The adoption of breaks crops in the Western Australian Wheat belt

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Introduction

In the Western Australian Wheat Belt, wheat and barley dominate the dryland agricultural farming systems. All other crops and pastures may be considered a form of break from the cereal. Crop rotation, or the use of break crops to manage disease, weeds, pests and soil fertility in cropping systems to ensure a field remains productive in the long term, is an old and established agricultural practice. Break crops have been a consistent feature of WA mixed farming systems as pasture breaks were needed in the early days of cereal production. Recent industry wide analysis from Western Australia suggest the proportion of oilseeds and lupins in the rotation has declined markedly since the turn of the century when 0.87 million hectares of oilseeds and 1.2 million hectares of lupins were planted across the state (ABS 2007). Approximately 0.53 million hectares are now sown to lupins and 0.41 million hectares are sown to canola (Figure 1) (ABS 2007). In contrast the area sown to wheat has fluctuated from 4 million hectares in 2007 to 5.1 million hectares 2004.

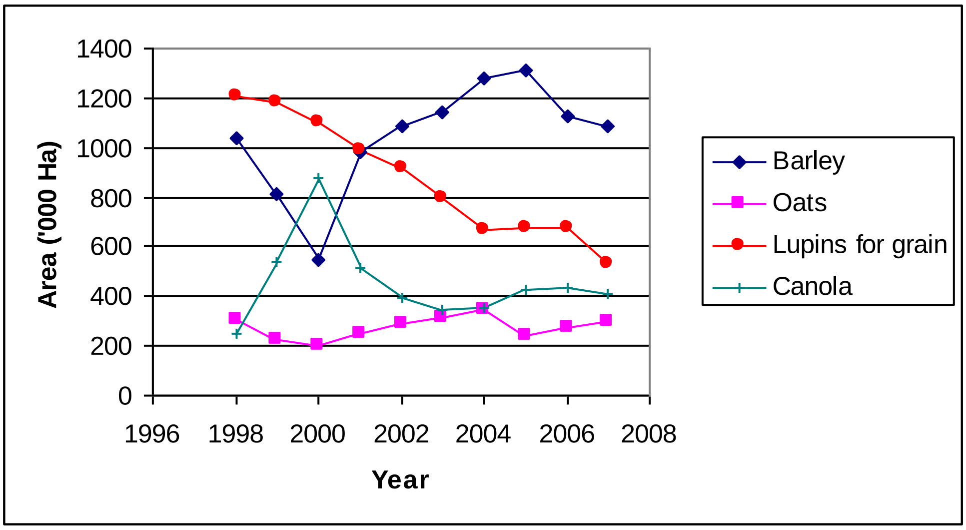

Figure 1. Area sown to Barley, Oats, Lupins and Canola from 1998 to 2007 for Western Australia. * Source ABS.

These industry-wide statistics imply that significant numbers of farmers have abandoned or reduced the area assigned to grain legumes and oilseeds. Industry wide trends capture general shifts in the production practices of farmers as a collective. However, individual farmers may adopt different practices and regardless of the industry trend, the amount of land devoted to break crops should vary from farmer to farmer. This variation could be explored to assess the effect of break crops on productivity. Recently, famer level industry data became available for statistical analysis in the Western Australian wheat belt and has been interrogated to gain insight into farmer decision making on break crops.

Industry information provides a unique insight into industry practise. However, few biological or process based insights can be derived from it. Nevertheless, it provides an historical account of farmers' behaviour. These insights can be confronting, as farmers make decisions based on a much broader suite of objectives than maximising crop yield (Sands and McArthy 2007). Additional factors such as the farmers' own perception of the risk of growing a particular crop, the expected return from a crop or pasture and their ability to grow and manage the crop or pasture successfully all influence the farmers' decision to grow legumes (Abadi 2000). Constraints, such as the availability of resources (rainfall, soil, finance, machinery and labour) may also influence the decision to grow legumes or oilseeds. These factors alone are likely to vary enormously throughout a district. As a consequence, industry data enables researchers to gain critical insight into the types of farming systems practiced by the industry at the farm scale.

In this study we analyse a survey data set derived from Farmanco Agricultural consultants who have collected economic and production data for 241 farm businesses from the low and medium rainfall zones of the Western Australian Wheatbelt. We classify the enterprise mix of these farms and explore the question of whether one 'type' of enterprise mix is more profitable than another. In addition, we identify the most 'typical' enterprise mix and finally, estimate the importance that the area allocated to break crops on the farm plays in influencing wheat yield, wheat profit and cost of production when other factors, such as growing season rainfall are accounted for in a statistical model. These analyses were conducted as part of the economic component of the GRDC LOOP project to discern the trends in the use of break crops.

Methods

Area, productivity, economic and enterprise data from 83 farms from a low rainfall region and 167 farms from a medium rainfall region were extracted from the Farmanco client database from 2004, 2005 and 2006. Records were not available for every farm in every year. Missing data were excluded from the analysis, not averaged or set to zero.

Table 1. Critical variables used in analysis of Farmanco data.

Farm Area (Ha)
Enterprise Area (Wheat, Barley, Lupin, Canola, Oats, Sheep, Cattle, Other)
Enterprise Yield (crops only)
Enterprise Ratio (Enterprise Area / Farm Area)
Whole farm profit / ha
Enterprise profit / ha
Total Enterprise costs / ha (Fixed plus Variable)
Variable wheat costs / ha
Fixed costs / ha
Growing Season Rainfall (April to October)
Farm (1..83 for low rainfall, 1..167 for medium rainfall)
Year (2004, 2005, 2006)

Profit estimates were conducted as earnings before interest and tax (E.B.I.T) allowing legitimate cross farm comparison where farms have different debt and tax liabilities.
EBIT = revenue - operating expenses, and includes profit before interest on loans and taxes are paid.
Prices reflect the returns from that year, they are not representative of today.
Variable costs accounted for cropping inputs and transport costs.
Fixed costs were the difference between total operating costs and variable costs.

Analytical Approach

Exploratory data analysis were conducted to evaluate the variation and extent and possible trends in enterprise mix from 2004 to 2006 in farms from the low rainfall and medium rainfall region of the WA wheatbelt.

A hierarchical cluster analysis was applied to the area allocated to each enterprise on the farm in 2006 to ascertain what, if any, particular enterprise mixes emerged. The dendrogram was cut at a height of 0.7 generating 6 groups. One group had a single member, and this farm was excluded from further analysis. Another group had just two members and these farms were also excluded from further analysis. Mean enterprise profit, costs and crop yields were calculated for the remaining 4 groups of farms in the medium rainfall region. The analysis was not repeated in the low rainfall zone because there was little variation in break crop use of farms. The enterprise mix was more uniform between low rainfall farms and they could not be meaningfully classified.

Linear models were developed using information criteria to ascertain the importance break crops have on wheat costs, wheat yield and wheat profit in low rainfall and medium rainfall environments. Linear models were constructed using a least squares approach. The models were selected using a stepwise approach and Akaike Information Criteria (AIC) to determine the most effective combination of effects.

