Macadamia industry benchmark report

2009 to 2018 seasons

Project MC18002

Queensland Government

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Acknowledgements

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Disclaimer

About the benchmarking project

The benchmarking project is supporting improved productivity and profitability within the Australian macadamia industry. The current project builds on previous benchmarking and best practice work conducted since 2001.

Yield, quality and planting information has been collected annually from macadamia farms throughout Australia since 2009. This information is provided either directly by growers or by processors on their behalf. Cost of production data has also been collected annually since 2013.

Each season all benchmarking participants receive a confidential, personalised report that compares their individual farm performance with the average performance of similar farms based on a range of criteria including region, locality, farm size, management structure, irrigation status and tree age. These reports highlight individual and average farm performance trends over multiple seasons.

This industry report provides all industry stakeholders with a summary of yield, quality and cost of production trends within the Australian macadamia industry.

Benchmark data supports a range of industry projects and initiatives. **Figure 1** shows some of these major linkages and the benefits gained from availability of reliable trend data for decision making.

Although summary information such as that published in this report is provided to a range of industry stakeholders, it is important to note that individual farm business data remains strictly confidential.

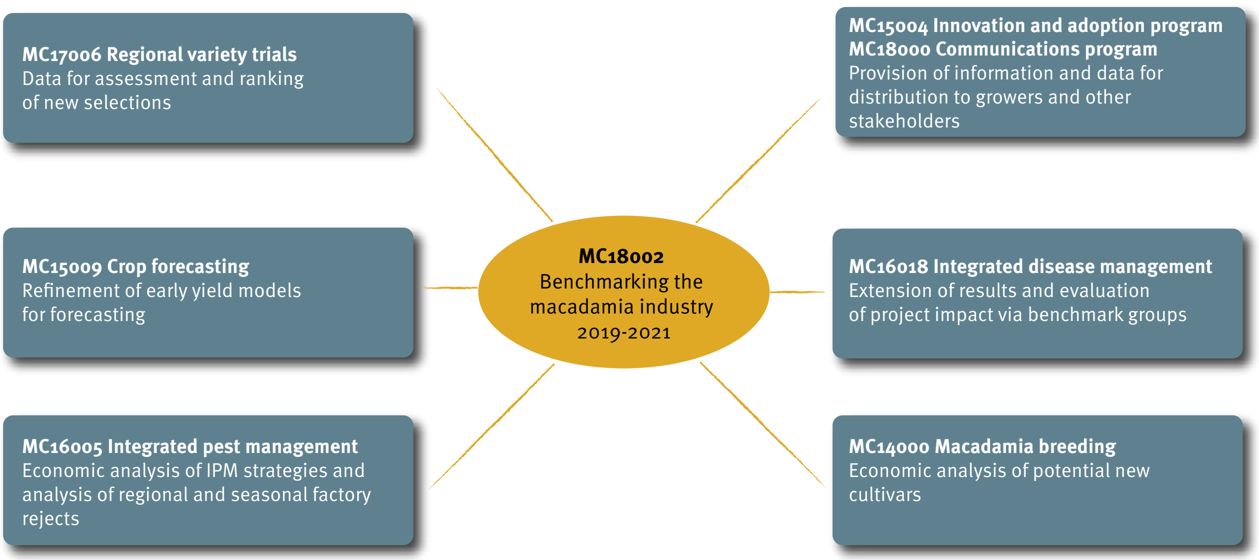


Figure 1: Benchmark project linkages

Scope and coverage

This report summarises macadamia farm yield and quality results for the 2009 to 2018 seasons and production costs for 2013 to 2018. Many of the yield benchmarks presented are based on tonnes of nut-in-shell (NIS) or saleable kernel (SK) per bearing hectare as these are widely accepted measures of orchard productivity.

Major production regions are shown in **Figure 2**. These are Central Queensland (CQ), South East Queensland (SEQ), Northern Rivers of New South Wales (NRNSW) and Mid North Coast of NSW (MNNSW).

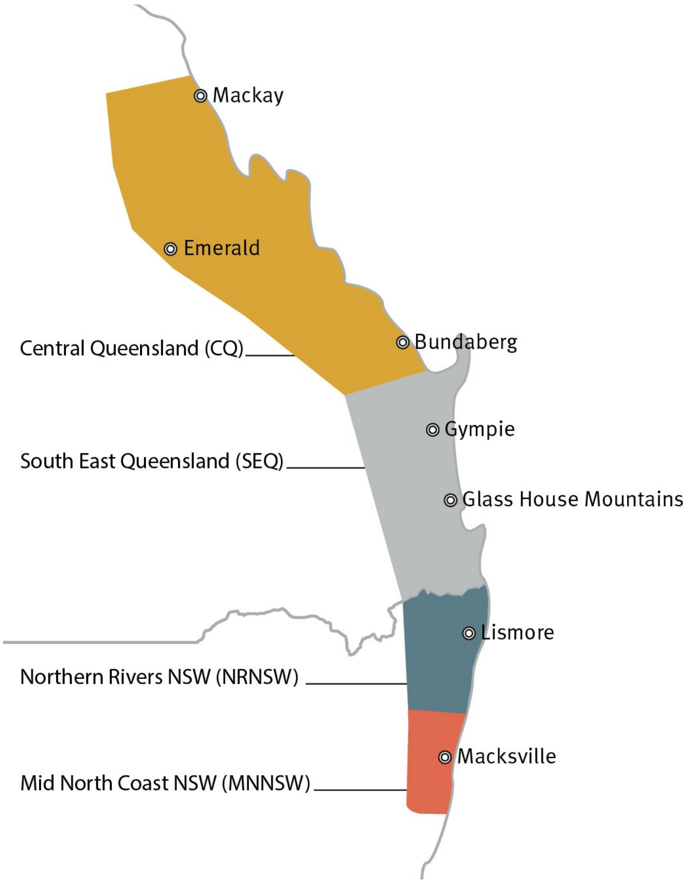


Figure 2: Production regions and localities participating in benchmarking

Table 1 shows the number of bearing farms participating in benchmarking in each major production region for the 2018 season. It also shows median farm size, average tree age and cost of production for farms within each of those regions. Total planted hectares can vary substantially between farms, particularly in some regions. Median rather than average planted hectares per farm are presented as these better represent typical farm sizes in these instances.

A total of 272 bearing farms submitted data for the 2018 season. These farms totalled 10,487 hectares and produced approximately 31,359 tonnes of NIS at 10% moisture content. This represents approximately 59.3% of the industry's total production in 2018, based on the Australian Macadamia Society estimate of 52,900 tonnes of NIS at 10% moisture content (published December 2018).

In 2018 more than half of all farms in the benchmark sample (53%) were from NRNSW, although the region accounted for a smaller percentage of the sample by production (25%). There were fewer farms in the CQ region (19%) however their relatively high median size meant that this region accounted for the largest percentage of the sample by production in 2018 (56%).

2018 regional breakdown

Region	Bearing farms	% of sample by number of farms	Mature cost of production farms	Costs per hectare	Costs per tonne of saleable kernel	Average tree age	Total planted hectares	Median planted hectares per farm	% of sample by planted hectare	Total NIS tonnes	% of sample by NIS tonnes
Central Queensland (CQ)	51	19%	22	$9884	$9728	14	5328	58.8	51%	17,582	56%
South East Queensland (SEQ)	52	19%	10	$8385	$6841	24	1454	13.1	14%	4862	15%
Northern Rivers of NSW (NRNSW)	143	53%	38	$7290	$9447	24	3303	17.1	31%	7765	25%
Mid North Coast of NSW (MNNSW)	26	9%	12	$8098	$10,348	20	402	7.6	4%	1150	4%
All regions	**272**		**82**	**$8238**	**$9337**	**18**	**10,487**	**18.7**		**31,359**	

Table 1: Regional distribution of farms in the 2018 benchmark sample

Table 2 shows the number of farms participating in benchmarking since 2009. Yield and quality data collected from bearing farms during that time totals 2414 farm-years. The term farm-year is used to describe data for an individual farm for a given year.

Since 2013 some participating businesses have also submitted data relating to costs of production. Cost data collected from farms between 2013 and 2018 totals 349 farm-years. A total of 85 bearing farms submitted cost data in 2018, totalling more than 3790 planted hectares. This represents approximately 37% of sample production and 22% of total industry production that year.

Participating farms by season											
Seasons	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2009–2018**
Yield and quality											
Mature farms	144	153	163	202	218	224	237	245	263	264	**2113**
Bearing farms	178	184	192	243	262	267	271	271	274	272	**2414**
All farms	192	195	207	252	265	268	271	273	278	278	**2479**
Cost of production											
Mature farms	–	–	–	–	36	37	33	48	64	82	**300**
Bearing farms	–	–	–	–	47	47	40	54	71	85	**344**
All farms	–	–	–	–	47	47	40	54	74	87	**349**

Table 2: Number of farms participating in benchmarking for each season and number of farms participating in cost of production 2009–2018

What you need to know about the data

Please consider the following points when interpreting results in this report:

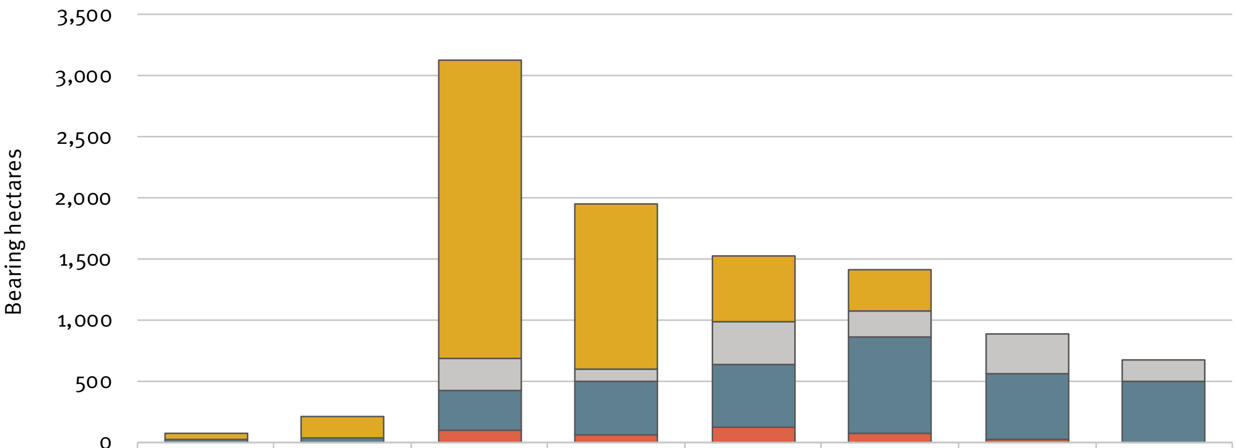
- Averages presented for any given season are based on data from a minimum of ten farms. This minimum is applied to safeguard the confidentiality of individual farm data.
- Average farm performance over multiple seasons is derived only from farms that have provided data for a minimum of four seasons. This is to minimise the impact of seasonal variability on long-term averages.
- All weights presented are based on the industry-standard moisture content of 10% for nut-in-shell and 1.5% for kernel.
- Plantings less than five years of age are generally excluded from estimates of bearing hectares. This is important for consistency across the benchmark sample.
- The sum of reject kernel category values presented equates to the total reject kernel recovery percentage, rather than totalling 100%. This standard is applied for consistency across the benchmark study.
- While we try to use well recognised terms to describe kernel recovery and reject analysis categories, processors may sometimes use different terminology to describe similar reject categories.
- Unless otherwise stated, all averages presented are unweighted. This means that all farms in the sample exert an equal influence on the average regardless of their size.
- The term farm-year is used to describe data for an individual farm for a given year. Unless otherwise specified, averages that span multiple seasons are derived from all available seasons.
- Cost data reported for any given season includes all cash costs incurred in the preceding financial year (2012/13 to 2017/18). Costs such as capital expenditure, depreciation and taxation are excluded.
- From 2017 onwards unpaid labour hours have also been collected. The value of this labour has been imputed at a nominal rate of $30 per hour to derive a more complete picture of orchard expenditure, particularly on owner-operated farms. Imputed labour includes physical labour undertaken by owners or managers that a farm employee would otherwise undertake under the direction of a manager or foreperson. It therefore includes activities such as tractor driving, mowing, harvesting, servicing machinery, fertiliser spreading and pest and disease control. It does not include higher-level management activities or decision-making.
- Unless otherwise stated all farm costs per hectare are based on total planted hectares. This may include non-bearing hectares for some farms as most businesses do not separate costs by tree age within their accounting systems.
- Heads of expenditure shown in this report are based on a standard chart of accounts, developed in conjunction with accountants and financial advisors. This is used to ensure consistent interpretation of costs across multiple farm businesses.
- Some averages may be based on subsets of all available data. Atypical or non-representative data may be excluded from some analyses to avoid adversely skewing averages. Where this has occurred it will generally be indicated in results (e.g. mature farms only).

Plantings

Figure 3 shows a breakdown of bearing hectares by region and tree age within the benchmark sample. Plantings less than five years of age are not considered bearing and are therefore excluded. Some farms, particularly in the Central Queensland (CQ) region, harvest nuts from four year old trees but these are usually small volumes. As individual tree ages vary between plantings on many farms, tree age categories shown in the chart are based on a weighted average tree age for each farm.

Farms with an average tree age between 10 and 14 years comprised the largest number of bearing hectares in the 2018 benchmark sample. This corresponds with trees planted between 2005 and 2009. Most of the farms in this age group are located in the CQ region, as are those in the 15–19 years age group.

Farms in the Northern Rivers of NSW (NRNSW) region have the widest diversity of average ages, from 8–9 years through to more than 35 years of age.

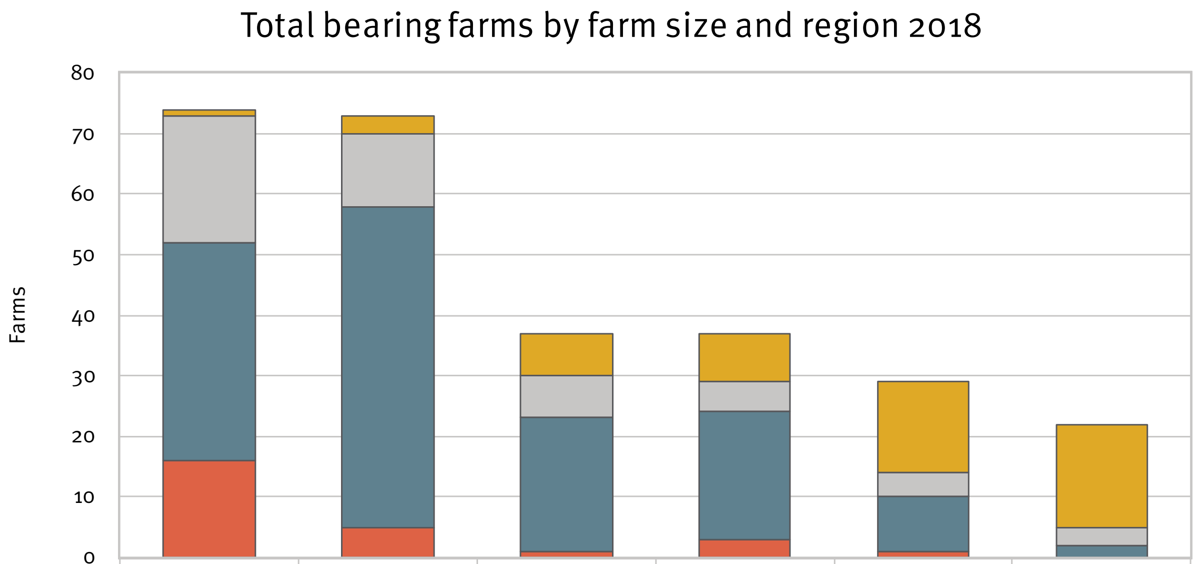


	5 to 7 years	8 to 9 years	10 to 14 years	15 to 19 years	20 to 24 years	25 to 29 years	30 to 34 years	35+ years
CQ	50	184	2,439	1,352	538	337	0	0
SEQ	0	0	264	105	359	215	316	171
NRNSW	29	33	331	431	508	788	536	502
MNNSW	0	0	96	64	126	71	30	0

Figure 3: Total bearing hectares for farms participating in benchmarking in 2018, displayed by tree age and region

Figure 4 shows a breakdown of farms in the benchmark sample according to their size. The chart shows the number of farms within each major production region for farm size categories ranging from less than 10 hectares to more than 100 hectares.

More than half of farms in the sample had less than 20 hectares of bearing trees. The majority of these farms are located in the Mid North Coast of NSW (MNNSW), NRNSW and South East Queensland (SEQ) regions. By comparison, the majority of larger farms (> 50 hectares) were located in the CQ region. Approximately 8% of farms in the sample had more than 100 hectares of bearing trees.



	< 10 ha	10 to 20 ha	20 to 30 ha	30 to 50 ha	50 to 100 ha	> 100 ha
CQ	1	3	7	8	15	17
SEQ	21	12	7	5	4	3
NRNSW	36	53	22	21	9	2
MNNSW	16	5	1	3	1	0

Figure 4: Number of bearing farms participating in benchmarking in 2018, displayed by farm size and region

In 2018 the median size of farms in the benchmark sample was 18.7 hectares. Average farm size was significantly higher at 36.9 hectares. This variation is due to the inclusion of a few very large farms in the sample.

Summary of the 2018 season

Figure 5 shows average yield, quality and cost measures for all 272 bearing farms in the benchmark sample in 2018. This includes some young farms that are yet to reach full maturity. Corresponding long-term averages or totals are shown in brackets. These figures span 2009 to 2018 for yield, quality and planting information and 2013 to 2018 for costs.

The 2018 season proved to be a successful year for many benchmark participants, with improved productivity and quality averages compared to both the 2017 season and long-term averages. Average productivity per hectare in 2018 was 3.06 tonnes per hectare (t/ha) nut-in-shell (NIS) and 1.03 t/ha saleable kernel (SK). This was higher than the long-term average of 2.58 t/ha NIS and 0.83 t/ha SK. Saleable kernel recovery (SKR) was also slightly higher in 2018 (35.74%) than the long-term average (34.05%).

Average total production costs were higher in 2018 ($8238/ha, $9337/t SK) than the long-term average ($7320/ha, $8651/t SK). It is important to note that these four cost averages exclude imputed labour costs, as these were not available prior to the 2017 season.

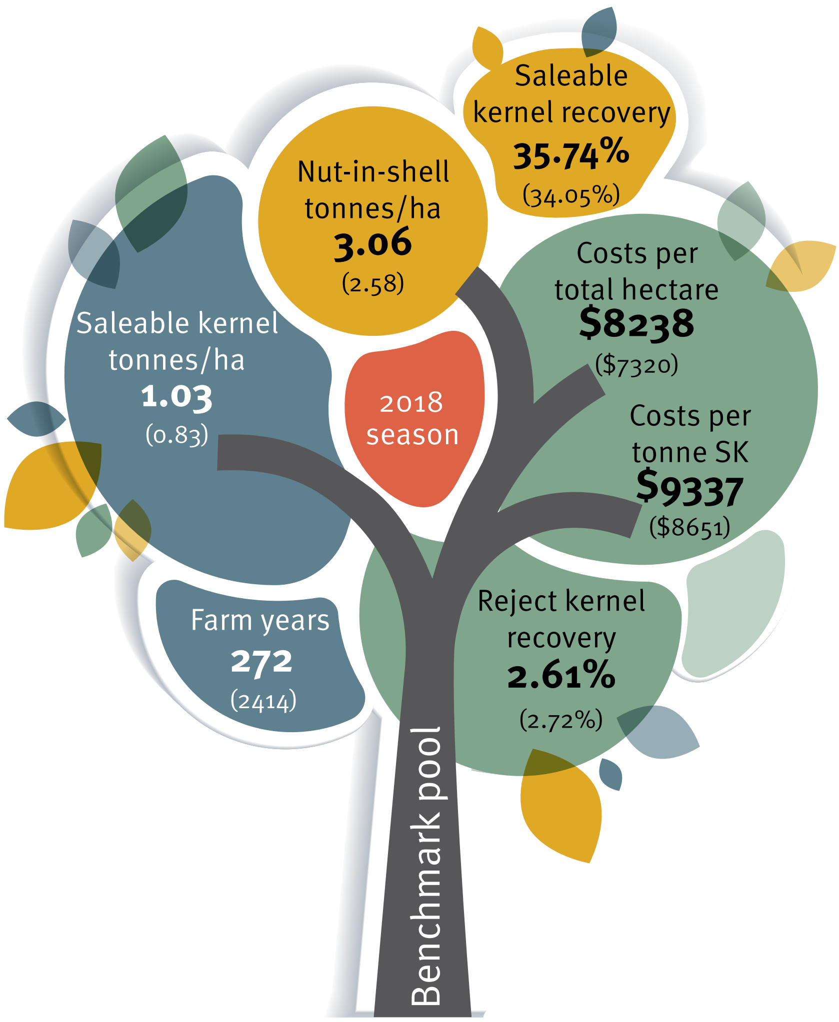


Figure 5: Summary of the 2018 benchmark sample (long-term averages/totals shown in brackets)

Since 2017 the benchmarking project has been collecting data on unpaid labour hours undertaken by owners and managers, to provide a more consistent basis for comparing costs between managed and owner-operated farms. These hours include activities that a farm employee would otherwise undertake under the direction of a manager or foreperson. Examples include tractor driving, mowing, harvesting, servicing machinery, fertilizer spreading and pest and disease control. It does not include management decisions. A standard hourly wage rate of $30 per hour is applied to unpaid labour hours to derive a notional cost. This rate was endorsed by the Project Steering Group.

Figure 6 shows a breakdown of average total production costs per planted hectare and per tonne of saleable kernel (SK) for the 82 mature farms (10+ years old) that provided cost data in the 2018 benchmark sample. The chart shows average costs per hectare and per tonne of SK for both managed and owner-operated farms. Each bar comprises both cash costs (grey) and the imputed cost of unpaid labour (red).

Of the 82 mature farms in the benchmark sample that provided cost data in 2018, 46% were owner-operated and 54% were managed. Imputed labour accounted for 31% of total production costs per hectare on owner-operated farms but only 6% of total costs per hectare on managed farms.

