Macadamia industry benchmark report

2009 to 2019 seasons
Project MC18002

Queensland Government

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Contents

Acknowledgements

This report has been produced as part of the “Benchmarking the macadamia industry 2019–2021” project (MC18002). This is a joint initiative of the Department of Agriculture and Fisheries, the University of Southern Queensland and the New South Wales Department of Primary Industries, with support from the Australian Macadamia Society.

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Disclaimer

Results presented in this report are based on data provided by industry participants. To ensure the confidentiality of individual farm data, this report includes only aggregated data. Figures presented are based on summary statistics, using underlying data that is not included in this report.

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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. Production cost data has also been collected annually since 2013.

Each season all benchmarking participants receive a confidential, personalised farm benchmark report that compares their individual farm performance with groups of similar farms based on a range of criteria including region, locality, farm size, management structure, irrigation status and tree age.

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

Benchmark data further supports a range of industry projects and initiatives. **Figure 1** shows linkages to some current projects that benefit from the availability of reliable industry benchmark data.

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

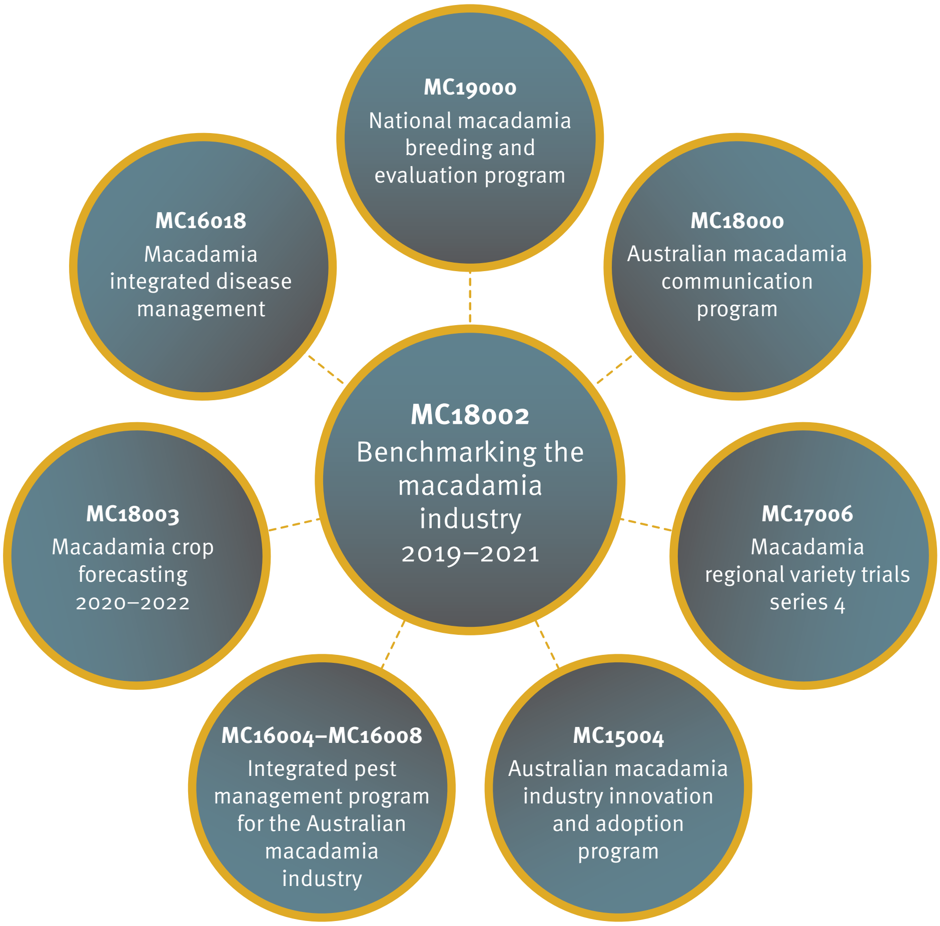


Figure 1: Benchmark project linkages

Scope and coverage

This report summarises macadamia farm yield and quality results for the 2009–2019 seasons and production costs for 2013–2019. 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 include Central Queensland (CQ), South East Queensland (SEQ), Northern Rivers of New South Wales (NRNSW) and Mid North Coast of New South Wales (MNNSW).

Figure 2: Production regions and localities participating in benchmarking

Table 1 shows the number of farms participating in benchmarking since 2009. Bearing farms shown are those greater than five years of age that provided factory consignment data for a specific season. Mature farms are bearing farms with a weighted average tree age of 10 or more years. Some analyses, such as average productivity or costs, are based on mature farms only to avoid skewing results due to very young trees.

Yield and quality data collected from bearing farms since 2009 totals 2681 farm-years. The term farm-year is used to describe data for an individual farm for a given year or season.

Since 2013 some participating businesses have also submitted data relating to production costs. Cost data collected from bearing farms since 2013 totals 440 farm-years.

Participating farms by season												
Seasons	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2009–2019**
Yield and quality												
Mature farms	144	153	163	202	218	224	237	245	262	266	258	2 372
Bearing farms	178	184	192	243	262	267	271	271	274	275	264	2 681
All farms	192	195	207	252	265	268	271	273	278	281	272	2 698
Cost of production												
Mature farms	–	–	–	–	36	37	33	48	64	83	91	392
Bearing farms	–	–	–	–	47	47	40	54	71	87	94	440
All farms	–	–	–	–	47	47	40	54	74	89	96	447

Table 1: Participating farms by season and data type from 2009–2019

Table 2 shows the number of bearing farms participating in benchmarking in each major production region for the 2019 season. It also shows median farm size and average tree age 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 264 bearing farms submitted yield and quality data for the 2019 season. These farms totalled 10,463 hectares (9817 bearing) and produced approximately 26,595 tonnes of NIS at 10% moisture content. This represents approximately 57% of the industry's total production in 2019, based on the Australian Macadamia Society's estimate of 46,600 tonnes of NIS at 10% moisture content (published December 2019).

A total of 94 bearing farms submitted cost data in 2019, totalling more than 4320 planted hectares. This represents approximately 40% of sample production and 23% of total industry production that year.

In 2019 more than half of all farms in the benchmark sample (51%) were from NRNSW, although the region accounted for a smaller percentage of the sample by production (30%). 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 2019 (52%).

2019 regional breakdown of bearing farms

Region	Farms (% of sample)	Median planted hectares per farm	Total planted hectares (% of sample)	Total NIS tonnes (% of sample)	Average tree age
Central Queensland (CQ)	49 (19%)	61.1	5392 (52%)	13,929 (52%)	15
South East Queensland (SEQ)	52 (20%)	13.6	1433 (14%)	3890 (15%)	25
Northern Rivers of NSW (NRNSW)	135 (51%)	17.6	3207 (31%)	7874 (30%)	24
Mid North Coast of NSW (MNNSW)	28 (11%)	8.6	431 (4%)	903 (3%)	20
All regions	264	19.4	10,463	26,595	19

Table 2: Regional breakdown of farms in the 2019 benchmark sample

Figure 3 shows a breakdown of planted hectares by tree age for the whole benchmark sample. The bars shown for each age are coloured according to production region.

In the 2019 season the weighted average age of trees was 18 years for all farms in the benchmark sample and 19 years for bearing farms. Trees in the CQ region were the youngest with an average of 15 years, while SEQ and NRNSW had the oldest (25 and 24 years respectively). More than 300,000 trees or 943 hectares were less than 5 years of age and therefore not considered bearing in 2019. Over 70% of those young trees are in the CQ region. More than 434,000 trees (1410 hectares) were less than 10 years of age, which represents approximately 13% of the whole benchmark sample.

Farms in the SEQ region had the largest span of tree ages, from newly planted through to 47 years of age. By comparison tree ages spanned 30 years in CQ, 45 in NRNSW and 39 in MNNSW.

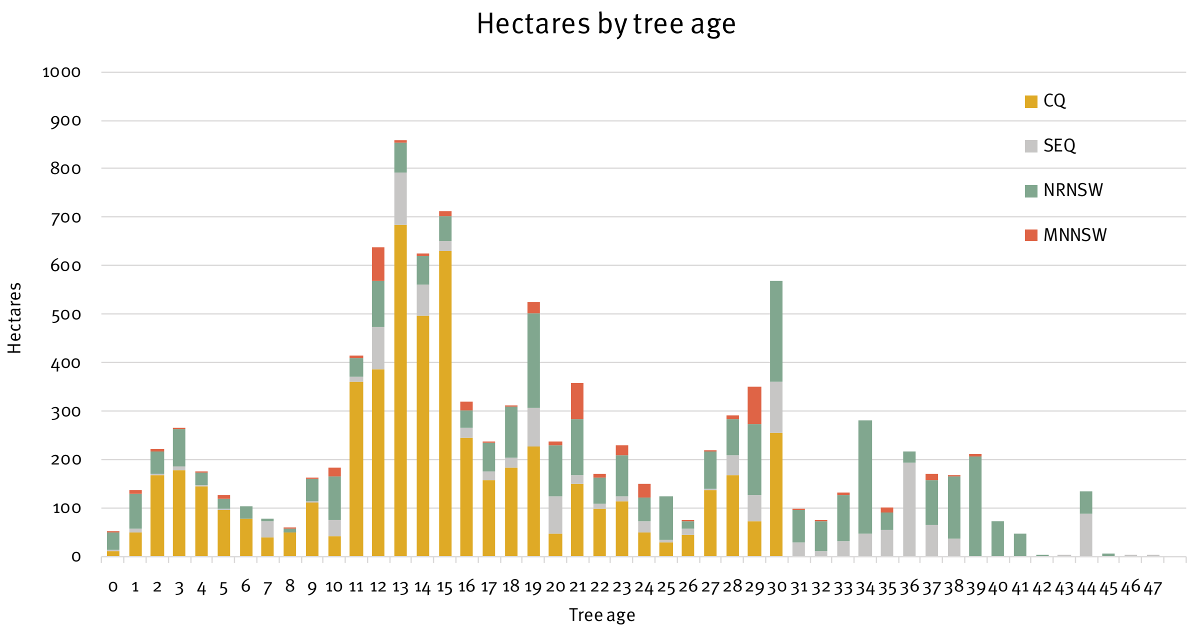
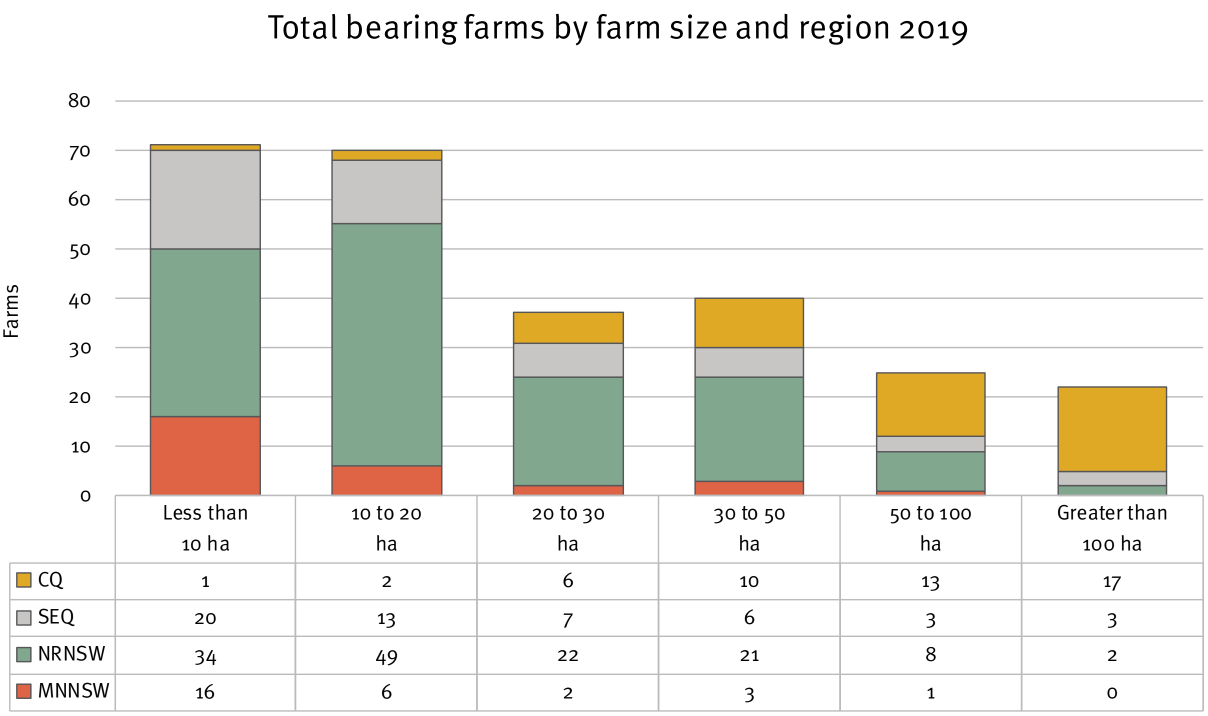


Figure 3: Total planted hectares by tree age and region for farms participating in benchmarking in 2019

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. Most of these farms are located in the MNNSW, NRNSW and SEQ regions. By comparison, most larger farms (> 50 hectares) were in the CQ region. Approximately 8% of farms in the sample had more than 100 hectares of bearing trees.



	Less than 10 ha	10 to 20 ha	20 to 30 ha	30 to 50 ha	50 to 100 ha	Greater than 100 ha
🟨 CQ	1	2	6	10	13	17
⬜ SEQ	20	13	7	6	3	3
🟩 NRNSW	34	49	22	21	8	2
🟥 MNNSW	16	6	2	3	1	0

Figure 4: Bearing farms participating in benchmarking in 2019 by farm size and region

In 2019 the median size of bearing farms in the benchmark sample was 19.4 hectares. Average farm size was significantly higher at 39.6 hectares. This variation is due to the inclusion of a few very large farms in the sample.