Results

Medium Rainfall Zone

Median farm size increased from 2635 ha in 2004 to 2851 ha in 2006. Median wheat yields ranged from 1.46 t/ha in 2006 to 2.25 t/ha in 2005 with the top 25% of farms achieving yields of 1.78 t/ha or more in 2006 and 2.64 t/ha or more in 2005. Growing season rainfalls (GSR) (April to October) varied from season to season, where farms received a median GSR of 247 mm in 2004, 306mm in 2005 and 180mm in 2006. Farm profit was closely aligned to growing season rainfall, where median profits were $5.34/ha, $16.40 /ha and $-27.75/ha from 2004 to 2006 respectively. The top 25% of farms generated at least $34.80/ha, $50.00/ha and $22.76/ha profit from 2004 to 2006 (Figure 2).

Importance of break crops

In 2006, lupin crops and canola crops occupied 5% and 4% of grower's properties, while wheat occupied 34% and barley occupied 10% (Figure 3). Lupin, canola and barley percentages were characterised by an exponential distribution implying that a large number of farms grew very few or no break crops (Figure 3). This distribution suggests these crops are either of little importance to the majority of producers or used judiciously in a targeted way to enhance the overall profitability on farm.

Between 2004 and 2006 the area attributed to wheat, barley, lupins and canola cropping enterprises declined by 6, 1, 2 and 1 percent. Farmers may have had a tendency to reduce the total area cropped due to dry conditions in 2006 (data not shown). Accordingly, the area of breaks sown relative to the total cropped area did not change significantly from one year to the next. Lupins occupied 10% of the cropped area in 2004 and 2005 and 8.5% in 2006. Similarly canola occupied 5% of the cropped area in 2004 and 6% in 2005 and 2006. Therefore any decline in break crop area may be in response to an overall reduction in cropping area. However, these trends are small and measured over a short time frame. The variation between individual farmers is substantial and in the medium rainfall region was sufficient to explore the possible benefits associated with growing break crops at the farm level.

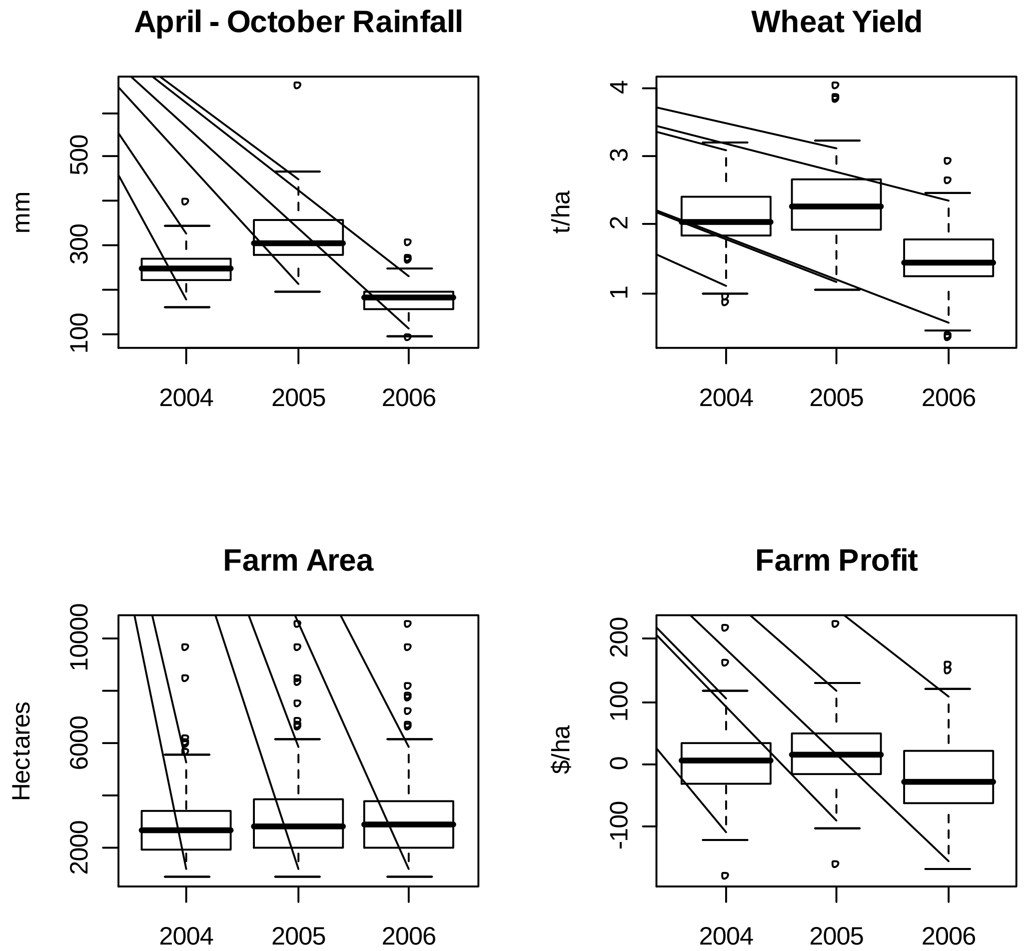

Figure 2. Boxplots of growing season rainfall, wheat yield, farm area and farm profit from 2004, 2005 and 2006 for the medium rainfall region. The bold line is the median value, the solid lines of the box indicate the 25th and 75th percentile, while the bars indicate the 10th and 90th percentiles. Individual points are data extremes.

Yield characteristics of lupins and canola

Lupin yields varied markedly from season to season. The 105 growers averaged 1.61 t/ha of Lupins in 2005. In 2006, 104 growers averaged just 0.86 t/ha and in 2004 96 growers averaged 1.19 t/ha. These yields varied markedly between growers, where the top 25% produced more than 1.47 t/ha in 2004, 1.9 t/ha in 2005 and 1.12 t/ha in 2006.

Canola yields also varied from season to season and 51 growers averaged 0.95 t/ha in 2004, 70 growers averaged 1.26 t/ha in 2005 and 68 growers averaged 0.73 t/ha in 2006. The top 25% of growers produced at least 1.12 t/ha in 2004, 1.49 t/ha in 2005 and 0.95 t/ha in 2006.

Cereals routinely out yield lupins and canola, where canola and lupins achieve approximately 50% of the cereals' yield. There was considerable variation in the lupin to cereal yield ratio for farms that grew wheat and lupins. In 2004 and 2006, lupin yields, on average, achieved 57% and 56% of cereal yield respectively. In 2005, when growing season rainfall was higher, lupin yields achieved 71% of cereal yield. Canola also performed poorly relative to cereals on farms that grew canola and wheat in 2004 and 2006. Canola achieved just 46% and 44% of wheat yield in those seasons. Again, in 2005, this ratio increased to 58%. Essentially, as conditions deteriorate, average farm lupin and canola yields deteriorate faster than average farm wheat yields.