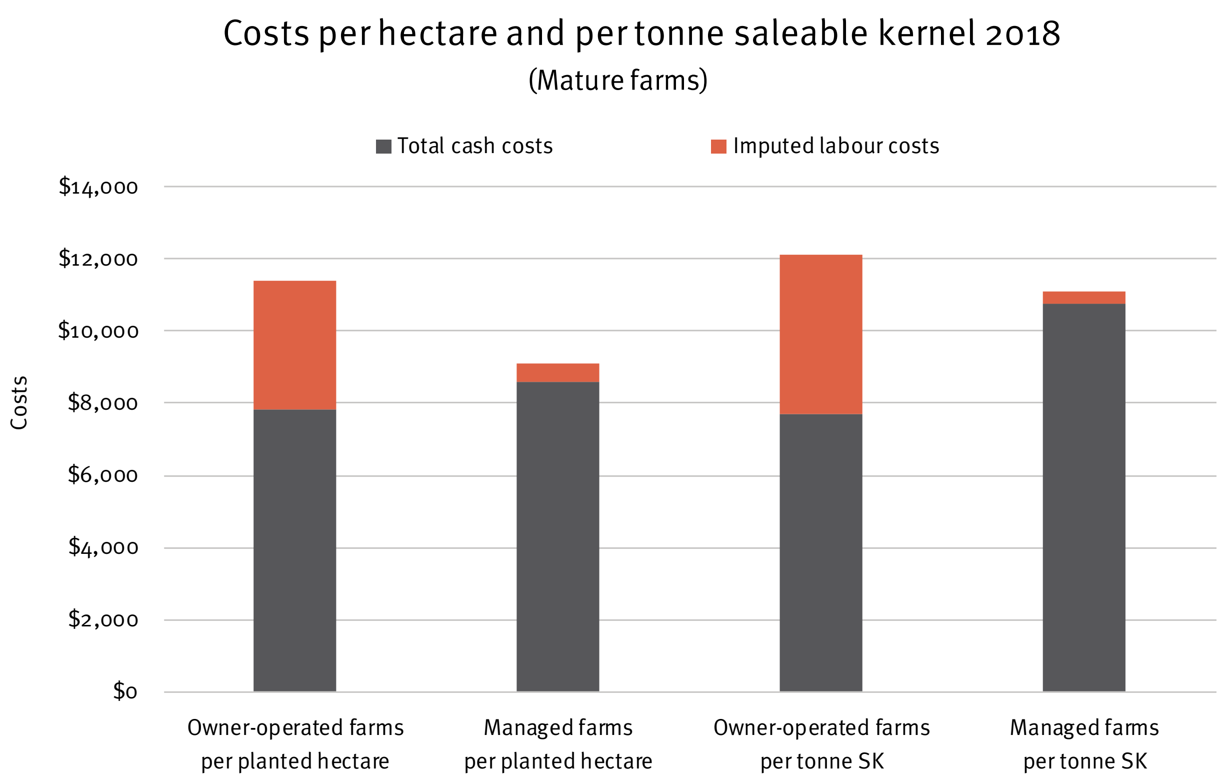


Figure 6: Costs and imputed labour per planted hectare and per tonne SK for managed and owner-operated mature farms in 2018

Imputed labour costs include unpaid physical labour undertaken by owners or managers. These are activities that a farm employee would otherwise undertake under the direction of a manager or foreperson. Examples include tractor driving, mowing, harvesting, servicing machinery, fertiliser spreading and pest and disease control. It does not include higher-level management activities or decision-making.

Figure 7 also shows imputed labour costs, this time in relation to employment costs rather than all production costs. Imputed labour accounted for 74% of employment costs per planted hectare on owner-operated farms compared to 16% for managed farms.

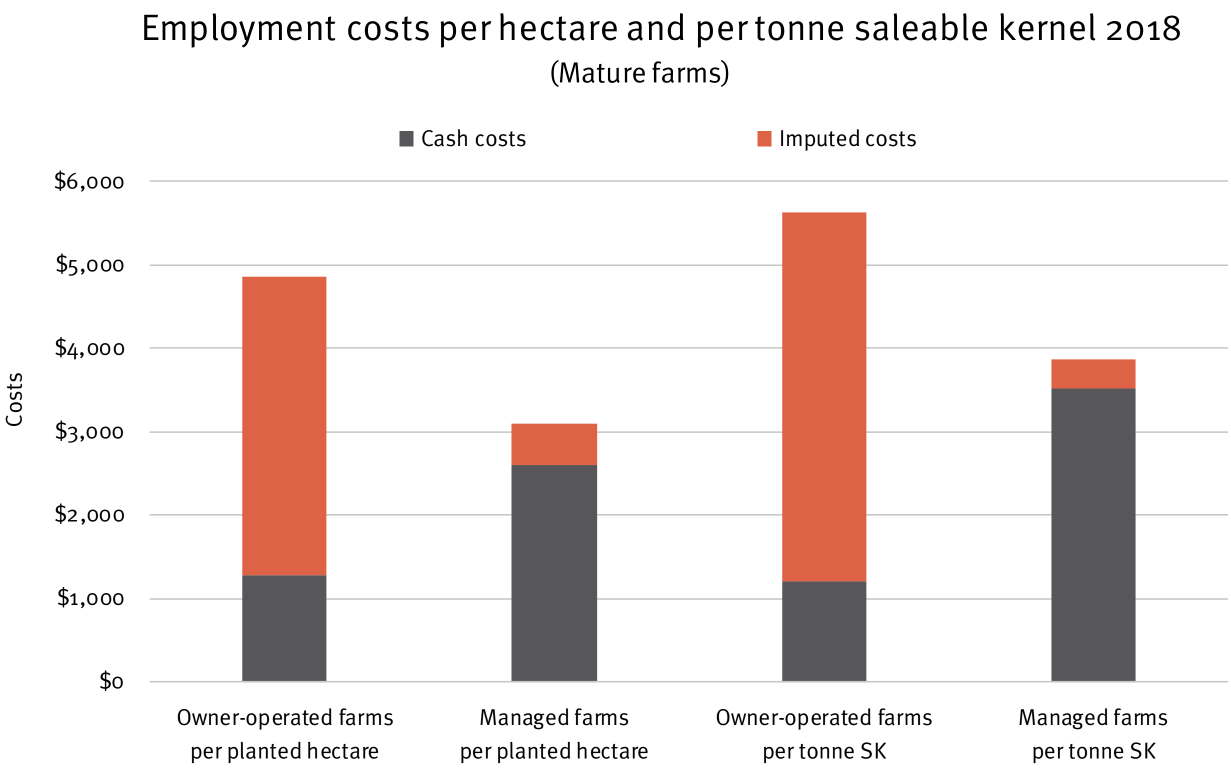


Figure 7: Cash and imputed employment costs per planted hectare and per tonne SK for managed and owner-operated mature farms in 2018

Figure 8 shows production costs per hectare broken down into heads of expenditure. Average expenditure for the 2018 season is compared with the six-year average (2013 to 2018). As unpaid labour was not collected prior to 2017, all employment figures shown exclude unpaid labour.

Costs were higher across most heads of expenditure in 2018 compared with the six-year average. The most substantial increases in 2018 were in contractors (> $240/ha increase), crop nutrition (>$200/ha increase) and employment (> $100/ha increase). Fuel/oil and lease costs were the only heads of expenditure that were lower in 2018 (5% and 28% respectively) than the six-year average.

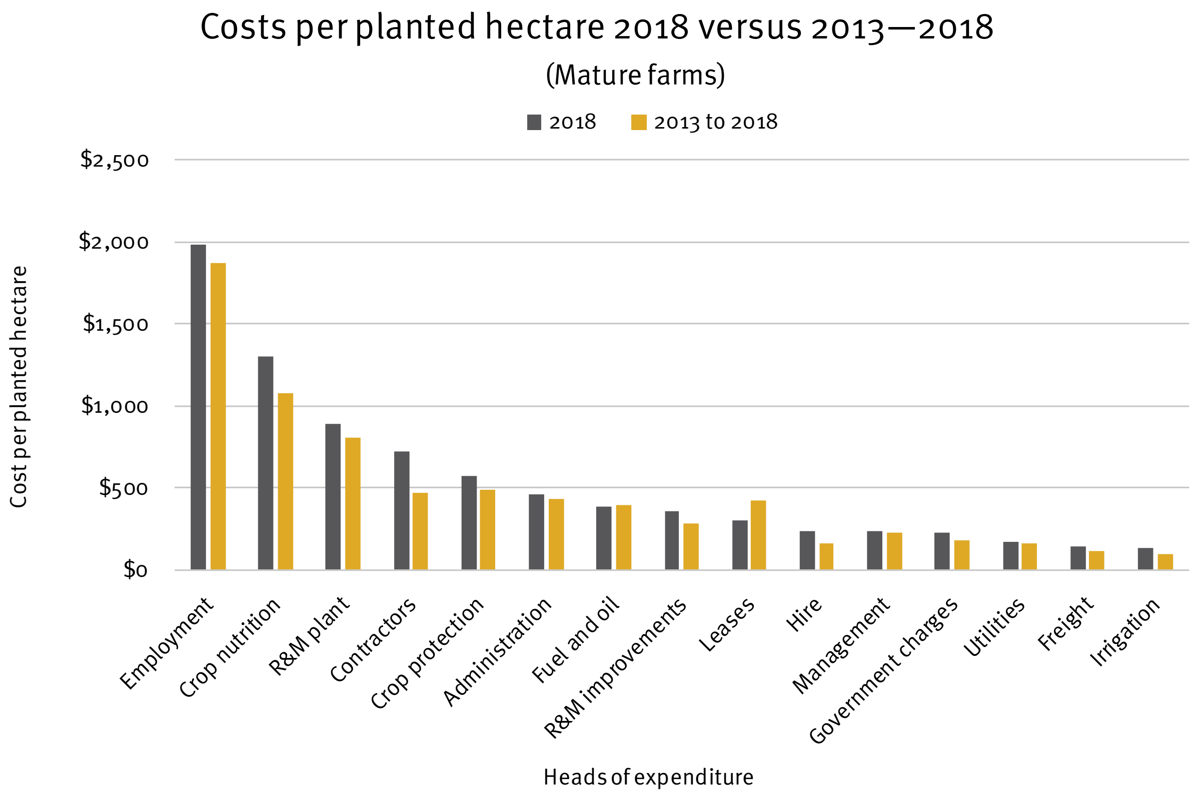


Figure 8: Major heads of expenditure per planted hectare for 2018 versus 2013 to 2018

Factors limiting production

Since 2017 benchmark participants have been asked to rank the major limiting factors affecting production on their farm, based on their observations during the season. A total of 232 farms provided these observations for the 2018 season.

The major factors reported included storm/hail, pests, and hot/dry weather (**Figure 9**). Approximately 12% of respondents indicated that their farms had no major limiting factors during the 2018 season.

Storm or hail damage was reported mainly in the Northern Rivers of NSW (NRNSW) region, where nearly half of farms in the benchmark sample are located. Mature farms that reported storm or hail as the major limitation to production in 2018 averaged 2.16 tonnes of NIS per bearing hectare compared to the benchmark average of 3.10 tonnes of NIS per bearing hectare. Hot/dry weather was reported mostly in the Central Queensland (CQ) region, and soil or tree health was the most common limiting factor in the Mid North Coast of NSW (MNNSW) region. In South East Queensland (SEQ) the greatest number of responses indicated no major limitations in 2018.

Mature farms reporting no major limiting factors across all regions in 2018 averaged 4.22 tonnes of NIS per bearing hectare. This was more than one tonne per hectare higher than the benchmark sample average for mature farms (3.10 t/ha).

A smaller number of farms reported additional limiting factors such as heavy pruning, mistletoe and lack of light due to tall or crowded canopies.

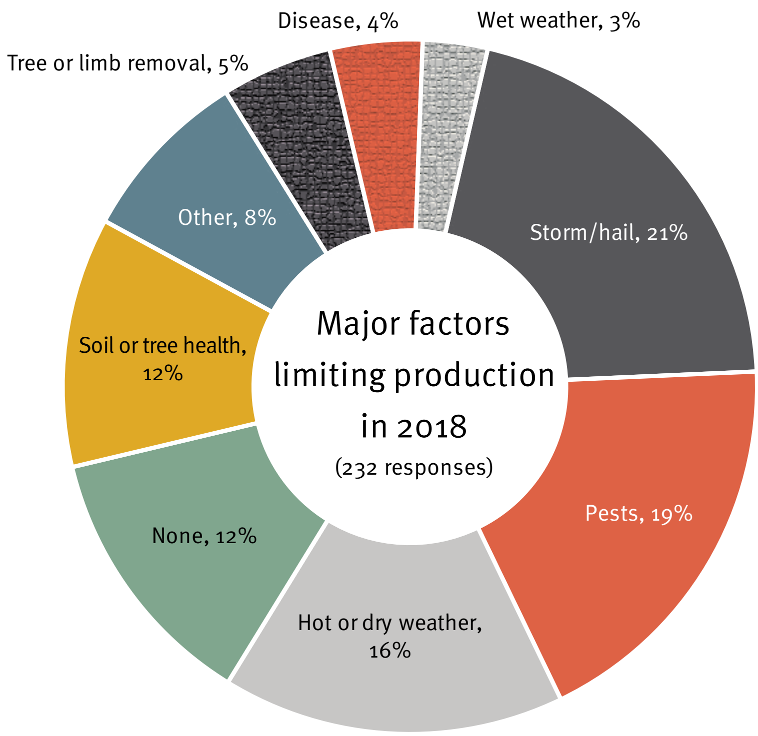


Figure 9: Major factors limiting production in 2018

Average NIS production per hectare for farms that reported no limiting factors was more than 30% higher than the sample average in 2018. Hot dry weather was reported as the factor most limiting production in Queensland, particularly in the CQ region. Storm or hail damage was the most frequently reported limiting factor in NRNSW.

Figure 10 shows the major factors limiting production for each of the main growing regions. In CQ hot or dry weather was reported as the top limitation to production, followed by soil or tree health. Other responses for CQ included storm/hail, wet weather and pests. Pests were the major limitation in SEQ, however over 25% of respondents reported no major limitation to production for the 2018 season, reflecting the high average productivity in this region. The top limiting factors in MNNSW were soil or tree health (31%) and pests (27%). Other limitations reported for MNNSW included tree or limb removal and disease. Storm/hail was the top limitation for the NRNSW (31%) followed by pests (27%) and hot or dry weather (14%). Other limitations for NRNSW included tree or limb removal, soil or tree health and disease.

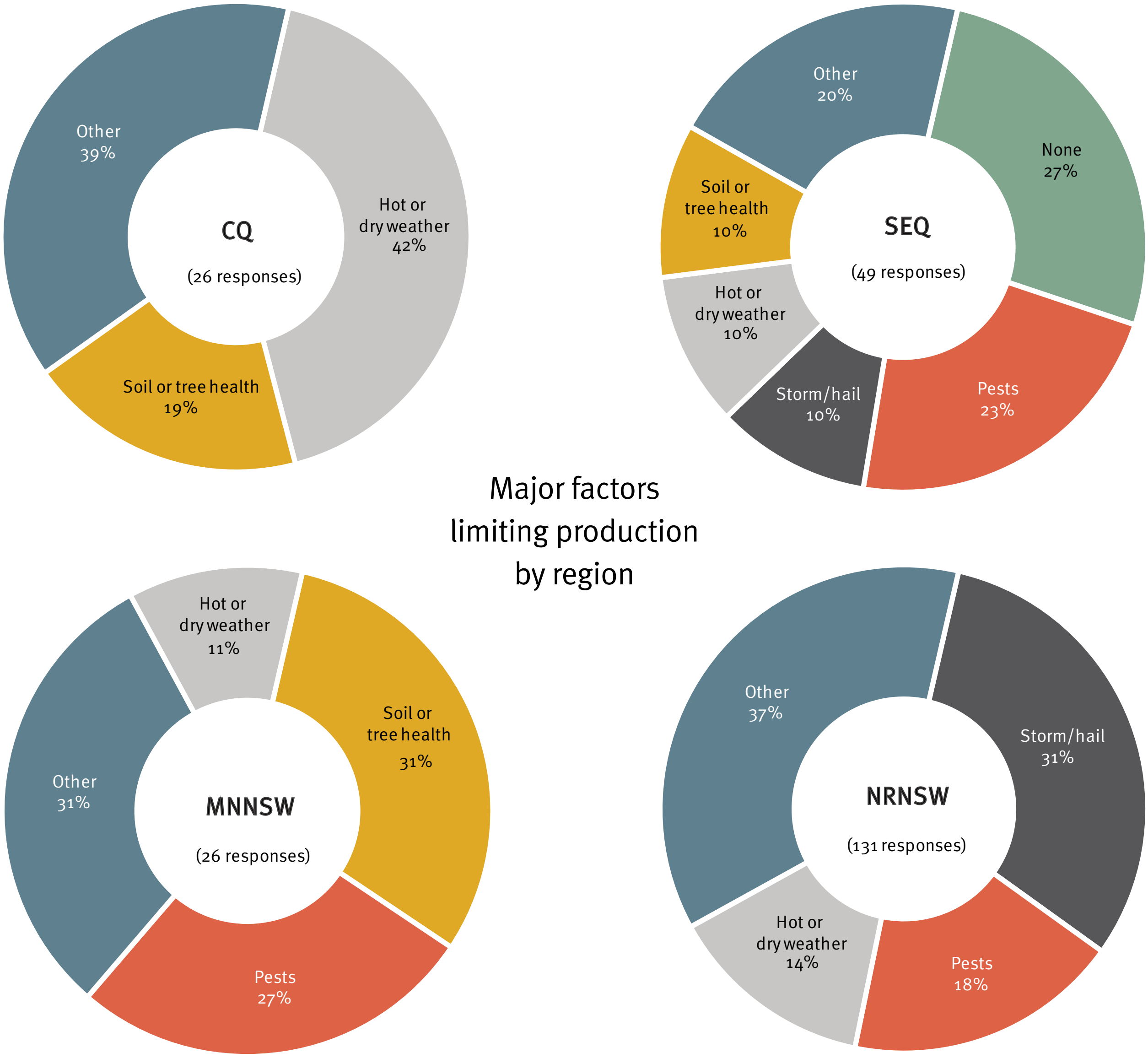


Figure 10: Major factors limiting production by region in 2018

Pest limitations

A total of 196 farms ranked their pest limitations for the 2018 season (**Figure 11**).

Fruit spotting bug was most commonly ranked as the major pest limiting production (37%). In NRNSW however the most significant pest reported was macadamia seed weevil (formerly known as *Sigastus* weevil). Mature NRNSW farms that nominated macadamia seed weevil as the major limiting pest in 2018 averaged 2.4 tonnes of NIS per bearing hectare, compared to an average of 2.77 for all mature benchmarked farms in this region. In MNNSW rats were the most significant pest (18%).

Ten percent of farms said they had no major pest limitations. Lace bug was the main limitation for a small proportion of farms (3%). The "Other" category (5%) included birds, nut borer, flower caterpillar, *Leptocoris*, feral pigs and kernel grub.

Image courtesy of NSW Department of Primary Industries

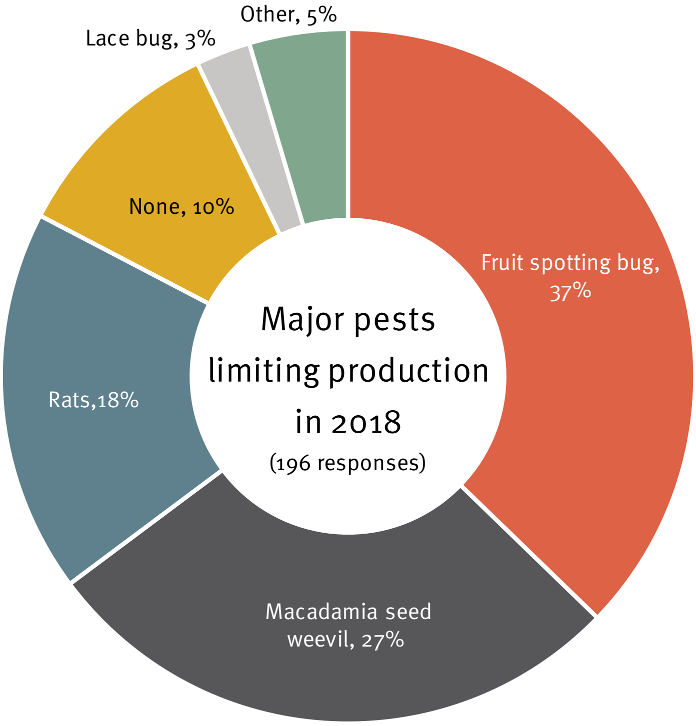


Figure 11: Major pests limiting production in 2018

Disease limitations

A total of 182 farms ranked their disease limitations (**Figure 12**). The disease most limiting across all regions was Phytophthora (26%). In CQ however, husk spot was reported as the major disease limiting production and was the second most common limiting disease across all regions (25%).

One in every four farms (25%) said they had no major disease limitation this year. Flower diseases were commonly reported as limiting (14%), followed by dieback (8%).

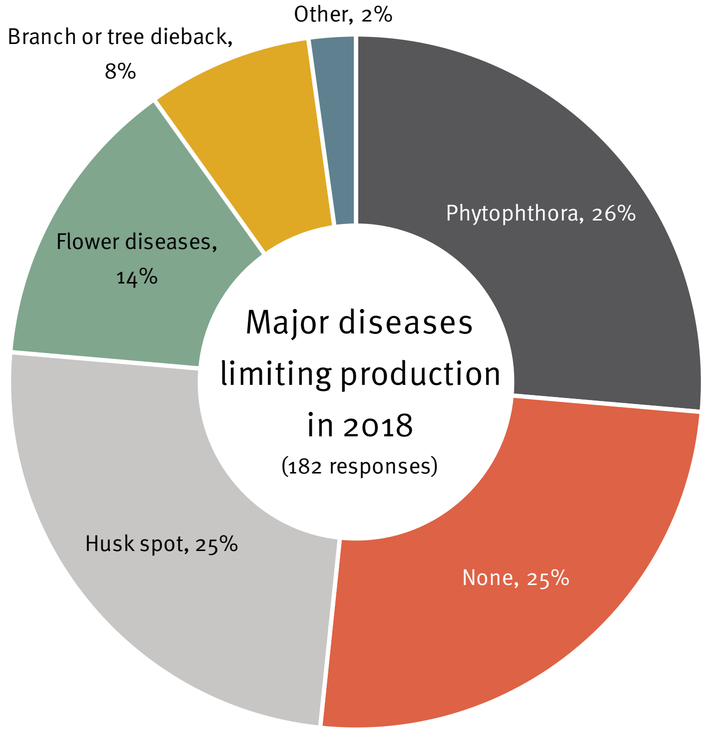


Figure 12: Major diseases limiting production in 2018

Factory losses

The value of factory reject kernel in 2018 was estimated for all farms in the benchmark sample. **Figure 13** shows a breakdown of those estimated losses per hectare for each factory reject category. The weight of rejects was derived from individual farm reject kernel recovery percentages and then converted to equivalent nut-in-shell (NIS) weights. Values were then derived using an average price of $5.20 per kilogram of NIS.

It is important to note that the averages shown in the figure are weighted according to NIS production, which means larger farms exert more influence on the average than smaller farms. This provides the most accurate estimate of the total weight of rejects across the benchmark sample.

The average value of factory losses in 2018 due to reject kernel for all farms participating in benchmarking was approximately $1,220 per hectare. This equates to a total value of approximately $12.05 million for all farms in the benchmark sample, based on 9,875 bearing hectares. This excludes the weight of nuts lost or rejected on farm, which may also significantly contribute to total rejects. It also excludes any handling or disposal costs incurred by processors or growers.

Brown centres accounted for more than one third of those rejects ($420 per hectare), followed by insect damage ($322/ha) then mould ($170/ha).