Results for the benchmark sample in 2019

Figure 5 shows seasonal and long-term yield, quality and costs for farms in the benchmark sample. The 2019 yield and quality summaries are derived from data from 264 bearing farms, including some young farms that are yet to reach full maturity. Cost summaries are derived from a subset of 94 participating farms that provided cost data in the 2019 season. Corresponding long-term averages, medians or totals are shown in brackets. These figures span 2009–2019 for yield, quality and planting information and 2013–2019 for costs.

The 2019 season proved challenging for many benchmark participants, particularly due to extended hot, dry conditions in many growing regions. This resulted in lower average productivity and kernel recovery compared with the successful 2018 season. Average productivity in 2019 was 2.72 tonnes per hectare (t/ha) nut-in-shell (NIS) and 0.86 t/ha saleable kernel (SK). Despite the challenging seasonal conditions productivity in 2019 still exceeded the long-term average for both NIS (2.59 t/ha) and SK (0.83 t/ha). Saleable kernel recovery (SKR) in 2019 was 33.62%, which was lower than both the average for 2018 (35.75%) and the long-term average of 34.01%. Average reject kernel recovery (RKR) in 2019 (2.47%) was lower than both the 2018 average (2.61%) and the long-term average (2.70%).

Median production costs were higher in 2019 ($7911/ha, $9118/t SK) than the long-term ($7067/ha, $7392/t SK). It is important to note that these figures exclude imputed labour costs, which were not available prior to the 2017 season. A detailed analysis of both cash costs and imputed labour is available in the cost trends section.

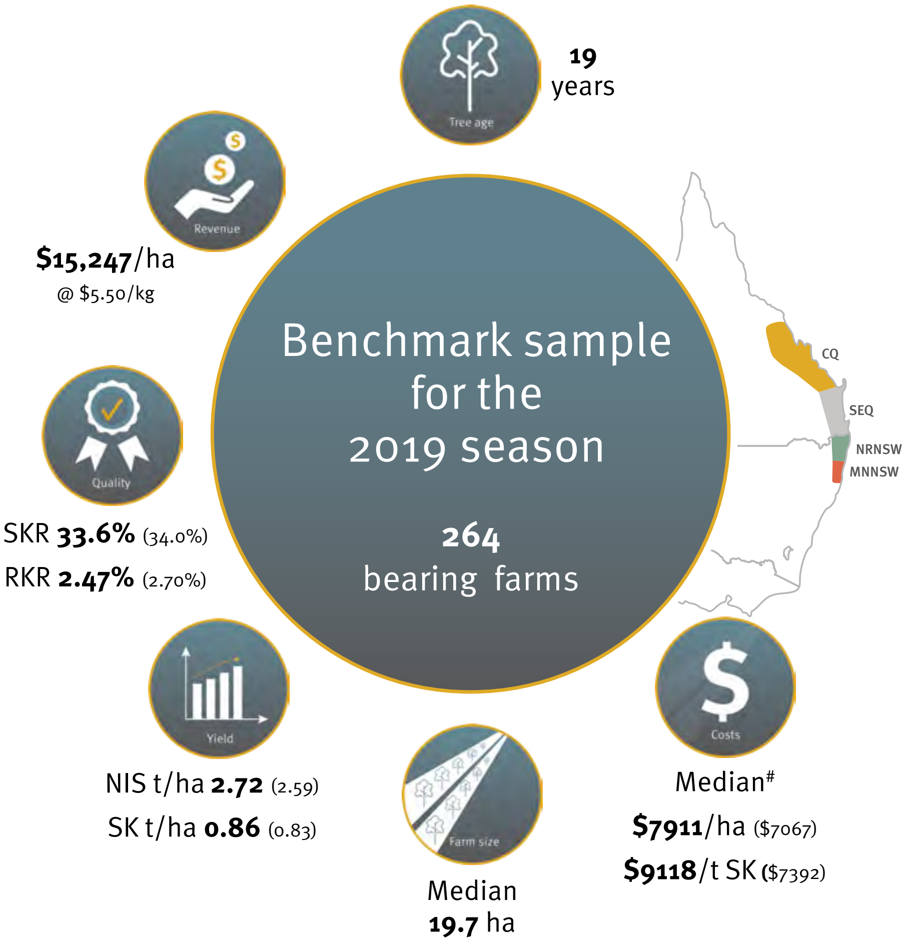


Figure 5: Benchmark sample summaries for the 2019 season (long-term equivalent values shown in brackets)

Factors limiting production in 2019

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. An average of 212 farms per season have provided these observations since 2017. Participants are asked to rank their top 3 limitations for the season in three categories including general factors, pests and diseases. **Figure 6** shows the major limiting factors reported in 2019. These are ranked according to how many times they were listed among the top 3 limitations for that season.

Hot or dry weather was the dominant limiting factor reported, accounting for 39% of responses. This was followed by pests (18%), wet weather (12%), disease and soil/tree health (each 8%). A smaller number of farms also reported other limiting factors such as tree/limb removal (5%), storm/hail (4%), other (4%). Just 2% of respondents reported no major seasonal limitations. A regional analysis of these seasonal limitations is available in the *Regional results and trends* section.

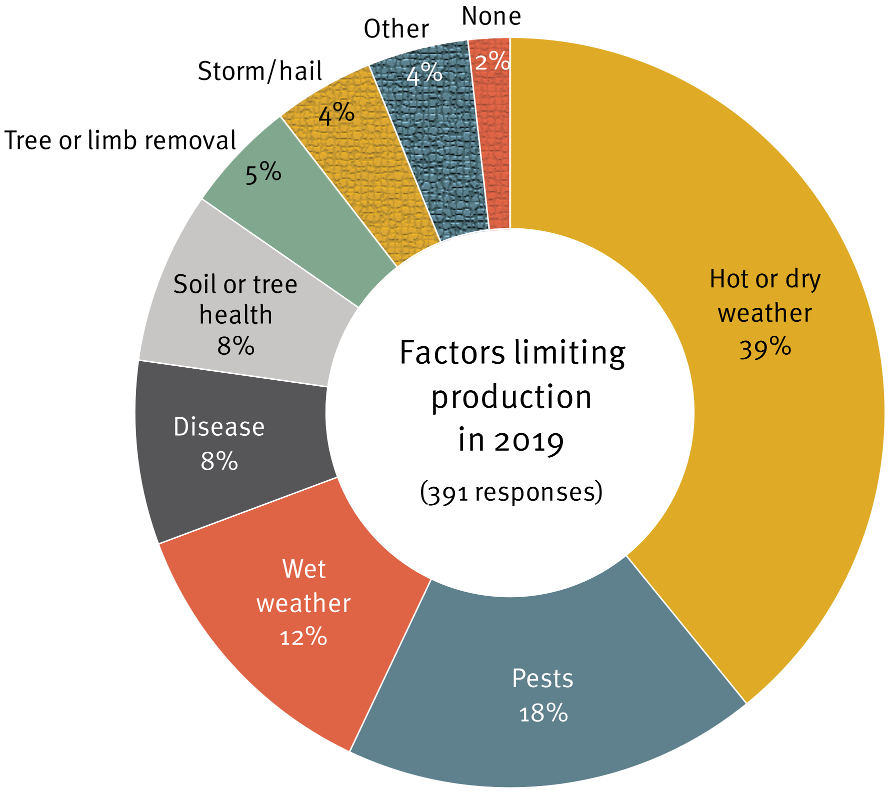


Figure 6: Major factors limiting production in 2019

Hot dry weather was reported as the factor most limiting production in all production regions in the 2019 season. All regions experienced below-average rainfall during nut development.

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Pest limitations in 2019

A total of 210 responses were received in relation to pest limitations for the 2019 season (**Figure 7**).

Fruit spotting bug was the most commonly ranked pest limiting production across all regions (31%). This was followed by rats (22%), Macadamia seed weevil (12%, NRNSW only), birds (11%), Macadamia nut borer (8%), Lace bug (6%) and Flower caterpillar (4%).

Bark beetle and Leptocoris were reported as a limitation for a small proportion of farms (each 1%) while 4% of responses were for "Other" pests. Descriptions for these included Green vegetable bug, thrips and mites, wild deer, Hairyline blue butterfly, pine hole borer, thrips (at flowering) and feral pigs. Although feral pigs were not widely reported across the sample, substantial production losses were reported in some cases where these were present.

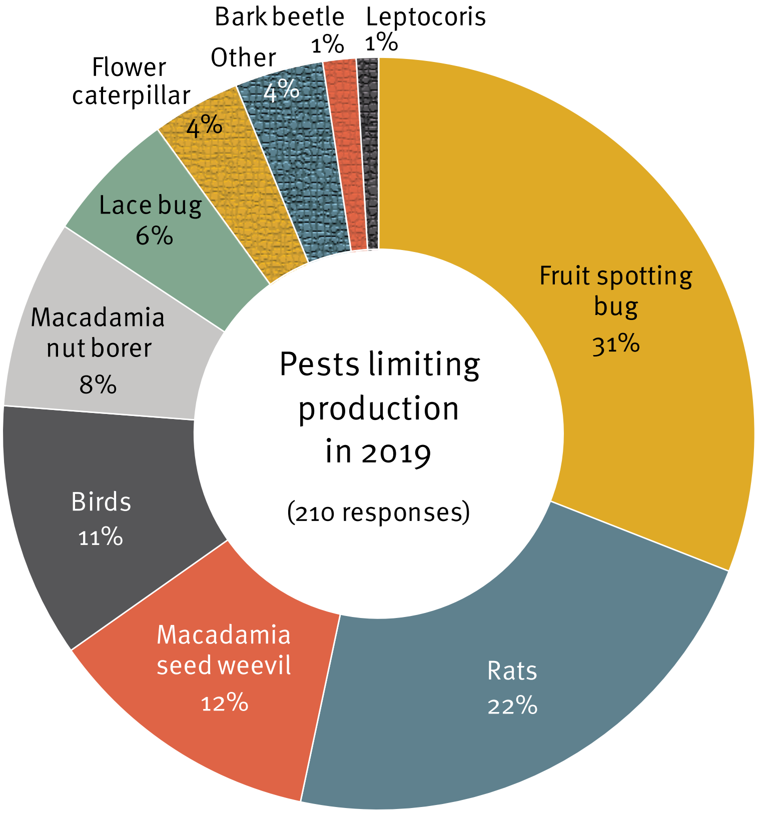


Figure 7: Major pests limiting production in 2019

Disease limitations in 2019

A total of 115 responses were received in relation to disease limitations in 2019 (**Figure 8**). The disease most reported as limiting production across all regions was Phytophthora (35%), followed by flower diseases (21%), branch or tree dieback (20%) and husk spot (17%). A smaller number of responses indicated other disease limitations including Abnormal Vertical Growth (AVG) (3%), husk rot (2%) and "Other" (2%).

In some cases branch or tree dieback can be associated with bark beetles. Increased bark beetle activity has been observed on some farms over the last few seasons, including 2019.

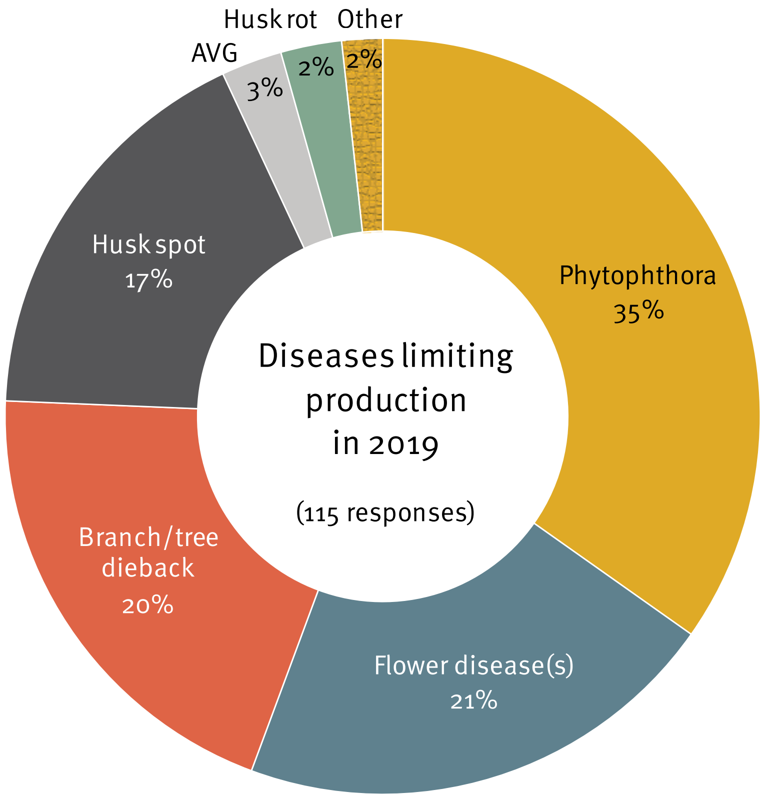
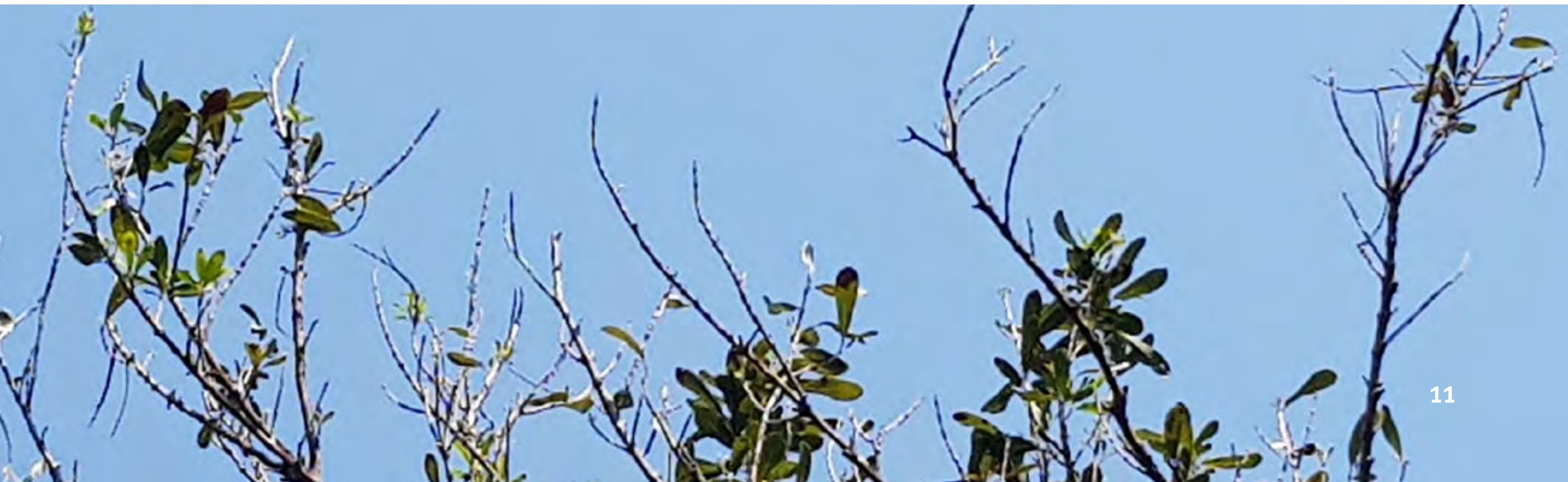


Figure 8: Major diseases limiting production in 2019



Factory losses in 2019

The value of losses due to factory reject in 2019 was estimated for all farms in the benchmark sample. **Figure 9** 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 $5.50 per kilogram of NIS @ 10% moisture content.