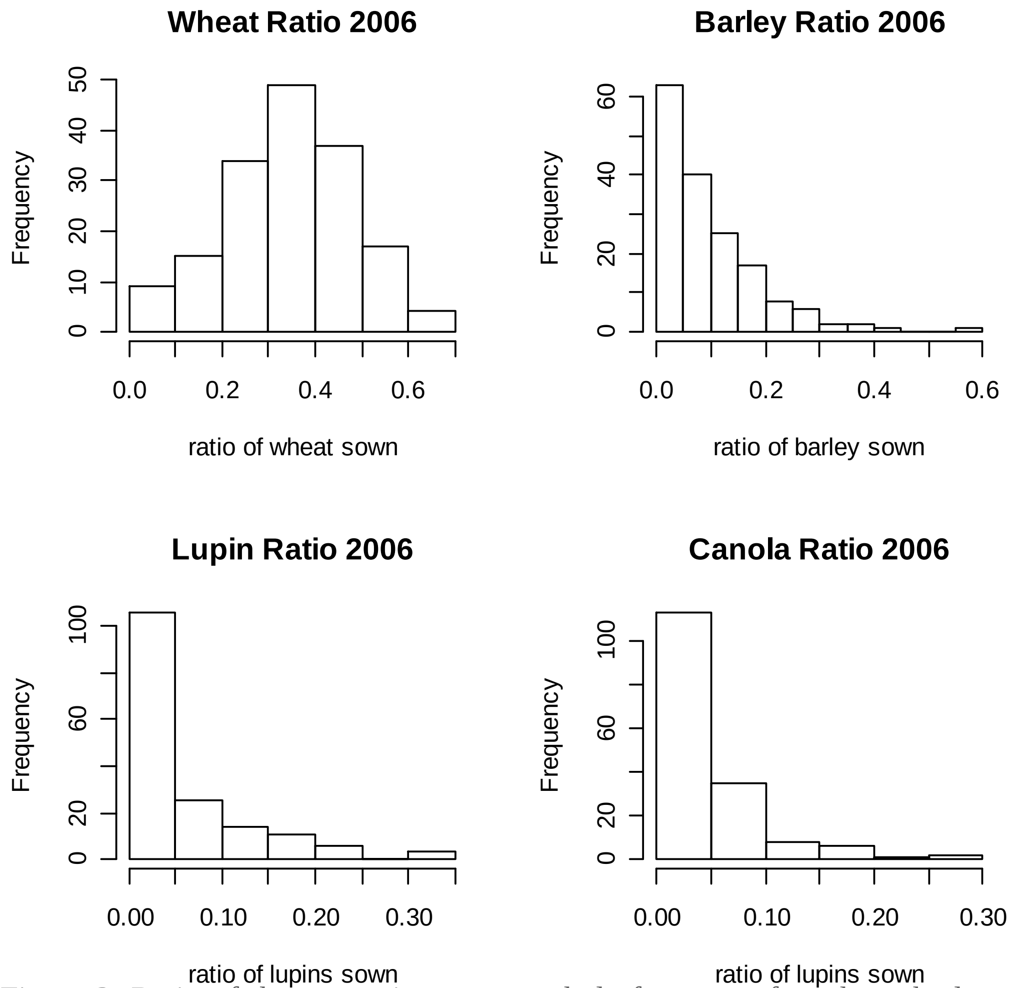

Figure 3. Ratio of the enterprise area to whole farm area for wheat, barley, lupins and canola in the medium rainfall region of the WA wheatbelt in 2006.

Profitability of cropping enterprises

Profitability of individual crops varied markedly between farms and crop species. In 2006, barley was the most profitable crop returning on average $45.93 ±12.43 /ha on average and the 20-25% of barley growers generated at least $137.80 profit from this crop. In contrast, 2006 operating profit for wheat averaged $-40.14 ± 8.18 /ha. The top 25% most profitable wheat producers generated at least $24.47/ha from their wheat enterprise (Figure 4).

Canola was grown by 70 producers who averaged $-26.86±16.83 and the top 25% were able to generate at least $75.16 operating profit from the crop. Although lupins were grown by 105 farmers, they were the least profitable returning an average of -98.20±11.84 /ha. The most profitable 25% did not all break even, returning at least $-33.98/ha. Only 19% of producers were able to grow a profitable lupin crop in 2006. In comparison, 38% of growers who grew canola did so profitably. 35% of wheat growers did so profitably and 63% of barley growers were also able to generate a profit from the enterprise (Figure 4).

