats, and/or annual legume pastures for sheep production spreads the risk associated with fluctuating commodity prices while maintaining (and potentially improving) gross margins achieved on the farm. There was, however, considerable within-rotation system variability in the gross margins recorded among years, mainly due to the effects of climate on crop yields and, to a lesser extent, on "spikes" in input costs as well as commodity prices. This suggests that while application of a suitable rotation system may assist to improve the stability in terms of gross margins recorded on the farm, factors other than the rotation system applied must also be considered when managing financial stability of the farming enterprise.

<u>Reducing input costs</u>

The total allocatable variable input costs of the rotation systems that included sheep production from pastures were lower than the input costs for continuous cropping systems. In most years the cost of fertiliser (mainly nitrogen) accounted for between 25% and 40% of the total input costs associated with the continuous cropping rotation systems

Concluding remarks

The project is progressing according to the research proposal and protocols. Management and production data are regularly presented to the local farming community in popular publications and on occasional farmer's days. The information is also made available to technical advisors of the various Agri-businesses that operate in the research area.

Bestuursopsomming

Verslag titel: **Bruto marge analise van gewas- en weidingsproduksie stelsels binne die langtermyn wisselbou proef te Tygerhoek Landbounavorsingsplaas (2002 to 2010)**

'n Komponent van die projek genaamd:

Ekonomiese volhoubaarheid van kort- en langtermyn wisselbou gewas/weidings-produksiestelsels in die Suid-Kaap

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As een van die hoof doelwitte van die langtermyn wisselbouprojek te Tygerhoek, naamlik: die bepaling van die effek van geselekteerde wisselboustelsels op die ekonomiese volhoubaarheid van gewas- en gewas/weidingstelsels in die Suid-Kaap, verskaf hierdie interim verslag volledige bruto marge analises om die doelwit te bereik. Die behoeftes wat geïdentifiseer is, ten opsigte van hierdie projek wat deur die verskillende stelsels getoets moes word, sluit die volgende in: verhoogde gewasopbrengste, verbeterde marge binne die stelsels, verhoging in proteïen- en oliesaadproduksie, verhoogde diversiteit in die plaasopset vir groter finansiële stabiliteit, asook verlaging in insetkostes.

Bewaringslandboupraktyke is gevolg tydens die bestuur van alle behandelings. Dit sluit 'n minimum- of geenbewerkingsaanslag tot grondvoorbereiding en aanplanting in, asook die behoud van oesreste (alhoewel die oesreste beskikbaar was vir die skape gedurende die warm somermaande binne die stelsels waar weiding ingesluit was). Data van die 2002 tot 2010 produksieseisoene is ingesluit in die bruto marge analise. Vyf hoof wisselbousisteme is gebruik naamlik, Wisselboustelsel 1 met 100% lusernweiding, Wisselboustelsel 2 met 67% eenjarige peulgewasweiding/ 33% gewasse (4 verskillende gewasvolgordes), Wisselboustelsel 3 met 50% eenjarige peulgewasweidings/ 50% gewasse (afwisselende gewas en weiding jare met 5 verskillende volgordes), Wissselboustelsel 4 met 50% eenjarige peulgewasweiding/ 50% gewasse (twee agtereenvolgende jare van gewasse gevolg deur twee jare van weiding met 4 verskillende gewasvolgordes), Wisselboustelsel 5 met 100% gewasse (2 verskillende aaneenlopende gewas volgordes).

Verhoging in opbrengs

Klimaatstoestande het die oorheersende effek op die produksie van alle gewasse en weidings binne die Tygerhoek proef gehad. Alhoewel gewasvolgorde nie 'n aansienlike bydra gelewer het ten opsigte van die opbrengs van spesifieke gewasse nie, was daar tog sekere tendense sigbaar (nie so duidelik nie). Die gemiddelde koringopbrengs (oor 9 jaar) na 'n enkel jaar peulgewasweiding was die hoogste met 3 412 kg/ha, gevolg deur koring na canola met 3 311 kg/ha, koring na 2 jaar agtereenvolgende peulgewasweiding met 3 297 kg/ha, koring na lupien 3 249 kg/ha en koring na hawer met 3 249 kg/ha. Die opbrengs van koring na lupiene was laer as wat verwag sou word, maar was moontlik die gevolg van die grond tipe waarop een van die herhalings geplant was. Waar koring op koring gevolg het was die gemiddelde opbrengs 3 095 kg/ha. Die gemiddelde koringopbrengs na weiding was 3 347 kg/ha en die na kontantgewasse 3 247 kg/ha.

Die effek van gewasvolgorde op die opbrengs van lupiene was nie so beduidend nie. Canolaproduksie in die volgehoue kontantgewasstelsel, KGLKGC, is geneig om die hoogste opbrengs te lewer. Gars-produksie het die hoogste gemiddeld opbrengs in die 6 jaar kontantgewasstelsel getoon.

Verbetering van marge

Die bruto marge wat verkry is het in die korttermyn verskil binne- en tussen jare. Dit kan deels toe geskryf word aan die wissellende toedeelbare veranderlike kostes, kommoditeitspryse en gewasopbrengste. Die inherente variasie in die produksie-potensiaal van die grond binne die proefarea het ook bygedra tot die variasie in die datastel ten spyte daarvan dat die eksperimentele-uitleg egter baie van die variasie verskans het.

Vanuit die data is dit duidelik dat die permanente lusernstelsel, gevolg deur 'n 6 jaar KGLKGC kontantgewasstelsels die mees konstante bruto marge oor seisoene getoon het. Die stelsels wat eenjarige peulgewasweidings ingesluit het, het 'n wissellende bruto marge getoon en die variasie kan moontlik toegeskryf word aan die spesifieke seisoenale klimaatsomstandighede. Die proefdata en bruto marg analises ondersteun die plaasstelsel van 5 – 6 jaar lusern gevolg deur 5 – 6 jaar kontant gewasse wat tans algemeen in gebruik is in die suid-Kaap.