It is important to note that the averages shown 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 and value of rejects across the benchmark sample.

The average total value of factory losses in 2019 due to reject kernel for all farms participating in benchmarking was approximately $1,049 per bearing hectare. This equates to a total value of approximately $10.3 million for all farms in the benchmark sample, based on 9817 bearing hectares.

The most significant loss was due to late insect damage ($3.06m), followed by brown centres ($3.04m), immaturity ($2.01m) and mould ($1.1m). Discolouration and germination accounted for relatively smaller losses at $0.78m and $0.22m respectively.

In 2019 the benchmark sample represented approximately 57% of the industry's total production of 46,600 tonnes of NIS. By extrapolating benchmark sample losses according to this proportion, the estimated total value of factory losses across industry in 2019 is approximately $18 million.

It's important to note that these estimates exclude the weight of nuts lost or rejected on farm, which may also significantly contribute to total rejects. They also exclude handling or disposal costs incurred by processors or growers.

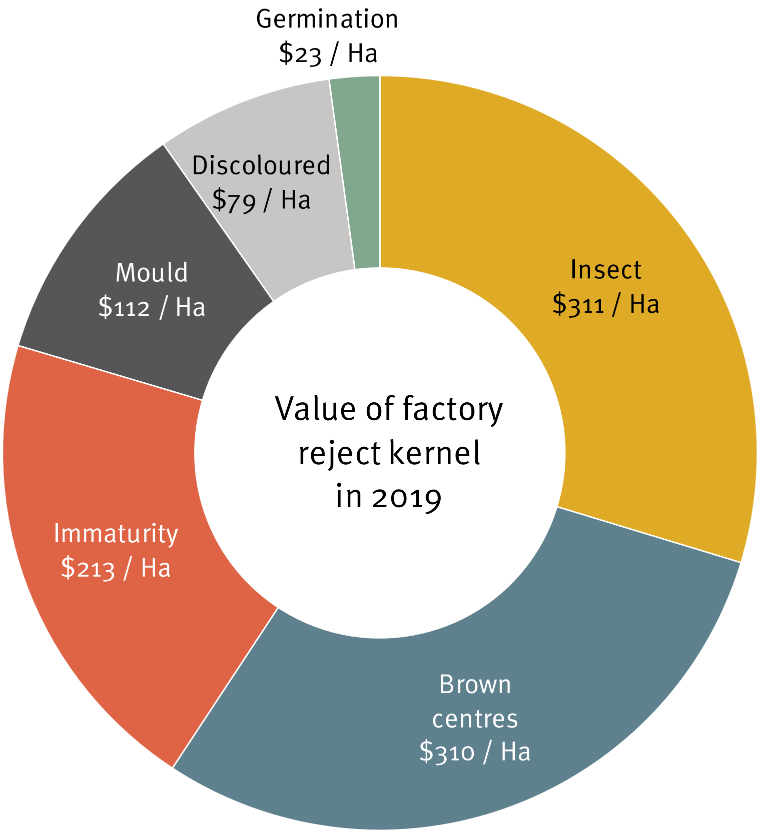


Figure 9: Estimated value per hectare of factory reject kernel for all farms in the benchmark sample in 2019

Costs in 2019

The benchmarking project has been collecting data since 2017 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. 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 10 shows median **total production costs** per planted hectare and per tonne of saleable kernel (SK) for 91 mature farms (10+ years old) that provided cost data in the 2019 season. This includes all cash operating costs as well as unpaid labour. Median rather than average costs are shown due to the presence of some outlying seasonal cost data within the sample. In this instance the median, which refers to the middle value of a sorted list of numbers, minimises the impact of these outliers and provides a better indication of typical expenditure across the sample.

The chart shows median 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 91 mature farms in the benchmark sample that provided cost data in 2019, 56% were owner-operated and 44% were managed. Imputed labour accounted for 15% of median total production costs per hectare for owner-operated farms and was negligible for managed farms.

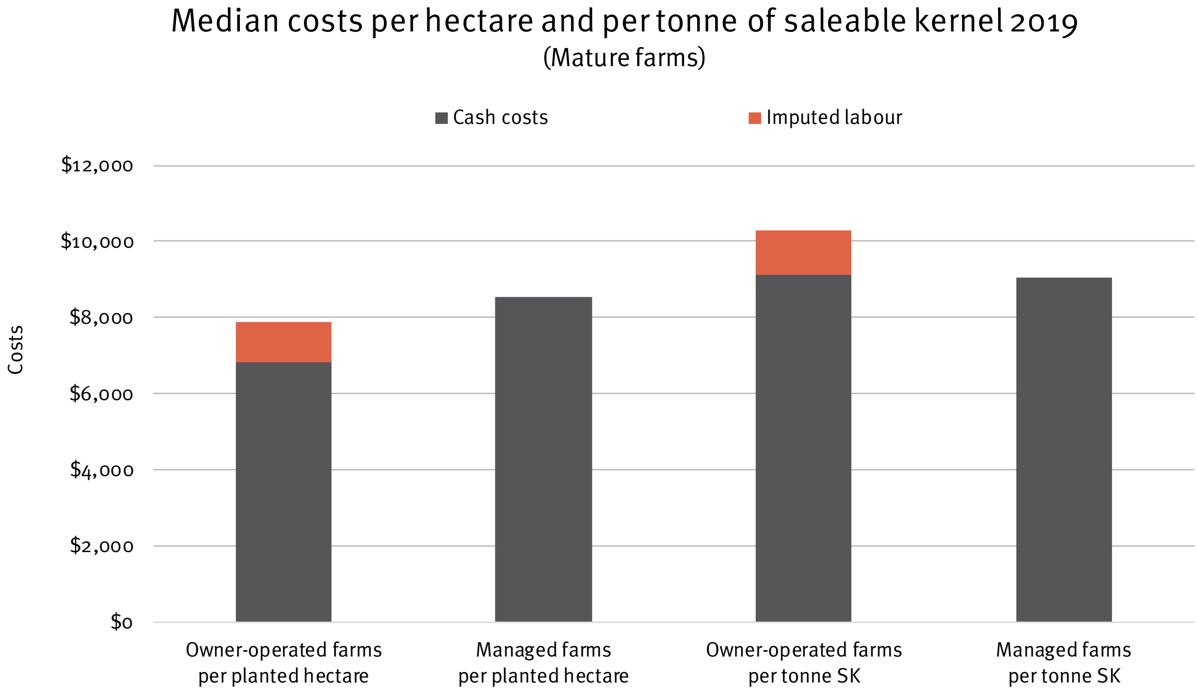


Figure 10: Total cash costs and imputed labour per hectare and per tonne of SK for managed and owner-operated farms in 2019

Figure 11 compares median **employment costs** per hectare and per tonne of saleable kernel for mature farms in 2019. The chart shows both cash and imputed labour costs for owner-operated and managed farms in the benchmark sample.

Imputed labour accounted for almost half of total employment costs for owner-operated farms and was negligible for managed farms. Median employment costs per hectare and per tonne SK were much more consistent between managed and owner-operated farms when imputed labour was included.

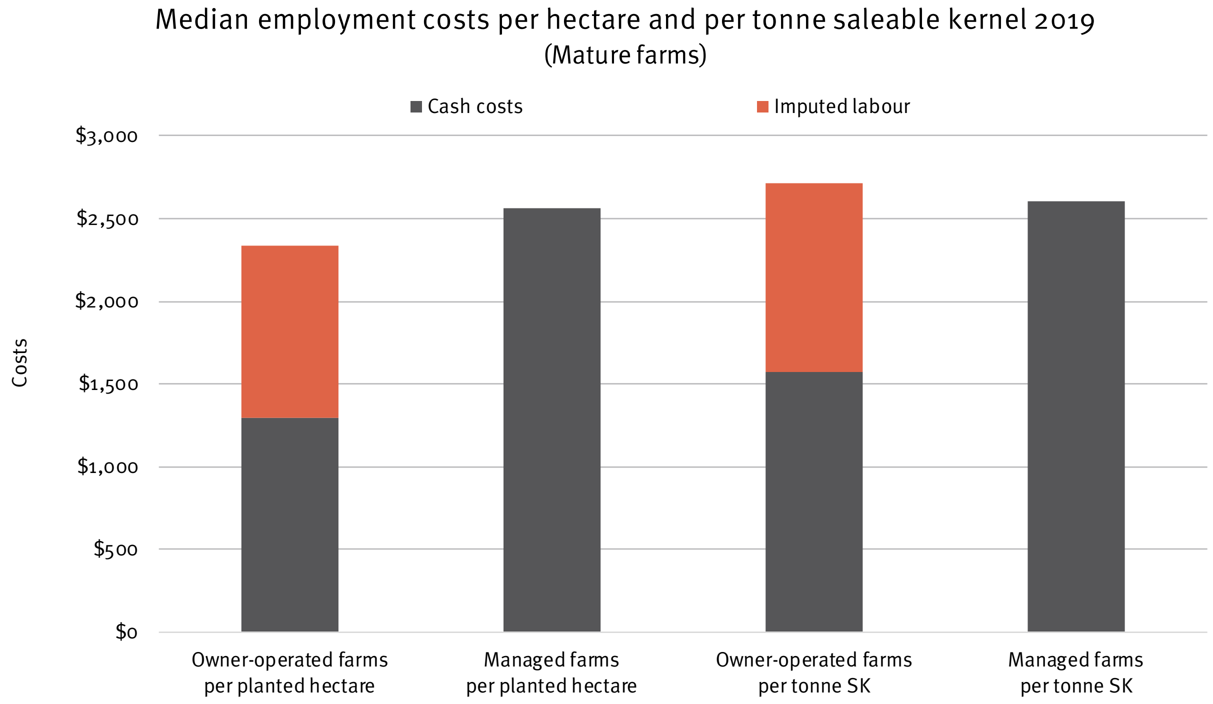


Figure 11: Employment cash costs and imputed labour per hectare and per tonne of SK for managed and owner-operated farms in 2019

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. A standard hourly wage rate of $30 per hour is applied to unpaid labour to derive a notional cost.

Figure 12 shows a breakdown of average cash costs by major heads of expenditure. Expenditure for the 2019 season is compared with the long-term average from 2013–2019. As unpaid labour was not collected prior to 2017, employment figures shown exclude imputed labour.

In 2019 average costs were higher than the long-term average across most heads of expenditure. In 2019 average total cash costs were $8799/ha versus $7535/ha for the long term. The biggest cash increases in 2019 relative to long-term averages were evident for hire ($341/ha, 130%), employment ($286/ha, 15%), crop nutrition ($185/ha, 16%), contractors ($110/ha, 22%) and repairs and maintenance (R&M) improvements ($91/ha, 29%).

Closer analysis of the sample revealed some substantial increases in expenditure on a few farms in 2019, skewing the seasonal average. This was particularly the case for some heads of expenditure such as hire and crop nutrition. Median expenditure was therefore also calculated to show mid-level expenditure within the sample.