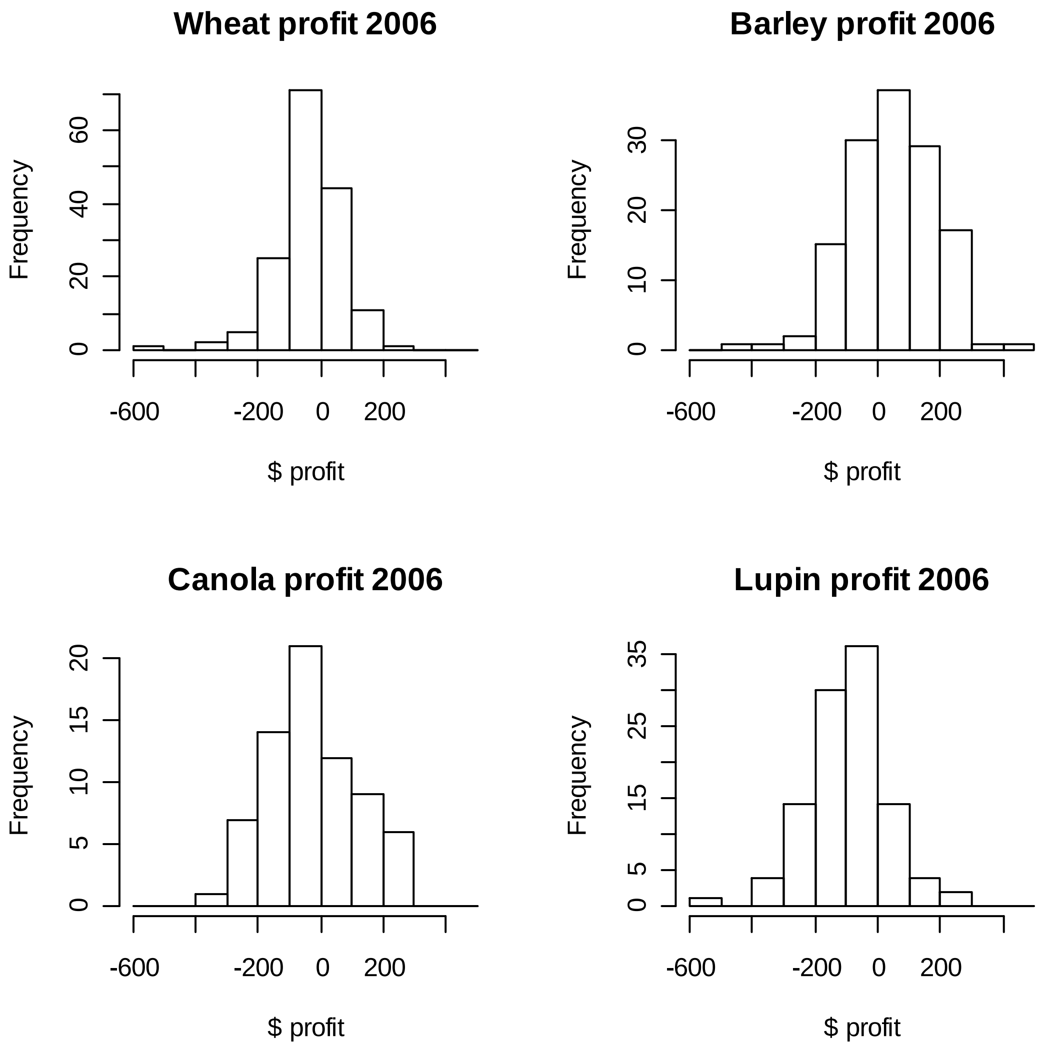

Figure 4. Wheat, barley, canola and lupin profit in 2006 from farms in the medium rainfall region of the wheat belt that grew these crops

Pasture and sheep

Livestock featured prominently in the medium rainfall region where the mean ratio of sheep grazing on pasture to whole farm area in 2006 was 0.4 and this was larger than the mean area assigned to wheat. A total of 16 farmers did not have sheep. Only 10 farmers operated a sheep trading enterprise, where sheep were agisted and a breeding flock was not maintained on the property. The remainder operated conventional wool or meat replacement flocks and some sheep were present on the farm for the entire year.

Cluster groups

Four distinct groups of farms where identified. The first group or classic mixed farm, was the most numerous with 82 of the 167 of farms as members. This group had large areas of pasture (47%) that was grazed by sheep. Wheat and barley were the dominant crops and on average occupied 32% and 9% of the farm respectively. 3% of the area was sown to lupins and 2% to canola. Other minor enterprises included oats, hay and pasture grazed by cattle.

The second group, or lupin – wheat farms were also common with 42 members. These farmers cropped 75% of the farm, with 25% of the area devoted to pasture production for sheep. Cereals (wheat 48% and barley 6%) occupied 54% of the area while lupins occupied 12% and canola 5% of the area. These were the most dominant lupin growers on a per area basis.

The third group with 24 members are livestock dominant farmers where 66% of the property is devoted to pasture for sheep. Cereals (wheat 11% and barley 7%) were the dominant crops with lupins (2%) and canola (4%) of comparatively minor importance.

The final group, with 15 members are intensive croppers. Pastures occupy just 12% of the property. The cropping operation is dominated by cereals (wheat 41% and barley 27%). Lupins 3% and canola 6% are not prominent in these farming systems, suggesting cereals must be planted after each other on a regular basis.

Although a myriad of farming systems are used by this group of farmers, pasture provides the most common break from a cereal. From the perspective of providing a disease, weed or nutrient boost for cereals, the greatest gains may be achieved by improving and appropriately managing pastures explicitly for this purpose.

Profitability of cluster groups

The whole farm profit / ha was highest for the intensive croppers (group4) with $24 and $48 / ha in 2006 and 2005 but were the least profitable $-22/ha in 2004. The mixed farmers (group1) and lupin wheat famers (group2) had similar levels of profitability in all three years (Figure 5). These two groups accounted for 75% of farmers surveyed and group profitability trended towards the overall mean. Livestock dominant farmers were the least profitable in 2006 ($-56/ha) but second most profitable in 2005 ($15/ha) (Figure 5). The variation in whole farm profit between the groups from year to year and from one farming system to the next suggests the execution of that farming system, rather than the enterprise mix of the farming system influences the whole farm profitability.

Wheat yield and profitability from the wheat enterprise varied slightly between the 4 groups (Figure 6). The livestock dominant farmers had the lowest yields and least profitable cereal crops. The mixed farmers and lupin wheat farmers had more profitable crops than the dominant croppers in 2004, but lower yields and less profitable crops in 2006. Therefore, wheat profitability varied between the groups of farms and no particular farming system with 50% or more of the farm in crop produced the most profitable wheat crops ever year.

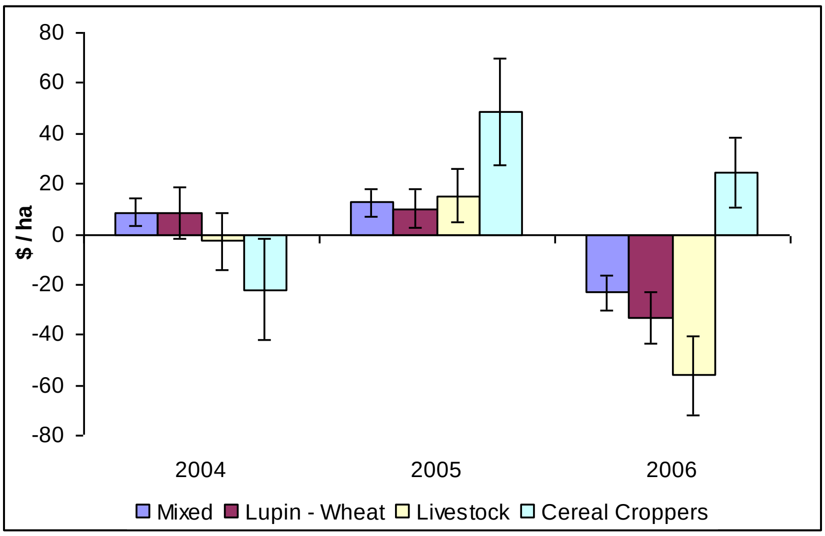

Figure 5. Whole farm profitability / hectare for the four types of farms; mixed, lupin-wheat, livestock dominant and cereal croppers. Error bars are the standard error of the mean

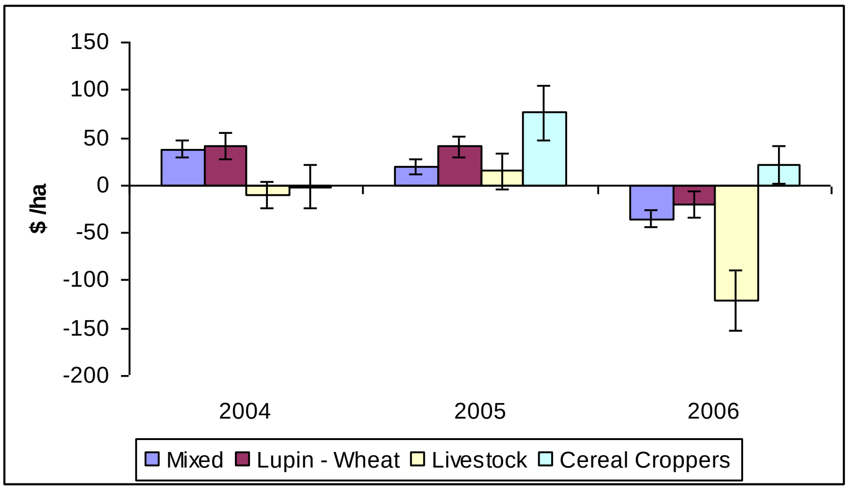

Figure 6. Wheat profitability / hectare for the four types of farms in the medium rainfall zone; mixed, lupin-wheat, livestock dominant and cereal croppers over three seasons. Error bars are the standard error of the mean.