<u>Verhoogde proteïen- en oliesaadproduksie</u>

Een van die belangrike resulte van hierdie analise was dat alhoewel die bruto marge van canola en lupiene soms negatief was, die insluiting daarvan in produksiestelsels die bruto marge nie negatief beïnvloed het nie. Resultate suggereer dus dat die area onder verbouing van canola en lupiene in die suid-Kaap vermeerder kan word sonder om die bruto marge van plase te benadeel en dit selfs moontlik kan verhoog en daardeur gevolglik die proteïen- en oliesaadproduksie uit die suid-Kaapstreek te verhoog.

<u>Verhoging in diversifikasie van die plaas vir verbeterde finansiële stabilteit</u>

Deur die gedeelte van die area wat met koring en gars beplant word te verlaag en dan die produksiestelsels te diversifiseer met die inbring van canola, lupiene en selfs ontbyt hawer en eenjarige peulgewasweidings vir skaapproduksie versprei die risiko wat hand aan hand loop met wissellende kommoditeitspryse terwyl dit bruto marge op die plaas handhaaf (of selfs verbeter). Daar was egter heelwat variasie binne stelsels se bruto marge in verskillende seisoene en dit kan hoofsaaklik toegeskryf aan die klimaatseffek op opbrengs en tot ‘n mindere mate die fluktuasies in insetkostes en ook die kommoditeitspryse. Dit suggereer dat alhoewel die keuse van ‘n gepaste wisselboustelsel kan bydra tot die stabiliteit van bruto marge van die plaas, ander faktore anders as net die spesifieke wisselboustelsel ook oorweeg moet word in die bestuur van finansiële stabiliteit van die plaas.

<u>Verlaging van insetkoste</u>

In die stelsels wat skaapproduksie ingesluit het was die totaal allokeerbare veranderlike insetkostes laer as die inset kostes vir suiwer gewasstelsels. In die oorgrote meerderheid van seisoene was die koste van kunsmis (hoofsaaklik stikstof) verantwoordelik vir 25% tot 40% van die totale insetkoste van die kontantgewasstelsels

Ter afsluiting

Die projek verloop volgens die proef soos dit oorspronklik voorgelê is, met doelstellings en doelwitte inaggenome. Bestuursinsette en produksie data word gereeld aan die boerderygemeenskap uitgedra in populêre artikels en boeredae. Die inligting word ook beskikbaar gestel aan die tegniese adviseurs van die verskeie Agri-besighede wat binne die area werksaam is.

Interim Report

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A component of the project entitled:

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1 Introduction

There are three separate research sites associated with the main project. Short term rotation systems are being tested at Tygerhoek, while long rotation systems are being tested at the Swellendam and Riversdale sites. This interim report is limited to a gross margin analysis of rotation systems being tested at the Tygerhoek site for the period 2002 to 2010.

The main project was initiated because of a lack of knowledge on 1) short- and long- rotation systems that could be used to provide biological and economic sustainability of crop production systems in the southern Cape, and 2) the main (internal and external) biological and economic factors within, and associated with, these production systems that support sustainable production.

1.1 Aims and objectives

This interim report focuses on the short- (annual) and medium-term economic implications, at the gross margin level, of implementing (on farm) short-rotation, continuous cropping and crop/pasture production systems that have been identified for the southern Cape cereal production region.

1.2 Key questions relating to the economics of the rotations being tested

Short-term:

1 Does rotation system influence the production potential of wheat, barley, oats, canola and lupin in the various cropping systems in a specific season?

2 Are input costs per crop or pasture, and per rotation system, affected by the choice of rotation system?

3 Are there short-term differences in the gross margins attained among the individual crops and pastures, and rotation systems, being tested?

Medium-term:

1 Are there medium-term differences in the gross margins attained among the rotation systems being tested?

2 Are there medium-term effects of incorporating crops such as canola and lupins, and annual legume pastures, into the cropping systems of the southern Cape on winter cereal crop production?

1.3 Background and broad description of the trial design

The trial started in 2002. The experimental layout is a randomised block design with two replicates of each rotation treatment in each year. Camp size during the pasture phase of the crop/pasture rotation systems is 2.0 ha which provides sufficient area to carry the number of sheep required to obtain reliable ewe and lamb performance data. Pasture camps are subdivided into smaller sub-camps to accommodate the designated cropping phase during the cropping year. Each subdivision (sub-camp) is dedicated to a particular crop or crop/pasture cycle for the duration of the experiment and is 0.25 ha in size. There are a total of 108 sub-camps within the experimental area. Normal farm machinery is used during planting, managing and harvesting of the crops. A conservation farming approach is applied to the management of all treatments and includes minimum- and no-till land preparation, planting, and retention of crop residues following harvesting (although crop residues were available to the sheep during the dry summer months in those systems that include a pasture phase).

All phases of each rotation are present in each year to accommodate commodity price fluctuations and inter-annual climatic effects on crop yield . For example, all possible crop sequences will be present for the rotation system PPW; which includes wheat (PPW), first year pasture after wheat (PWP) and second consecutive year of pasture production (WPP).

The following short rotation systems are being compared at Tygerhoek:

(P = annual legume (medic/annual clover spp) mixed pasture; W = wheat; O = oats; B = barley; C = canola; L = lupin; Luc = lucerne. The "annual legume" pasture referred to above comprises the best mix of medics and annual clovers for the soils and rainfall patterns of the experimental area. Although lucerne pasture cannot be considered part of a "short-rotation" system, information on the gross margin analyses of sheep production from permanent lucerne pastures is included for comparative purposes.