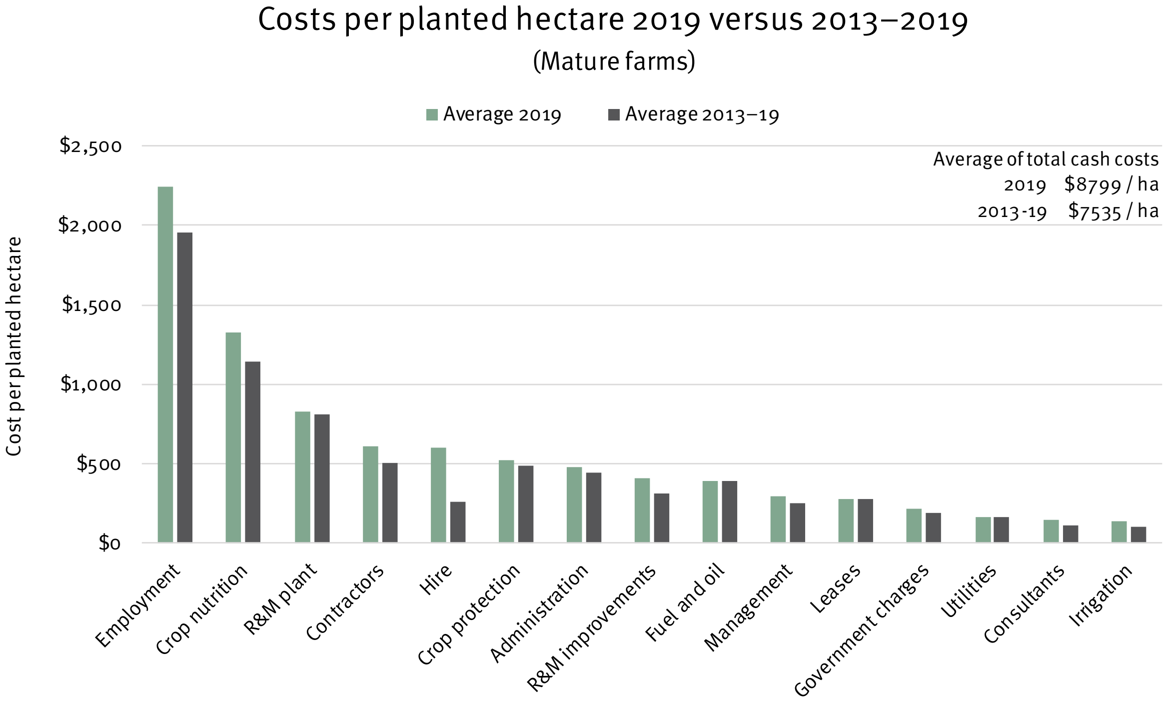


Figure 12: Average expenditure per planted hectare by head of expenditure for 2019 versus 2013–2019

Figure 13 shows the median cash costs by major heads of expenditure for 2019 versus the long-term (2013–2019).

The median of total costs was lower than the equivalent average in both 2019 and also over the long-term. As with the averages shown in the previous chart, the median of total costs was higher in 2019 compared with the long-term. The biggest median cash increases relative to the long-term were evident for employment ($454/ha, 24%), contractors ($202/ha, 89%) and crop protection ($118/ha, 27%).

The rank order of median expense categories also reveals some differences compared with the averages shown in the previous chart. Median crop protection and administration were ranked higher than the equivalent averages for the sample. By comparison, expenses such as hire, leases and management were negligible compared with the averages for the sample. This disparity indicates a skewing of expenditure for some individual expense categories as well as for total production costs within the benchmark sample.

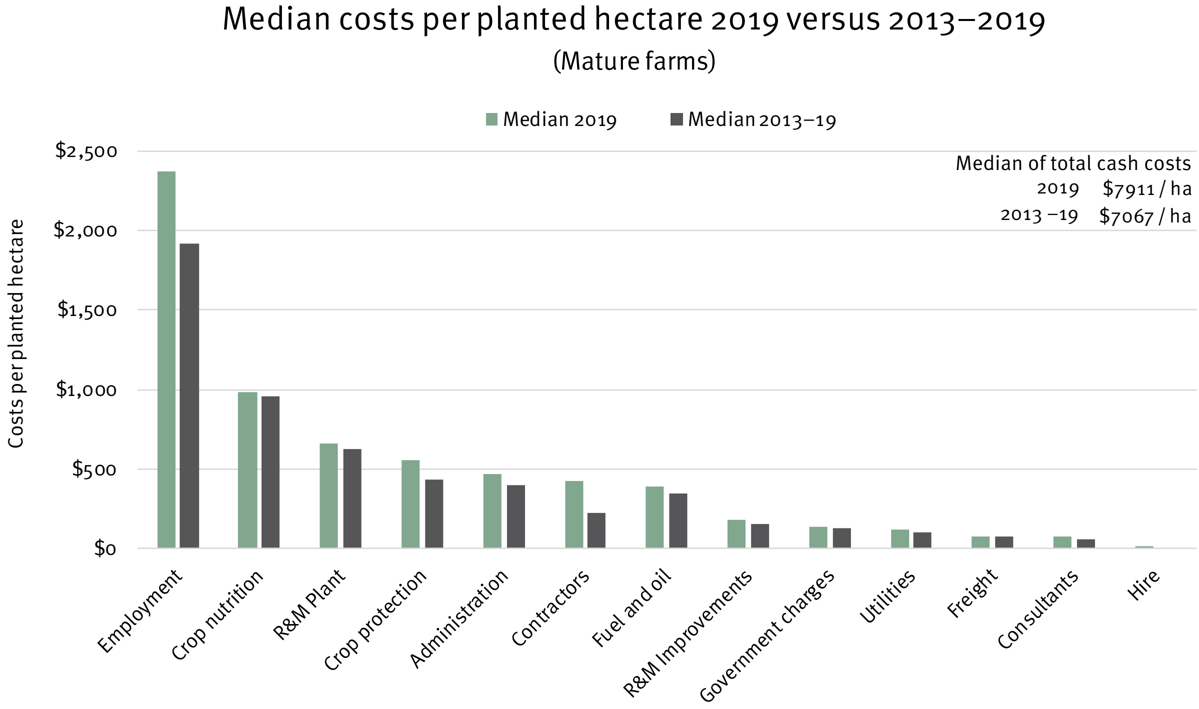


Figure 13: Median expenditure per planted hectare by head of expenditure for 2019 versus 2013–2019

Over 25% of mature farms in the cost of production sample undertook orchard rejuvenation in the 2019 season. Key rejuvenation activities included mulching or composting (36%), tree removal (32%), canopy management (24%) and machinery repair or replacement (8%). Average cash costs for farms undertaking rejuvenation were $9257/ha compared to $8171/ha for farms that were not rejuvenating. Additional expenditure on hire, contractors, repairs and maintenance (R&M) improvements, management, employment and crop nutrition were observed for farms undertaking rejuvenation in 2019.

Trends for the benchmark sample

This section shows seasonal trends in productivity and kernel recovery from 2009–2019. This provides insight into long-term trends as well as seasonal variability within the sample.

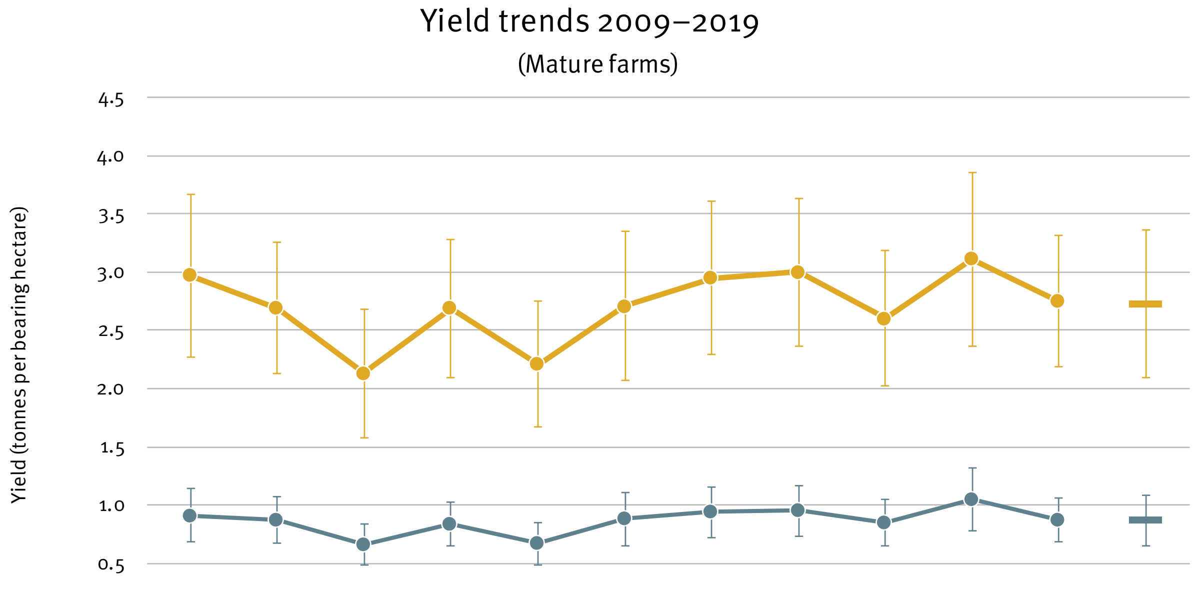
Cost trends are also shown for each year since 2013, when collection of cost data commenced. Both average and median values are presented as seasonal costs are highly variable across the benchmark sample. Costs are shown according to both planted area and production to accommodate differences in farm productivity and to demonstrate potential links between expenditure and productivity.

Yield and quality trends

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 within the sample.

The long-term average NIS yield for the benchmark sample was 2.73 t/ha with a standard deviation of 1.27 t/ha (47%). The long-term average SK yield was 0.87 t/ha with a standard deviation of 0.44 t/ha (51%). Although average yield in 2019 was lower than 2018 both NIS and SK for 2019 were consistent with the long-term average.

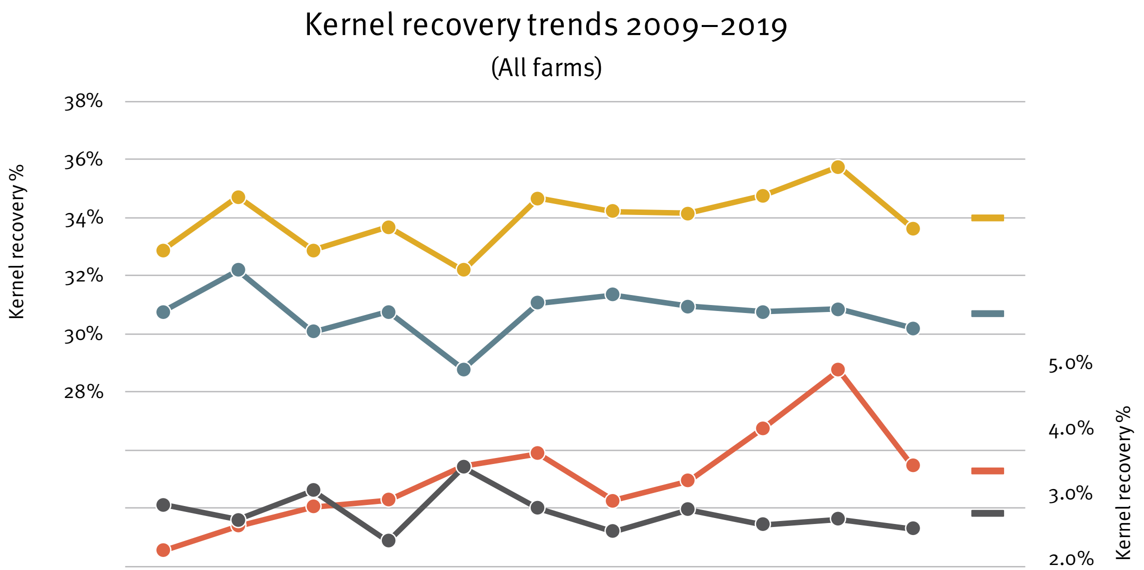
Analysis of the 5-year moving average from 2009–2019 shows a net increase across the benchmark sample of 0.3 t/ha NIS and 0.1 t/ha SK over that period.



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	09–19
NIS yield	2.97	2.69	2.13	2.69	2.21	2.71	2.95	3.00	2.60	3.11	2.75	2.73
NIS Std.dev.	1.40	1.13	1.11	1.19	1.08	1.28	1.31	1.27	1.16	1.50	1.13	1.27
SK yield	0.91	0.87	0.66	0.84	0.67	0.88	0.94	0.95	0.85	1.05	0.87	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	0.38	0.44

Figure 14: Average nut-in-shell and saleable kernel productivity for mature farms 2009–2019

Figure 15 shows trends in average kernel recovery for all farms in the benchmark sample from 2009–2019. 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	2019	09–19
Premium KR%	30.76	32.20	30.08	30.76	28.78	31.05	31.34	30.95	30.76	30.86	30.19	30.68
Saleable KR%	32.88	34.71	32.88	33.67	32.20	34.67	34.22	34.15	34.76	35.75	33.62	34.01
Commercial KR%	2.13	2.51	2.80	2.91	3.42	3.62	2.89	3.20	4.00	4.89	3.43	3.34
Reject KR%	2.83	2.60	3.05	2.28	3.41	2.78	2.43	2.76	2.53	2.61	2.47	2.70

Figure 15: Average kernel recovery 2009–2019

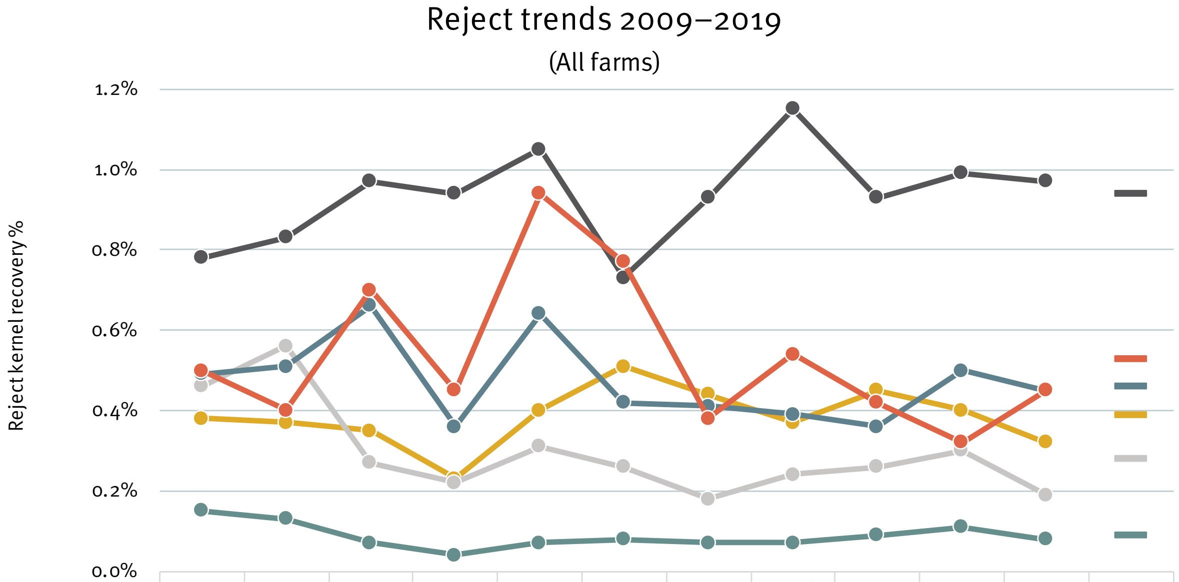
All categories of kernel recovery were lower in 2019 than in 2018. The high average CKR levels in 2018, which were particularly evident on smaller farms, declined by 30% in 2019 to reach levels consistent with the long-term average. PKR, SKR and RKR were all slightly lower in 2019 than the long-term average for the benchmark sample.