Geographic Location of cluster groups and enterprise proportion

Cluster groups

The most prevalent groups, the mixed farmers were distributed evenly throughout the medium rainfall zone of the WA wheatbelt (Figure 7). Livestock dominant farmers were concentrated around Narrogin and west of Katanning, while the cereal croppers were predominantly located near the south coast of the state. There were exceptions and some livestock dominant farmers and cereal croppers were located in the Northern Agricultural region. Lupin – Wheat growers were principally located in the Central and Northern Agricultural regions, although some were present in the southern and central regions of the wheat belt. Overall, there were slight, but not substantial spatial trends in the spatial distribution of cluster groups, and importantly positional data were only available for 135 of 167 farms surveyed.

Wheat percentage

Wheat is the dominant crop grown in the wheat belt, but the proportion of wheat grown on farm varied markedly between farmers. Geographic trends were evident, with higher proportions of wheat grown in the Avon and Northern Agricultural regions than the Southern region (Figure 8). Wheat was also prevalent along the South Coast. There were occasional outliers, with some farmers growing more wheat than their neighbours in the south. Conversely, some grew a lower proportion of wheat than average in the north. The basis for these variations could not be resolved with the data available.

Lupin percentage

Strong geographic trends were evident for lupins (Figure 9). They were popular in the Northern Agricultural and Avon regions where many lupins occupied between 10 and 32% of the farm. However these farmers were interspersed with others who had abandoned lupin production and it is clear that farmers in comparatively similar rainfall zones in similar agro-environments have adopted disparate farming systems. Lupins were less popular in the southern and south coast regions, but again, there were occasional outliers.

Canola percentage

No geographic trends were evident for canola. Farmers who grew little or no canola often resided near farmers who sowed more than 10% of their farm to canola. Regional differences were difficult to interpret (Figure 10).

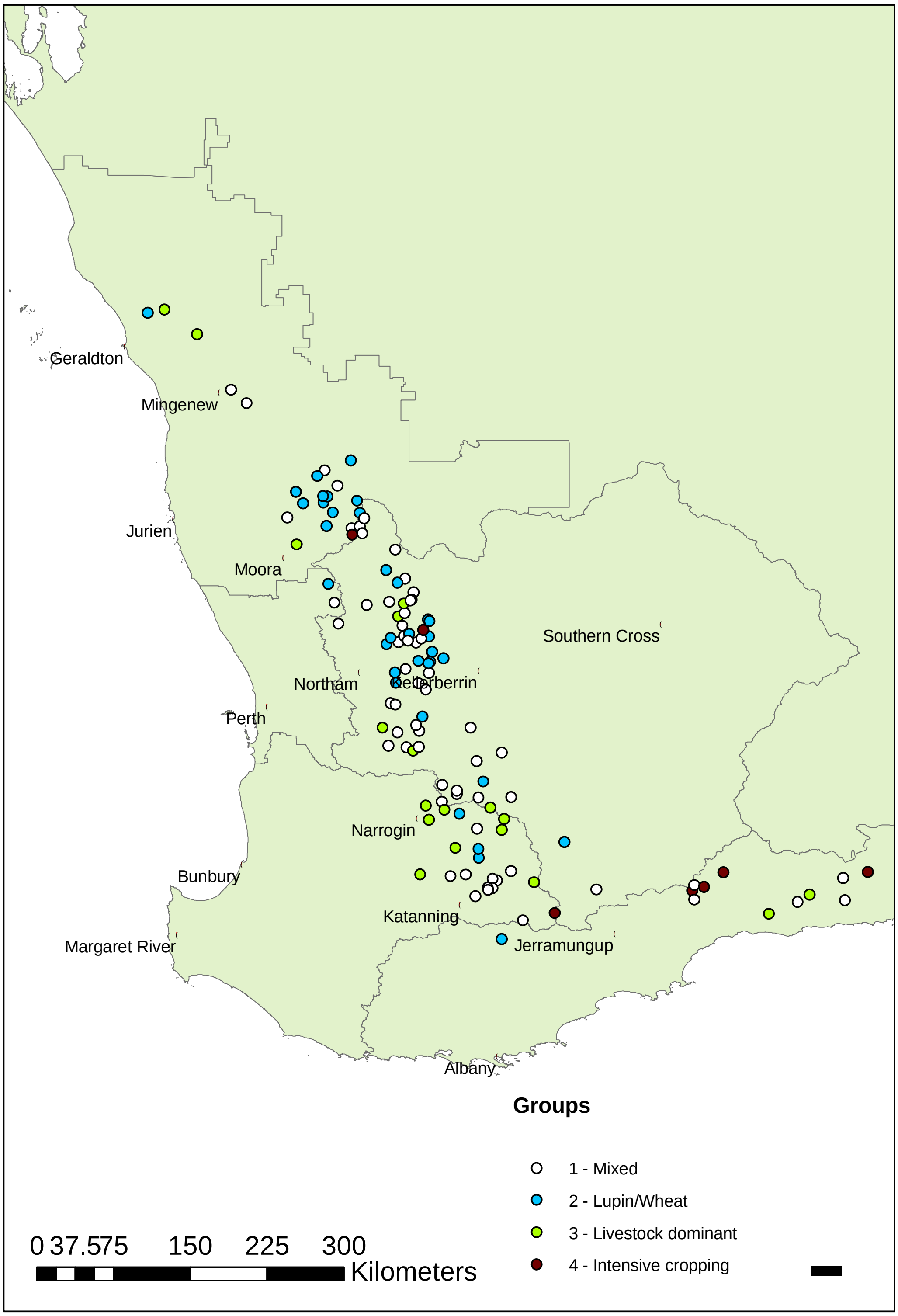

Figure 7: Geographic location of farm groups in the medium rainfall zone of the WA wheatbelt.