Rotation System 1: 100% lucerne (Luc) pasture
(sheep on lucerne pasture all year - with supplements when necessary)

Rotation System 2: 67% annual legume pasture/ 33% crops
4 different rotations are included viz.
2a – PPW
2b – PPO
2c – PPB
2d - PPVar (variable)[1]
See note on "variable" crop choice below

Crops used as variable (Var) in system 2d:
Wheat in 2002, 2006 to 2010
Canola in 2003 to 2005

Rotation System 3: 50% annual legume pastures/ 50% crops
5 different rotations are included viz.
3a – PWPW
3b – PWPO
3c – PWPB
3d – PWPC
3e - PVarPVar (variable)[1]
See footnote on "variable" crop choice below

Crops used as variable (Var) in system 3e:
Wheat in 2002, 2006 to 2010
Canola in 2003 and 2005
Oats in 2004

[1] **"variable (Var)" implies that the crop to be planted depends on the season and farming conditions that prevail in a particular year. The technical committee who guide the management of the trial, assisted in deciding on the crop to be planted in the "Var" treatment plots each year.**

Rotation System 4: 50% annual legume pastures/ 50% crops
4 different rotations are included viz.
4a – PPWW
4b – PPOW
4c – PPWB
4d – PPCW

Rotation System 5: 100% crops (5 ha)
2 different rotations are included viz.
5a – WCWL
5b – WBCWBL

1.4 Crop and pasture management

Protocols for the management of each crop and pasture were developed to ensure consistent application of the best available information on the production requirements of each crop over time. These protocols are regularly updated, annually if necessary (particularly with respect to appropriate cultivars), as new technology becomes available regarding management requirements of each crop. A no-till approach has been adopted within the management system. Crops are planted, protected against weeds, diseases and insect pests, and harvested using standard farm implements. Weed, insect and disease control measures are implemented by field staff in collaboration with the specialist associated with that crop.

The appropriate cultivar for each crop is used each year and managed according to the management protocols referred to above. The pastures were planted with the appropriate mixtures of medic and clover cultivars and re-seeded with the same seed mixture when necessary.

The pastures are stocked at a fixed stocking rate; the sheep are stocked on the two-hectare pasture camps from May to November and then moved to the crop residues of their companion crop sub-camps for as long as the crop residues are of value to them. The ewes are usually mated while grazing on crop residues from mid-November to the end of December. The ewes are returned to their pastures to make use of excess pods and pasture residues for the remainder of the summer months. It is usually necessary to feed the ewes with a good quality protein supplement from just before lambing until there is sufficient pasture for them in late autumn.

2 The data set used for this Interim Report (2002 to 2010)

For each year all direct and in-direct allocatable variable input costs per hectare and gross income per hectare (excluding marketing costs) for each crop, and for the sheep component of each rotation system being tested in the trial, were recorded (detailed management, input and yield records are available on file).

All yield, input cost and gross margin data from each treatment camps and sub-camps for the period 2002 to 2010 are presented in the summary tables. However, due to the fact that the trial was started in 2002 and that the "rotation effect" takes time to become established, it was decided to limit discussion on the effects of rotation system and crop sequence on yield, input costs and gross margins, to the 2005 to 2010 seasons. This approach implies that the different rotation systems would be in different phases of their rotation cycles in 2005. System 2 (a three-year cycle) would have completed a full rotation cycle; Systems 3, 4 and 5a (each four-year cycles) would have completed 3 quarters of their first cycle; and System 5b (a six-year cycle) would have completed half of its first cycle. Despite the short duration of the rotations, the fact that all phases of each rotation system being tested are present in each year allows for evaluating the short-term effects of crop sequence and rotation system on yield, input costs and gross margin of those rotation systems and their various components.

An EXCEL version of MICRO-COMBUD was written specifically to accommodate the experimental design. The program allows the user to easily verify each data point, either captured or calculated, in the gross margin analysis of any treatment.

Gross margin analysis was conducted for each treatment plot for each year from 2002 to 2010 based on the following:

Gross income:

- Yield per hectare x product price at the date when delivered to the silo (during harvest). Quality was taken into account.
- Price per ton after silo and marketing costs.

Directly allocatable variable costs:

- Actual price paid for products and services at the date the product or service was supplied to the trial site.

In-directly allocatable variable costs:

- Energy cost is based on the average (coastal) price per litre (diesel) for the period April to October as supplied by the Automobile Association for a specific year.
- Fuel-use is based on 'Guide to Machinery costs' for a specific year for the *actual machinery and implements used on the experimental site.*
- Repairs and maintenance is based on the 'Guide to Machinery costs' for a specific year for the *actual machinery and implements used on the experimental site.*

2.1 Data summaries

Crop sequence in this report is the terminology used when referring to the yield, allocatable variable costs, gross income and gross margin of a specific crop (or livestock) output in the current year of a crop or crop/pasture sequence. For example, the **crop sequence** - **WLWC** refers to the canola production following wheat, which in turn followed lupin. In the **crop sequence** - **WPPW** refers to the 1st year of wheat following 2 years of annual legume pasture, and the **crop sequence** – **PPWW,** refers to the 2nd year of wheat following 2 years of annual legume pastures for the same PPWW rotation system.

Rotation system in this report is the terminology used when referring to the, per farm hectare, allocatable variable costs, gross income and gross margin, averaged over all four phases of a rotation system. For example, the **rotation system - WWPP** refers to a "farm" where, in each year, half of the area is planted to wheat and the other half to pastures, but differs from the alternate years of wheat and pasture in the WPWP rotation system (where the farm is also 50% pasture and 50% wheat). In the WWPP rotation system there are two consecutive years of pasture and two consecutive years of wheat.

The experimental layout is a randomised, complete block design with two replications of each **crop sequence** and **rotation system**.