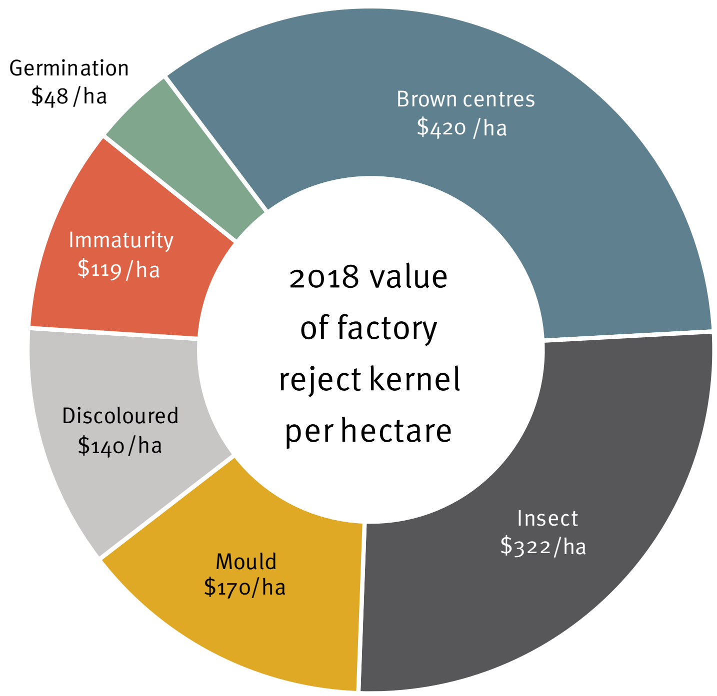


Figure 13: Estimated value of factory reject kernel for all farms in the benchmark sample in 2018

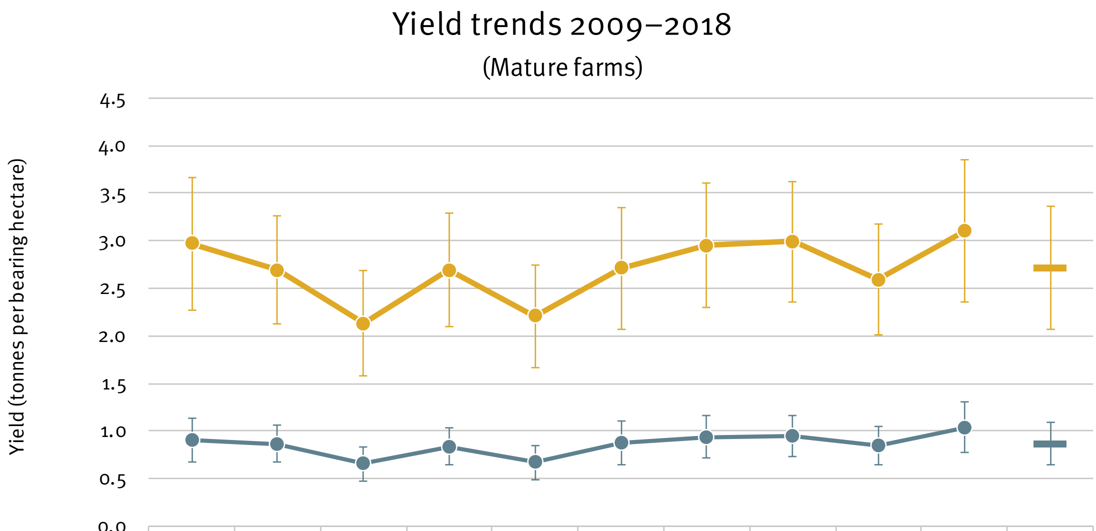
In 2018, average farm operating costs accounted for 52% of gross income for farms in the benchmark sample. Losses from factory rejects amounted to approximately 8% of gross income.

Seasonal trends

This section shows seasonal orchard productivity and quality from 2009 to 2018. This provides insight into long-term trends as well as seasonal variability within the sample. Cost trends are also shown for each year in which data was collected (2013 to 2018).

Figure 14 shows trends in average nut-in-shell (NIS) and saleable kernel (SK) yield per bearing hectare for mature farms (10+ years old) in the benchmark sample. The vertical error bars show the standard deviation for each season. Larger error bars indicate higher variability between farms in the sample.

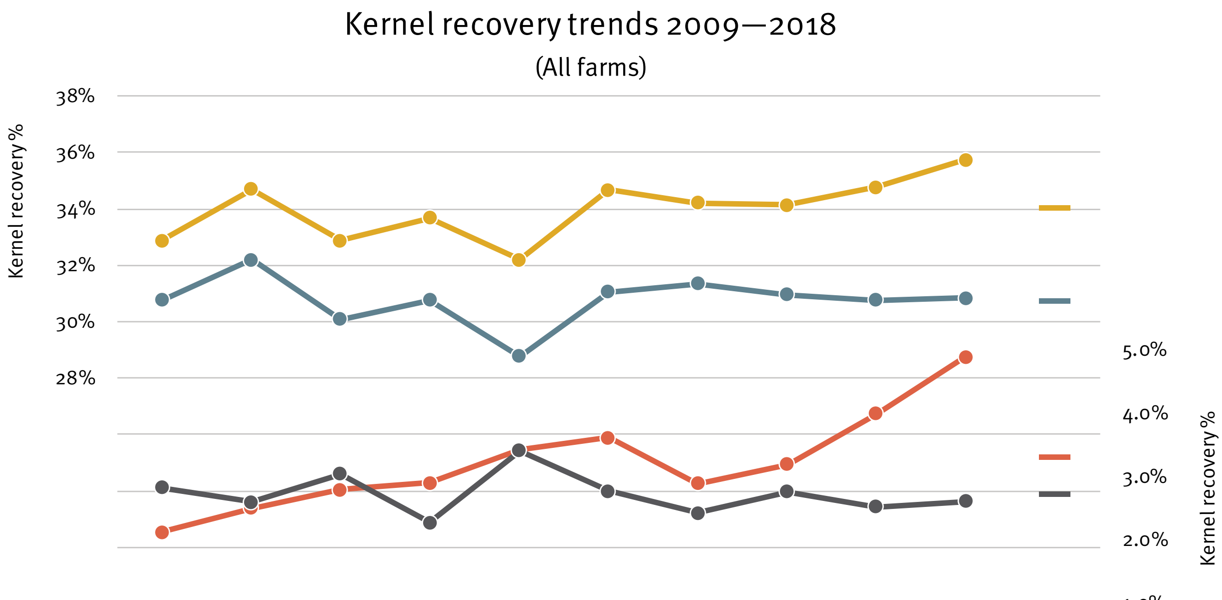
The long-term standard deviation in NIS productivity averaged 1.29 tonnes per bearing hectare, or approximately 47% of the average. Standard deviation in long-term SK was 0.45 t/ha, or approximately 52% of average SK production.



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2009–18
NIS yield	2.97	2.69	2.13	2.69	2.21	2.71	2.95	2.99	2.59	3.10	2.72
NIS Std.dev.	1.40	1.13	1.11	1.19	1.08	1.28	1.31	1.27	1.16	1.50	1.29
SK yield	0.91	0.87	0.66	0.84	0.67	0.88	0.94	0.95	0.85	1.04	0.87
SK Std.dev.	0.46	0.40	0.36	0.38	0.36	0.46	0.44	0.44	0.40	0.53	0.45

Figure 14: Average nut-in-shell and saleable kernel productivity for mature farms 2009–2018

Figure 15 shows trends in average kernel recovery for all farms in the benchmark sample from 2009–2018. The left axis shows trends in premium (or sound) kernel recovery (PKR) and saleable kernel recovery (SKR). SKR is the sum of premium and commercial grades. The right axis shows trends in commercial kernel recovery (CKR) and reject kernel recovery (RKR).



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2009–18
Premium KR%	30.76	32.20	30.08	30.76	28.78	31.05	31.34	30.95	30.76	30.85	30.73
Saleable KR%	32.88	34.71	32.88	33.67	32.20	34.67	34.22	34.15	34.76	35.74	34.05
Commercial KR%	2.13	2.51	2.80	2.91	3.42	3.62	2.89	3.20	4.00	4.89	3.32
Reject KR%	2.83	2.60	3.05	2.28	3.41	2.78	2.43	2.76	2.53	2.61	2.72

Figure 15: Average kernel recovery percentages 2009–2018

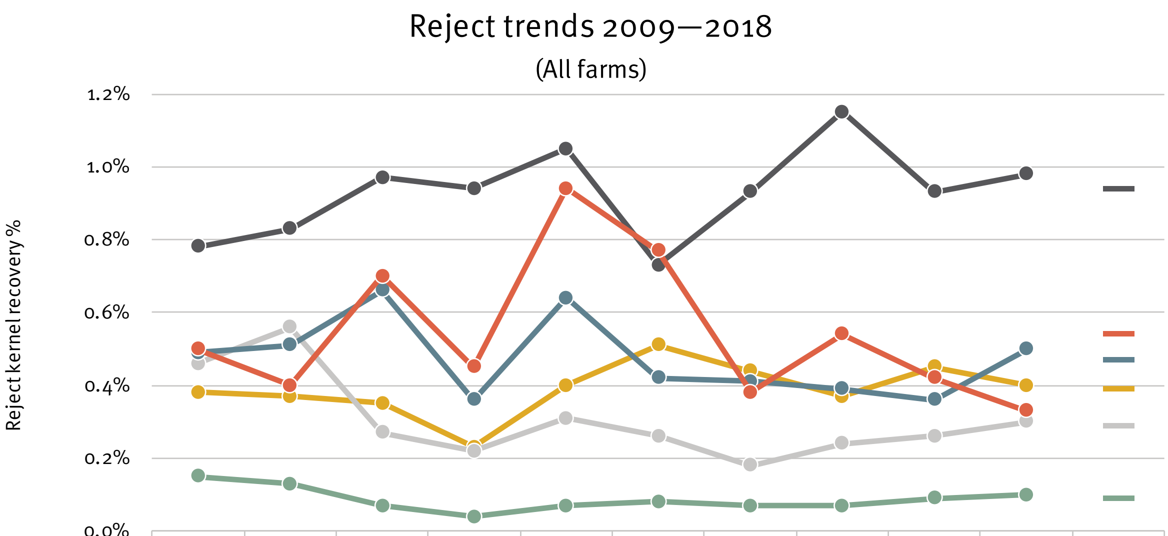
Average RKR was slightly lower in 2018 than the long-term average for the benchmark sample. Average SKR was higher in 2018 than the long-term average, mainly due to an increase in CKR. PKR has remained relatively stable over the last three seasons.

When weighted by NIS production, average CKR for the 2018 season reduced to 4.05%, which suggests that the high average CKR that season was particularly evident on smaller farms.

Productivity varies significantly between farms in the benchmark sample. Average nut-in-shell productivity for mature farms over the last nine seasons was 2.67 t/ha with a standard deviation of 1.25 t/ha, or 47% of the average.

Analysis of factory reject categories provides insight into the specific causes of post-harvest losses in any season. **Figure 16** shows the averages of all major factory reject categories for farms in the benchmark sample from 2009 to 2018. It is important to note that these averages are unweighted, which means each farm in the sample exerts equal influence on the average regardless of its size or level of production.

Insect damage has been the leading cause of factory reject across the benchmark sample in all years except 2014. Factory insect damage rejects were the leading cause of reject in all regions other than Central Queensland (CQ), where internal discolouration (brown centres) was the major cause of reject.

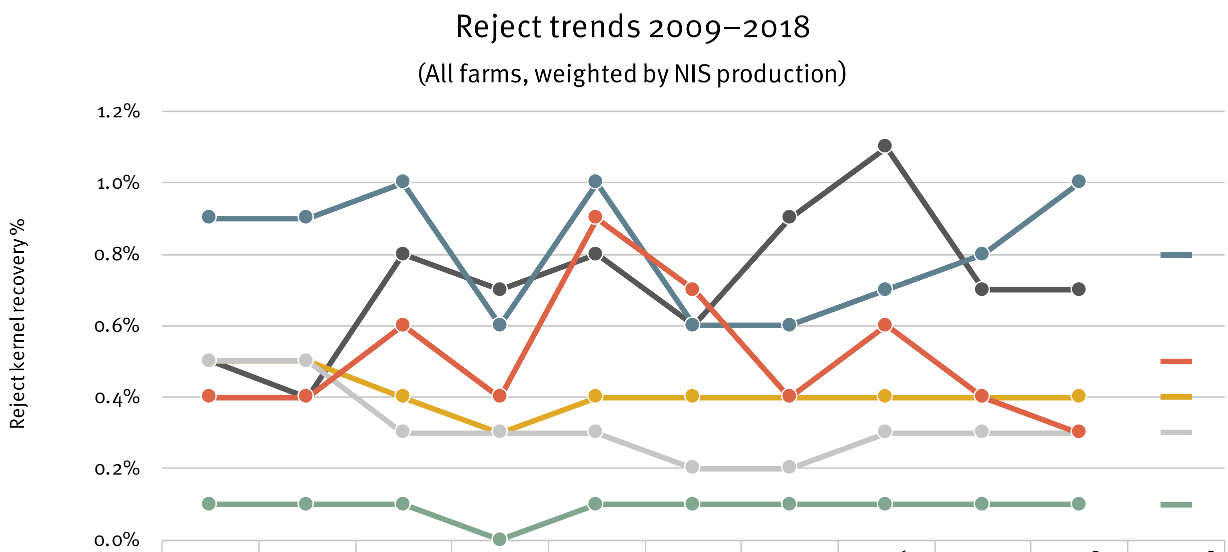


	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2009–18
Insect	0.78	0.83	0.97	0.94	1.05	0.73	0.93	1.15	0.93	0.98	0.94
Mould	0.38	0.37	0.35	0.23	0.40	0.51	0.44	0.37	0.45	0.40	0.39
Discoloured	0.46	0.56	0.27	0.22	0.31	0.26	0.18	0.24	0.26	0.30	0.29
Brown centres	0.49	0.51	0.66	0.36	0.64	0.42	0.41	0.39	0.36	0.50	0.47
Immature	0.50	0.40	0.70	0.45	0.94	0.77	0.38	0.54	0.42	0.33	0.54
Germinated	0.15	0.13	0.07	0.04	0.07	0.08	0.07	0.07	0.09	0.10	0.09

Figure 16: Unweighted average reject kernel percentages for each reject category 2009–2018

Figure 17 shows the equivalent factory reject averages weighted by nut-in-shell production. In this case farms that produce more NIS exert more influence on the average, so this chart provides insight into the relative significance of each reject category at a whole-industry level.

When weighted by production brown centres emerges as the most significant cause of factory rejects in 2018, followed by insect damage. The long-term weighted averages for both of these reject categories are identical (0.8%).



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2009–18
Insect	0.50	0.40	0.80	0.70	0.80	0.60	0.90	1.10	0.70	0.70	0.80
Mould	0.50	0.50	0.40	0.30	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Discoloured	0.50	0.50	0.30	0.30	0.30	0.20	0.20	0.30	0.30	0.30	0.30
Brown centres	0.90	0.90	1.00	0.60	1.00	0.60	0.60	0.70	0.80	1.00	0.80
Immature	0.40	0.40	0.60	0.40	0.90	0.70	0.40	0.60	0.40	0.30	0.50
Germinated	0.10	0.10	0.10	0.00	0.10	0.10	0.10	0.10	0.10	0.10	0.10

Figure 17: Weighted average reject kernel percentages for each reject category 2009–2018

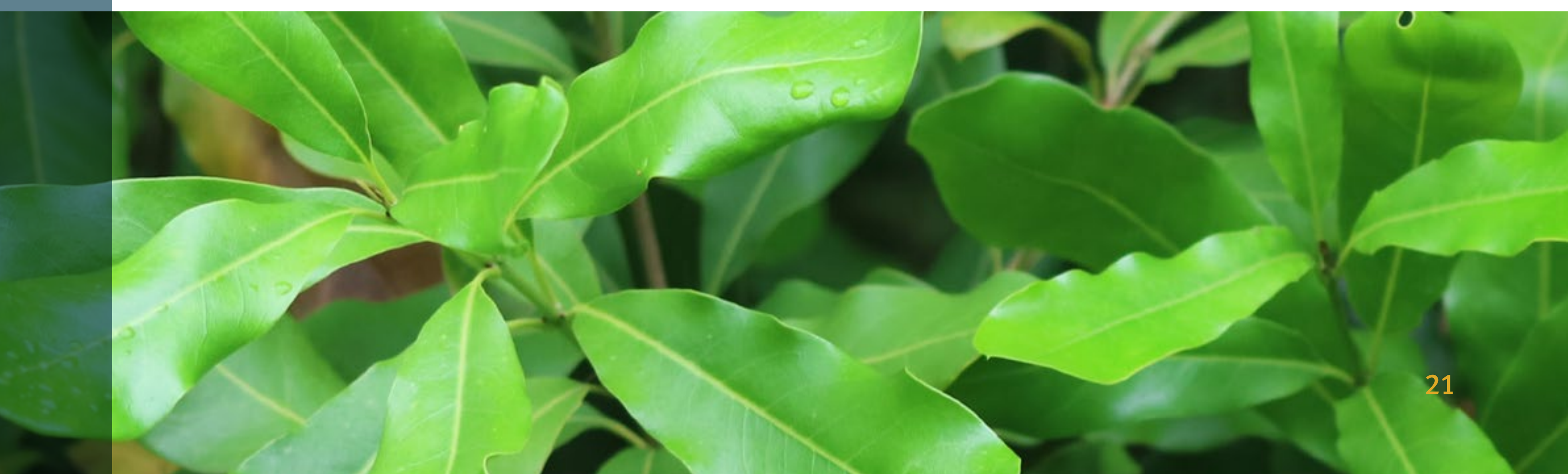
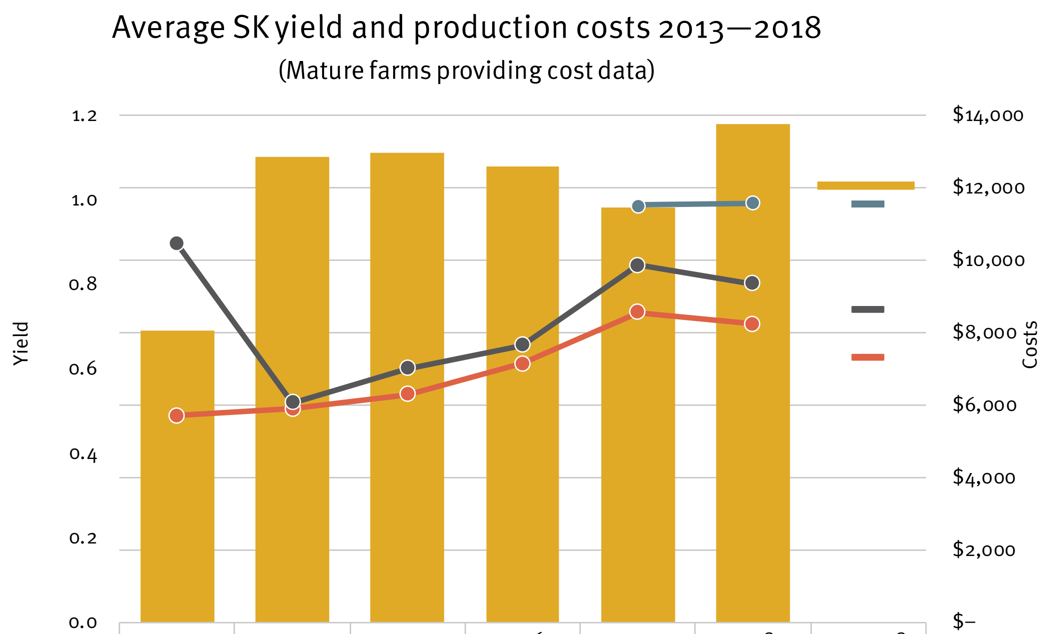


Figure 18 shows saleable kernel (SK) productivity (t/ha) and average production costs (per hectare and per tonne of SK) for mature farms (10+ years old) that provided cost data between 2013 and 2018. Unpaid labour has been imputed as part of total production costs since 2017, so these data are also shown for the 2017 and 2018 seasons. In the 2017 and 2018 seasons average total costs including imputed labour equalled approximately 60% of revenue, based on a NIS price of $5.20/kg.

Average costs per hectare have increased steadily since 2013. Recent favourable NIS prices may have supported these sustained higher levels of on-farm expenditure and investment.

The higher costs per tonne of SK in 2013 were directly related to lower average productivity that season. The decline in average costs per tonne of SK was due to both above-average productivity and a slight reduction in average costs per hectare in 2018. When imputed at a standard hourly rate of $30, unpaid labour accounted for almost 24% of total costs per tonne of SK in 2018.

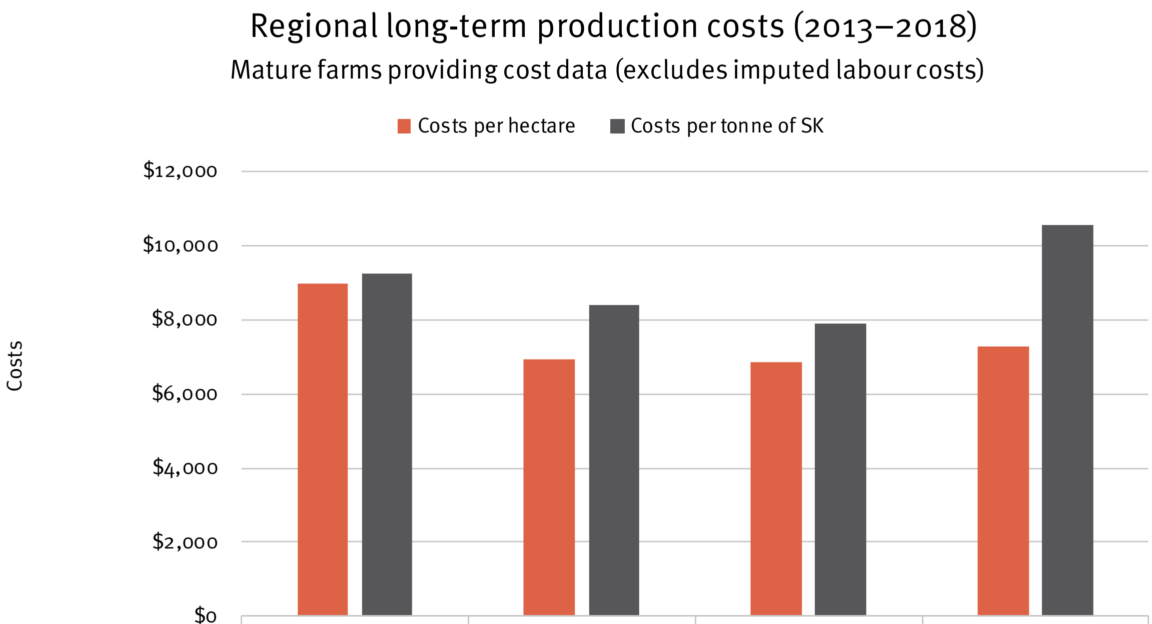


	2013	2014	2015	2016	2017	2018	2013–18
SK yield	0.69	1.10	1.11	1.08	0.98	1.18	1.04
Costs per hectare	$5,695	$5,887	$6,287	$7,141	$8,552	$8,238	$7,320
Costs per tonne SK	$10,436	$6,053	$7,013	$7,652	$9,862	$9,337	$8,651
Costs + imp. labour per tonne SK	–	–	–	–	$11,514	$11,568	$11,544

Figure 18: Saleable kernel yield and cost of production (per hectare and per tonne) for mature farms 2013–2018

Average productivity for mature farms providing cost data in 2017 and 2018 was 3.24 t/ha. At a NIS price of $5.20/kg this equates to an average gross margin of around $6900/ha. At this same average productivity a minimum NIS price of just over $3.00/kg would be required to cover their costs of production.

Figure 19 shows the regional comparison of total expenditure for mature farms over 6 years (2013–2018). Imputed labour costs are excluded as these were not available prior to 2017. Northern Rivers NSW farms (NRNSW) had the lowest average costs per tonne of SK at $7905. This is 25% lower than Mid North Coast NSW farms (MNNSW), which had the highest average at $10,555 per tonne of SK.