The benchmark sample has seen a net increase of **0.34 t/ha** in the 5-year moving average for NIS productivity since data collection commenced in 2009. At a 10-year average price of $4.32/kg this equates to an increase of roughly **$25.5** million in the gross value of production across industry during that time, assuming 57% national coverage and uniform representation of industry-average yield.

Analysis of factory reject categories provides insight into the specific causes of postharvest losses in any season. **Figure 16** shows the averages of all major factory reject categories for farms in the benchmark sample from 2009–2019. It's 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. This provides insight into the relative significance of each reject category at a farm level.

Insect damage remains the major cause of factory reject for most farms in the benchmark sample, with levels averaging almost twice that of the next highest reject category of immaturity. In 2019 all factory reject categories declined compared with 2018, with the exception of immaturity which increased by 0.13%. Extended hot and dry conditions prior to the 2019 harvest season are likely to have created periods of moisture stress that may have contributed to an increase in immaturity in 2019. Dry conditions may also have resulted in lower pest and disease pressure, which may have contributed to a general decrease in related reject categories.

Detailed regional analyses of factory rejects are shown in the *Regional results and trends* section.



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	09–19
Insect	0.78	0.83	0.97	0.94	1.05	0.73	0.93	1.15	0.93	0.99	0.97	0.94
Mould	0.38	0.37	0.35	0.23	0.40	0.51	0.44	0.37	0.45	0.40	0.32	0.39
Discoloured	0.46	0.56	0.27	0.22	0.31	0.26	0.18	0.24	0.26	0.30	0.19	0.28
Brown centres	0.49	0.51	0.66	0.36	0.64	0.42	0.41	0.39	0.36	0.50	0.45	0.46
Immature	0.50	0.40	0.70	0.45	0.94	0.77	0.38	0.54	0.42	0.32	0.45	0.53
Germinated	0.15	0.13	0.07	0.04	0.07	0.08	0.07	0.07	0.09	0.11	0.08	0.09

Figure 16: Average reject kernel recovery by category 2009–2019 (unweighted)

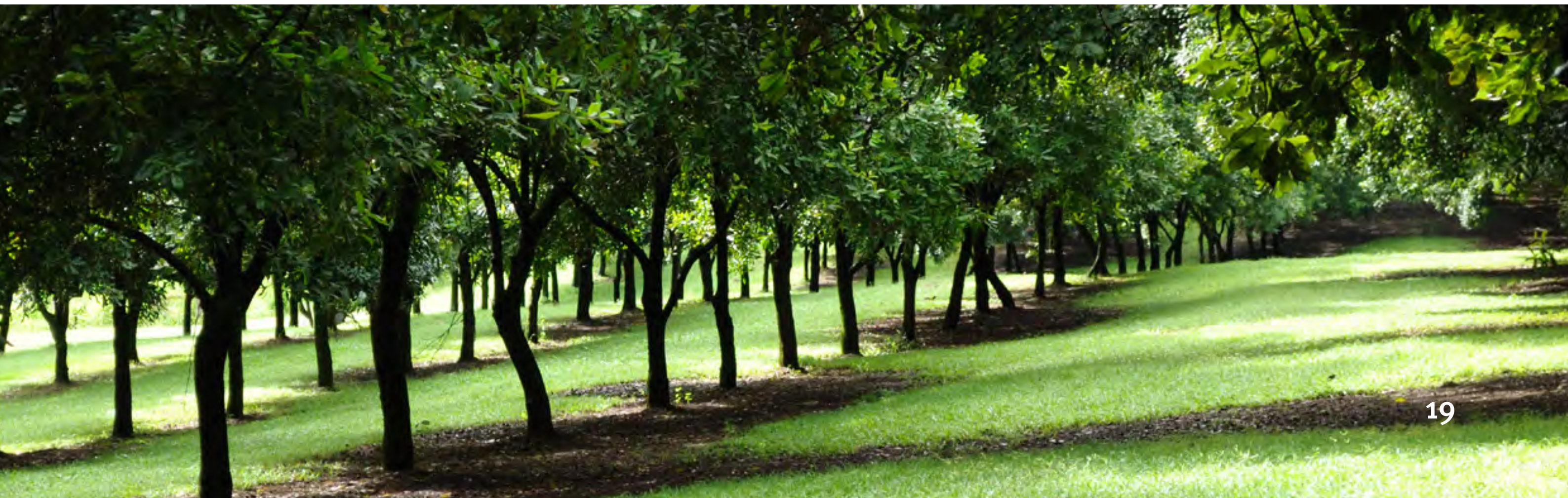
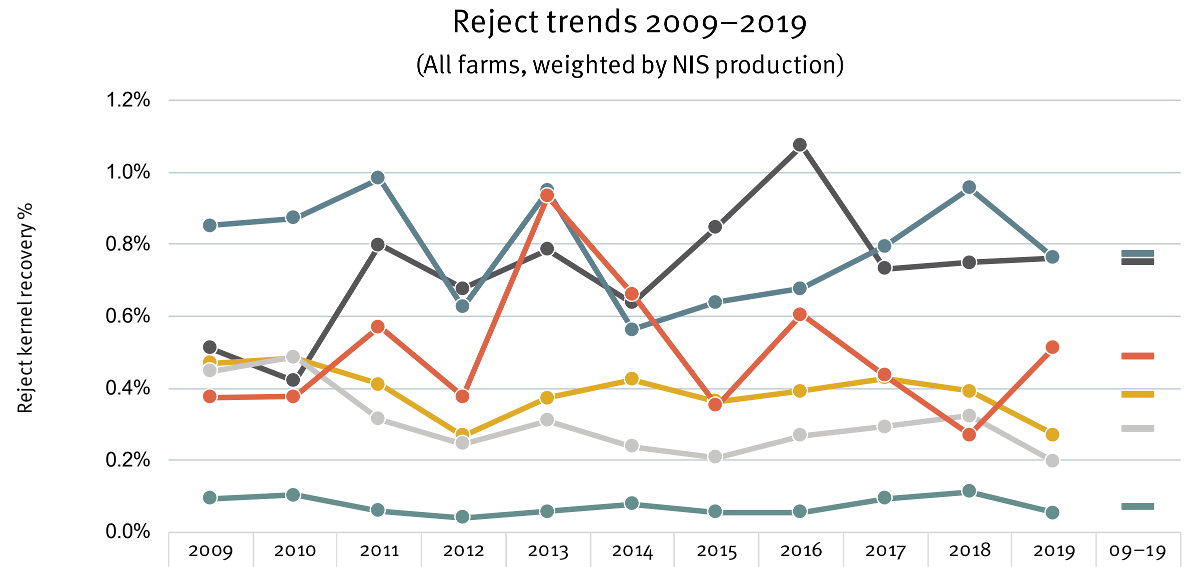


Figure 17 shows the equivalent factory reject averages weighted by nut-in-shell production. In this case farms that produce more NIS exert greater influence on the average, so this chart provides insight into the relative significance of each reject category at a whole-industry level.

When weighted by production brown centres emerges as the most significant cause of factory rejects in the long term (0.78%). This is closely followed by insect damage, which caused similar average factory losses in 2019 (0.76) but slightly lower losses over the long term (0.75%).

In 2019 reject levels in all categories were either close to, or lower than, their long-term average.



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	09–19
Insect	0.51	0.42	0.80	0.68	0.79	0.64	0.85	1.07	0.73	0.75	0.76	0.75
Mould	0.47	0.49	0.41	0.27	0.37	0.43	0.36	0.39	0.43	0.39	0.27	0.38
Discoloured	0.45	0.49	0.32	0.25	0.31	0.24	0.21	0.27	0.29	0.32	0.20	0.29
Brown centres	0.85	0.87	0.98	0.63	0.95	0.56	0.64	0.68	0.80	0.96	0.76	0.78
Immature	0.37	0.38	0.57	0.38	0.93	0.66	0.35	0.61	0.44	0.27	0.51	0.49
Germinated	0.09	0.10	0.06	0.04	0.06	0.08	0.06	0.06	0.09	0.11	0.05	0.07

Figure 17: Average reject kernel recovery by category 2009–2019 (weighted)

The total value of factory losses across the benchmark sample for 2009–2019 was calculated from the annual weight of rejects and historical NIS prices @ 33% SKR. **Figure 18** shows the estimated value of factory reject losses by category over this period.

Although reject percentages have remained relatively stable over the last decade, the value of those rejects has increased substantially with both expanded production and significant increases in NIS prices. The estimated value of factory reject losses across the benchmark sample has increased from $2.4 million in 2009 (@$1.90/ kg NIS) to almost $11 million in 2019 (@ $5.83/kg NIS).

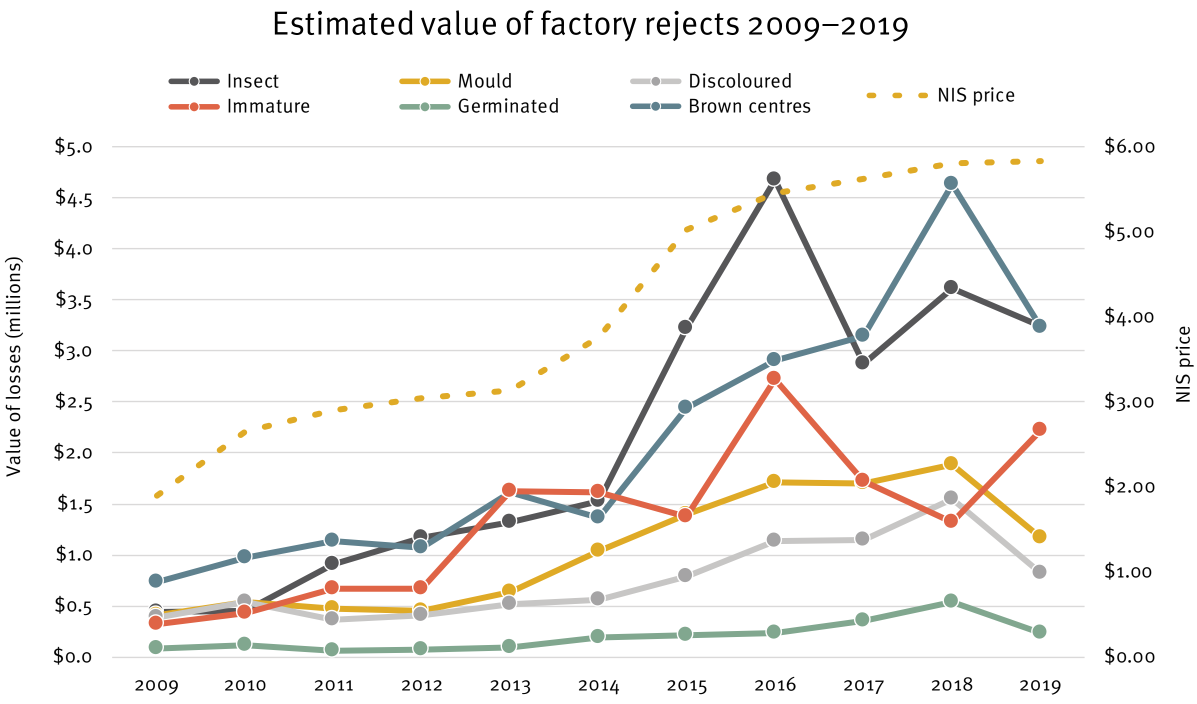


Figure 18: Estimated value of factory rejects by category 2009–2019

Table 3 shows the cumulative weight and estimated value of factory rejects for the benchmark sample from 2009–2019. The most significant factory losses by weight over this period were due to brown centres (5307 tonnes) followed by insect damage (5118 tonnes). The economic value of these losses was also estimated according to seasonal NIS prices. Based on seasonal fluctuations in NIS price insect damage had the highest economic value over this period ($23.5m), followed by brown centres ($23.3m). The combined value of all factory rejects from 2009–2019 is estimated at $83.2m.

Cumulative weight and estimated value of factory rejects 2009–2019

Region	Insect	Mould	Discoloured	Brown centres	Immaturity	Germination	Total
Weight (tonnes)	5118	2626	1965	5307	3420	493	18,929
Estimated value ($millions)	$23.5	$11.4	$8.2	$23.3	$14.7	$2.2	$83.2

Table 3: Cumulative weight and estimated value of factory rejects for farms in the benchmark sample from 2009–2019

Cost trends

Annual cash operating costs have been collected since 2013. Since 2017 participants have also been asked to estimate unpaid labour hours, which are imputed at a standard wage rate of $30 per hour to derive a more comprehensive estimate of total labour costs. In the following analyses only cost data from mature farms (10+ years old) is included.