The statistical analysis of the data set has not been completed, but figures have been derived from the tables to assist with the discussion of the data. For each year the allocatable variable costs, crop yield, gross income and gross margins are presented as the per sub-camp value for each of the replicates of each crop sequence and rotation system. Annual allocatable variable costs per input item are also presented for each crop sequence and rotation system per sub-camp.

"Box and whisker" plots were used to summarise yield, total allocatable variable cost, and gross margin data of each crop sequence and rotation system for the period 2005 to 2010 (2002 to 2004 were excluded from these analyses for reasons discussed earlier in this report). Each "box and whisker" plot summarises the data into three segments. The top "whisker" contains the highest 25% of data points thus showing the maximum values of the variable being summarised. The bottom "whisker" contains the lowest 25% of data points thus showing the minimum data values of the series being summarised. The "box" contains the remaining 50% of the data points. Elongated "boxes" indicate large variation about the median values of a data set whilst short "boxes" indicate relative consistency about the median value of the variable of interest. Similarly, long "whiskers" indicate the potential to have large fluctuations outside of the "box" for the variable of interest.

The range and median of the data points for each crop sequence and rotation system over the period 2005 to 2010 are also presented. The range has the same extremities as the "box and whisker" plot, and the median value indicates, for the range of observed values, the point at which there are an equal number of values above and below the point.

3 Results and Discussion

3.1 Rainfall

A summary of monthly rainfall for the 9 years (2002 to 2010) is shown in Table 1. About 58% of the average annual rainfall for the period 2002 to 2010 occurred during the growing season (April to September). There was, however, considerable variation among years with seasonal rainfall varying from 31% to 70% of total annual rainfall. The average annual rainfall over the 9 year period was 424mm, while the average rainfall during the production season from April to September was 246mm (Figure 1). It should be noted that with a similar total annual rainfall but lower percentage of annual rainfall occurring during the growing season in the southern Cape compared to the Swartland, crop and pasture production systems practiced in the Southern Cape are potentially at greater financial risk than in the Swartland. A more detailed discussion on the rainfall per season is given in Appendix 1.

3.2 Allocatable variable costs (Rand per hectare)

3.2.1 Allocatable variable cost/hectare (AVC) per crop in the final year of each crop sequence

The average AVC per input (e.g. fertiliser) for each crop and pasture in all crop sequences, for the period 2002 to 2010, are presented in Tables 2 to 10 respectively. Averages were calculated from the two replicates (see Appendix 2 for trial layout) of each crop per crop sequence that are represented in each year. The significant increases in the cost of fertiliser in 2008 that persisted into 2010 are clear. Costs due to the use of contractors in certain years are attributed to the making of hay, crop spraying and lime spreading.

Total input cost for each replicate of each crop and pasture in each year from 2005 to 2010 are presented for each crop sequence in Table 11a to 11c and all inputs and prices used for the calculation of gross margins and total AVC (2002 to 2010) are presented in Appendix 3.

a Fertiliser and weed control

Fertiliser accounted for the highest input cost in the wheat, oats and canola crop sequences excepting in 2003, 2004 and 2006 when the cost of weed control in wheat was often similar to the fertilizer cost (Tables 2 to 10). In the pasture sequences weed control accounted for the highest input cost in most years, while the cost of weed control in lupin was more than double that of the fertiliser input cost for lupin in most years.

Fertiliser input cost for canola in the continuous cropping rotations was approximately double the cost of weed control. Weed control costs for canola in the continuous cropping rotations were also higher than weed control for canola in rotation with annual legume pastures.

Fertiliser and weed control input costs for barley were very similar throughout the trial period (Tables 2 to 10).

Weed control input costs for the permanent lucerne pasture were, for most years, lower than weed control costs for any other crop or pasture.

Together fertiliser and weed control input costs contributed more than 50% of the total input costs for canola in all years and as high as 73% in 2002 and 2003 (Tables 2 to 10). For oats the total contribution of fertiliser and weed control inputs was higher than 50% in 2008 to 2010 when it was harvested for its grain. The contribution of these two inputs to the total AVC of wheat was also higher than 50% in most years.

b Fungicides, fuel, seed and "repairs and maintenance"

Fuel, seed and "repairs and maintenance" input cost made up the balance of the input costs for canola, while fungicide inputs also contributed the costs of wheat, barley, oats and lupin (Tables 2 to 10). Whereas the contribution of fungicide input cost was low in wheat and oats, in barley it made a meaningful contribution (16% on ave 2002 to 2010) to the total AVC in most years. In 2008 fungicide contributed 21% to the total AVC for barley. Input costs of fungicide, seed, fuel and "repairs and maintenance" were negligible in the pasture treatments.

For all years except 2002, lupin had the highest seed input costs of all cash crops. The seed input for the lucerne pasture was the highest for all systems in 2002, when the trial was established.

Seed cost was negligible in most pasture treatments for most years. Medic/clover pastures showed varied results in seed cost since it was necessary to re-establish some camps during the 9 years since the trial started. Wheat showed higher seed inputs than canola in all years (Tables 2 to 10).

c Pest control

Pest control input costs were insignificant relative to the other input cost items over all crops and for all years excepting in canola (in 2004 and 2005), barley (in 2009 & 2010) and wheat (in 2008).

The high input costs of pest control in some crops in certain years indicate the risk of infestations in these crops over time. Input cost data from this trial indicate that canola production requires higher pest control input costs than all other crops and pastures in most years.

d Supplementary feed and veterinary costs

Supplementary feed costs of the sheep were the highest input cost contribution to sheep production from 2004 onwards. Veterinary costs made an insignificant contribution to the AVC for sheep production.