	CQ	SEQ	NRNSW	MNNSW
Costs per hectare	$8,966	$6,932	$6,849	$7,280
Costs per tonne of SK	$9,245	$8,374	$7,905	$10,555

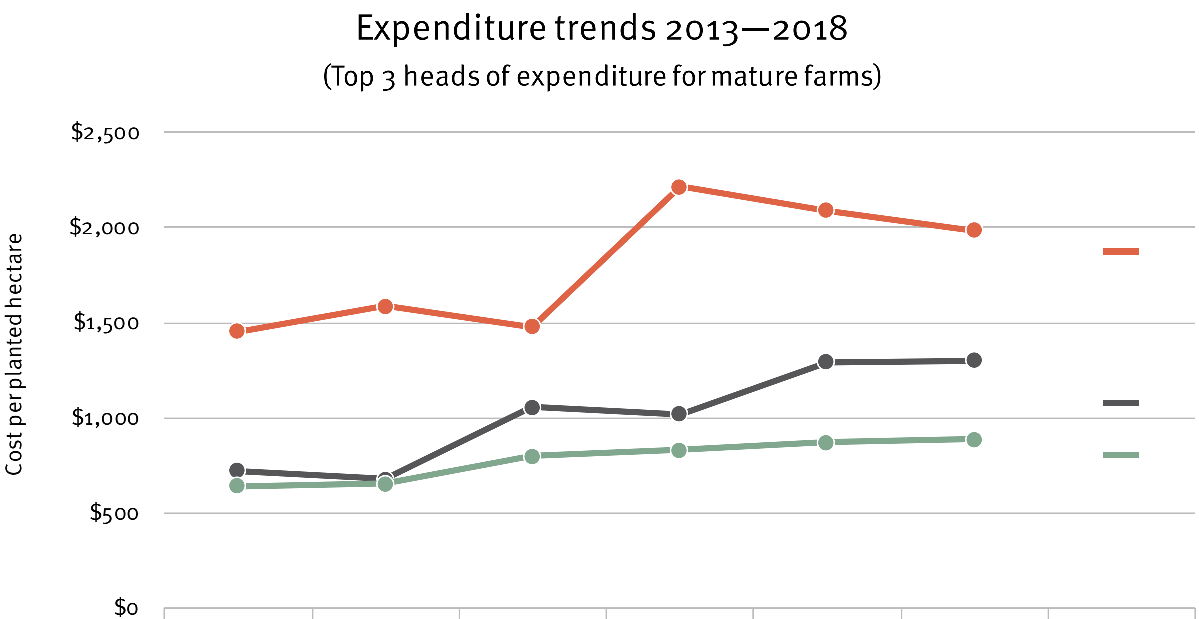
Figure 19: Total expenditure per hectare and per tonne of saleable kernel for each benchmarking region

Figure 20 shows the top three heads of expenditure (per planted hectare) for mature farms that provided cost data from 2013 to 2018. The top three expenses include employment, crop nutrition and repairs & maintenance (R&M) plant. Other expenses not shown included crop protection, contractors, administration, leases, fuel and oil, R&M improvements, management, government charges, utilities, hire, freight, consultants and irrigation.

Employment accounted for the largest proportion of total costs (26% excluding imputed labour). This is consistent with the previous *On-farm Economic Analysis study* from 2003–2006, with employment costs accounting for 24% of total costs at that time. This expenditure includes all costs associated with employment including permanent and casual wages, superannuation, training and expenses incurred as part of occupational health and safety and worker's compensation.

The employment costs shown do not include unpaid labour costs, which were not collected prior to 2017. Analysis of these costs for mature farms between 2017 and 2018 suggests that when unpaid labour is also imputed, employment costs account for approximately 37% of total costs. This figure falls to 32% for managed farms and rises to 43% for owner-operated farms.

In each season there are significant differences in both total costs and the breakdown of those costs between farms. This seasonal variation can often be attributed to significant periodic management activities such as canopy management, tree removal, erosion control and soil health improvement.



	2013	2014	2015	2016	2017	2018	2013–18
Employment	$1,456	$1,588	$1,478	$2,216	$2,092	$1,985	$1,876
Crop nutrition	$722	$678	$1,057	$1,022	$1,295	$1,302	$1,082
R&M plant	$642	$653	$797	$831	$870	$888	$807

Figure 20: Employment, crop nutrition and R&M plant expenditure of mature farms 2013–2018

Healthy soils leads to good returns for Tony Flick

Benchmark participant Tony Flick consistently achieves high productivity on his orchards and attributes his good results to soil health. Tony has seen significant improvement in soil health by using mulch and chicken manure.

Benchmarking allows Tony to compare the eight orchards that he manages with other participating farms.

"Benchmarking offers good information where I can compare my results against that of the rest of industry.

It is a good check for me on not only production but my costs also."

ABOVE: Northern Rivers NSW grower Tony Flick showing a newly established orchard.

Top performing farms

The benchmarking study has revealed high variability in productivity between farms and also between seasons for individual farms. Analysis of the top performing farms in the sample is included to identify any trends associated with sustained high orchard productivity.

To be regarded as a top performing farm, high orchard productivity must be sustained over a minimum of four seasons, including the most recent production season. These farms are then ranked according to their average saleable kernel productivity (t/ha) over all seasons for which they have submitted data. Only farms that fall within the top 25% of this group are regarded as top performing farms. As inclusion in this group is based on average performance over multiple seasons it is possible that some top performing farms may not have been among the most productive farms in a particular season.

Table 3 shows a breakdown of the top performing farms by region, farm size and tree age compared with all other farms in the benchmark sample.

All regions were proportionately represented within the top performing farms group, based on the total number of participating farms in each of those regions.

Although small to medium farms make up the majority of top performing farms, all farm size categories are represented. A total of 65% of top performing farms were less than 20 hectares in size compared with 52% for all other farms in the benchmark sample. It is important to remember that many larger farms in the benchmark sample are, on average, younger than smaller farms and therefore yet to reach their bearing potential.

Farms with an average tree age of 25 to 29 years were the most strongly represented among the top performing farms (33%) followed by 20 to 24 years (25%) and 15–19 years (23%).

Approximately 6% of top performing farms had an average tree age less than 15 years. By comparison, 25% of the whole benchmark sample had an average tree age less than 15 years.

Over 10% of top performing farms had an average tree age of 30 years or more. This is important to note as it demonstrates that high productivity is being maintained in some older orchards.

Top performing farms versus all other farms		
	Top performing farms (48 farms)	All other farms (224 farms)
Region		
CQ	17%	19%
SEQ	21%	19%
NRNSW	50%	53%
MNNSW	12%	9%
Farm size		
Less than 10 ha	42%	24%
10 ha – 19 ha	23%	28%
20 ha – 29 ha	17%	13%
30 ha – 49 ha	6%	15%
50 ha – 99 ha	4%	12%
100 ha and greater	8%	8%
Tree age		
Less than 8 years	0%	1%
8 – 9 years	0%	2%
10 – 14 years	6%	22%
15 – 19 years	23%	17%
20 – 24 years	25%	20%
25 – 29 years	33%	18%
30 years and older	13%	20%

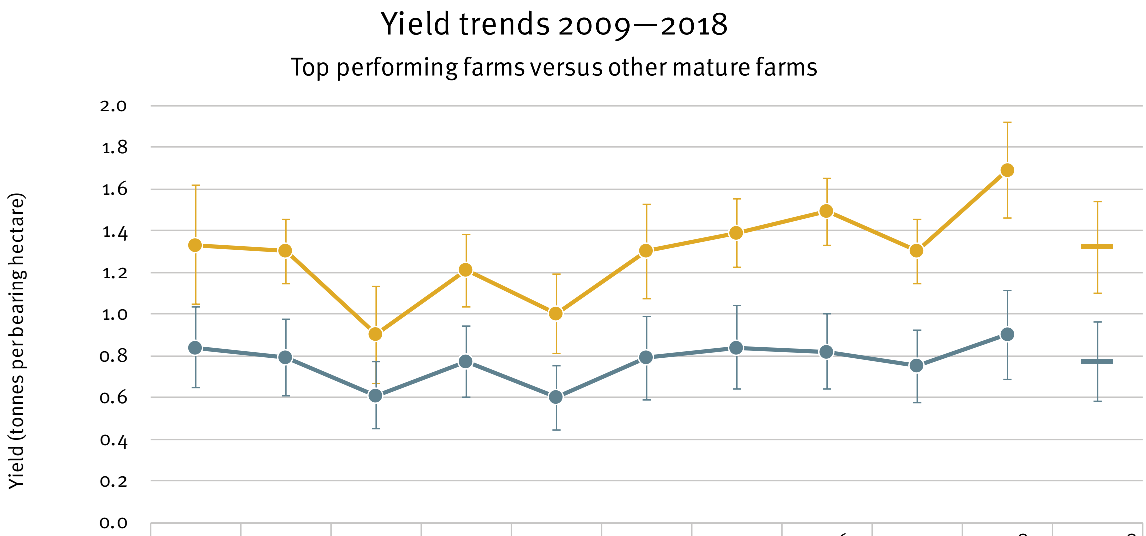
Table 3: Top performing farms versus all other farms in the benchmark sample (2009–2018)

Figure 21 shows the average saleable kernel (SK) yields per bearing hectare for the top performing farms from 2009 to 2018, and compares these with other mature farms in the benchmark sample. Farms aged less than 10 years are excluded from both groups for consistency. The error bars on the chart represent the standard deviations from these average yields.

It is important to remember that top performing farms must have provided data for at least four years, including 2018, to be considered for inclusion within this group.

This chart confirms that top performing farms, like the broader benchmark sample, experience seasonal yield fluctuations. It also shows that the pattern of this fluctuation is reasonably consistent between the two groups from season to season. The error bars show that even low yields for farms in the top performing farms group rarely overlap with average yields in even the best cropping years for other mature farms in the benchmark sample.

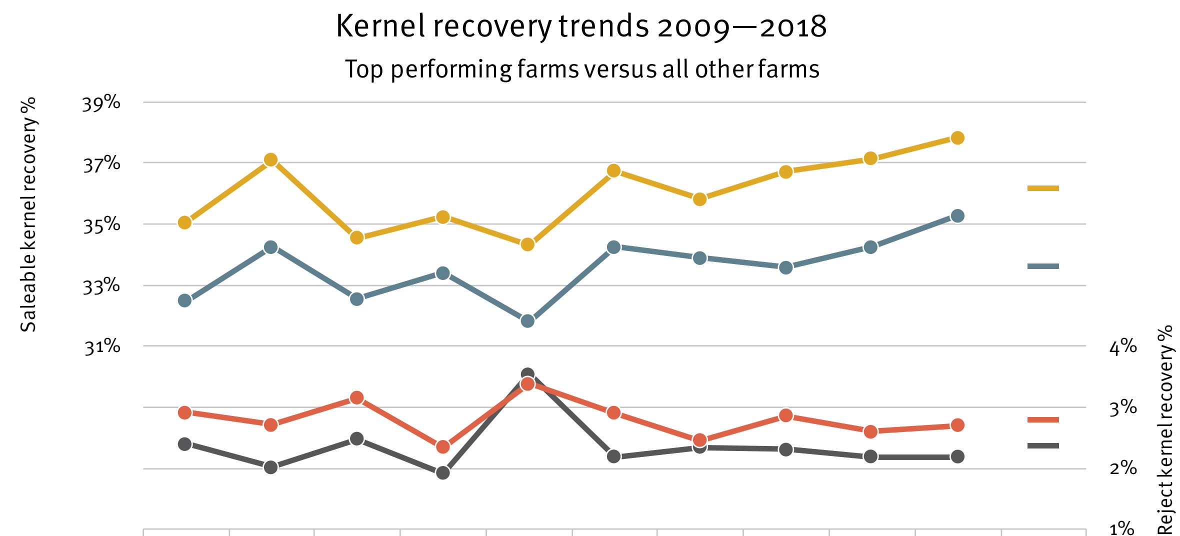
The top performing farms averaged 1.32 tonnes of SK per bearing hectare over the ten years from 2009 to 2018, compared with 0.77 tonnes for other mature farms in the benchmark sample. Long-term average SK yield for top performing farms was therefore more than 70% higher than that of other mature farms in the benchmark sample.



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2009–18
SK yield (Top)	1.33	1.30	0.90	1.21	1.00	1.30	1.39	1.49	1.30	1.69	1.32
Std.dev. (Top)	0.57	0.31	0.46	0.35	0.38	0.45	0.33	0.32	0.31	0.46	0.44
SK yield (Other)	0.84	0.79	0.61	0.77	0.60	0.79	0.84	0.82	0.75	0.90	0.77
Std.dev. (Other)	0.39	0.37	0.32	0.34	0.31	0.40	0.40	0.36	0.35	0.43	0.38

Figure 21: Saleable kernel yield for top performing farms versus other mature farms in the benchmark sample (2009–2018)

Figure 22 compares average kernel recovery trends from 2009 to 2018 for the top performing farms with other farms in the benchmark sample. Between 2009 and 2018, top performing farms achieved lower average reject kernel recovery (RKR) than the average for other farms in the benchmark sample in all years, apart from 2013.



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2009–18
SKR% (Top)	35.06	37.09	34.55	35.23	34.31	36.75	35.82	36.73	37.14	37.83	36.16
SKR% (Other)	32.48	34.26	32.56	33.40	31.81	34.26	33.89	33.59	34.26	35.28	33.63
RKR% (Top)	2.40	2.02	2.48	1.92	3.54	2.19	2.34	2.31	2.18	2.18	2.36
RKR% (Other)	2.91	2.71	3.15	2.34	3.39	2.90	2.45	2.86	2.60	2.70	2.79

Figure 22: Kernel recovery for the top performing farms versus all other farms in the benchmark sample (2009–2018)

The top performing farms (based on average yield per hectare) consistently achieved a higher average saleable kernel recovery (SKR) than other farms in the benchmark sample across the ten seasons. The top performing farms averaged 36.16% SKR over the past ten years, compared with 33.63% for other farms (approximately 2.5% higher). The difference in SKR between the groups varied from 1.83% in 2012 to 3.14% in 2016. These SKR differences mean that the top performing farms also achieved a higher price per kilogram of nut-in-shell (NIS) each year than other farms in the benchmark sample.

In addition to higher average saleable kernel yield, top performing farms also achieved higher average saleable kernel recovery and generally lower average reject kernel recovery than other farms in the benchmark sample between 2009 and 2018.

Figure 23 shows the average percentage of rejects by reject category for top performing farms compared with all other farms in the benchmark sample from 2009 to 2018. These averages are unweighted, which means that each farm in the data sample exerts equal influence on the average, regardless of size or amount of production.

The long-term average reject kernel recovery for top performing farms is significantly lower than that of other farms ($P < 0.01$). Insect damage was the dominant reject category for most seasons from 2009 to 2018. Over this whole period top performing farms had significantly lower rejects due to insect damage, mould, discolouration and immaturity than other farms ($P < 0.01$). The only categories of reject that did not differ significantly between the two groups were brown centres and germination ($P > 0.05$).

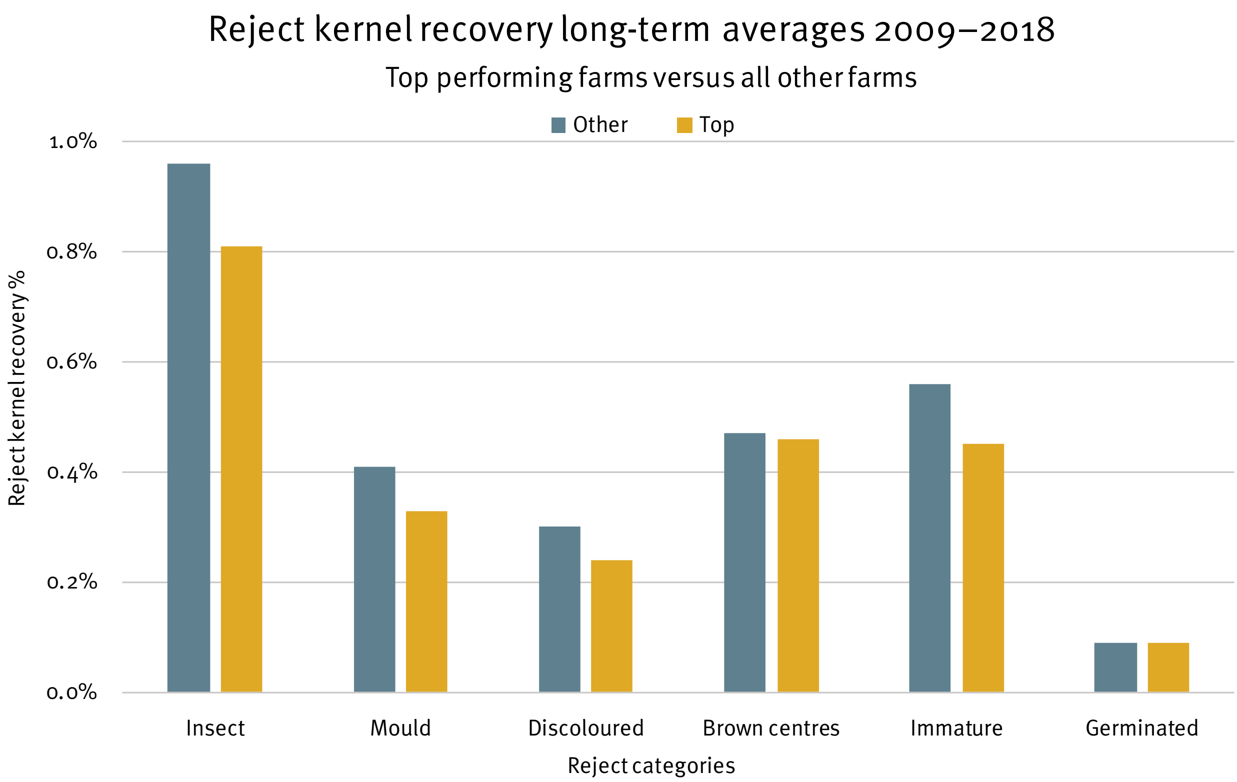


Figure 23: Reject breakdown for top performing farms versus all other farms (2009–2018)

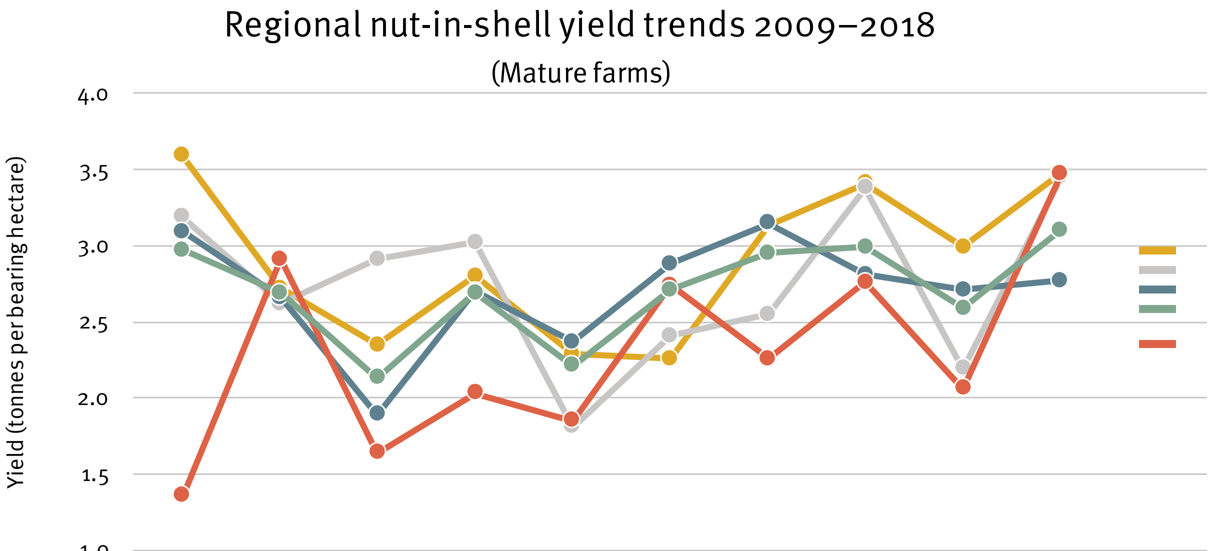
Figure 24 shows reject category trends for top performing farms compared with all other farms in the benchmark sample between 2009 and 2018. While top performing farms achieved lower long-term average reject levels in each category, the seasonal trends show this is not the case in all years.

Figure 24: Reject category trends for top performing farms versus all other farms (2009–2018)

Seasonal trends by region

Yield and quality results were compared across the four major production regions of Central Queensland (CQ), South East Queensland (SEQ), Northern Rivers of NSW (NRNSW) and the Mid North Coast of NSW (MNNSW). **Figure 25** compares average annual nut-in-shell (NIS) yield per bearing hectare for mature farms (10+ years old) in each of these regions. These averages are unweighted, meaning all farms exert equal influence regardless of their size.

Over the last 10 years the average yield of mature farms in CQ (2.97 t/ha) was significantly higher than that of any of the other three regions ($P < 0.05$). Ten year averages for SEQ and NRNSW (2.75 and 2.72 t/ha respectively) were not significantly different to each other ($P > 0.05$). The MNNSW ten year average yield (2.36 t/ha) was significantly lower than the other three regions ($P < 0.01$).