A total of 91 mature farms provided production cost data in 2019. High variability between farms and seasons can significantly skew averages, so median values are presented in some of the following analyses to provide a more appropriate indicator of typical expenditure.

Figure 19 shows long-term cash costs versus saleable kernel productivity for 120 participating farms between 2013 and 2019. Each dot represents long-term average total cash costs vs average saleable kernel production per hectare for one participating farm. These averages are based on anywhere between one and seven seasons (average 3.2). The dots are colour-coded by production region.

The chart shows the high variability between farms in terms of expenditure and associated yield. This variability is evident across all regions within the benchmark sample.

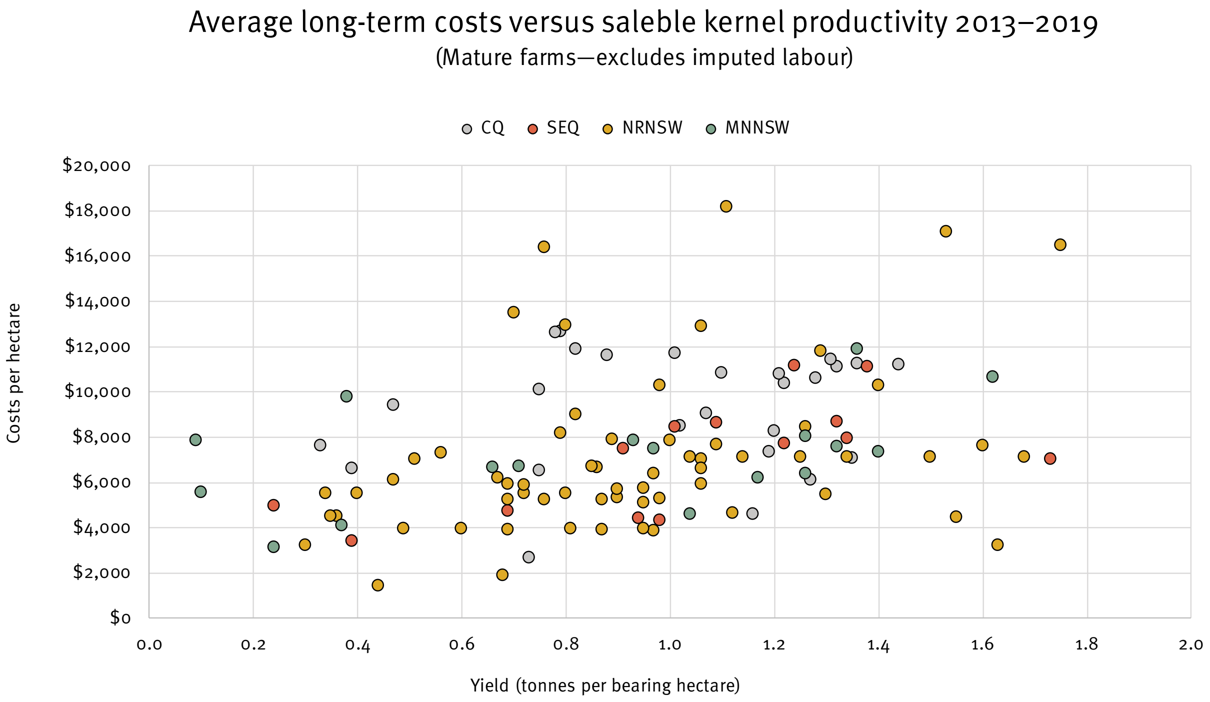
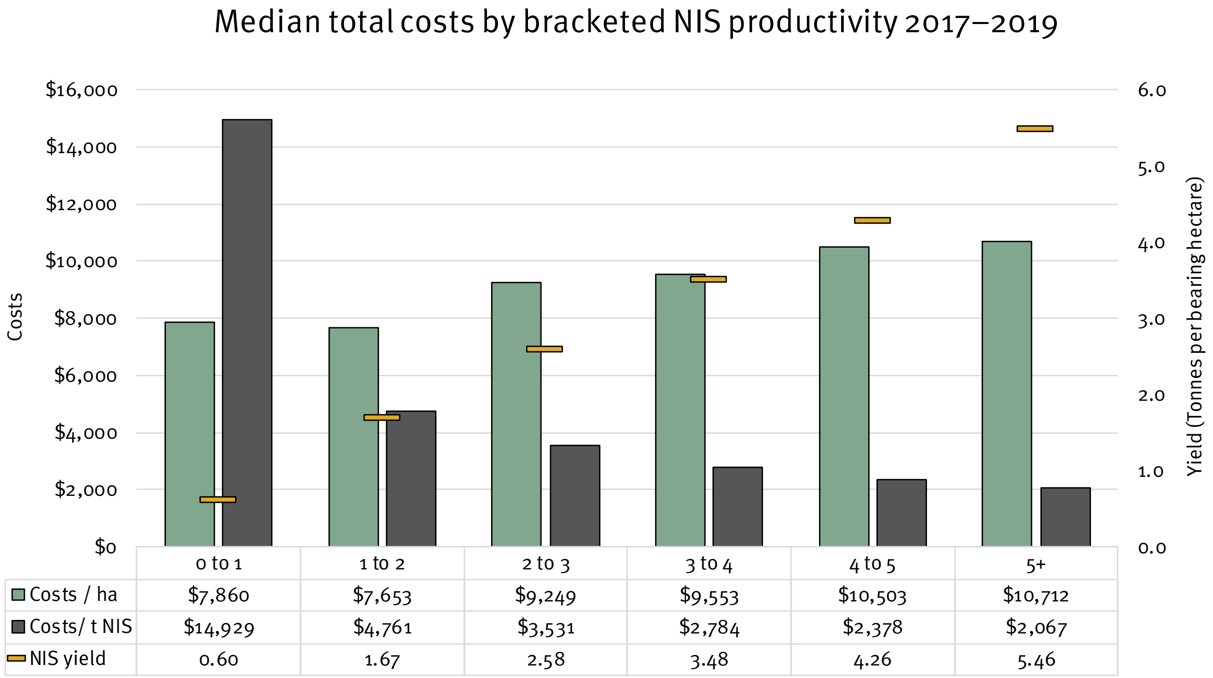


Figure 19: Average long-term cash costs versus saleable kernel productivity by farm 2013–2019

Figure 20 shows median total costs by NIS productivity categories ranging from less than 1 t/ha to more than 5 t/ha. The chart includes both cash and imputed labour costs spanning 237 farm-years over the three seasons this data has been collected (2017–2019). Costs per hectare (green bars) and costs per tonne of NIS (grey bars) are shown. The gold steps show the corresponding median NIS t/ha for each of the productivity categories.



	0 to 1	1 to 2	2 to 3	3 to 4	4 to 5	5+
🟩 Costs / ha	$7,860	$7,653	$9,249	$9,553	$10,503	$10,712
⬛ Costs/ t NIS	$14,929	$4,761	$3,531	$2,784	$2,378	$2,067
▬ NIS yield	0.60	1.67	2.58	3.48	4.26	5.46

Figure 20: Median total costs (cash + imputed labour) by bracketed NIS productivity 2017–2019

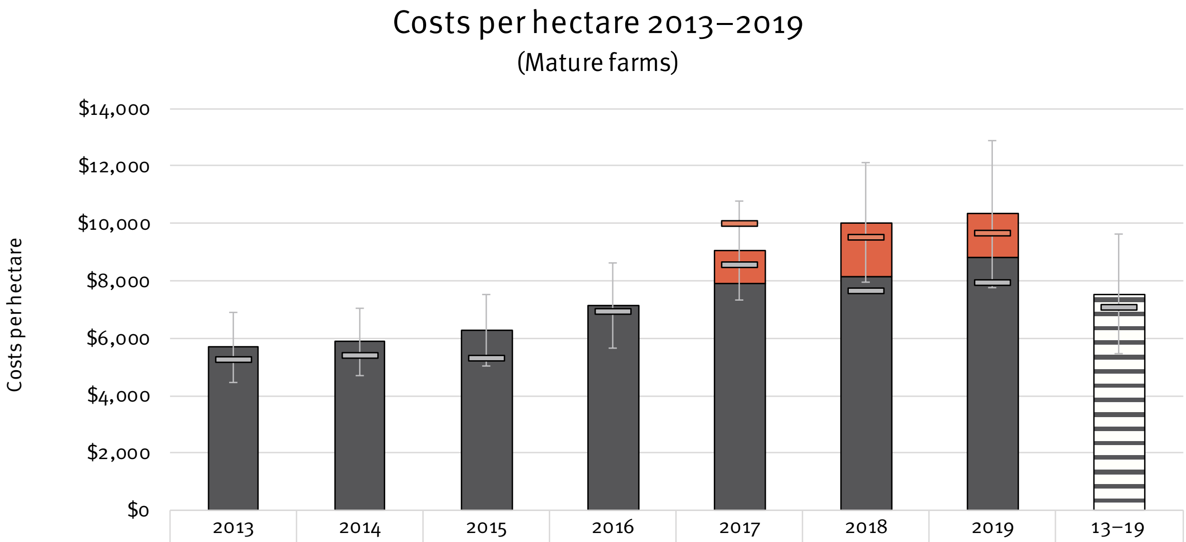
The chart shows a correlation between total expenditure per hectare and NIS productivity ($P<0.05$). This means that there is a general trend of increased expenditure per hectare among farms in higher average productivity categories. It is important to note that while the above data shows broad expenditure patterns, it does not identify the specific agronomic inputs associated with that expenditure.

As expected, the opposite relationship is the case for productivity versus costs per tonne of NIS, with lower costs per tonne associated with higher productivity.

Figure 21 shows seasonal average costs per hectare for mature farms (10+ years old) from 2013–2019. Costs shown from 2013–2016 are cash only (grey bars) while those from 2017 onwards also include imputed labour (red bars). The grey error bars show standard deviation, to provide insight into the seasonal variability around these averages. In many seasons the average is skewed by a small number of farms with expenditure well above that of others in the sample. Median values are therefore also shown on the chart to indicate the mid-point of the sample. Median cash-only costs are shown for 2013–2016 (grey steps) and for cash + imputed labour costs from 2017 onwards (red steps).

Average cash costs per hectare increased each year from 2013 to 2019. Average total costs (cash + imputed) have also steadily increased from 2017 to 2019. Median expenditure per hectare was generally stable from 2013 to 2015 but saw a marked increase between 2015 and 2017 followed by a reduction in 2018 and 2019. The base NIS price has increased from $3.14/kg in 2013 to $5.40/kg in 2019, an increase of over 70%. Corresponding average cash costs over the same period have increased by 55% per hectare, which may suggest that increased margins may have some influence on expenditure.

When imputed at a standard hourly rate of $30, unpaid labour accounted for 16% of total costs per hectare from 2017–2019.



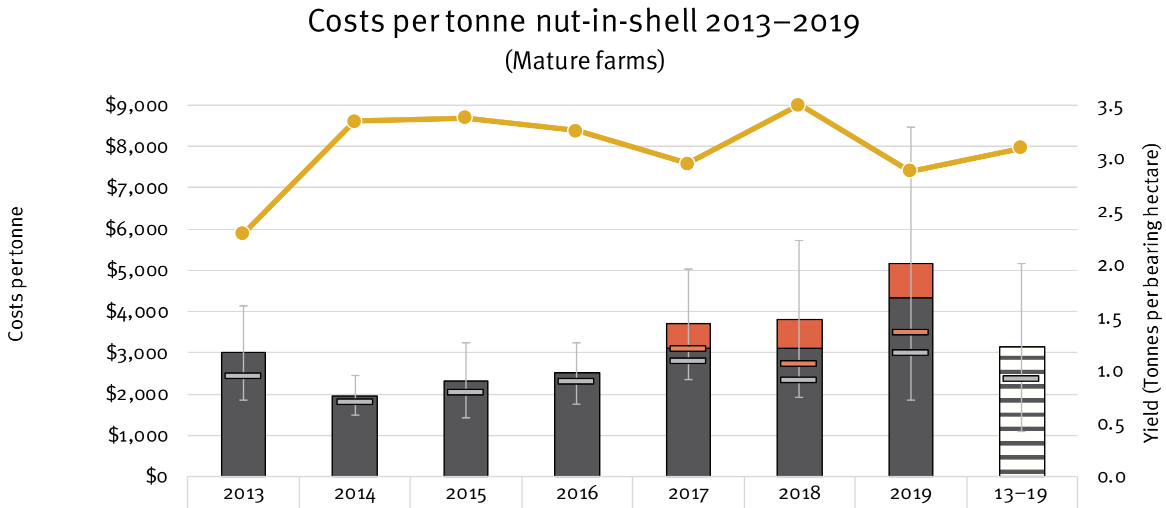
	2013	2014	2015	2016	2017	2018	2019	13–19
🟥 Imputed labour	-	-	-	-	$1,166	$1,898	$1,529	-
⬛ Cash costs	$5,695	$5,887	$6,287	$7,150	$7,908	$8,128	$8,799	$7,535
Std.dev.	$2,445	$2,346	$2,514	$2,978	$3,443	$4,183	$5,122	$4,189
▭ Median cash costs	$5,201	$5,348	$5,283	$6,890	$8,507	$7,629	$7,911	$7,022
▬ Median total costs	-	-	-	-	$9,950	$9,509	$9,614	-

Figure 21: Cash and imputed labour costs per hectare for mature farms 2013–2019

Figure 22 shows seasonal costs per tonne of nut-in-shell for mature farms (10+ years old) from 2013–2019. Average cash-only costs are shown from 2013–2016 (grey bars) while those from 2017 onwards also include imputed labour (red bars). The grey error bars show standard deviations of those averages. Median values are also shown for cash-only costs from 2013–2016 (grey steps) and cash + imputed costs for 2017 onwards (red steps).