3.2.2 Allocatable variable cost/hectare (AVC) per rotation system – the combined effect of all crops/pastures in a rotation system

The AVC (R/ha) for each input item of each rotation system for the period 2002 to 2010 are presented in Tables 12 to 20 respectively. Summarised AVC (expressed in R/ha and as a percentage of total AVC) are presented for selected input items in Figures 2 to 9.

a Fertiliser and weed control

Fertiliser cost was the highest for WLWC and WBLWBC continuous cropping rotation systems within all years and decreased as the proportion of annual legume pasture in the rotation increased (Figure 2a). The permanent lucerne system recorded the lowest fertiliser input costs over all seasons. The relative input cost of fertiliser also tended to be highest for the two cash crop systems (Figure 2b) while herbicides (Figure 3a) provided the 2nd largest contribution to input costs associated with all systems in most years. In some years (e.g. 2003 and 2005) the contribution of herbicides to input costs was greater than the fertilizer input costs.

In Figure 2a it is clear that fertiliser input costs tended to decrease from 2002 to 2007, but increased dramatically from 2008 onwards due to a large increase in the cost of fertilizer products world-wide. The relative contribution of fertiliser to total input costs also tended to decline from 2002 to 2007 but did not increase as dramatically from 2008 to 2010 (Figure 2b). The contribution of herbicide towards the total AVC in Figure 3b showed a slight increase after 2008 following a decreasing trend to 2007, which could be attributed to poor weed control during the very dry 2008 season as well as increasing prices for herbicides.

Figure 3a illustrates the between- and within-year variability in herbicide AVC per rotation system. Systems with 2 consecutive years of pasture tended to have lower total herbicide AVC than the systems where cash crops followed a single year of pasture. The high herbicide input cost for the WLWC system could be ascribed to the soil type on which one of the replications of this system is planted. The specific soil type has a tendency to compact naturally, which results in increased stress during plant growth and development on these soils which, in turn, reduces the efficacy of herbicide applications.

Interestingly herbicide input cost increased in 2009 and 2010 for the annual legume pastures (Figure 3b). A possible explanation for this was the use costly herbicides, such as Kerb® in those years.

When referring to Figure 3b a clear decline in the relative contribution of herbicide AVC can be seen from 2003 to 2008. The only exception being 2005, where high summer rainfalls in the December/ January period resulted in high densities of summer weeds that required additional "out of season" herbicide input.

b Fungicides, fuel, seed and "repairs and maintenance"

Figure 4a shows the fungicide input costs. The 6 year continuous cropping (WBLWBC) and crop/pasture systems that included barley tended to have the highest fungicide input costs of all systems in all years (Figure 4a and b). While fungicide input costs varied by as much as 400% within years among systems and among years within systems (Figure 4a) fungicide input costs accounted for < 5% of the total AVC in most systems, and did not contribute to the input costs on lucerne pasture (Figure 4b).

Continuous cropping systems maintain the highest within year fuel cost relative to the systems that include pastures (Figure 5a). During the trial period there were significant fluctuations in the price of fuel, which in turn influenced the AVC associated with fuel. However, fuel input costs accounted for < 10% (and in many instances < 5%) of the total AVC in all systems and all years.

Seed input costs were highest in the continuous cropping systems due to the annual sowing requirement of those systems, except in 2002 and 2003, when the pastures were established, and in 2008 and 2010 when it was necessary to re-establish some of the pasture camps (Figure 6a). It should be noted that after the initial high seed cost of establishing pastures the total seed cost from 2004 accounted for less than 10% of the total AVC in almost all systems. The cost of lupin seed was the main contributor to seed costs for the continuous cropping systems.

Although the percentage contribution of fuel and seed cost to total AVC stayed consistent over the trial period (Figures 5b and 6b), both input costs showed increases towards 2010 (Figures 5a and 6a).

The AVC for "repair and maintenance" was similar to the fuel AVC across all rotation systems and years (Figure 7a & b).

c Supplementary feed and veterinary costs

Poor pasture production in 2008 resulted in the high cost of feed over all systems where pasture was produced excepting for the continuous lucerne pasture treatment (Figure 8a & b). Late early-season rainfall in most years resulted in poor early-season pasture production and the need for the additional feed purchased.

Note the high feed cost (relative to total AVC) for lucerne pastures (Figure 8a) but this should be seen in the context of a low total AVC for lucerne pastures in general (Tables 3c to 10c).

There was a 100% increase in veterinary input costs for the period 2007 to 2010 when compared to the period 2002 to 2006. However, the contribution of veterinary input costs to total AVC in all pasture systems remained very low for the period 2002 to 2010(Figure 9a & b). Within years the higher veterinary costs in the lucerne pasture were due to higher sheep stocking rates on the lucerne when compared to the annual legume pastures. .

3.3 Summarised allocatable variable cost data

The "box and whisker" plots provide summaries of the data sets. The plots are based on the data presented in Table 11 but exclude the data from 2002 to 2004 (for reasons previously discussed). The "box and whisker" plot for each crop sequence or rotation system therefore summarises 12 data points (two data points per crop sequence for each year from 2005 to 2010). For each crop sequence or rotation system, therefore, the top and bottom "whiskers" each include 3 data points whilst the "box" contains 6 data points.

3.3.1 Allocatable variable cost/ha (AVC) per crop in the final year of each crop sequence

The AVC for wheat, barley, oats, canola, lupin and pastures in each crop sequence are presented in Figures 10 to 15 (a & b).

Wheat following canola (LWCW) or two years of pasture (PPW) showed the narrowest ranges in AVC, although the LWCW and PPCW sequences showed the best stability as indicated by the narrow range of the "box" (Figure 10a & b).

In the sequences where wheat followed a single year of pasture, most values were located in the higher portion of the range. The longer upper "whiskers" for all the wheat following canola and lupin sequences indicate the potential for greater increased costs above the norm (indicated by the "box"), although the LWCW sequence was more evenly spread (Figure 10b). The potential of increased costs for these systems lies in the possibility of increased pesticide and fungicide input requirements in certain years.