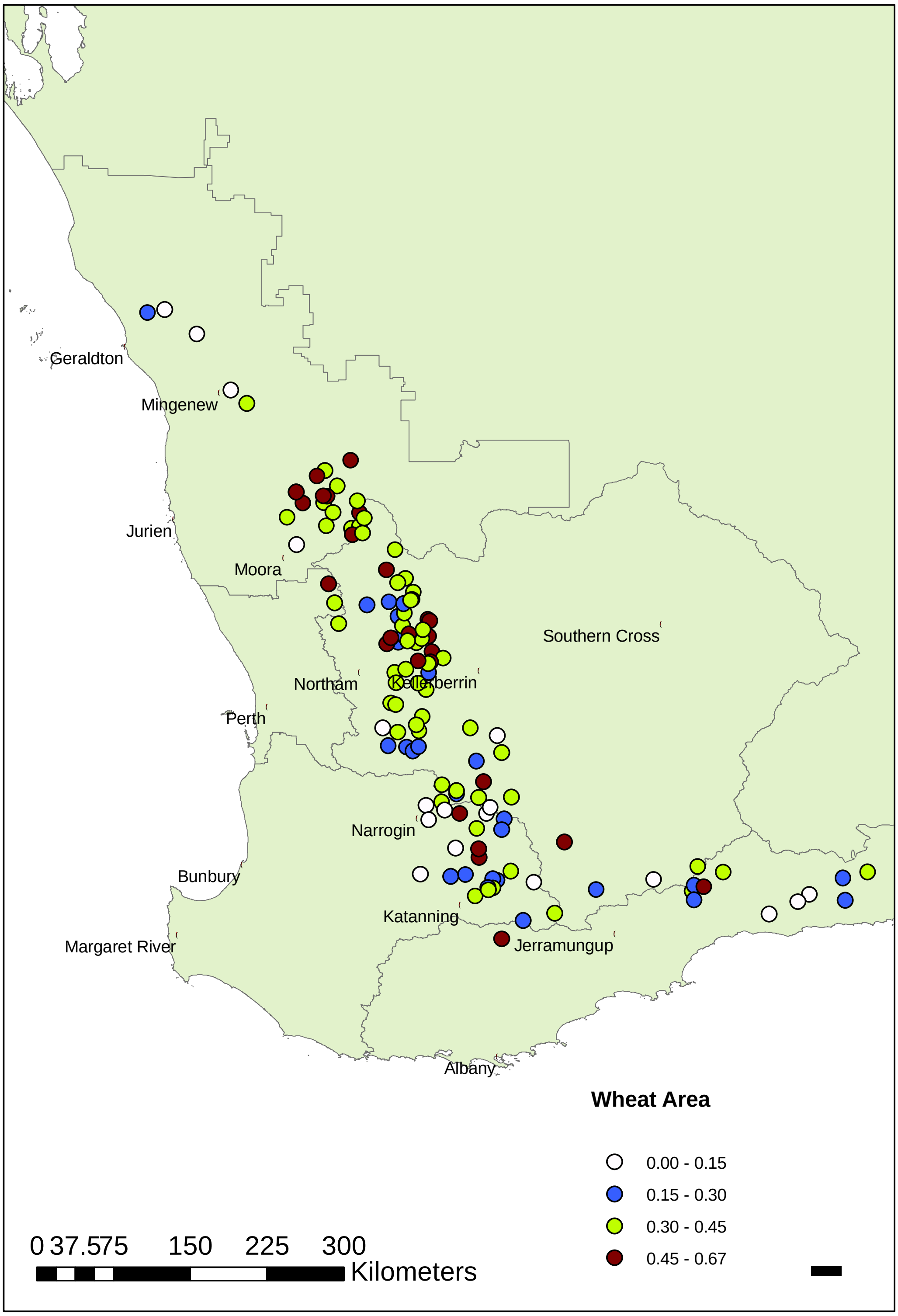

Figure 8: Geographic location of portion of wheat sown on properties in the medium rainfall zone of the WA wheatbelt.

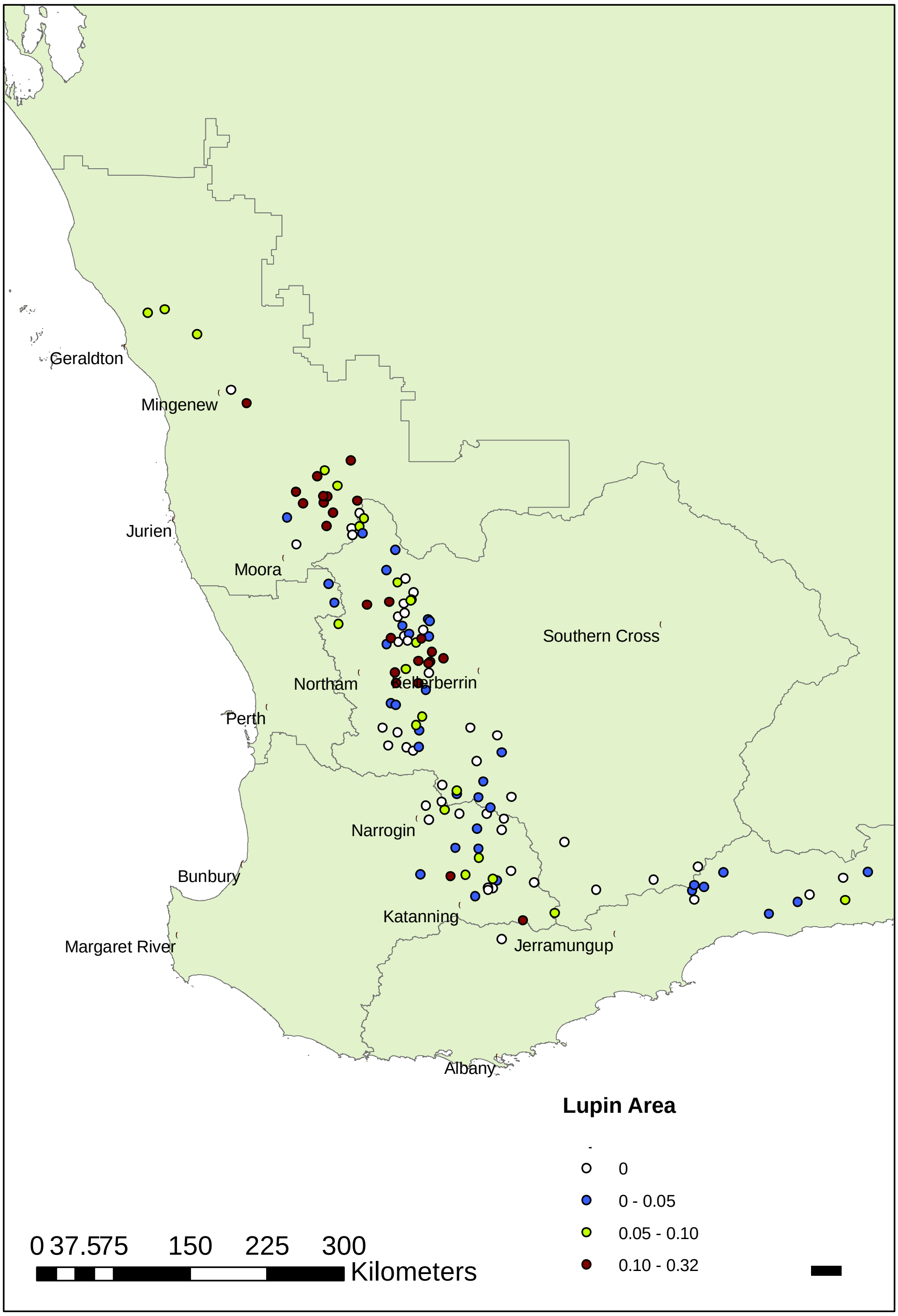

Figure 9: Geographic location of portion of lupins sown on properties in the medium rainfall zone of the WA wheatbelt.