Seasonal fluctuations in both average and median costs per tonne of NIS are heavily influenced by NIS productivity. Lower average and median costs in 2018 coincided with higher average productivity that season. In 2017 and 2019 lower average productivity coincided with higher median costs per tonne. In 2019 both average and median costs per hectare and per tonne of NIS were above their long-term equivalents.

When imputed at a standard hourly rate of $30, unpaid labour accounted for an average of 24% of total costs per tonne of SK from 2017–2019.



	2013	2014	2015	2016	2017	2018	2019	13–19
🟥 Imputed labour	-	-	-	-	$587	$715	$833	-
⬛ Cash costs	$2,997	$1,965	$2,331	$2,498	$3,102	$3,097	$4,327	$3,127
Std.dev.	$1,149	$475	$910	$730	$1,330	$1,897	$3,310	$2,025
▭ Median cash costs	$2,406	$1,795	$2,002	$2,275	$2,791	$2,330	$2,960	$2,332
▬ Median total costs	-	-	-	-	$3,070	$2,706	$3,488	-
●NIS yield	2.29	3.35	3.38	3.26	2.95	3.50	2.88	3.10

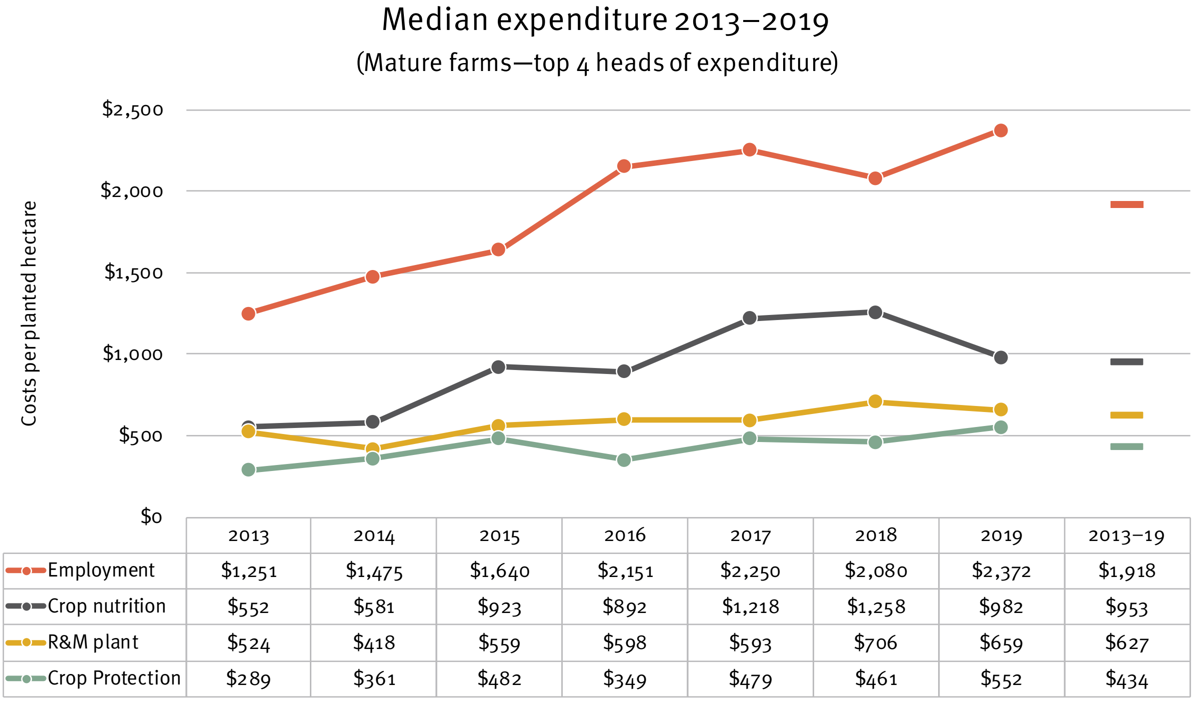
Figure 22: Cash and imputed labour costs per tonne NIS for mature farms 2013–2019

Figure 23 shows the top four heads of expenditure per planted hectare for mature farms that provided cost data from 2013–2019. The top four expenses include employment, crop nutrition, repairs & maintenance (R&M) plant and crop protection. Other expenses not shown included administration, contractors, fuel and oil, R&M improvements, government charges, utilities, freight, consultants, hire and irrigation, leases and management.

Employment costs have seen the biggest increase since 2013 and 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 cash 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 unpaid labour for mature farms between 2017 and 2019 suggests that when unpaid labour is imputed, employment costs account for approximately 37% of total costs. This figure falls to 34% for managed farms and rises to 41% 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 activities such as canopy management, tree removal, erosion control and soil health improvement.

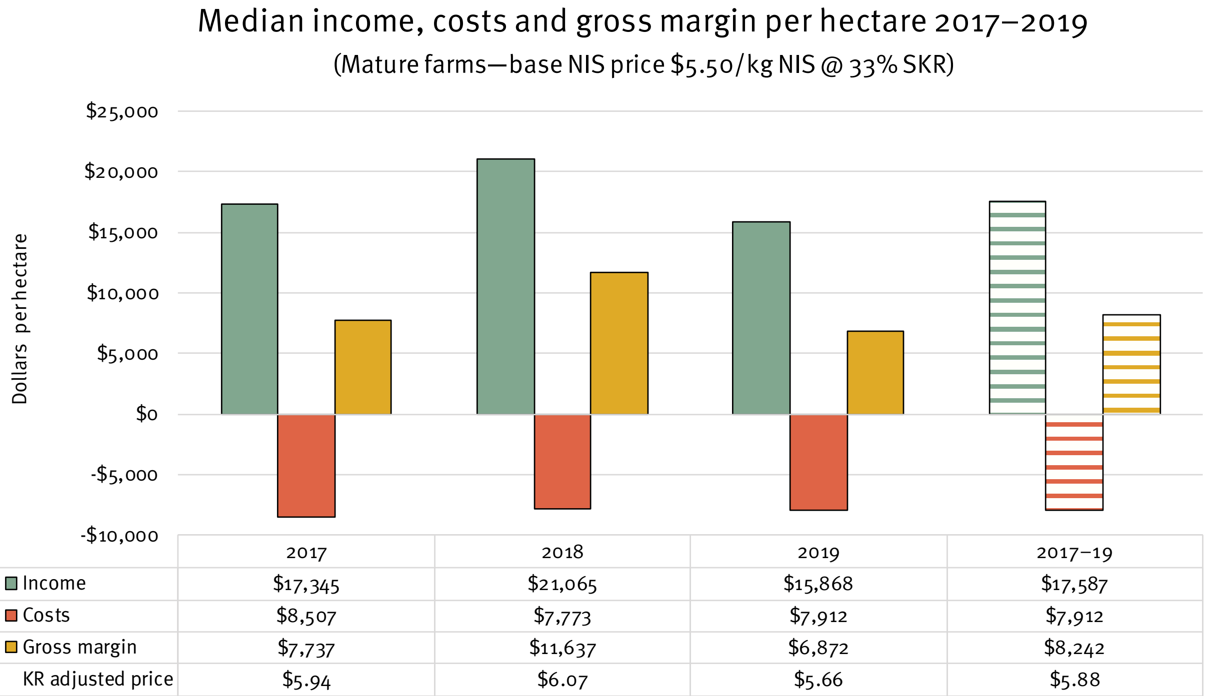


	2013	2014	2015	2016	2017	2018	2019	2013–19
● Employment	$1,251	$1,475	$1,640	$2,151	$2,250	$2,080	$2,372	$1,918
● Crop nutrition	$552	$581	$923	$892	$1,218	$1,258	$982	$953
● R&M plant	$524	$418	$559	$598	$593	$706	$659	$627
● Crop Protection	$289	$361	$482	$349	$479	$461	$552	$434

Figure 23: Employment, crop nutrition, R&M plant and crop protection expenditure per planted hectare for mature farms 2013–2019

Figure 24 shows median income, operating costs and gross margins per bearing hectare for mature farms that provided cost data from 2017–2019. An average of 79 mature farms contributed data each year during this period.

Medians are shown to identify the middle point of the sample and provide an estimate of what is typical within the benchmark pool. Income is estimated using a base price of $5.50/kg NIS @ 10% moisture content. The base price is adjusted for each farm according to the actual saleable kernel recovery achieved. The median of these adjusted prices for each season is shown in the table. Levies are also subtracted from the income figures shown. Operating costs include cash as well as unpaid labour, which has been imputed at a standard rate of $30 per hour. The gross margin is calculated for each farm by subtracting operating costs from income. As the median values shown for income, costs and gross margins are independently derived from individual farm data, the figures shown in the table cannot be related to each other (i.e. subtracting costs from income will not yield the same gross margin as that shown in the table).



	2017	2018	2019	2017–19
🟩 Income	$17,345	$21,065	$15,868	$17,587
🟥 Costs	$8,507	$7,773	$7,912	$7,912
🟨 Gross margin	$7,737	$11,637	$6,872	$8,242
KR adjusted price	$5.94	$6.07	$5.66	$5.88

Figure 24: Average income, costs and gross margins for mature farms that provided cost data from 2017–2019

From 2017 to 2018 both median saleable kernel yield and median income increased by 21%, then declined again by 25% in 2019. This corresponds with a 2% increase in median saleable kernel recovery in 2018 followed by almost a 7% decrease in 2019.

From 2017 to 2018 median costs declined by approximately 9% and then increased by almost 2% in 2019. The net result was an increase in 2018 of $3900/ha in median gross margin followed by a reduction of $4765/ha in 2019.

Figure 25 compares median cash costs for farms indicating above-average verses average seasonal expenditure between 2017–2019. Average expenditure was specified by a total of 81 farm-years and above-average expenditure by 71 farm-years during this period.

The bars show expense categories with the largest differences in median expenditure per hectare between average and above-average seasons. The overall difference in median costs between farms with above-average and average expenditure was $1179/ha, which is an increase of approximately 18%. The biggest differences were in employment costs, followed by crop nutrition, contractors, repairs and maintenance plant and fuel and oil.

It's important to note that median costs for some expense categories were actually lower among farms that indicated above-average expenditure. These included repairs and maintenance improvements, administration, consultants, utilities and crop protection. The total combined difference for these expenses was -$290/ha.

Participants were also asked to rank the top three activities they were undertaking that contributed to their increased expenditure. From a total of 145 responses the key activities included mulching or composting (28%), canopy management (27%), drainage (27%), other (22%), tree removal (6%) and tree planting (3%). Activities listed in the "other" category included orchard floor management, profiling, hail repairs, orchard rectification or rejuvenation, ground cover establishment, mistletoe removal, pest control, land preparation, repairs & maintenance and harvesting.

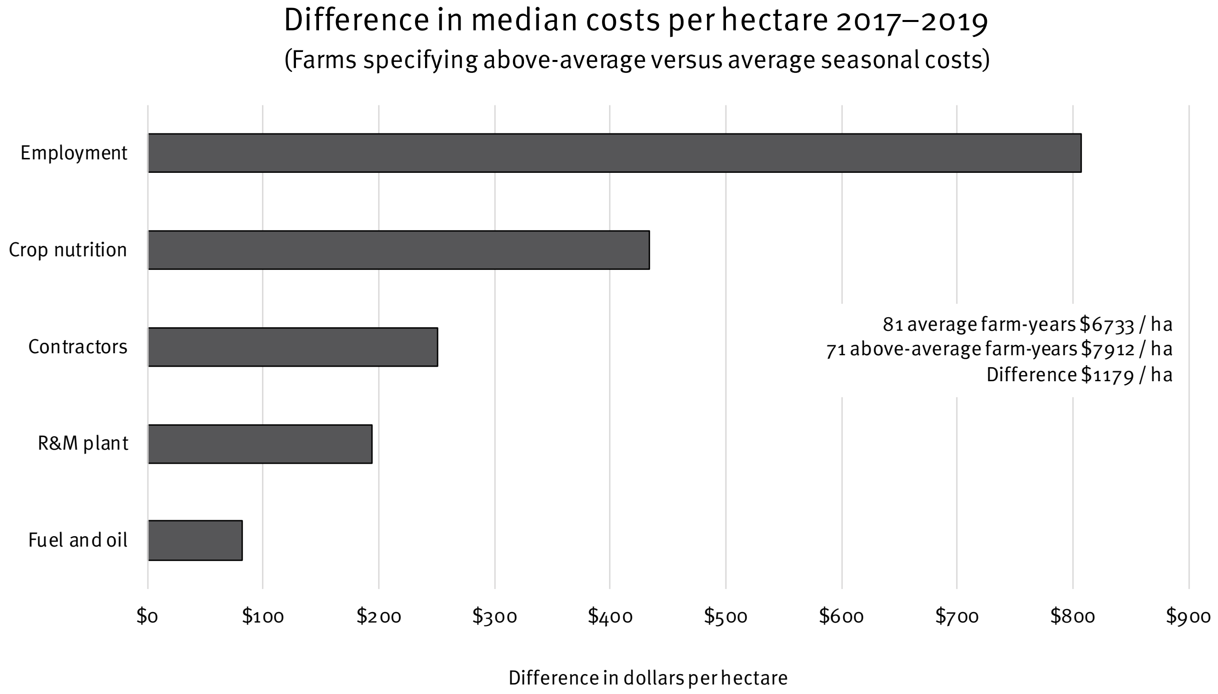


Figure 25: Average versus above-average seasonal costs 2017–2019

Expenditure was also analysed according to the expense priorities indicated by participating farms. **Figure 26** ranks average total costs per hectare for a range of expense priorities for mature farms that provided cost data in 2018–2019. The grey bars show average total expenditure for each category and the light grey error bars show standard deviation. The gold steps show the corresponding average yield of NIS/ha for those farms.