The AVC of barley following a single year of pasture or wheat tended to be similar (Figure 11a). The median AVC for oats was similar among sequences (see "boxes" in Figure 12a and median values in Figure 12b). The AVC for canola showed similar trends among sequences to the trends shown for oats (Figure 13a). Lupin AVC tended to be slightly higher in the WCWL sequence than in the 6 year sequence (Figure 14b). This was due to a problem with the soil in one replication of the WCWL sequence, as indicated before.

The AVC in the pastures varied among systems (Figures 15a and 15b). This can be attributed to the additional costs associated with the re-establishment of pastures in the "pasture/crop/pasture/crop" system (Treatment 3) in two of the seasons (2008 and 2010) covered in this interim report. These additional input costs were not required for the other pasture treatments. The narrowest ranges for AVC occurred in the "crop/crop/pasture/pasture" (Treatment 4) sequences (Figure 15b).

3.3.2 Allocatable variable cost/ha (AVC) per rotation system – the combined effect of all crops/pastures in a rotation system

The median AVC of the two continuous cropping systems was higher than for the pasture-based systems (Figure 16b). The median AVC for the 67% pasture 33% crop rotation system were generally lower than the AVC for the 50% pasture/ 50% crop systems. The continuous lucerne system had the lowest AVC of all systems tested.

The inclusion of pastures in the rotation widens the range of AVC, due to the general low total AVC for the pasture component. Seasonal effects of rainfall and the necessity to purchase feed for livestock accounts for the long top "whisker" in the systems that include pastures. It appears that although the continuous cropping systems had the highest AVC, the range in AVC was more constant than in the pasture-based systems.

The widest spread in AVC was in the systems that included two consecutive years of pasture and two consecutive cash crops (Figure 16b).

3.4 Crop yields

Actual crop yield data from all plots of each crop sequence and each crop system are presented for wheat (Table 21a & b, Figure 17a, b, c & d), barley (Table 22, Figure 18a & b), oats (Table 23a & b, Figure 19a & b), canola (Table 24a & b, Figure 20a & b) and lupin (Table 25a & b, Figure 21a & b).

Median wheat yields were similar among crop sequences (Figure 17b). In all sequences the upper "whisker" tended to be longer than the lower indicating the potential for greater yield gains than reductions, except for the WPPW sequence, when compared to the expected "average yield" indicated by the "box" (Figure 17a).

The range and median wheat yields (kg/ha) were similar among the rotation systems being tested (Figures 17 c & d) but some trends in the average wheat yields per crop sequence over the period 2005 to 2010 were apparent.

The average wheat yield after a single year of pasture was the highest (3 412 kg/ha), followed by wheat after canola (3 311 kg/ha), wheat after two years of pasture (3 297 kg/ha), wheat after lupin (3 249 kg/ha) and wheat after oats in the crop sequence (3 249 kg/ha). Where wheat followed wheat in the sequence the average yield was 3 095 kg/ha. The yield (over 9 seasons) for wheat in all crop sequences with pastures was 3 347 kg/ha compared to the average wheat yield of 3 247 kg/ha in the cash crop systems (data not shown).

In the continuous cropping sequences barley tended to have a narrower range in yield over time than when barley followed pastures (Figure 18). The relatively long bottom "whiskers" in the pasture-based crop sequences indicate the potential for obtaining a wider range of lower barley yields in these sequences (Figure 18b). While the median values (Figure 18b) showed small differences in barley yields among rotation systems, barley production in the continuous cropping systems tended to be more stable than in the pasture-based systems (shown by the short "whiskers" & "boxes" in Figure 18a – refer also to the data presented in Tables 22a & 22b). Barley yield in the PWPB crop sequence tended to be lower than for barley yield in other crop sequences.

Oat cereal yields and hay production were similar over all crop sequences (Table 23 a & b).

The average yield of canola following pasture for the period 2005 to 2010 was 1 453 kg/ha, while the average in the continuous cropping systems was lower (1 387 kg/ha) (data not shown). In all crop sequences, except WPPC, the top "whiskers" tended to be longer than the lower one, indicating the possibility for a wider range of higher yields in these sequences (Figure 20b). The lower range and median values for canola yield in the WLWC sequence when compared to the WBLWBC sequence is due largely to the negative effects of the self compacting soil that occurs in one of the replicates of the WLWC rotation system as discussed earlier in this report.

Lupin yields tended to be lower in the WCWL crop sequence than in the longer 6-year crop sequence (WBCWBL) (Table 25a). Again, this is due mainly to the negative effects of the self compacting soil that occurs in one of the replicates of the WLWC rotation system.

3.5 Gross income (R/ha)

Gross income (excluding marketing costs) data are presented for each crop in the final year of each crop sequence in Tables 2 to 10 and for each rotation system in

Tables 12 to 20. These data are presented for each year over the period 2002 to 2010 and were used with the total of directly- and indirectly-allocatable costs (presented as "Total cost" in the Tables) to calculate the gross margins per crop sequence and rotation system that are presented in Tables 2 to 10 and 12 to 20 respectively.

3.6 Gross margin (R/ha)

The gross margin recorded for each crop within each crop sequence and rotation system are presented for each year for wheat in Table 26, for barley, oats, canola and lupin in Table 27, pastures in Table 28a & b and summarised in Figures 22 to 35. Average gross margin data for each crop sequence and rotation system are also presented in Tables 2 to 10 and Tables 12 to 20 respectively.

Figures 22 (wheat), 23 (barley), 24 (oats), 25 (canola), 26 (lupin) and 27 (pastures) are presented to illustrate the variability in average gross margin per year for each crop in each crop sequence for the period 2005 to 2010.