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2009–18
CQ	3.59	2.72	2.35	2.80	2.29	2.26	3.14	3.41	2.99	3.48	2.97
SEQ	3.19	2.62	2.91	3.02	1.81	2.41	2.55	3.38	2.19	3.45	2.75
NRNSW	3.09	2.66	1.89	2.70	2.37	2.88	3.15	2.81	2.71	2.77	2.72
MNNSW	1.36	2.91	1.64	2.03	1.85	2.74	2.26	2.76	2.06	3.47	2.36
All regions	2.97	2.69	2.13	2.69	2.21	2.71	2.95	2.99	2.59	3.10	2.72

Figure 25: Regional nut-in-shell yields per bearing hectare for mature farms (2009–2018)

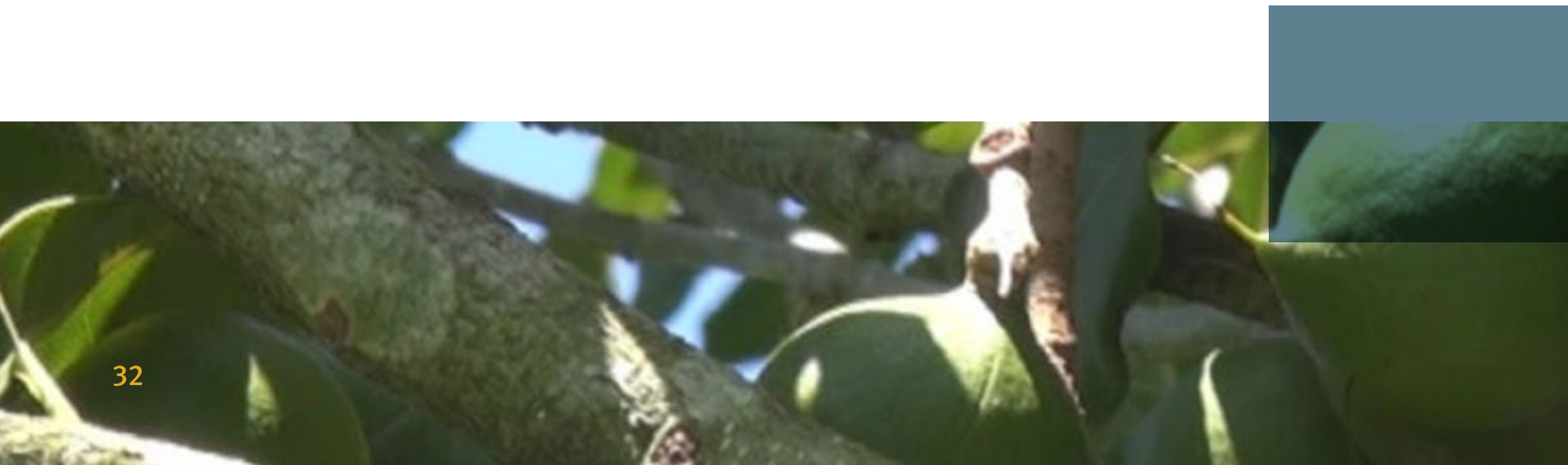
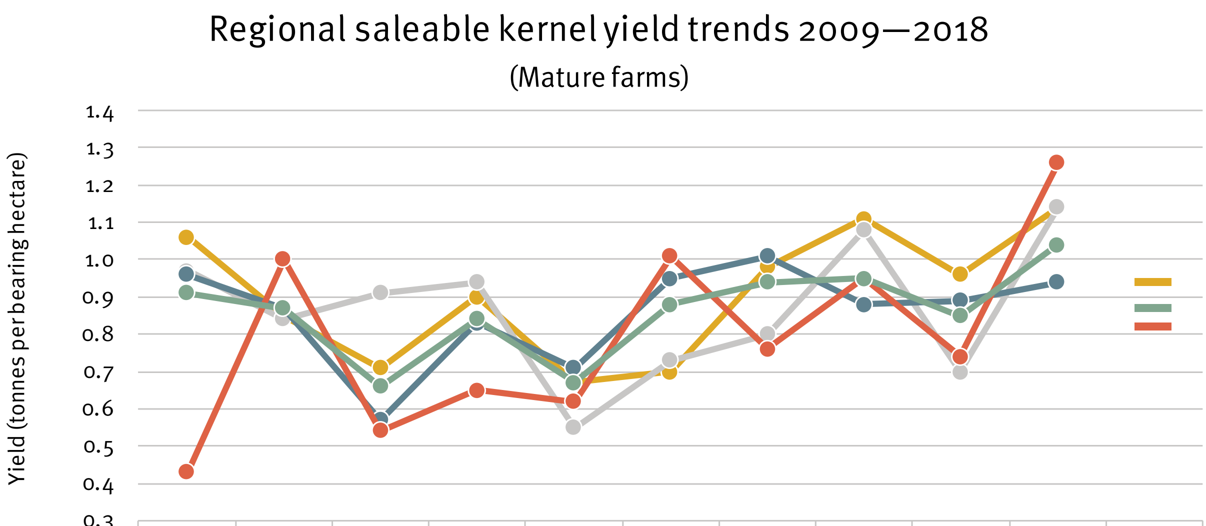


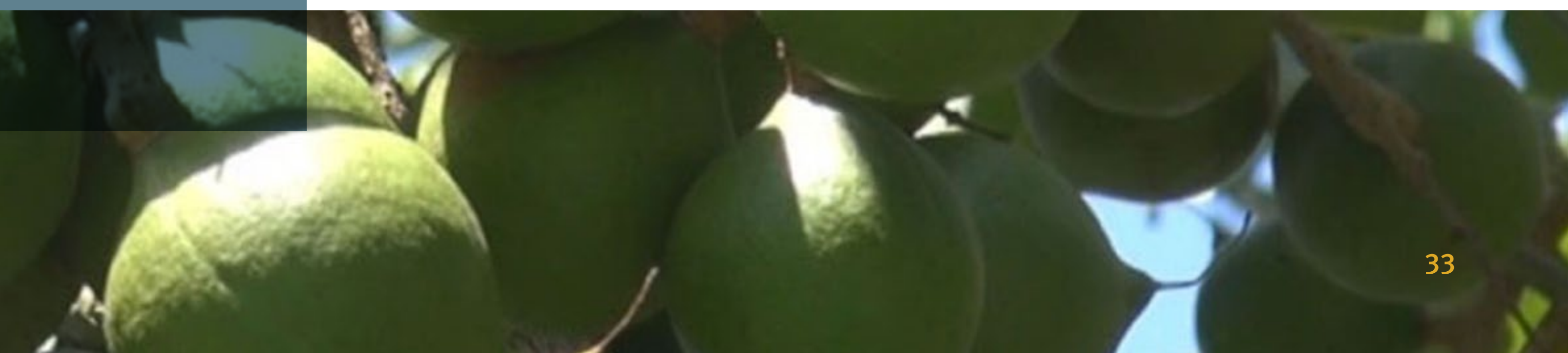
Figure 26 compares average yields of saleable kernel (SK) per bearing hectare from 2009 to 2018 for mature farms in each of the four regions in the benchmark sample. This chart shows a similar general trend to NIS productivity for this period, with some variation in specific regions and seasons due to differences in saleable kernel recovery.

Farms in the CQ region achieved significantly higher long-term average SK productivity (0.94 t/ha) than all other regions between 2009 to 2018 ($P < 0.05$). SK productivity in NRNSW and SEQ (both 0.87 t/ha) was not statistically different to MNNSW (0.82 t/ha).



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2009–18
CQ	1.06	0.85	0.71	0.90	0.67	0.70	0.98	1.11	0.96	1.14	0.94
SEQ	0.97	0.84	0.91	0.94	0.55	0.73	0.80	1.08	0.70	1.14	0.87
NRNSW	0.96	0.87	0.57	0.83	0.71	0.95	1.01	0.88	0.89	0.94	0.87
MNNSW	0.43	1.00	0.54	0.65	0.62	1.01	0.76	0.95	0.74	1.26	0.82
All regions	0.91	0.87	0.66	0.84	0.67	0.88	0.94	0.95	0.85	1.04	0.87

Figure 26: Regional saleable kernel yields per bearing hectare for mature farms (2009–2018)



Finding value in benchmarking

ABOVE: Daniel Jackson on his 12 hectare orchard in the Glass House Mountains.

Since taking over their orchard in 2017, Daniel and Angela Jackson have focused on improving soil health. Applying mulch has been particularly critical for gradually improving soil health and maintaining soil moisture.

"We have invested in drip irrigation to help manage the climate variability."

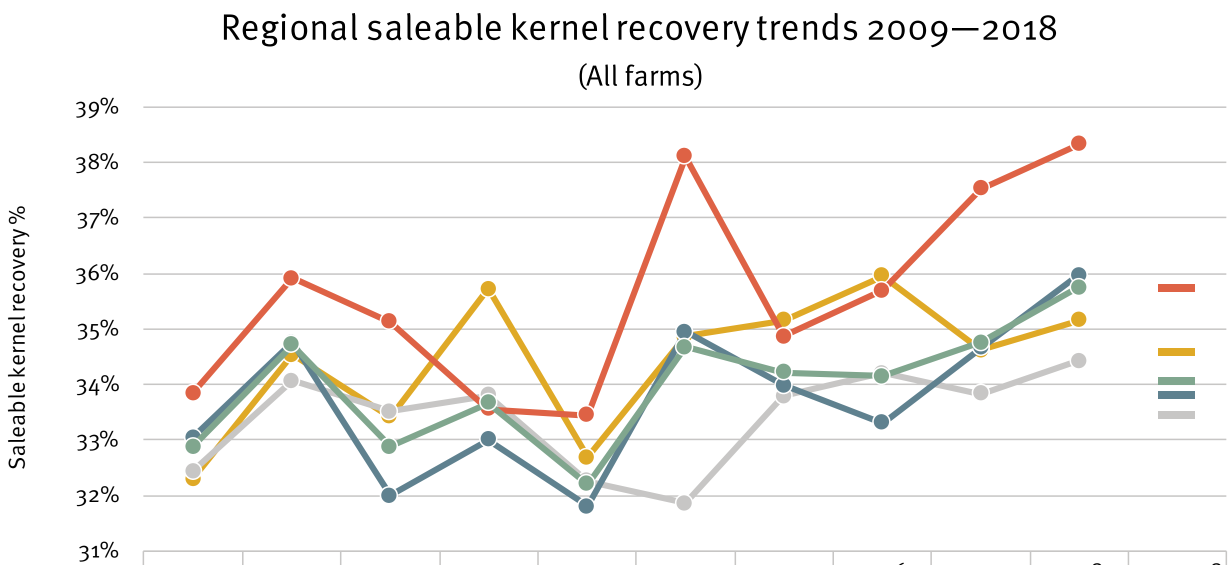
High organic matter enables Angela and Daniel to make the most of their available water.

The Jacksons say they participate in benchmarking to track the productivity of their orchard and also find real value in regional Benchmark Group meetings.

"The open discussion between growers in the meetings is the real benefit. It assists in developing strategies for next season."

Figure 27 compares average regional saleable kernel recovery (SKR) for farms in each major production region from 2009 to 2018. SKR is the sum of premium kernel recovery (PKR) and commercial kernel recovery (CKR).

Average SKR in the CQ and MNNSW regions was significantly higher than that in the SEQ and NRNSW regions ($P < 0.01$).

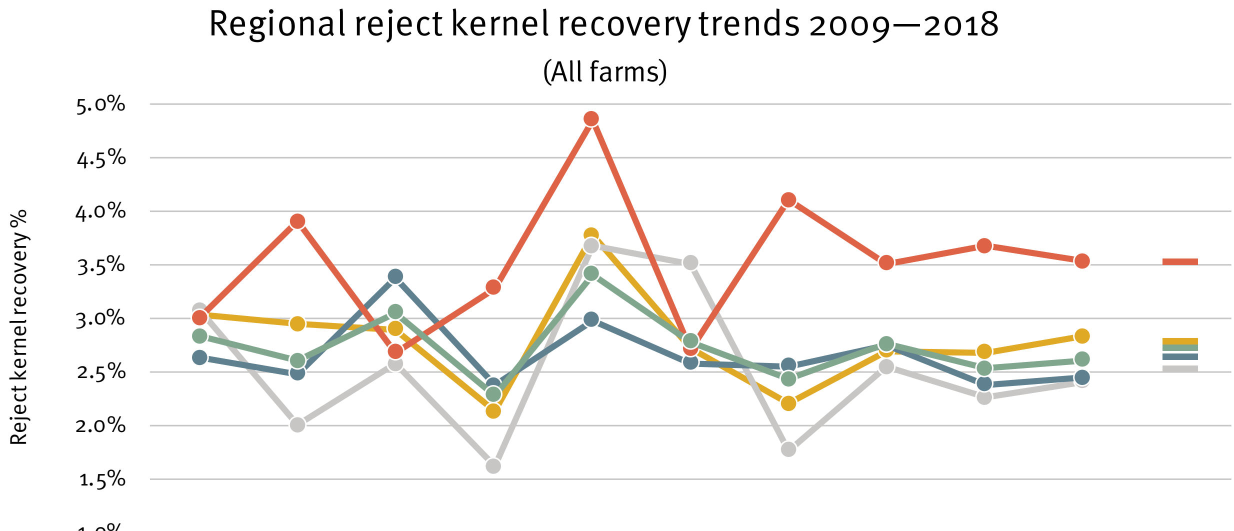


	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2009–18
CQ	32.30	34.53	33.42	35.72	32.69	34.86	35.16	35.96	34.62	35.16	34.57
SEQ	32.44	34.07	33.52	33.81	32.26	31.86	33.79	34.20	33.83	34.43	33.45
NRNSW	33.04	34.76	32.00	33.00	31.81	34.95	33.98	33.31	34.66	35.97	33.81
MNNSW	33.85	35.91	35.12	33.56	33.45	38.10	34.87	35.69	37.52	38.33	35.75
All regions	32.88	34.71	32.88	33.67	32.20	34.67	34.22	34.15	34.76	35.74	34.05

Figure 27: Regional saleable kernel recoveries for all farms (2009–2018)

Figure 28 compares average reject kernel recovery (RKR) for each region from 2009 to 2018.

The long-term average RKR for the MNNSW region (3.52%) was significantly higher than other regions ($P < 0.01$). This was followed by CQ which had significantly higher ($P < 0.05$) average RKR (2.78%) than SEQ (2.53%), but was not significantly different to NRNSW (2.64%) ($P > 0.05$).



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2009–18
CQ	3.03	2.94	2.89	2.13	3.77	2.72	2.20	2.69	2.68	2.83	2.78
SEQ	3.07	2.00	2.57	1.61	3.67	3.51	1.76	2.54	2.26	2.41	2.53
NRNSW	2.63	2.48	3.38	2.37	2.98	2.58	2.55	2.75	2.38	2.44	2.64
MNNSW	3.00	3.90	2.68	3.28	4.85	2.71	4.10	3.51	3.67	3.53	3.52
All regions	2.83	2.60	3.05	2.28	3.41	2.78	2.43	2.76	2.53	2.61	2.72

Figure 28: Regional reject kernel recoveries (2009–2018)

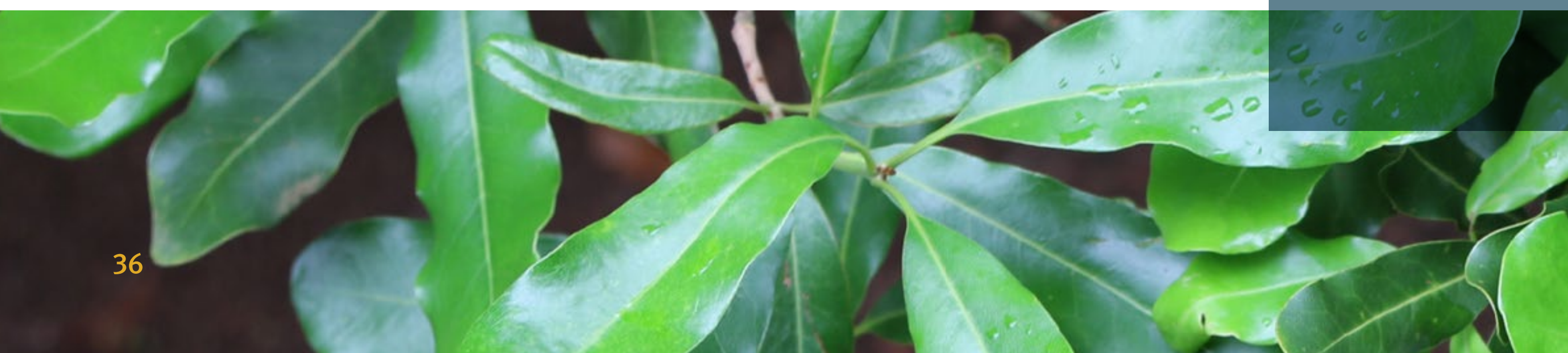
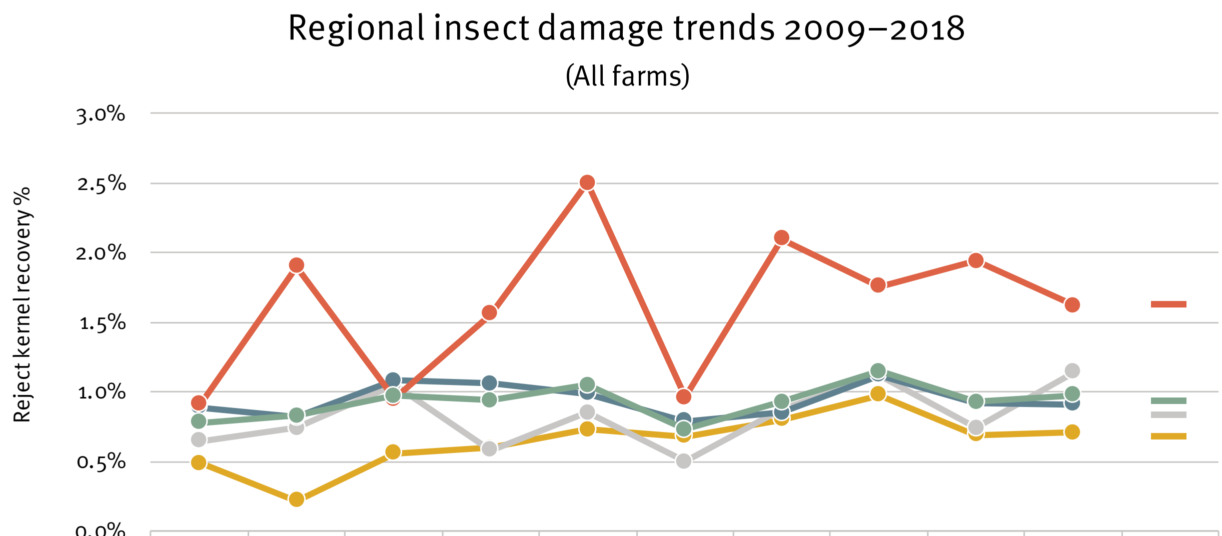


Figure 29 shows average factory rejects due to insect damage for participating farms in each of the four major production regions from 2009 to 2018.

Average insect damage levels were significantly higher in MNNSW (1.63%) than in all other regions over the 2009–2018 period ($P < 0.01$). NRNSW and SEQ average insect reject levels (0.94% and 0.84% respectively) were statistically similar to each other and significantly higher than CQ (0.68%) ($P < 0.01$ and $P < 0.05$ respectively).



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2009–18
CQ	0.49	0.22	0.56	0.60	0.73	0.68	0.80	0.98	0.69	0.71	0.68
SEQ	0.65	0.74	1.05	0.58	0.85	0.50	0.88	1.12	0.74	1.14	0.84
NRNSW	0.89	0.82	1.08	1.06	0.99	0.79	0.85	1.12	0.92	0.91	0.94
MNNSW	0.91	1.90	0.95	1.56	2.50	0.96	2.10	1.76	1.94	1.62	1.63
All regions	0.78	0.83	0.97	0.94	1.05	0.73	0.93	1.15	0.93	0.98	0.94

Figure 29: Regional insect damage rejects (2009–2018)

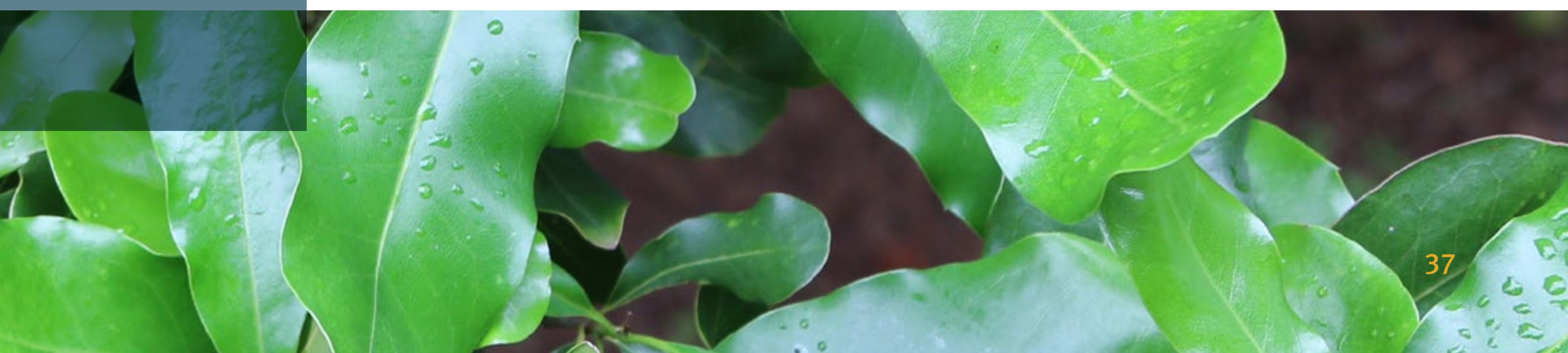
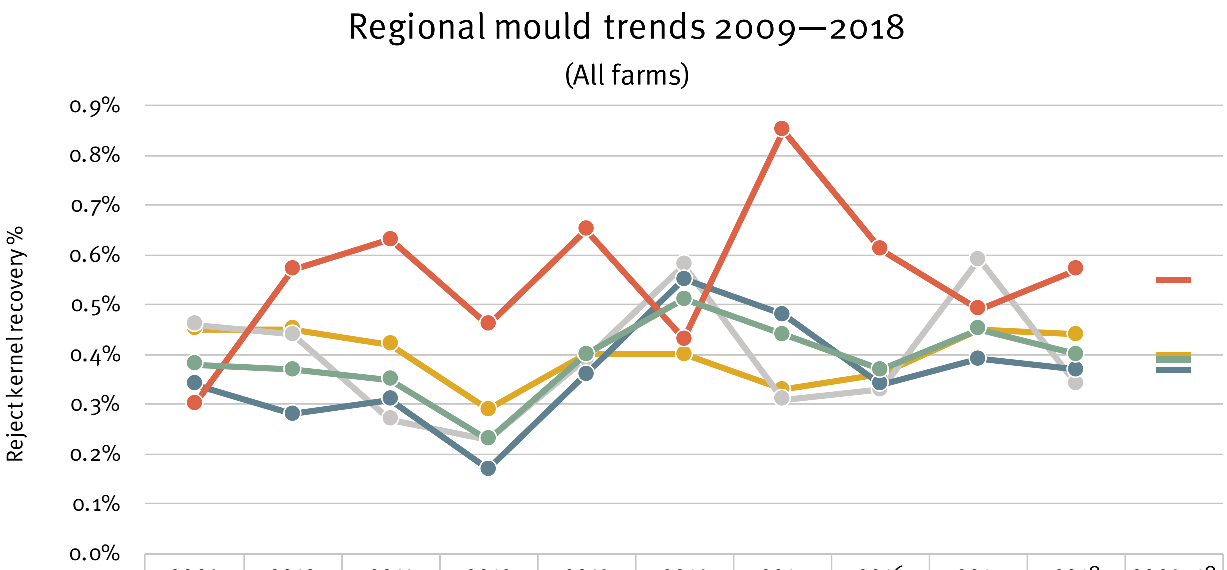


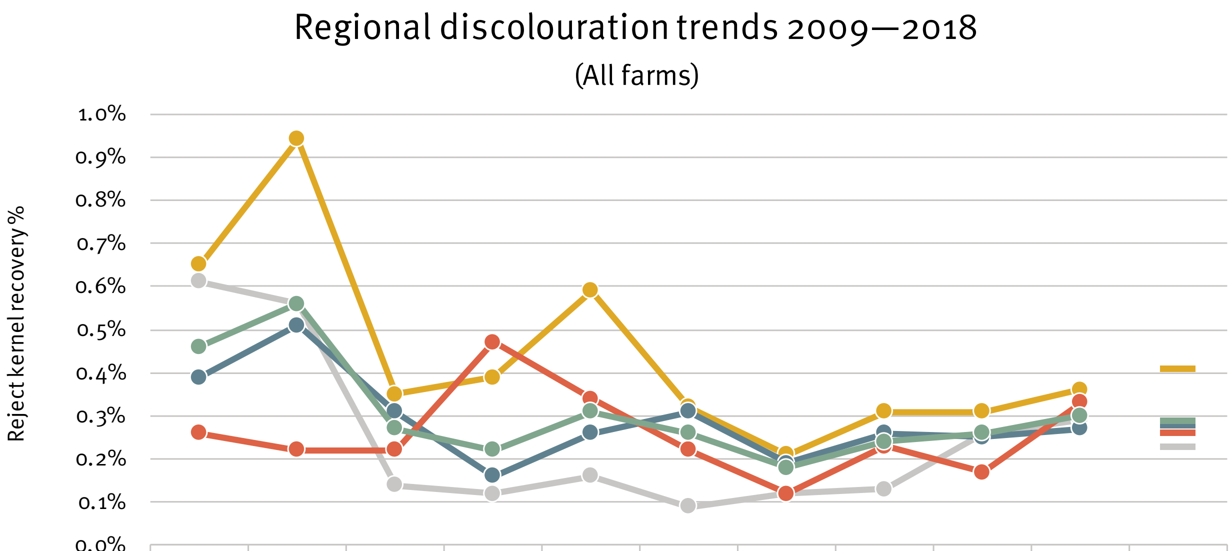
Figure 30 shows average factory rejects due to mould from 2009 to 2018 for each of the four regions in the benchmark sample. MNNSW had a significantly higher average level of mould rejects (0.55%) than all other regions over the 2009–2018 period (*P* ‹0.01). Long-term average mould rejects were statistically similar in all other regions.