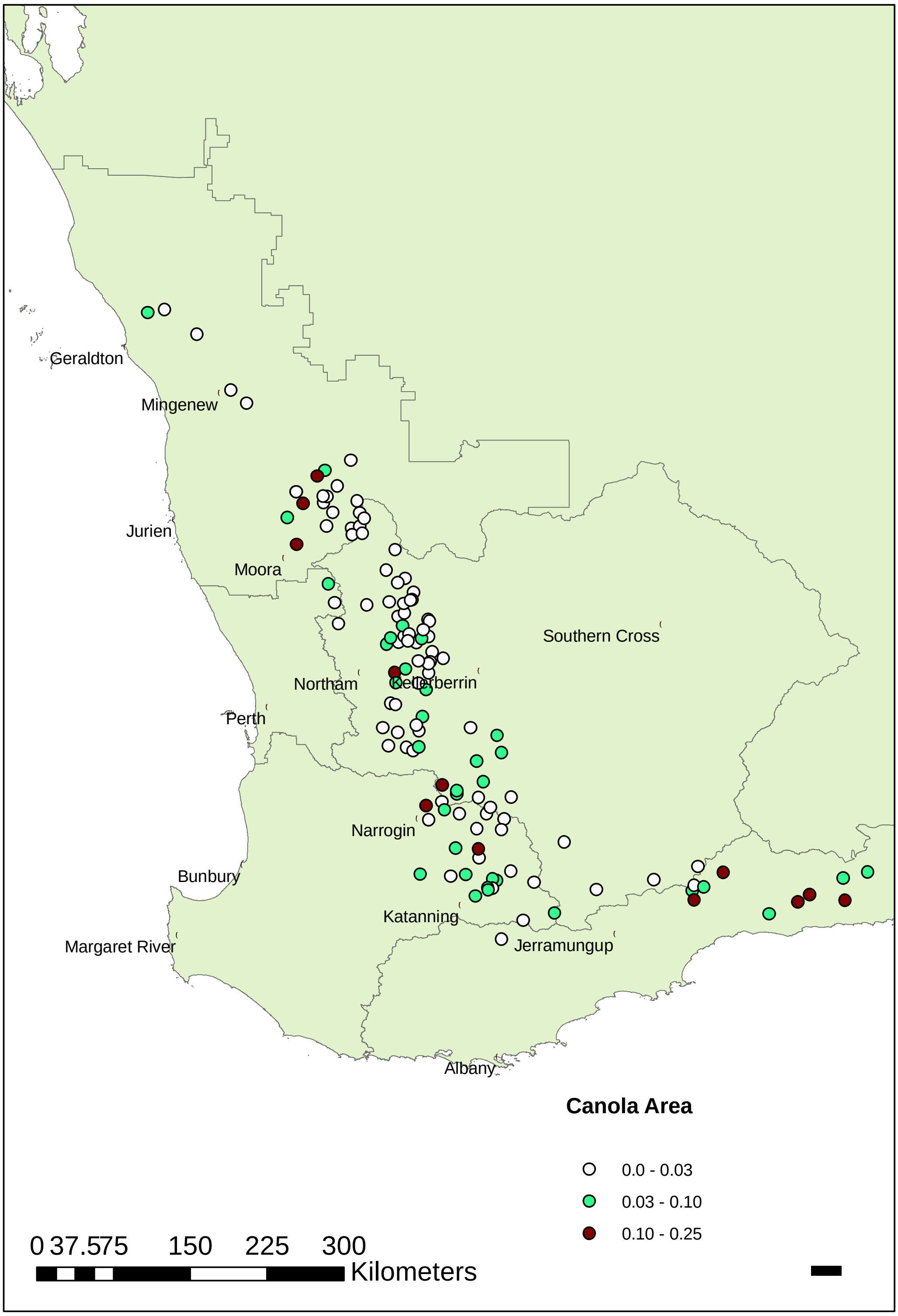

Figure 10: Geographic location of portion of canola sown on properties in the medium rainfall zone of the WA wheatbelt.

Regression analysis on farm profitability data

Wheat yield was primarily influenced by the farm of origin, growing season rainfall and the year the crop was grown in. The ratio of wheat area to whole farm area and the ratio of break crop to whole farm area were retained in the model (eq 1).

$$Yield_{ijklm} = mean + farm_i + b_j*gsr_j + b_k*w\_ratio_k + b_l*b\_ratio_l + year_m + error_{ijklm} \quad (eq1)$$

Where yield is the wheat yield (t/ha) for the i[th] farm, with j[th] growing season rainfall, k[th] wheat ratio, l[th] break crop ratio, for the m[th] year.

The model accounted for 84.4% of the variation in wheat yield with farm, growing season rainfall and year capturing 46, 33 and 2.8% of the explained variation respectively. The grand mean from equation 1 was 0.53 t/ha, which is low because the effects were not evenly distributed. Farm effects ranged from -0.7 t/ha to +1.40 t/ha. Every mm of growing season rainfall increased crop yield by 0.0033 ± 0.0004 t/ha, so a 50mm increase in growing season rainfall increased crop yield by 0.16 t/ha when all other effects were accounted for. Yields in 2006 were 0.32 t/ha lower than 2004 and 2005, although there was no difference between yields in 2004 and 2005. The ratio of break crops grown on the farm accounted for 1.07% of the variation and positively influenced wheat yield by 0.0168 ± 000.4 t/ha for every 1% of the farm sown to break crops. Therefore if 10% of the farm was sown to break crops, wheat yields would, on average be 168 kg/ha higher than a farm without break crops.

This increase in yield due to break crops translated into a higher profit for the wheat crop. Wheat profit was generally explained by farm, growing season rainfall, year, wheat costs, wheat area relative to total farm area and the area of lupins relative to whole farm area. Farm area also improved the model. (eq 2)

$$Wheat\_profit_{ijklmno} = mean + farm_i + b_j*gsr_j + b_k*w\_ratio_k + b_l*lupin\_ratio_l + year_m + b_n*farm\_area_n + b_o*wheat\_costs_o + error_{ijklmno} \quad (eq2)$$

The model accounted for 70% of the variation in wheat profit, with farm, growing season rainfall and year explaining 49.5%, 13.8% and 2.7% of the variation respectively. Year captures edaphic factors other growing season rainfall that broadly influence yield in that season. The grand mean was $-383 / ha, while farm effects ranged from $– 88/ ha to $395/ha. Every mm of growing season rainfall contributed an additional $0.56/ha, so a 50mm variation in growing season rainfall contributed an additional $28 profit. The differences between years was small and increasing wheat costs decreased wheat profit by $1.70/ha. Lupin area, on average, returned an additional $390.1/ha ± $110/ha to the wheat crop. Therefore, a farm with 10% lupins generated an additional $39/ha profit for the wheat crop when compared to a farm with no lupins.