Average gross margins for wheat over all crop sequences varied among years and among crop sequences within years (Figure 22). The average gross margin over the period 2005 to 2010 was R3 419/ha (data not shown).

Gross margins for all other crops also tended to vary among years. It is clear that 2005 and 2008 were difficult seasons with low production potential due to low seasonal rainfall (as discussed in Appendix 1), while 2007 was an exceptional season producing the highest gross margins for the report period. Lupin showed negative margins in 2006 and 2010, due to the problems experienced with the soil in the one replication of the WCWL system as previously discussed (Figure 26). Gross margins for sheep production on the legume pastures also varied over years, but in most instances showed positive margins except in 2008 (Figure 27), which can be attributed to high feeding costs in that year (Table 8c).

The following discussion summarises gross margin data presented in Tables 26 to 28 (summary data are not shown in these tables). The average gross margin for wheat from 2005 to 2010 was R3419/ha, which was 131% more than that of canola (R1482) and 272% more than that of lupin (R918/ha) in the same period. Even in a favourable year such as 2007 the average gross margin from wheat (R6402/ha) was 102% higher than for canola (R3163/ha) per ha. Average (2005 to 2010) gross margin for wheat (R3419/ha) was 11% higher than for barley (R3079/ha) and 12.5% higher than for lucerne pasture (R3040/ha) , while the average 6 year gross margin for oats was R629/ha less than that of wheat, it must be remembered that in 4 of the 6 years oats were harvested as cereal. In 2007 oats had the highest average gross margin of all crops with R6 678/ha (hay). Lucerne pasture gross margin was the most consistent over the 6 year period. Both wheat and barley had higher gross margins than the lucerne in 3 of the 6 years, while canola only showed higher gross margins than the lucerne in 1 of the 6 years.

The mean annual gross margin per rotation system, calculated for the period 2005 to 2010 is presented in Figure 28. The following patterns are highlighted.

- There was greater among season variation in the gross margin achieved by the annual pasture-based systems than the continuous cropping systems and the pure lucerne pasture system.
- The highest gross margins recorded for the 50% pasture/ 50% crop rotation systems were in a favourable production season (2007). However, all pasture-based rotation systems recorded a lower gross margin than the continuous cropping rotation systems and continuous lucerne in 2008, a season with low rainfall (Figure 28 and Appendix 1).
- The use of pure cash crop rotations in a predominantly lucerne pasture environment is a viable option for the region. This is evident from Figure 28 where it is clear that the two cash crop systems as a whole and the pure legume pasture system delivered more consistent annual gross margins over all seasons when compared to all other systems. This is also no doubt the reason why most farms in the southern Cape have found the longer rotation systems, where a pasture phase consisting of 5 to 6 years of lucerne followed by a 5 to 6 year cropping phase provide for a more stable production system.

3.7 Summarised gross margin data

The “box and whisker” plots provide summaries of the data sets. The gross margin data presented in the analysis for the various plots are based on the data presented in Tables 26 to 28, which exclude the data from 2002 to 2004.

3.7.1 Gross margin per crop in the final year of each crop sequence and for wheat and barley in each rotation system

The summarized gross margins for wheat, barley, oats, canola, lupin and variable in each crop sequence and crop rotation are presented in Figures 22 to 28. Summaries in form of "box and whisker" plots, and of the range and median values for each crop sequence are presented in Figures 29 to 35.

The gross margins for wheat varied among crop sequences (Figure 29a). The PPCW sequence showed the highest median of all crop sequences followed by the 6 year sequence of BCWBLW (Figure 29b). In most cases the top "whisker" of all the crop sequences tended to be longer than the bottom "whiskers", which suggests a greater range in gross margins above the "norm" (indicated by the size and position of the "box"). A similar pattern is evident in the gross margins for wheat in the different **rotation systems** (Fig 29c & d).

Gross margins for barley (Figure 30a) in the different crop sequences followed the same trend as gross margins for wheat. The two continuous cropping sequences tended to be the most stable across seasons, as indicated by the shorter "boxes" and "whiskers" and ranges, than for the other systems (Figures 30a & 30b). Barley production within the PWPB crop sequence showed the potential of higher gross margins with a longer top "whisker". Although the PPB, and CWBLWB crop sequences, showed the highest median of all systems, there appears to be a greater chance within the PPB sequence for lower gross margins, indicated by the long bottom "whisker", when compared with the other barley crop sequences (Figures 30c and d). This might be due to the double pasture in these systems, which tends to increase kernel protein of the barley to a level which is too high for classification as malting barley which decreases the value of the crop, normally consigning it to "feed" grade.

The median and range of gross margins for the crop sequences for oats were similar (Figures 31a and b) and varied from –R175/ha to R8 100/ha.

Differences among crop sequences in the stability of gross margins recorded for canola are apparent from Figures 32a & b. The relatively short "box" for the PWPC crop sequence (where 50% of the data points lie within the "box") indicates that the gross margin for canola in this crop sequence may be more stable than for canola in the other crop sequences. The PWPC system also has the longest upper "whisker" indicating that in the upper quartile of production seasons, gross margins would be greater than the gross margins expected for canola in the upper quartile of the remaining three crop sequences that include canola. The highest gross margins for canola were achieved in the PWPC and WPPC crop sequences. The same trend was recorded at the Langgewens site indicating that gross margin (and crop yield) is enhanced where canola follows annual legume pastures. The short range in gross margin for the WLWC crop sequence suggests that this system is the most stable. It must be noted that a TT cultivar was used in all of the years under discussion in order to combat weeds, which in turn is responsible for lower yields which negatively affected the gross margins recorded for the crop (Figure 32b).