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2009–18
CQ	0.45	0.45	0.42	0.29	0.40	0.40	0.33	0.36	0.45	0.44	0.40
SEQ	0.46	0.44	0.27	0.23	0.39	0.58	0.31	0.33	0.59	0.34	0.39
NRNSW	0.34	0.28	0.31	0.17	0.36	0.55	0.48	0.34	0.39	0.37	0.37
MNNSW	0.30	0.57	0.63	0.46	0.65	0.43	0.85	0.61	0.49	0.57	0.55
All regions	0.38	0.37	0.35	0.23	0.40	0.51	0.44	0.37	0.45	0.40	0.39

Figure 30: Regional mould rejects (2009–2018)

Figure 31 shows factory rejects due to discolouration over the period 2009 to 2018 for each of the four regions in the benchmark sample. SEQ and MNNSW achieved the lowest average discolouration level (0.23% and 0.26% respectively) for this category, each significantly lower than CQ ($P < 0.01$). The SEQ average discolouration level was also significantly lower than that of NRNSW ($P < 0.05$). CQ had the highest average for this reject category ($P < 0.01$).



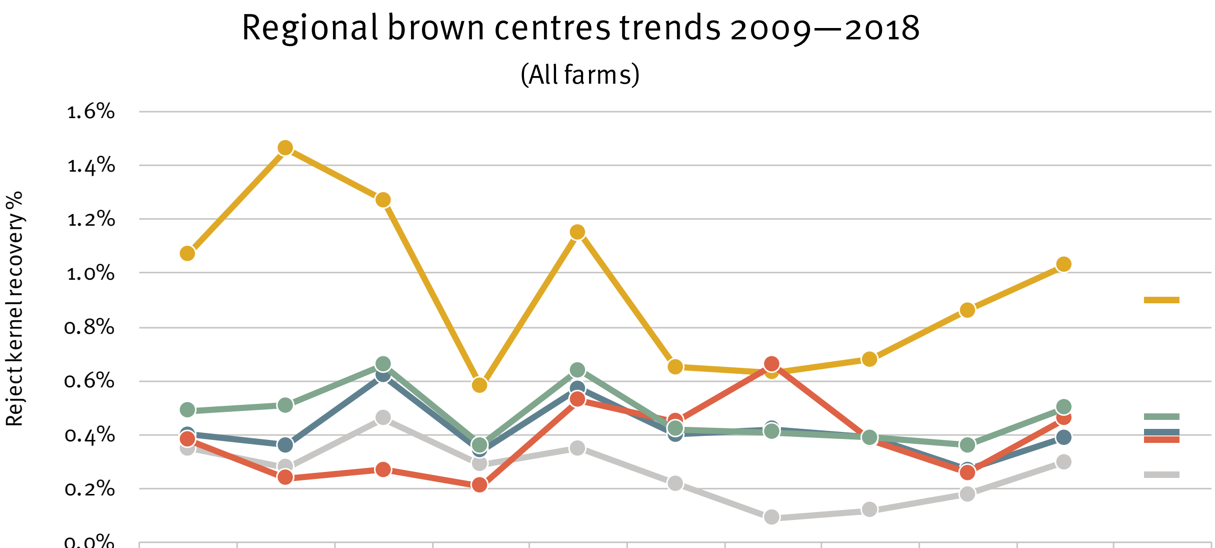
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2009–18
CQ	0.65	0.94	0.35	0.39	0.59	0.32	0.21	0.31	0.31	0.36	0.41
SEQ	0.61	0.56	0.14	0.12	0.16	0.09	0.12	0.13	0.26	0.29	0.23
NRNSW	0.39	0.51	0.31	0.16	0.26	0.31	0.19	0.26	0.25	0.27	0.28
MNNSW	0.26	0.22	0.22	0.47	0.34	0.22	0.12	0.23	0.17	0.33	0.26
All regions	0.46	0.56	0.27	0.22	0.31	0.26	0.18	0.24	0.26	0.30	0.29

Figure 31: Regional discolouration rejects (2009–2018)

Figure 32 shows factory rejects due to brown centres from 2009 to 2018 for each of the four regions in the benchmark sample.

In most seasons, farms in the CQ region have had higher average rejects due to brown centres than those in other regions. The CQ long-term average (0.90%) over the study period shows brown centre reject levels were higher than any other region (*P* ‹0.01). The average of brown centre reject levels for SEQ (0.25%) was lower than any other region (*P* ‹0.01).

Benchmark data has shown that CQ farms are, on average, much larger than farms in the other regions. Grower surveys from the Macadamia Kernel Quality project (MC07008) found that on average brown centres increased with increasing farm size, maximum silo size and nut storage bed depth.



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2009–18
CQ	1.07	1.46	1.27	0.58	1.15	0.65	0.63	0.68	0.86	1.03	0.90
SEQ	0.35	0.28	0.46	0.29	0.35	0.22	0.09	0.12	0.18	0.30	0.25
NRNSW	0.40	0.36	0.62	0.34	0.57	0.40	0.42	0.39	0.27	0.39	0.41
MNNSW	0.38	0.24	0.27	0.21	0.53	0.45	0.66	0.38	0.26	0.46	0.38
All regions	0.49	0.51	0.66	0.36	0.64	0.42	0.41	0.39	0.36	0.50	0.47

Figure 32: Regional brown centres rejects (2009–2018)

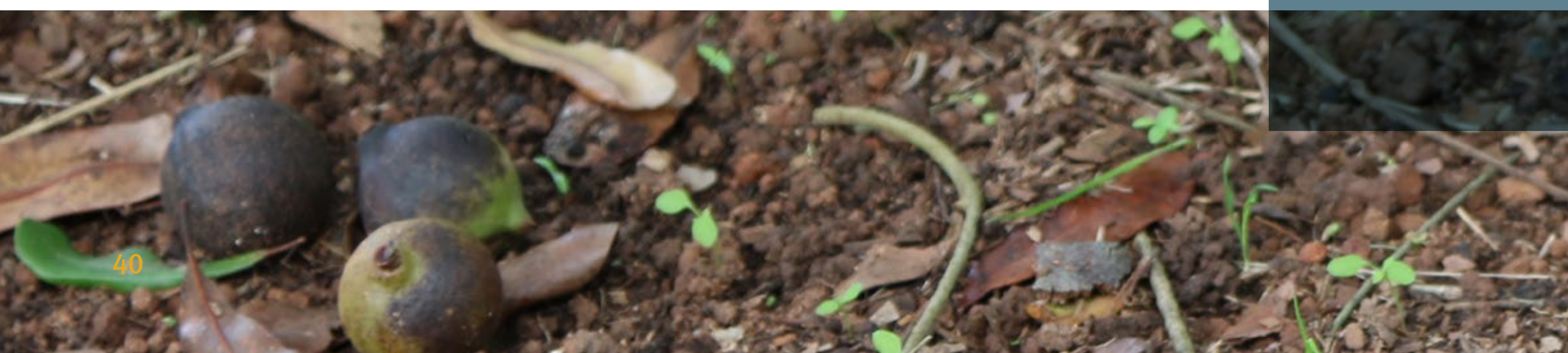
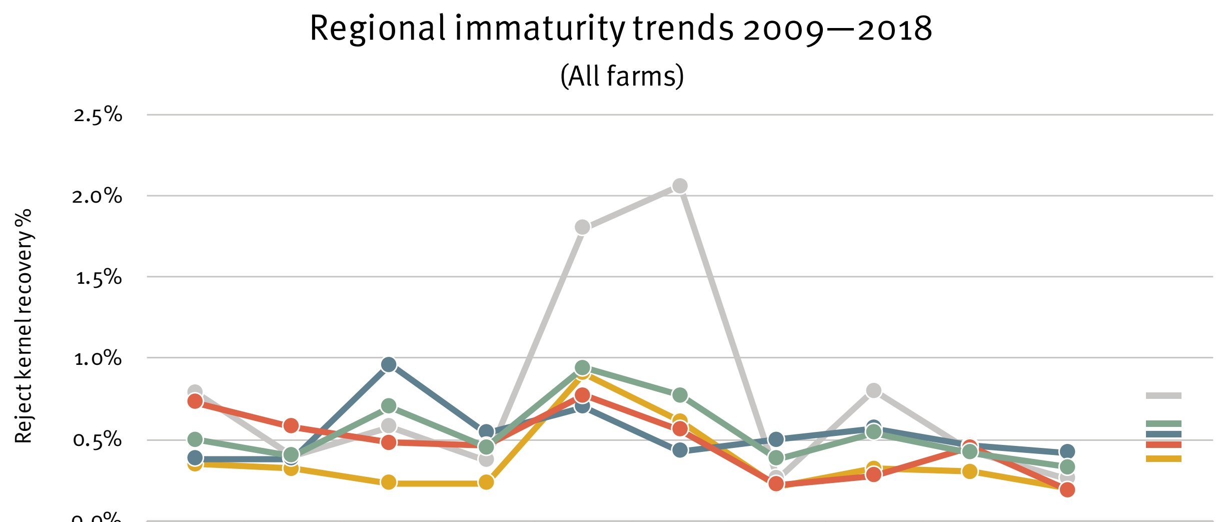


Figure 33 shows factory rejects due to immaturity from 2009 to 2018 for each of the four regions in the benchmark sample.

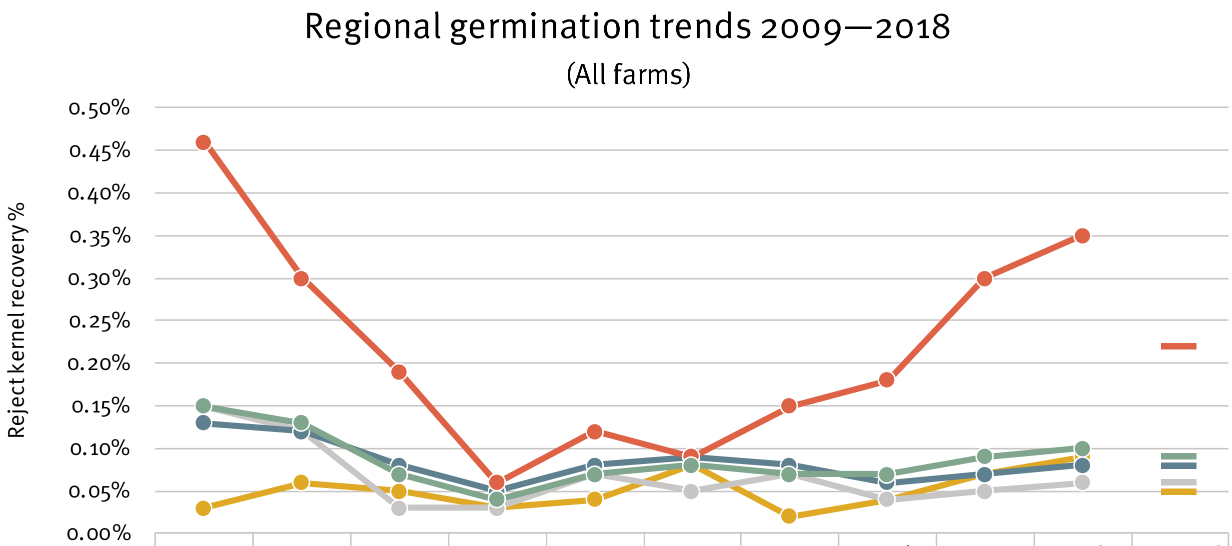
SEQ had the highest levels of immaturity over the 2009–2018 period (*P* ‹0.01). Previous high immaturity levels in SEQ in 2013 and 2014 have largely been attributed to very dry conditions leading to moisture stress during nut growth and oil accumulation stages. Prior to 2012 much of the immaturity in SEQ and NSW was attributed to premature nut drop caused by husk spot. Husk spot was not as prevalent during 2012 to 2018 and was not considered a major cause of immaturity in these seasons.



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2009–18
CQ	0.35	0.32	0.23	0.23	0.91	0.61	0.21	0.32	0.30	0.20	0.38
SEQ	0.79	0.40	0.58	0.37	1.80	2.06	0.26	0.80	0.43	0.26	0.77
NRNSW	0.38	0.38	0.96	0.54	0.70	0.43	0.50	0.57	0.46	0.42	0.53
MNNSW	0.73	0.58	0.48	0.46	0.77	0.56	0.22	0.28	0.45	0.19	0.47
All regions	0.50	0.40	0.70	0.45	0.94	0.77	0.38	0.54	0.42	0.33	0.54

Figure 33: Regional immaturity rejects (2009–2018)

Figure 34 shows factory rejects due to germination from 2009 to 2018 for each of the four regions in the benchmark sample. Average germination rejects have remained low across most regions since 2012, with average losses due to germination being the least prevalent type of reject across the benchmark sample from 2009 to 2018. MNNSW however had higher average levels of germination than the other regions in most years, with its average over the whole period (0.22%), significantly higher than other regions ($P < 0.01$).



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2009–18
CQ	0.03	0.06	0.05	0.03	0.04	0.08	0.02	0.04	0.07	0.09	0.05
SEQ	0.15	0.12	0.03	0.03	0.07	0.05	0.07	0.04	0.05	0.06	0.06
NRNSW	0.13	0.12	0.08	0.05	0.08	0.09	0.08	0.06	0.07	0.08	0.08
MNNSW	0.46	0.30	0.19	0.06	0.12	0.09	0.15	0.18	0.30	0.35	0.22
All regions	0.15	0.13	0.07	0.04	0.07	0.08	0.07	0.07	0.09	0.10	0.09

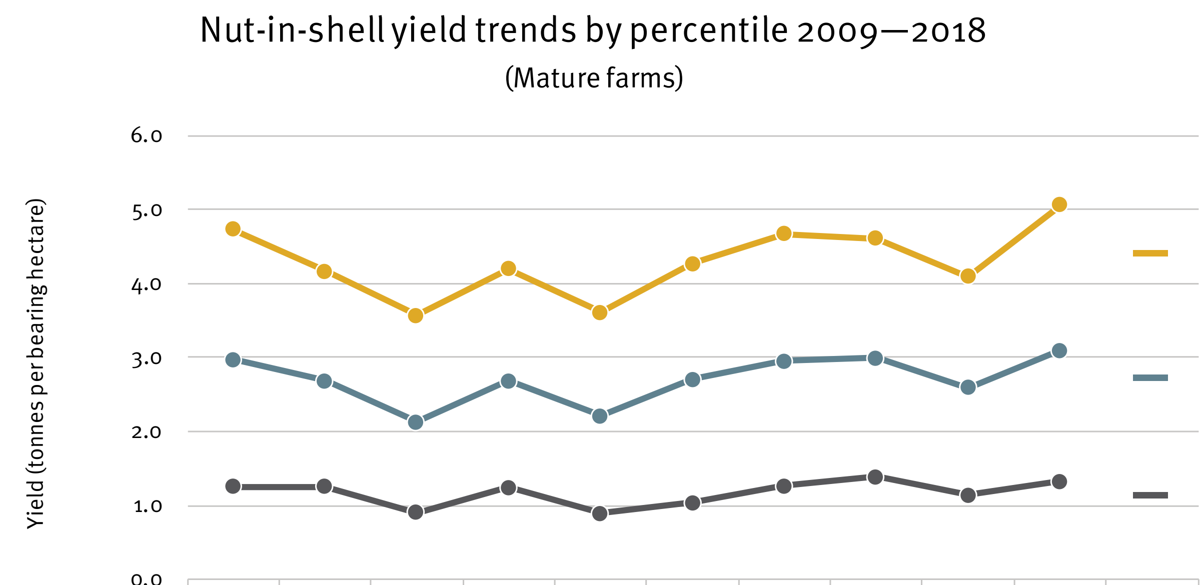
Figure 34: Regional germination rejects (2009–2018)

Productivity and quality percentiles

In this section yield and quality information is presented as percentiles. Averages for the top 25% and bottom 25% of the benchmark sample are compared with the sample average. It is important to note that the farms included in percentile averages are different for each season and yield or quality attribute. This means for example that the top 25% of farms for nut-in-shell (NIS) production in any given season may not be the same farms as the top 25% for saleable kernel (SK) production. This is quite different to the top performing farms in the previous section, which are based on a static group of farms that returned consistently high SK production per bearing hectare over multiple seasons. Percentiles therefore provide insight into sample variability rather than providing indication of long-term performance.

Yield percentiles are based on mature farms to avoid the influence of young farms that are yet to reach full production. Quality percentiles are based on all farms in the benchmark sample. Substantial variability in both yield and quality was evident within the benchmark sample.

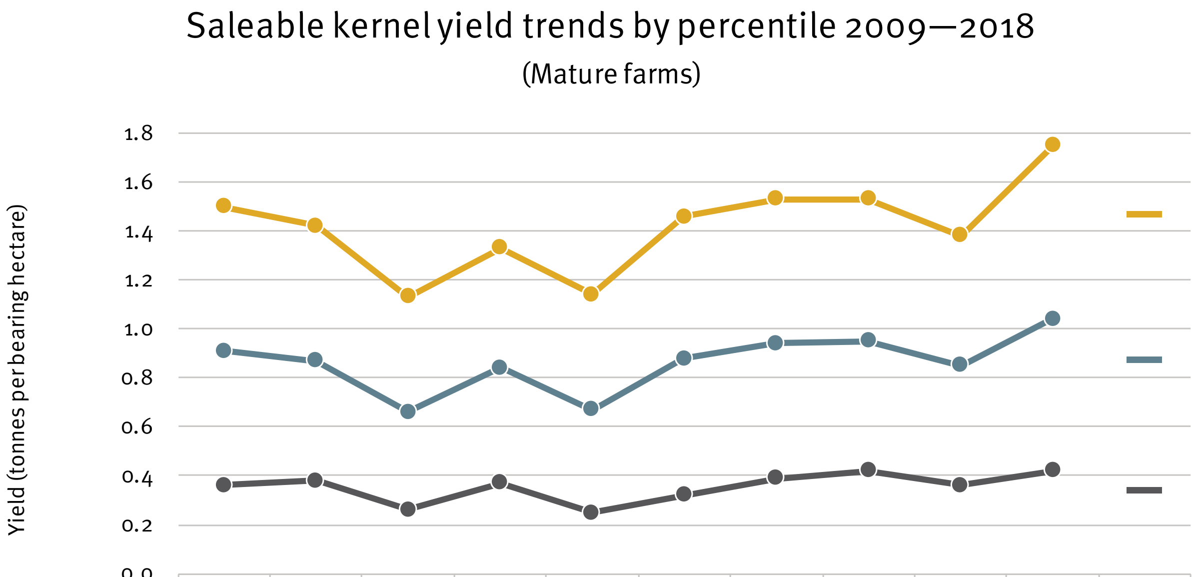
Figure 35 compares the average tonnes of NIS per bearing hectare for the top 25%, bottom 25% and all mature farms in the benchmark sample for each year from 2009 to 2018. In terms of average NIS, over this period the top 25% of the sample was almost four times as productive as the bottom 25% of the sample.



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2009–18
Top 25%	4.73	4.17	3.57	4.20	3.61	4.27	4.67	4.61	4.10	5.06	4.41
All mature farms	2.97	2.69	2.13	2.69	2.21	2.71	2.95	2.99	2.59	3.10	2.72
Bottom 25%	1.25	1.25	0.90	1.24	0.89	1.04	1.26	1.39	1.14	1.33	1.14

Figure 35: Nut-in-shell average yields with top and bottom quartile yields from 2009–2018

Figure 36 compares the average tonnes of saleable kernel (SK) per bearing hectare for the top 25%, bottom 25% and all farms in the benchmark sample for each year from 2009 to 2018. SK productivity increased across all groups from 2013, with a dip in 2017. Yield increases and decreases were generally more pronounced in the top 25%. The average SK productivity of the top 25% of the sample over the entire period was over four times that of the bottom 25%.

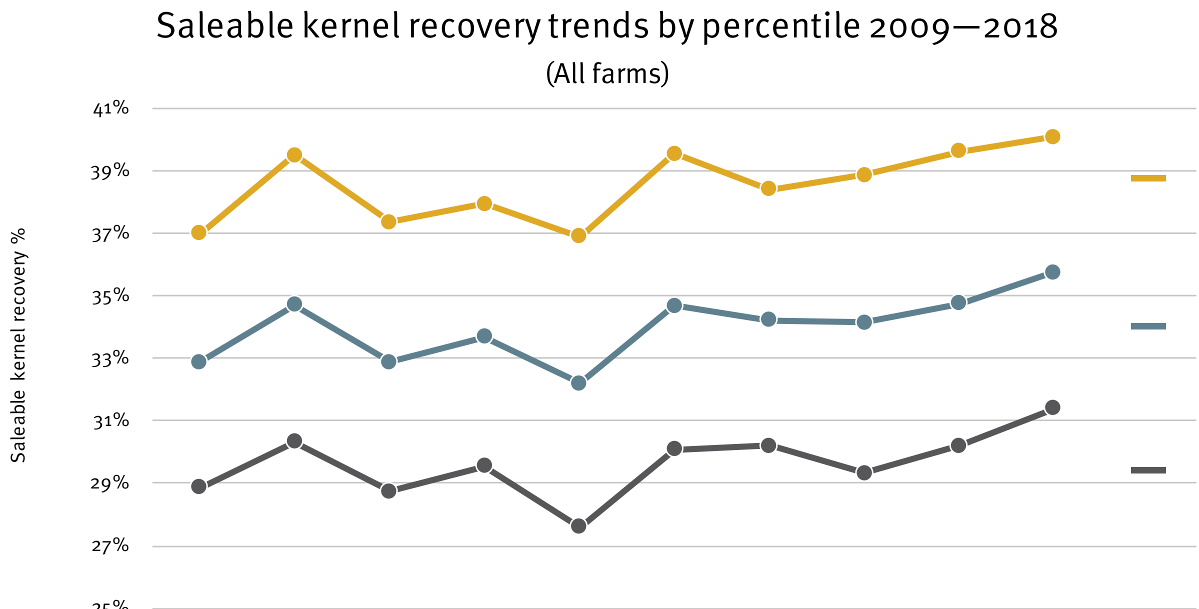


	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2009–18
Top 25%	1.50	1.42	1.13	1.33	1.14	1.46	1.53	1.53	1.38	1.75	1.47
All mature farms	0.91	0.87	0.66	0.84	0.67	0.88	0.94	0.95	0.85	1.04	0.87
Bottom 25%	0.36	0.38	0.26	0.37	0.25	0.32	0.39	0.42	0.36	0.42	0.34

Figure 36: Saleable kernel average yields with top and bottom quartile yields from 2009–2018

For the ten years from 2009 to 2018 average saleable kernel productivity for the top 25% of the benchmark sample (1.47 t/ha) has been more than four times higher than the bottom 25% of the sample (0.34 t/ha).

Figure 37 compares average saleable kernel recovery (SKR) for the top 25%, bottom 25% and all farms in the benchmark sample for each year from 2009 to 2018. SKR is equivalent to the sum of premium kernel recovery (PKR) and commercial kernel recovery (CKR). Over the last ten years average SKR for the top 25% of the sample was more than 30% higher than that of the bottom 25%.