Low Rainfall Farms

There were fewer low rainfall farms (83) than medium rainfall farms (167). In general rainfalls were 50mm below those of the medium rainfall counterparts (Figure 1 cf. Figure 11), although there was considerable variation between farms (Figure 11). Median growing season rainfalls were 217mm in 2004, 253 mm in 2005 and 151mm in 2006 (Figure 11). Seasonal trends in wheat yields followed a similar pattern and median yields 1.39 t/ha in 2004, 1.71 t/ha in 2005 and 1.0 t/ha in 2006 (Figure 11). The top 25% of farms for wheat yield achieved at least 1.75 t/ha, 2.1 t/ha and 1.33 t/ha in these seasons. Farms were larger in the low rainfall region and farm size remained relatively constant from 2004 to 2006. In 2006 median farm size was 3200 ha although the largest 25% of farms were at least 4450 ha (Figure 11). Farm profit / ha was noticeably lower than the medium rainfall farms. Median farm incomes in 2004 were $-23.12 / ha, increasing to $-1.32 / ha in 2005 and declining again to $-48.97 in 2006 (Figure 7). The most profitable 25% of farms generated a return of at least $0.0 / ha in 2004, $24.50 in 2005 and $-10.59 in 2006.

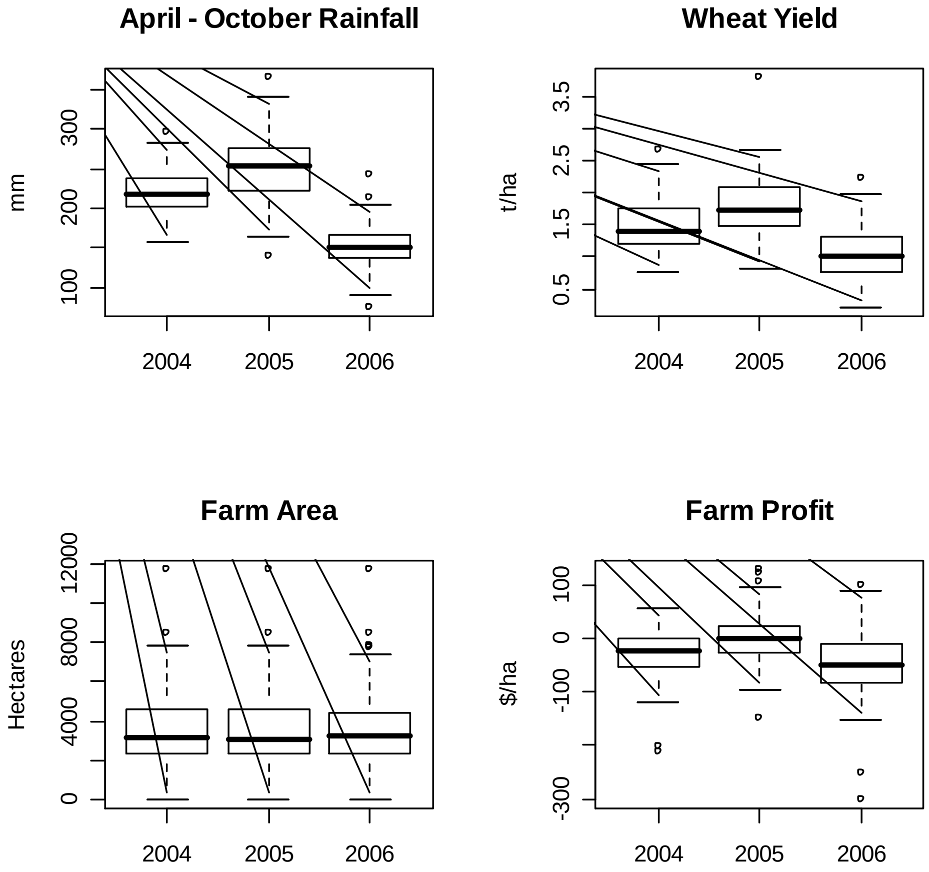

Figure 11. Growing season rainfall, wheat yields, area and whole farm profit of 83 farms from the low rainfall region in 2004, 2005 and 2006.

Regression analysis of the importance of break crops

Break crops did not influence wheat yield or wheat profit. Wheat yield and wheat profit were not influenced by ratio of break crops to whole farm area. However, the area assigned to break crops did increase the cost associated with growing wheat by $25/ha assuming 10% of the farm was planted to lupins. Most of this increase occurs through higher variable costs, which were $20 / ha higher for farms with 10% of the area assigned to lupins.

Discussion

Break crops play a relatively minor role in medium and low rainfall farming systems. The dominant break from cereal is pasture, and most farm income is derived from cereal production. In addition, many farmers can grow cereals, lupins and canola in seasons with adequate rainfall, but as rainfall decreases, lupin and canola yields decrease more than cereal yields.

Despite this finding a small portion of farmers can profitably grow legumes and oilseeds and the basis for their success should be explored to determine whether it is due to an abnormally favourable combination of soils and rainfall, or superior management skill.

If a higher degree of management skill is required to grow legumes, then it is conceivable that the perceived risk associated with growing these crops is much higher than the risk associated with growing cereals. However, if legumes and oilseeds are unsuited to the combination of soils and rainfalls prevalent on most farms then the area sown to these crops is unlikely to increase until the potential yield of legume and oilseed crops improves on the dominant soil types.

These issues raise fundamental questions about the role of break crops in low and medium rainfall farms in the Western Australian wheatbelt. Are they viewed as a mechanism to enhance the yield of subsequent wheat crops? Or are they viewed as an independent enterprise which must generate a healthy financial return like other enterprises on farm? Whatever the outcome, the purpose of break crops needs to be considered carefully. If farmers are growing them to be profitable in their own right, then direct comparison with cereal production is warranted. If they are grown as break even or low-cost solution that provides a foundation for subsequent cereal crops then the costs associated with this action must be compared with those of a legume pasture. In this situation, all costs and benefits associated with break crops, including disease breaks, nutrient cycling, possible increases in herbicide use and likely build up of herbicide resistance weed populations must be carefully evaluated. If break crops are used and they increase the cost of growing a wheat crop and deliver a negative return to growers then their role in this farming system may be questioned.

Research Direction

It is imperative that the agro-environment of break crops be carefully defined to ensure farmers know what season, what soil type and in what rotational context break crops should be grown in. In addition, their contribution to paddock level and farm level profitability must be considered carefully. The costs and benefits associated with growing break crops will express themselves at the paddock level across seasons and at the whole farm level where efficiencies may be gained in livestock enterprises and utilisation of machinery capital. Additional paddock level data should be interrogated to inform future research, extension priorities and decision support systems that model the costs and benefits of break crops. Whole farm data should be analysed to incorporate spatial and soil components to isolate the factors that influence farmer's decisions to grow break crops. For example, some farmers may be avoiding break crops simply because their soils are unsuitable, or the growing season rainfall is too low. Whatever the reason, detailed interrogation of paddock level and farm level data is likely to provide important insights into the apparent dis-adoption of legume and oilseed crops.

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