Gross margins for lupin production (Figure 33a and b) tended to be much higher in the 6 year cash crop rotation than in the 4 year rotation. The longer rotation system showed greater stability and never produced negative margins for lupin production. The problems associated with soils in one of the replications of the 4 year system have been discussed as the cause of the negative margins recorded for the lupins in the WCWL crop sequence.

Gross margins for the lucerne system (Figure 34a) were the most stable of all pasture crop sequences. Most other legume pasture sequences showed large variations in range (Figure 34b). Overall the annual legume pasture gross margins tended to be similar among sequences and over years.

In the two crop sequences where a variable (see earlier explanation) formed part of the cropping sequence no negative margins were obtained (Figure 35). It must be noted that, for the period 2005 to 2010, the variable under discussion was planted to wheat in all seasons, excepting in 2005 where canola was used in the PPVar crop sequence.

4 Final observations and conclusions

The interim report provides detailed gross margin analyses towards meeting one of the major aims of the long-term crop rotation project located at the Tygerhoek research farm in the southern Cape. This project aims to determining the effect of selected crop rotation systems on economically sustainable crop and crop/pasture production systems for this important grain producing region of the Western Cape. Crop yields depend largely on seasonal climatic conditions and on management inputs such as fertilization; weed, pest and disease control; and rotation or crop sequence. As all crops and pastures were managed according to "best practice" principles and were subjected to the same climatic conditions each season it was expected that rotation (crop sequence) would have the greatest influence on crop yields. However, for the period under discussion crop sequence did not have a clearly defined effect on the yield of individual crops. The following trends were observed:

Average wheat production tended to be highest (3412 kg/ha) in systems where wheat followed a single year of legume pasture, followed by wheat after canola (3311 kg/ha), after two years of annual legume pasture, after lupin or after oats (3249 kg/ha).

Barley yields (median value from about 3000 to 3500 kg/ha) tended to be more stable in the continuous cropping system than in the annual legume pasture-based systems.

Average canola yield in the pasture-based systems was 1453 kg/ha compared to 1387 kg/ha in the continuous cropping systems.

Average lupin yields varied from about 1500 kg/ha to 2000 kg/ha

In the short term gross margins differ among rotation systems both within and between years. This was, in part, due to large variations in allocatable variable costs, in commodity prices and crop yields. The experimental design accounted for the variation in the soil of the trial area, and for variation within and between season commodity prices and climatic conditions.

In almost all years the lucerne pasture had the highest gross margins of all systems tested, closely followed by the 6 year (WBLWBC) cash crop system (Figure 28). In some years the late onset of seasonal (autumn) rains resulted in poor pasture production that negatively affected livestock production (particularly in the rotation with alternate years of crops and pasture), and in large variations in soil physical properties that negatively affected cash crop production (particularly following two consecutive pasture years).

Gross margins for canola and lupin production, although sometimes low or even negative, were in general positive over all crop systems where it was included in the rotation. It is the system as a whole that is important and wheat yields following canola and lupin were on average at least 200kg/ha greater than where wheat followed wheat (even after two years of annual legume pastures). From research done on canola harvest losses it is clear that improved canola yields would be achieved with improved methods of harvesting the crop.

Additional observations:

- Input costs were lower in the pasture systems in comparison to the cash crop systems. Reasons for this include lower fertiliser, disease control and seed input costs, and a lower energy requirement to maintain the pasture systems.
- Fertilisers were the highest input cost for wheat and canola throughout the trial period.
- Seed costs were the highest in the continuous cropping rotation systems with lupin seed making a major contribution to that cost.
- Pest control costs were low in all crops and pastures relative to other input costs, but showed increased contributions in some crops in some years due to insect infestations. Input cost data from this trial indicate that canola production requires higher pest control input costs than all other crops and pastures in most years.
- The use of expensive herbicides such as Kerb® and Broadstrike® resulted in an increase in the input costs for the pasture phase of pasture-based systems as a whole.
- The amount, but more importantly the timing, of rainfall has a major effect on the production of annual legume pastures. In seasons when re-establishment of the pastures is slow due to a late start of autumn rains, livestock prevented the pasture from reestablishment and growth of the pastures and, most importantly, limited seed production which resulted in soil seed banks being depleted and the need to re-seed some of the pastures in some years thus increasing the input costs for those rotation systems. Furthermore, poor pasture dry matter production results in dramatic increases in livestock supplementary feeding costs in some years.
- The gross margins obtained were the most stable in the continuous lucerne and the two continuous cropping systems. The reason for the

performance of the cash crop systems has been explained, while the reason for the lucerne performance might be attributed to the very low allocatable variable costs associated with sheep production from lucerne pastures (relative to any of the other rotation systems tested). In addition, summer rains also promote growth of lucerne providing feed when annual legume pastures are not producing forage. Sheep grazing on lucerne pastures therefore required considerably less "bought feed" than the sheep on annual legume pasture systems (Tables 2 to 10 but in particular see Table 8c).

- The data obtained from the Tygerhoek trial support the common practice of combining a 6 year cropping phase with a 6-year lucerne phase on farm. From the results it is clear that a combination of these two systems would potentially show more stable gross margins than the systems tested in the trial.
- Although canola and lupin often showed low or negative gross margins as a crop, the inclusion of these alternative crops did not impact negatively on the gross margins of the systems that included them. The inclusion of such crops as part of an on-farm rotation system makes sense, in presenting other benefits such as spreading risk of negative fluctuations in input costs and commodity prices and facilitating the use of alternative "modes of action" when applying herbicides.
- The biggest risk for annual legume pastures is the late onset of seasonal rainfall, which negatively impacts on the production of these pastures. The farmer should plan to manage this risk through the provision of inexpensive, alternative feed sources during autumn until the annual legume pastures have established. A fodder shrub such as saltbush may be a viable option on some farms

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