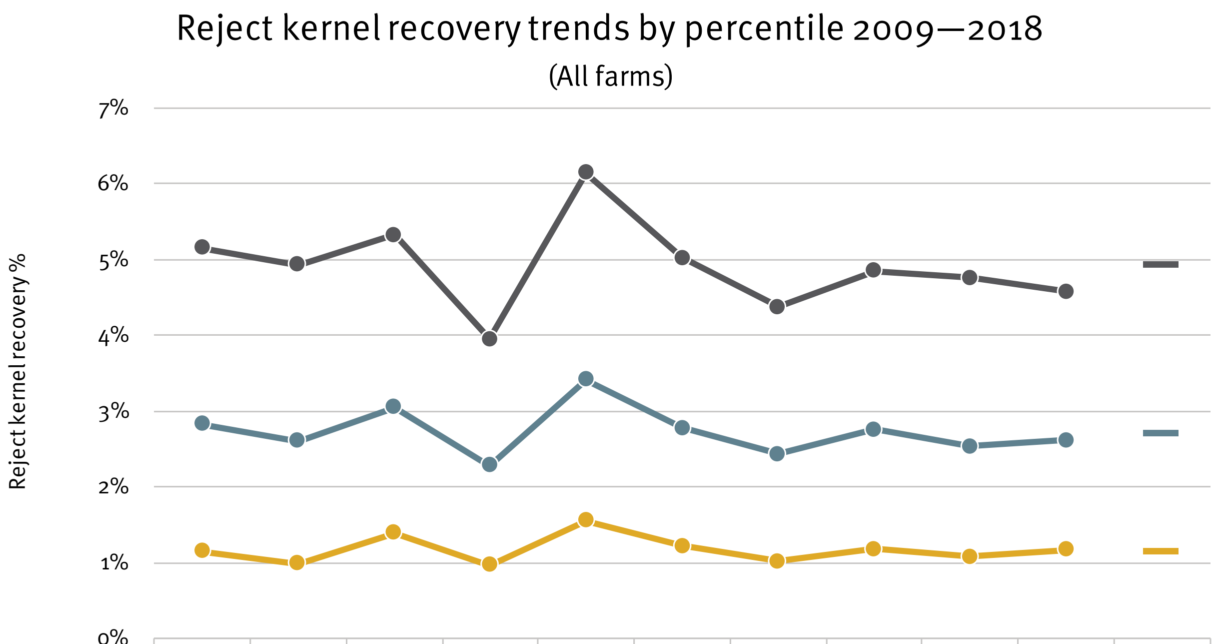


	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2009–18
Top 25%	36.98	39.50	37.35	37.93	36.90	39.54	38.40	38.86	39.62	40.07	38.74
All farms	32.88	34.71	32.88	33.67	32.20	34.67	34.22	34.15	34.76	35.74	34.05
Bottom 25%	28.85	30.32	28.73	29.54	27.60	30.09	30.21	29.32	30.21	31.38	29.41

Figure 37: Saleable kernel recovery averages with top and bottom quartile averages from 2009–2018

Figure 38 compares average reject kernel recovery (RKR) for the top 25%, bottom 25% and all farms in the benchmark sample for each year from 2009 to 2018. RKR and associated reject category percentiles are inverted, as low RKR and individual reject levels represent better quality.

Over the ten seasons, average RKR levels were lowest in 2012 and peaked in 2013 across all percentile groups. Over the whole study period the average RKR of the top 25% of farms was around one fifth of that of the bottom 25% of farms.



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2009–18
Top 25%	1.15	0.99	1.39	0.97	1.55	1.22	1.02	1.18	1.08	1.17	1.16
All farms	2.83	2.6	3.05	2.28	3.41	2.78	2.43	2.76	2.53	2.61	2.72
Bottom 25%	5.15	4.93	5.32	3.95	6.14	5.02	4.37	4.85	4.76	4.58	4.94

Figure 38: Reject kernel recovery averages with top and bottom quartile averages from 2009–2018

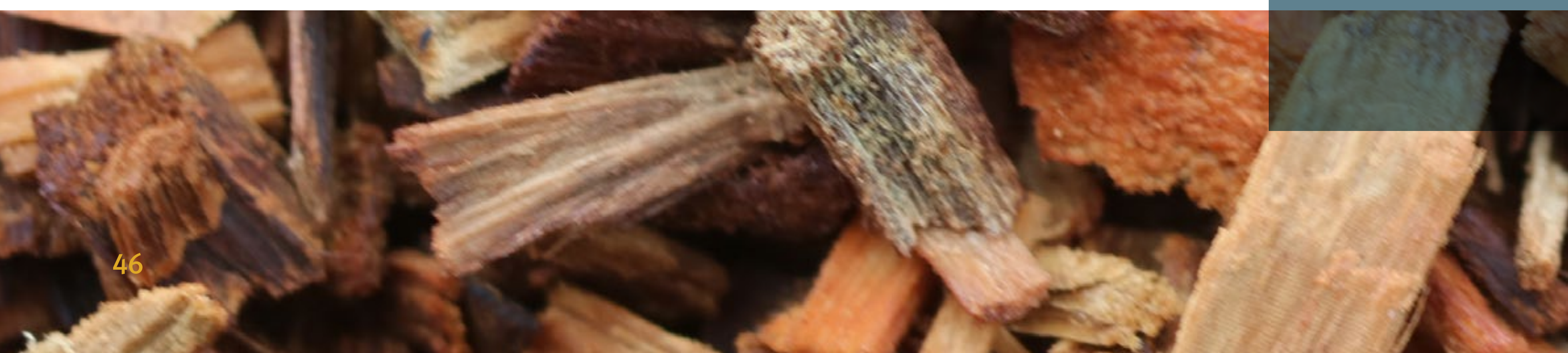


Figure 39 shows the frequency distribution of long-term average productivity for 248 mature farms (10+ years old) that have participated in benchmarking for more than four seasons since 2009, including 2018. The chart demonstrates the relatively high long-term production variability between farms within the benchmark sample. Median SK per bearing hectare was 0.86 t/ha, with a sample standard deviation of 0.45 t/ha. Approximately 64% of farms in the sample had long-term average saleable kernel productivity of between 0.7 and 1.2 t/ha.

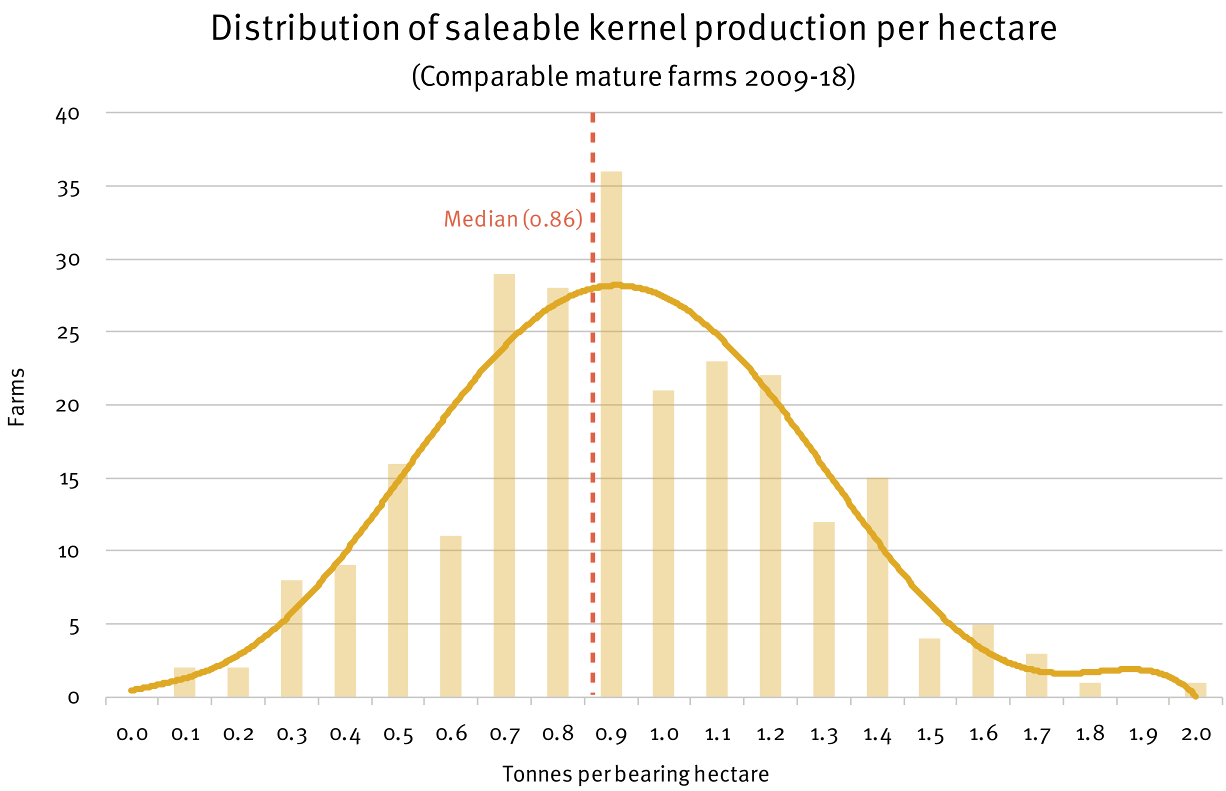


Figure 39: Distribution of saleable kernel per hectare per year of all benchmarking farms over the period 2009–2018

Figure 40 shows the regional frequency distribution of average productivity from 2009 to 2018 for 248 mature farms (10+ years old) that have participated in benchmarking for more than four seasons. The Central Queensland (CQ) productivity curve is biased to the right, reflecting the higher median productivity (0.93 t/ha) compared with other regions. CQ farms also had more uniform productivity compared with other regions, which was indicated by the smaller standard deviation in SK productivity for this region (0.34 t/ha).

Over 79% of farms in the CQ region had long-term average saleable kernel productivity of between 0.7 and 1.2 t/ha. The number of farms within this productivity range dropped to 67% in NRNSW and just 52% in both SEQ and MNNSW.

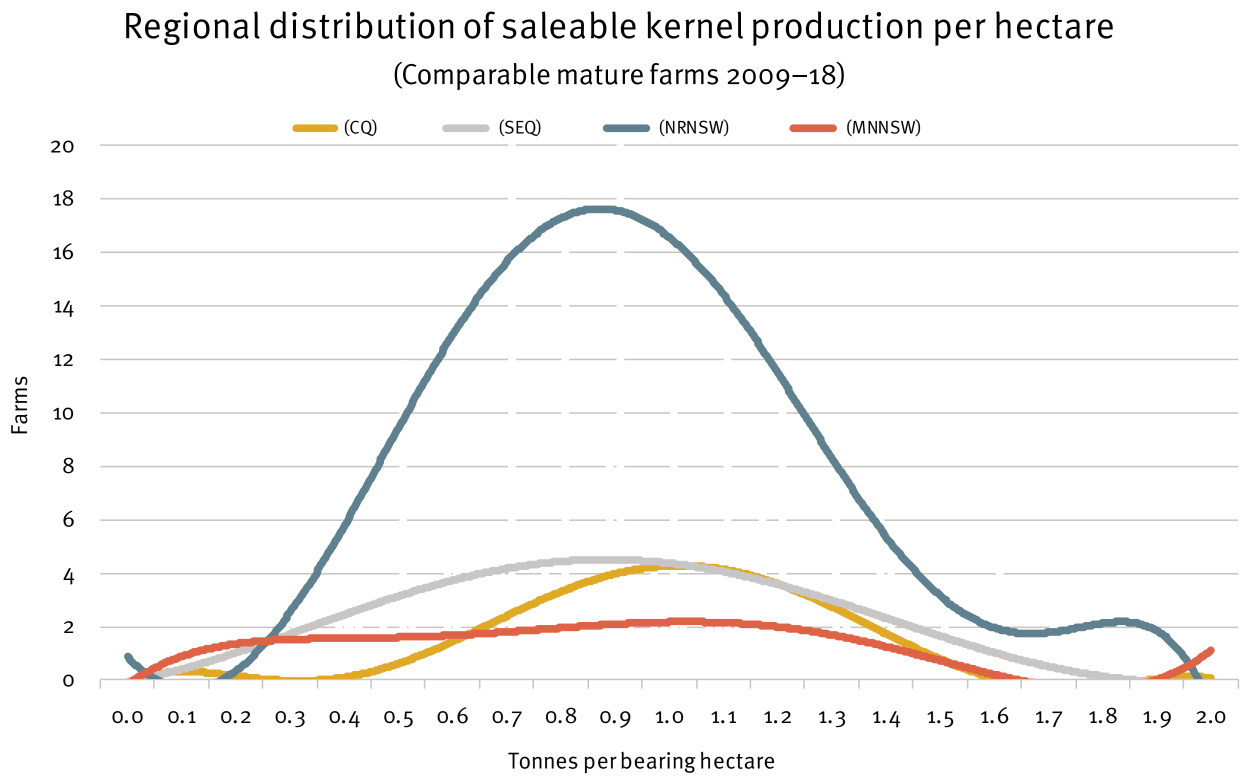


Figure 40: Distribution of saleable kernel per hectare per year for the benchmarking farms in each growing region 2009–2018

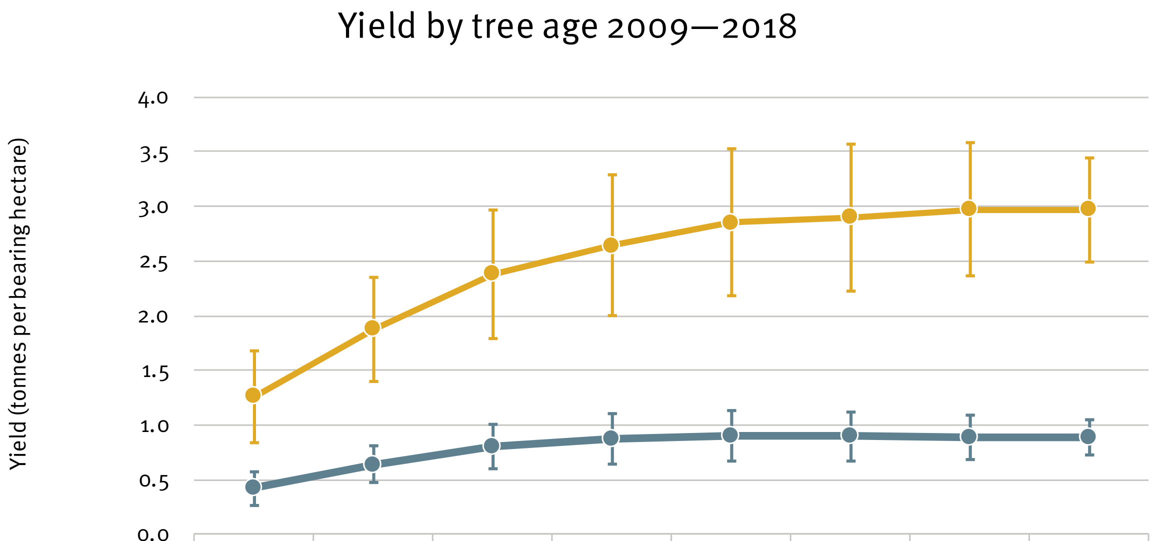
Productivity and quality by tree age

Yield and quality were plotted by tree age to identify age-related trends in orchard performance. It is important to note that all age-related analyses are based on weighted average tree age, as very few farms record harvest results by individual block or tree age group. Some farms also have plantings of various tree ages and so weighted average tree age is calculated from planting data recorded for each farm. Tree age categories are then used to identify and compare data from farms of similar ages.

Tree ages may vary substantially both within and between production regions. Planting densities also vary between farms in various age categories and this may also impact on yields per hectare, particularly during the early bearing years before trees grow together within rows.

Figure 41 shows average yields of nut-in-shell (NIS) and saleable kernel (SK) per bearing hectare for all years from 2009 to 2018 for farms from various tree age categories. Results are presented only where sufficient data exists to maintain individual farm confidentiality (i.e. more than 10 data points).

The average NIS and SK yield both increased significantly with tree age up to the 15–19 years category (*P* ‹0.01). At average tree ages greater than 19 years there is no significant correlation between NIS yield and tree age (*P* ›0.05) or SK yield and tree age (*P* ›0.05).



	5 to 7 years	8 to 9 years	10 to 14 years	15 to 19 years	20 to 24 years	25 to 29 years	30 to 34 years	35+ years
NIS yield (2009-18)	1.26	1.88	2.38	2.64	2.85	2.90	2.97	2.97
NIS Std.dev (2009-18)	0.84	0.95	1.17	1.29	1.34	1.34	1.22	0.95
SK yield (2009-18)	0.42	0.64	0.80	0.87	0.90	0.90	0.89	0.89
SK Std.dev (2009-18)	0.30	0.34	0.41	0.46	0.46	0.45	0.41	0.33

Figure 41: Average yield of nut-in-shell and saleable kernel across tree age groups 2009–2018

Average nut-in-shell yield generally increases with tree age.
Lower average saleable kernel recovery among older farms means
that saleable kernel production per hectare is less influenced by tree age.

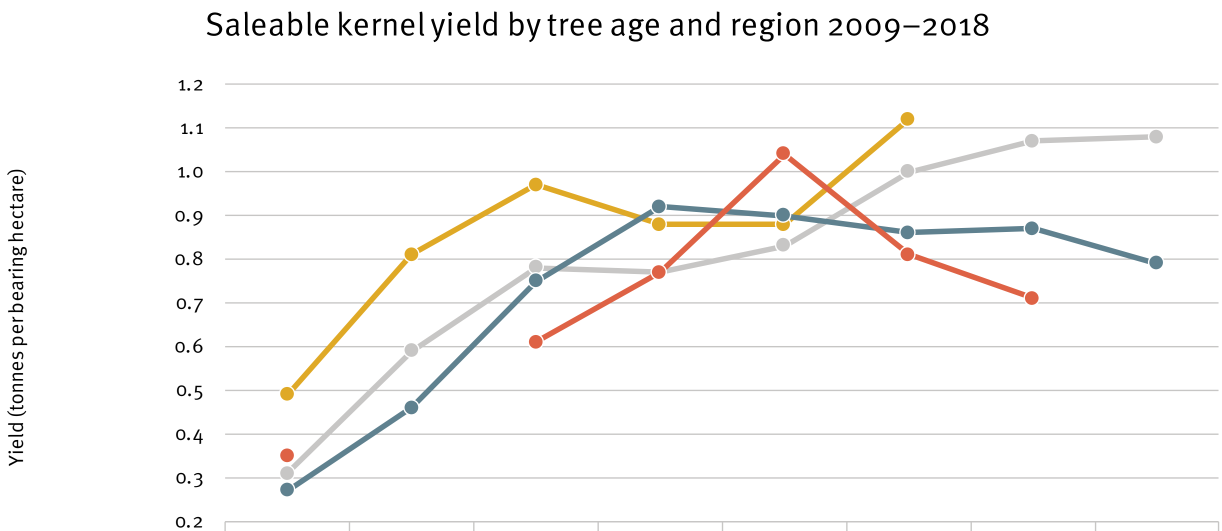
Figure 42 shows the average yield of SK per bearing hectare by tree age category for 2009 to 2018 across the major production regions. As insufficient data was available for individual tree age categories in some regions, it was not possible to plot beyond 25–29 years within the Central Queensland (CQ) region, or to plot 8 to 9 years and over 34 years for the Mid North Coast of NSW (MNNSW).

CQ farms with an average tree age 14 years or younger had a higher average yield of SK per hectare than farms of the same age in the other regions (*P* ‹0.05). This indicates that while there is a significant positive correlation between tree age and yields across all age groups, relationships are complex and other regional, genetic or management factors can influence the early performance of orchards (*P* ‹0.01).

For NRNSW there is a significant negative correlation between tree age and yield (SK and NIS per bearing hectare) among farms 35 years and over, indicating a decline in yields for trees above this age in this region (*P* ‹0.05). This may also be related to a number of external factors including canopy architecture and tree health.

In SEQ there is a significant positive correlation between tree age and SK yield per hectare across all age groups (*P* ‹0.01).

In MNNSW SK yields appeared to peak in the 20 to 24 years group, and while statistically this group was no different to this region's 25 to 29 year old trees (*P* ›0.05), it did yield significantly higher than all other tree age categories reported for this region (*P* ‹0.05).



	5 to 7 years	8 to 9 years	10 to 14 years	15 to 19 years	20 to 24 years	25 to 29 years	30 to 34 years	35+ years
CQ SK yield (2009-18)	0.49	0.81	0.97	0.88	0.88	1.12		
CQ SK std.dev (2009-18)	0.25	0.31	0.34	0.35	0.29	0.26		
SEQ SK yield (2009-18)	0.31	0.59	0.78	0.77	0.83	1.00	1.07	1.08
SEQ SK std.dev (2009-18)	0.21	0.29	0.45	0.51	0.51	0.44	0.53	0.43
NRNSW SK yield (2009-18)	0.27	0.46	0.75	0.92	0.90	0.86	0.87	0.79
NRNSW SK std.dev (2009-18)	0.22	0.31	0.41	0.45	0.43	0.42	0.33	0.21
MNNSW SK yield (2009-18)	0.35		0.61	0.77	1.04	0.81	0.71	
MNNSW SK std.dev (2009-18)	0.59		0.39	0.51	0.64	0.71	0.50	

Figure 42: Saleable kernel productivity by tree age and region 2009–2018

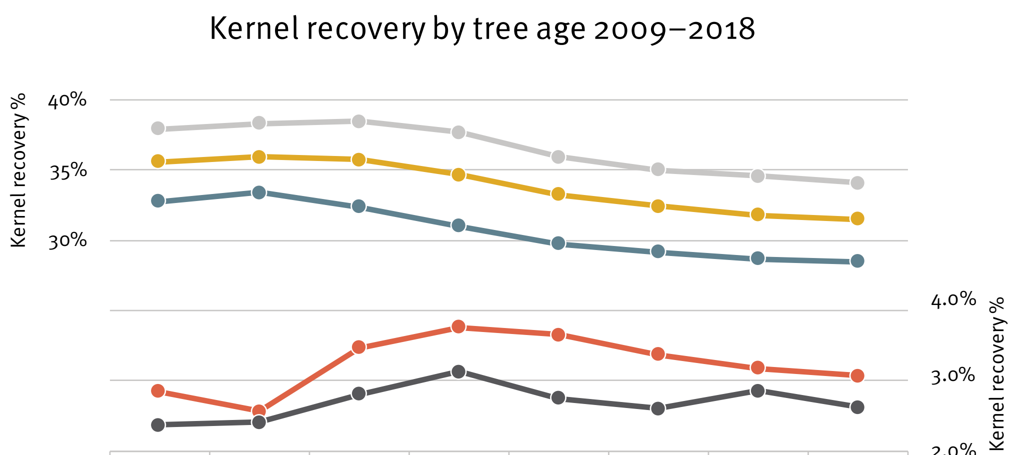
Figure 43 shows the averages from 2009 to 2018 of kernel recoveries by tree age category, including total kernel recovery (TKR), saleable kernel recovery (SKR), premium kernel recovery (PKR), commercial kernel recovery (CKR) and reject kernel recovery (RKR). TKR is the sum of premium, commercial and reject kernel recovery. Saleable kernel recovery is the sum of premium kernel recovery and commercial kernel recovery.

Farms in the younger tree age categories (5 to 7, 8 to 9 and 10 to 14 years) achieved significantly higher average PKR and SKR than farms in the older age categories (15 years and older) (*P* ‹0.01). There is a significant negative correlation between tree age and PKR, SKR and TKR indicating that on average they decrease with tree age (*P* ‹0.01).

There is no significant correlation between tree age and CKR indicating that on average CKR is not associated with tree age (*P* ›0.05). However, trees in the middle age groups of 10 to 14 and 15 to 19 years had significantly higher CKR than the 5 to 7 (*P* ‹0.05 and *P* ‹0.01 respectively) and 8 to 9 age groups (*P* ‹0.01 and *P* ‹0.01 respectively). The 15 to 19 year age groups also had significantly higher CKR than the 25 to 29 and the 30 to 34 age group (*P* ‹0.05 and *P* ‹0.01 respectively). There is no significant difference between the 35 years and older age group and the younger age groups less than 15 years of age (*P* ›0.05). This indicates that the middle age groups on average tend to have higher levels of CKR.

Farms with tree ages under 15 do not have significantly different TKR from each other (*P* ‹0.01), however they do have significantly higher TKR than older age categories (*P* ‹0.01). Trees under 15 years of age have an average TKR of 38.34% compared to farms 15 years and older which achieved an average TKR of 36.05%. TKR is significantly negatively correlated with tree age indicating that on average TKR declines with tree age (*P* ‹0.01). Varietal selection is one of the major factors influencing kernel recovery. Many macadamia varieties planted on younger farms have higher potential kernel recoveries than many of the varieties planted on older farms.

Farms aged 15–19 years of age had significantly higher average RKR than all other tree age categories up to 30 years of age (*P* ‹0.01). RKR is significantly negatively correlated (*P* ‹0.01) with tree ages 15 years and older and significantly positively correlated with farm size (*P* ‹0.01), indicating that on average older farms have lower RKR and larger farms have higher RKR.



	5 to 7 years	8 to 9 years	10 to 14 years	15 to 19 years	20 to 24 years	25 to 29 years	30 to 34 years	35+ years
Total KR%	37.92	38.31	38.48	37.70	35.95	34.99	34.59	34.06
Saleable KR%	35.57	35.92	35.74	34.64	33.26	32.43	31.79	31.48
Premium KR%	32.79	33.41	32.38	31.02	29.73	29.16	28.70	28.49
Commercial KR%	2.78	2.52	3.36	3.63	3.53	3.27	3.09	2.99
Reject KR%	2.34	2.38	2.75	3.05	2.69	2.56	2.79	2.58

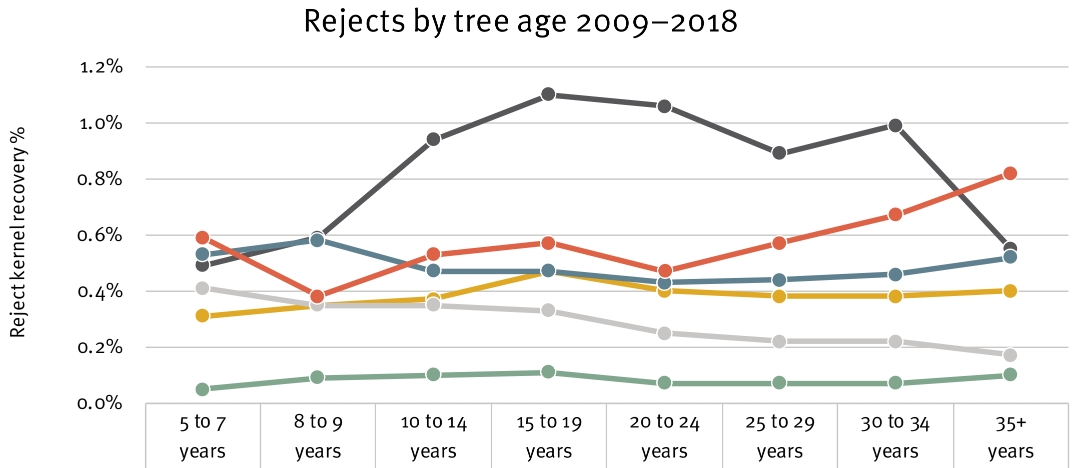
Figure 43: Average total kernel recovery percent, and its component percentages of saleable, premium, commercial and reject kernel recoveries, by tree age categories 2009–2018

Figure 44 shows a breakdown of factory rejects by category from 2009 to 2018 for farms of various average tree ages.

Insect damage was the major reject category for farms with an average tree age of 8 or more years. Average insect damage levels were highest among farms aged 15 to 19 years, although analysis of rejects by farm size revealed that most small farms fall within this age group, which may be a contributing factor to these high levels of damage. See the *Productivity and Quality by Farm Size* section within this report for more information.

Average immaturity levels were highest among farms aged over 25 years old. Some of this immaturity may be related to premature nut drop associated with husk spot damage. It is important however to note that in some seasons there have also been significant levels of immaturity in farms in this age group resulting from weather related moisture stress, such as farms in the SEQ region in 2013 and 2014.

Immaturity, brown centres and insect damage were the major reject categories amongst farms with an average tree age less than 8 years. Farms younger than 8 years had the highest average rejects due to discolouration. These differences could also be related to the fact that most farms in the benchmark sample with an average tree age less than 8 years are also larger farms and mostly located in the CQ region.



	5 to 7 years	8 to 9 years	10 to 14 years	15 to 19 years	20 to 24 years	25 to 29 years	30 to 34 years	35+ years
Insect	0.49	0.59	0.94	1.10	1.06	0.89	0.99	0.55
Mould	0.31	0.35	0.37	0.47	0.40	0.38	0.38	0.40
Discolouration	0.41	0.35	0.35	0.33	0.25	0.22	0.22	0.17
Brown centres	0.53	0.58	0.47	0.47	0.43	0.44	0.46	0.52
Immaturity	0.59	0.38	0.53	0.57	0.47	0.57	0.67	0.82
Germination	0.05	0.09	0.10	0.11	0.07	0.07	0.07	0.10

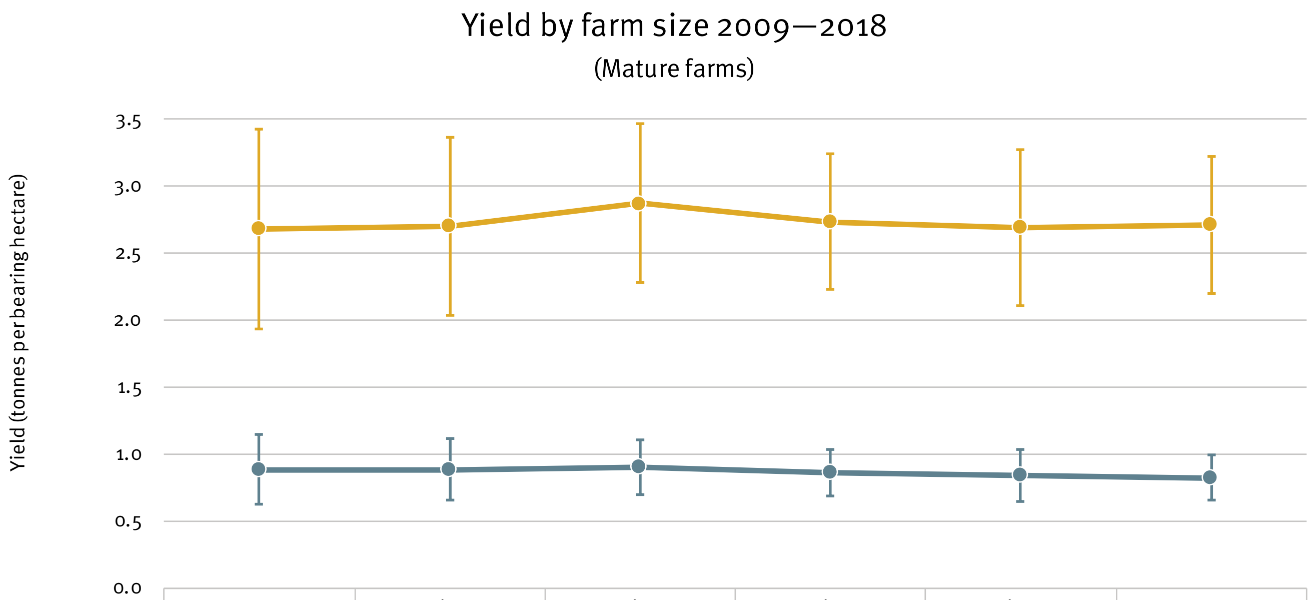
Figure 44: Reject kernel recovery by reject category and tree age 2009–2018

Productivity and quality by farm size

Analysis of yield and quality trends reveal some differences in kernel recovery related to farm size. It should be noted that certain farm sizes are more prevalent in particular regions. Larger farms within the benchmark sample also tend to be younger than smaller farms. Care must be taken when interpreting these results as regional or tree age factors may be involved.

Figure 45 shows average yield of nut-in-shell (NIS) and saleable kernel (SK) per bearing hectare, for different farm size categories for all years from 2009 to 2018. These averages are based on mature farms in the benchmark sample (i.e. farms with an average tree age of 10 or more years).

Farms between 20 and 30 hectares had significantly higher NIS yield than farms less than 10 hectares ($P < 0.05$). There is no significant difference in NIS yield for other farms sizes ($P > 0.05$). There was no significant difference in saleable kernel across different farm sizes or correlation between farm size and NIS or SK yield ($P > 0.05$). Farms less than 10 hectares had the highest standard deviation in both SK and NIS yield, 0.52t/ha and 1.49 t/ha respectively.



	< 10 ha	10 to 20 ha	20 to 30 ha	30 to 50 ha	50 to 100 ha	> 100 ha
NIS yield	2.68	2.70	2.87	2.73	2.69	2.71
NIS std.dev	1.49	1.33	1.18	1.01	1.17	1.02
SK yield	0.88	0.88	0.90	0.86	0.84	0.82
SK std.dev	0.52	0.46	0.40	0.34	0.39	0.34

Figure 45: Nut-in-shell per bearing hectare and saleable kernel per bearing hectare by size of farm 2009–2018

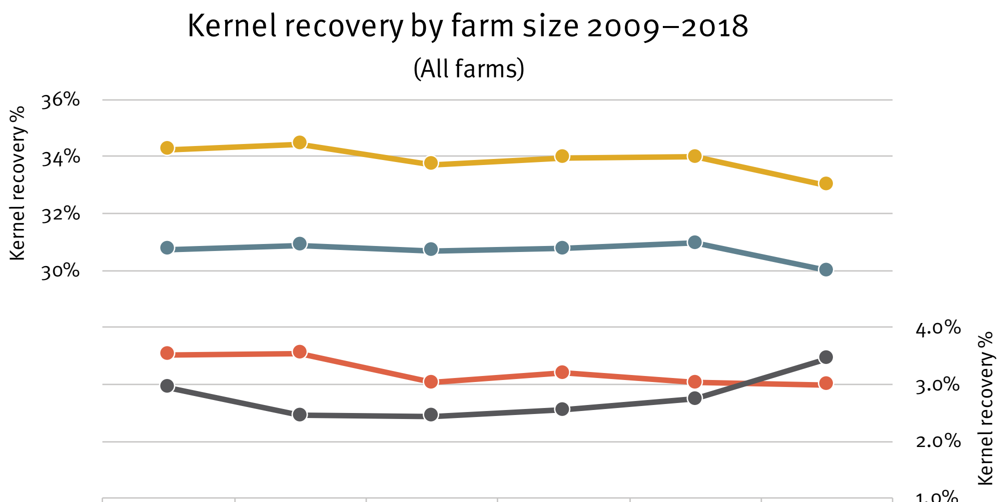
Figure 46 shows average commercial kernel recovery (CKR), saleable kernel recovery (SKR), premium kernel recovery (PKR), and reject kernel recovery (RKR) for all years from 2009 to 2018 for different farm size categories in the benchmark sample. These kernel recovery trends are based on all farms in the benchmark sample.

Farms less than 10 hectares had significantly lower PKR than farms 10 to 20 hectares and farms 50 to 100 hectares in size ($P < 0.01$). Farms greater than 100 hectares had significantly lower ($P < 0.05$) PKR than farms 50 to 100 hectares but were not significantly different to other farm sizes ($P > 0.05$). There is no significant correlation between farm size and PKR indicating that on average farm size is not associated with PKR ($P > 0.05$).

Farms less than 10 hectares have significantly less ($P < 0.01$) SKR than farms 10 to 20 hectares, but were not significantly different to all other farms sizes ($P > 0.05$). SKR is not significantly correlated with farm size indicating that on average farm size is not associated with SKR ($P > 0.05$).

Farms greater than 100 hectares have significantly lower ($P < 0.01$) CKR that farms less than 10 hectares and farms 10 to 20 hectares, but are not significantly different to any other farm sizes ($P > 0.05$). CKR is significantly negatively correlated with farm size, indicating that on average as farm size increases CKR tends to decrease ($P < 0.01$).

Farms greater than 100 hectares have significantly higher average RKR than all other farm sizes ($P < 0.01$). RKR is significantly positively correlated with farm size indicating that on average RKR increases with farm size ($P < 0.01$).



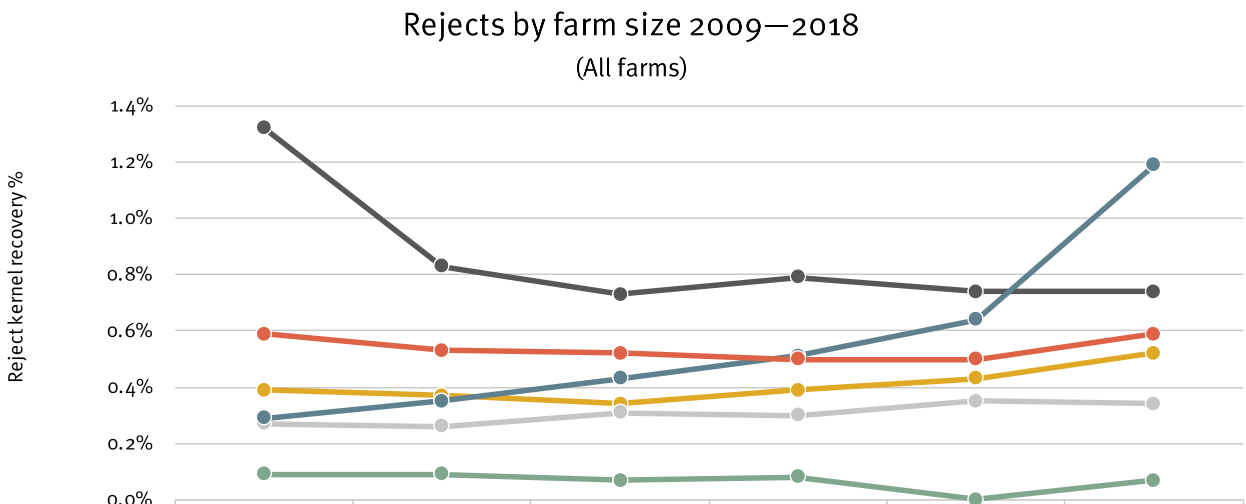
	‹ 10 ha	10 to 20 ha	20 to 30 ha	30 to 50 ha	50 to 100 ha	› 100 ha
Saleable KR%	34.25	34.43	33.73	33.97	33.98	32.99
Premium KR%	30.74	30.89	30.70	30.76	30.95	30.00
Commercial KR%	3.52	3.54	3.03	3.20	3.03	2.99
Reject KR%	2.94	2.45	2.44	2.55	2.74	3.45

Figure 46: Average percentage of kernel classified as either premium, commercial or reject and average percentage saleable kernel, by farm size category 2009–2018

Figure 47 shows the average reject percentage and breakdown for the different farm size categories in the benchmark sample for all years from 2009 to 2018. These averages are again based on all farms in the benchmark sample.

Rejects due to brown centres are correlated with increasing farm size (*P* <0.01). Farms less than 10 hectares had significantly lower average brown centres than all other farm size categories with average rejects of 0.29% compared with 1.19% for farms greater than 100 hectares (*P* <0.01).

Rejects due to insect damage were inversely correlated with smaller farm size (*P* <0.01), and significantly higher on farms less than 10 hectares than all other farm sizes (*P* <0.01). Farms less than 10 hectares had average insect damage rejects of 1.32% compared with other farm size categories that ranged from 0.73% to 0.83%. Immaturity, discolouration and germination rejects did not vary as much with farm size as insect damage and brown centres.



	< 10 ha	10 to 20 ha	20 to 30 ha	30 to 50 ha	50 to 100 ha	> 100 ha
Insect	1.32%	0.83%	0.73%	0.79%	0.74%	0.74%
Mould	0.39%	0.37%	0.34%	0.39%	0.43%	0.52%
Discolouration	0.27%	0.26%	0.31%	0.30%	0.35%	0.34%
Brown centres	0.29%	0.35%	0.43%	0.51%	0.64%	1.19%
Immaturity	0.59%	0.53%	0.52%	0.50%	0.50%	0.59%
Germination	0.09%	0.09%	0.07%	0.08%	0.00%	0.07%

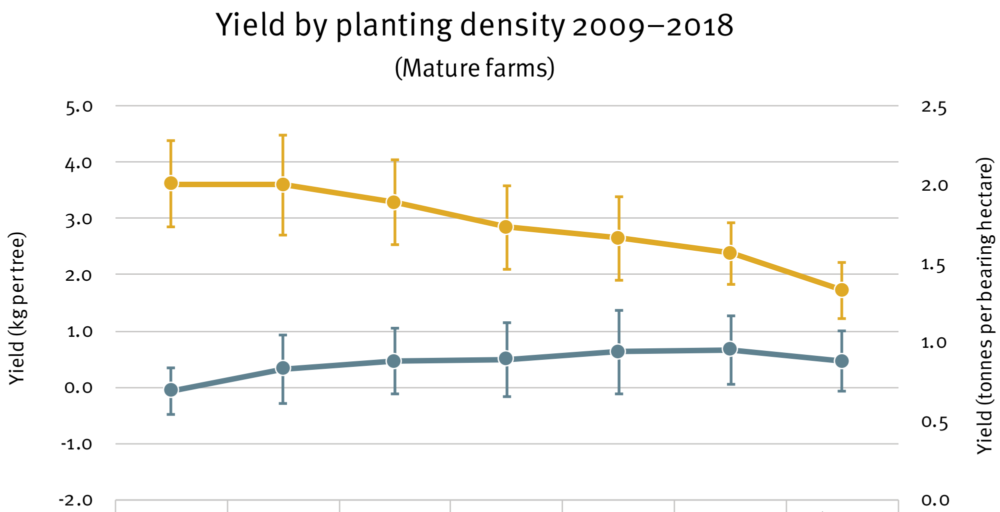
Figure 47: Percentage reject from each reject category by farm size, averaged over 2009–2018

Factory rejects due to brown centres increased with increasing farm size. By comparison, rejects due to insect damage were highest amongst smaller farms, particularly those less than 10 hectares.

Productivity and quality by planting density

Figure 48 shows average saleable kernel (SK) productivity in tonnes per bearing hectare and kilograms per tree for mature farms at a range of planting densities. Weighted average planting density is calculated for each farm from tree spacing information provided. The weighted average planting density for mature farms in the benchmark sample is 327 trees per hectare.

SK productivity per tree declines markedly in a significant correlation with increasing planting density, particularly at planting densities above 250 trees per hectare ($P < 0.01$). Higher planting densities are significantly correlated with higher overall yield per hectare ($P < 0.01$).



	100-200 trees/ha	201-250 trees/ha	251-300 trees/ha	301-350 trees/ha	351-400 trees/ha	401-450 trees/ha	› 450 trees/ha
SK yield (Kg/Tree)	3.61	3.60	3.28	2.84	2.65	2.38	1.72
SK SD (Kg/Tree)	1.54	1.78	1.51	1.49	1.49	1.11	0.98
SK yield (T/Ha)	0.69	0.83	0.88	0.89	0.94	0.95	0.88
SK SD (T/Ha)	0.30	0.43	0.41	0.47	0.53	0.44	0.38

Figure 48: Saleable kernel (SK) productivity in tonnes per hectare and kilograms per tree for mature farms at a range of planting densities, averaged over 2009–2018

Analysis methods

Percentiles

A percentile is a statistical measure indicating the value below which a given percentage of observations in a sample fall. For example, the 25th percentile in a data sample is the value below which 25% of the observations may be found. The 25th percentile is also known as the first quartile. Percentiles have been included in this report to identify differences between the top 25%, average and bottom 25% of farms or farm years.

For ease of understanding and to minimise skewing due to individual farm results, percentile groups used in this report are based on relatively uniform sample sizes. A standard approach was used to identify these groups. The following example shows how this process works on a 100 point data sample:

The sample is ranked according to a dependent variable such as tonnes of saleable kernel per bearing hectare. A marker is placed on the 25th data point and its value is identified. Adjoining points in both directions within the sample are iteratively compared with the current marker point to determine the nearest data point whose value is different to the current marker. If required, the marker is moved to reflect the closest unique data value (i.e. its value is different to at least one adjoining point). This becomes the cut point for the 75th percentile.

The above process is repeated on the 75th data point to determine a similar unique cut point for the 25th percentile. Values that fall above the cut point for the 75th percentile are grouped to form the top 25% and those that fall below the 25th percentile form the bottom 25%. As a result, the number of data points in each quartile is not always the same.

Weighted and unweighted averages

Weighted averages are calculated by dividing the total amount by the bearing hectares in each sample (e.g. the total weight of saleable kernel divided by the total bearing hectares for a region for a particular year).

This means that larger farms will have more influence on a weighted average than smaller farms. This is important for comparing results and trends on a whole industry or a whole region basis.

This analysis provides a different perspective to the unweighted averages (i.e. arithmetic means) which are used in most of the descriptive and statistical analyses throughout this report. Unweighted averages result in each farm in the data sample exerting equal influence on the average. In other words, the data for a 10 hectare farm will have just as much effect on the average as that of a 200 hectare farm.

Standard deviation

Standard deviation provides a measure of the amount of variation around the average or mean for a set of data. A low standard deviation means that most of the numbers in that set are very close to the average. A high standard deviation means that the numbers are spread out. Standard deviation provides an important measure of the amount of variability within the benchmark sample. For example, it is useful to know the average productivity for all farms in a given region or season, but the standard deviation of that average provides additional insight into how uniform productivity is among those farms.

Median

The median value of a data set represents the middle (or 50%) point in the data. In comparison the average, or mean is the sum of all values divided by the total number of data points. The average is very useful for understanding a given set of data when that data is normally distributed, however if data is skewed by extreme or outlying values these can influence the mean. For example, one very large farm in a region of otherwise small farms could raise the sample average above what is characteristic of most farms in that region. As the median comes from the middle point in a data set it is not influenced by such outlying or extreme data.

Statistical analyses

Fishers Least Significant Difference (LSD) was used to determine if there is a significant difference between multiple data sets.

The Pearson Correlation Coefficient was used to determine if two variables are significantly linearly related. A correlation coefficient of 1 indicates perfect positive correlation and – 1 indicates perfect negative correlation. Correlation does not provide a measure of cause or effect, but rather of probable directional relationships. The level of statistical probabilities presented are 99% ($P < 0.01$) and 95% ($P < 0.05$).

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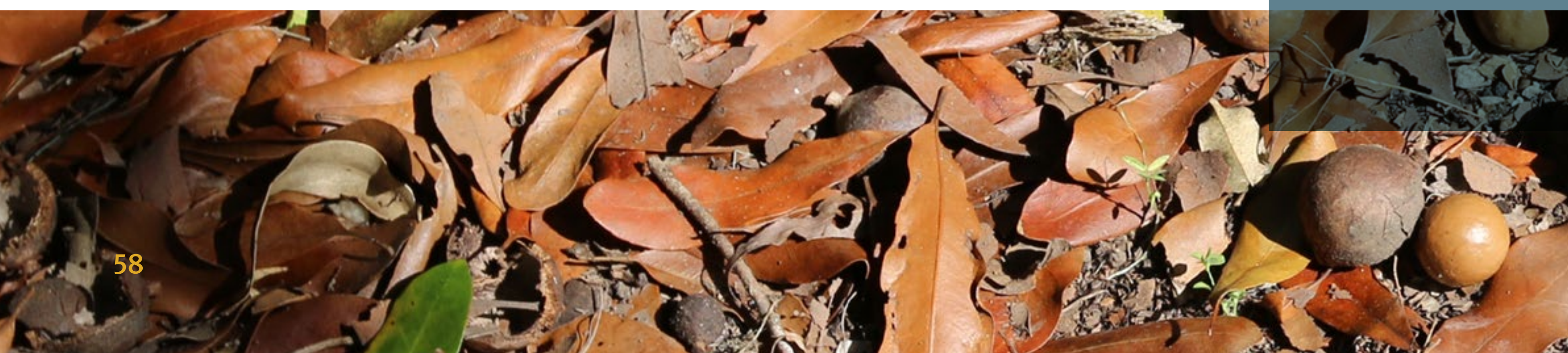

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