Farms with the highest average expenditure ($12,973/ha) nominated tree removal as their top priority, closely followed by those undertaking drainage work ($12,556/ha). Farms undertaking tree removal also had the highest standard deviation in average expenditure ($6433/ha) and the lowest average NIS yield per hectare (2.54 t/ha).

The next most significant priority indicated was "other", which encompassed a range of activities including orchard floor management, profiling, hail repairs, orchard repair or rejuvenation, ground cover establishment, mistletoe removal, pest control, land preparation, repairs & maintenance and harvesting.

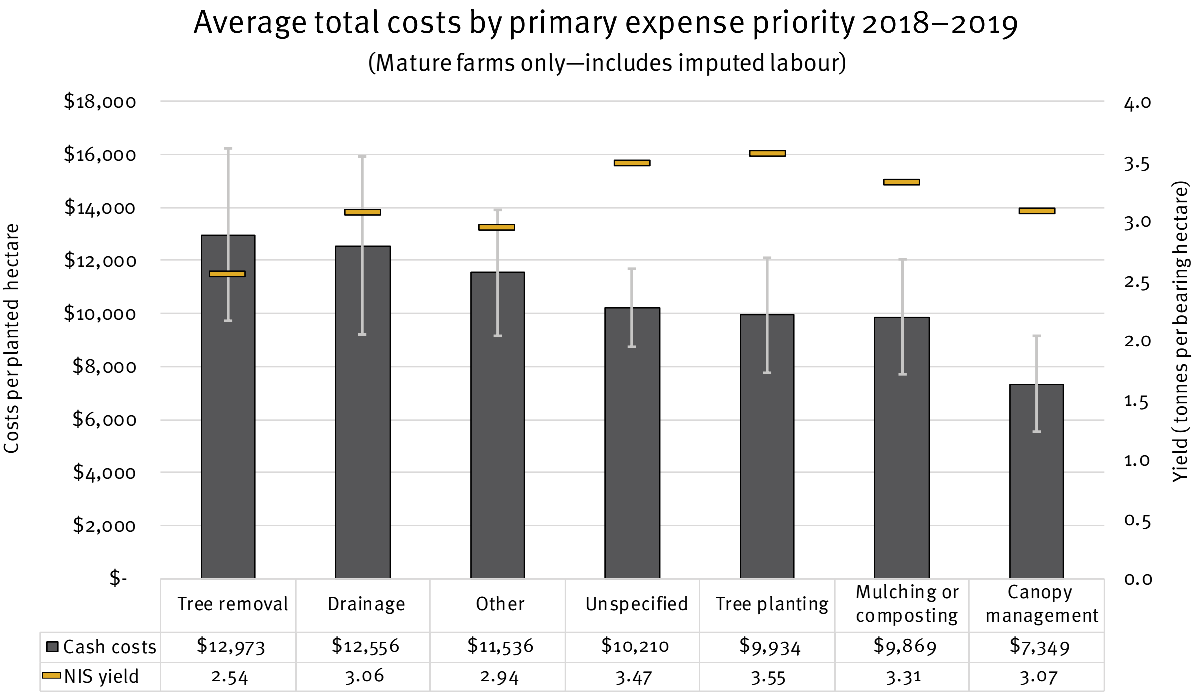
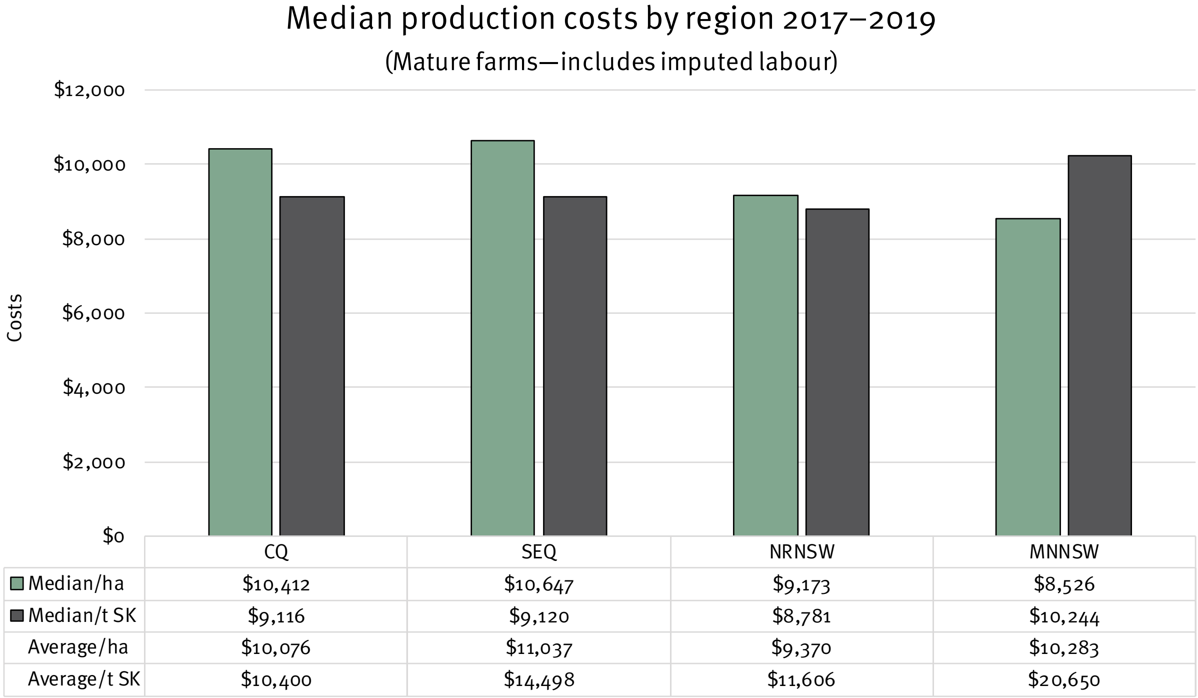


Figure 26: Average total costs by primary expense priority 2018–2019

In 2019 median operating costs accounted for 50% of median gross income for farms in the benchmark sample. Losses from factory rejects amounted to the equivalent of almost 7% of median gross income.

Figure 27 compares median total expenditure by region for mature farms that provided cost data from 2017–2019. This includes both cash and imputed labour costs for a total of 237 farm-years during this period. The green bars show costs per planted hectare and the grey bars show costs per tonne of saleable kernel (SK) produced. Median costs are displayed in the chart as high variability in both costs and productivity between farms and seasons can significantly skew sample averages. This was particularly evident for costs per hectare NRNSW and for costs per tonne of SK in MNNSW. High variability between seasons may be related to periodic activities that either influence seasonal yield or require substantial investment, such as those identified in the previous chart. Average costs per hectare and per tonne SK are included for comparison in the table below the chart.



	CQ	SEQ	NRNSW	MNNSW
🟩 Median/ha	$10,412	$10,647	$9,173	$8,526
⬛ Median/t SK	$9,116	$9,120	$8,781	$10,244
Average/ha	$10,076	$11,037	$9,370	$10,283
Average/t SK	$10,400	$14,498	$11,606	$20,650

Figure 27: Long-term median total costs per hectare and per tonne of saleable kernel by region 2017–2019

MNNSW farms had the lowest median costs per hectare and the highest median cost per tonne of SK. NRNSW farms had the lowest median costs per tonne of SK and the second lowest median costs per hectare. SEQ farms had the highest median costs per hectare and the second highest median costs per tonne of SK.

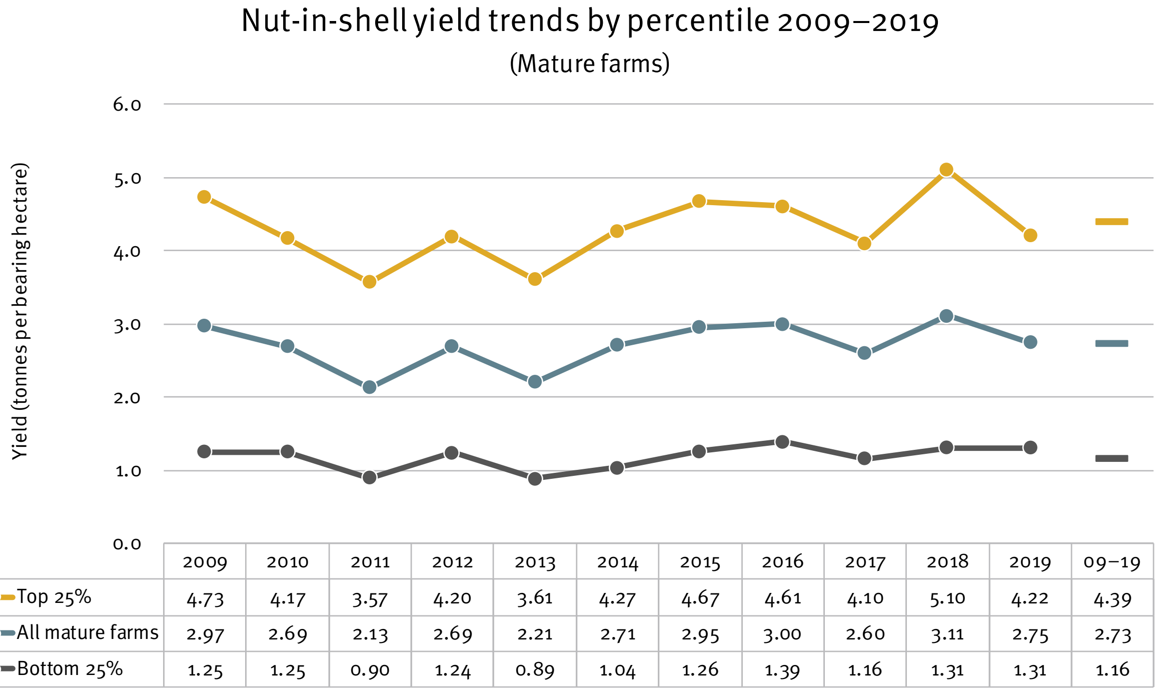
The biggest differences between median and average costs were apparent in the MNNSW and SEQ regions. It is important to note that these regions had relatively small sample sizes (37 and 27 farm-years respectively), so the inclusion of any farms with either high seasonal expenditure or low productivity could significantly influence averages.

Trends by percentile

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 these percentiles will vary depending on their seasonal performance for each attribute. This means, 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 analysis, which is based on a static group of farms that achieved high average SK/ha productivity over multiple seasons. Percentiles therefore provide insight into sample and seasonal variability rather than long-term performance.

Yield percentiles are based on mature farms (10+ years old) 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 has been evident within the benchmark sample in all seasons.

Figure 28 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 2009–2019. Over this period the average NIS production for the top 25% of the sample was almost four times that of the bottom 25%.

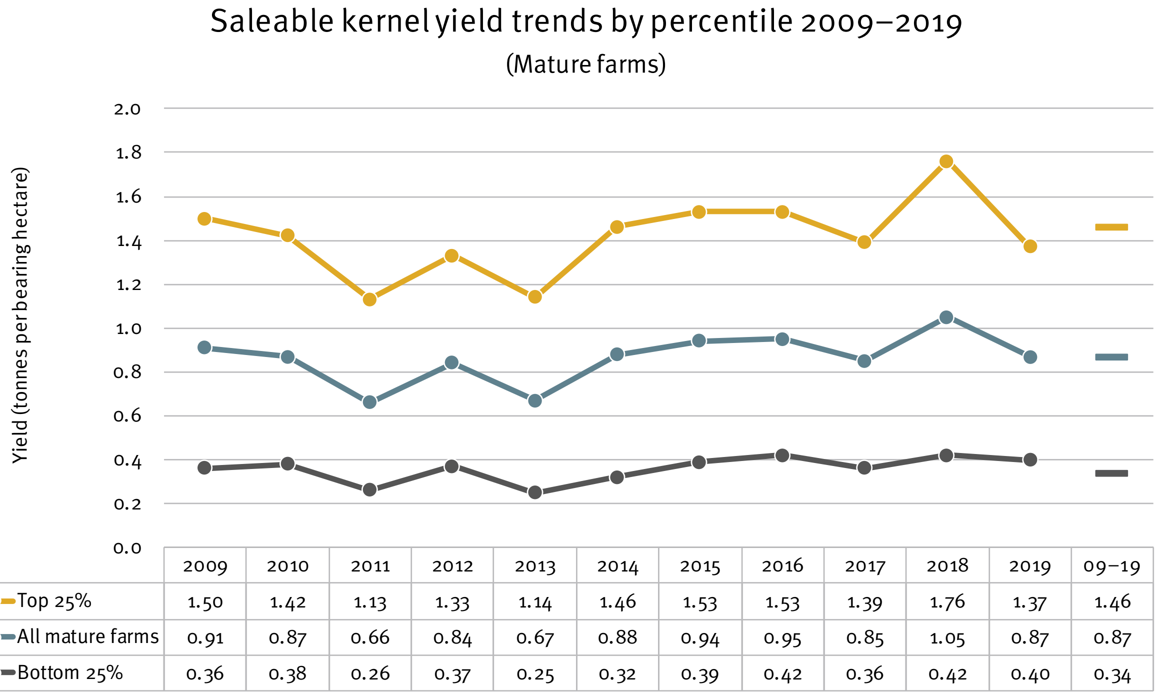


	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	09–19
Top 25%	4.73	4.17	3.57	4.20	3.61	4.27	4.67	4.61	4.10	5.10	4.22	4.39
All mature farms	2.97	2.69	2.13	2.69	2.21	2.71	2.95	3.00	2.60	3.11	2.75	2.73
Bottom 25%	1.25	1.25	0.90	1.24	0.89	1.04	1.26	1.39	1.16	1.31	1.31	1.16

Figure 28: Top 25%, bottom 25% and average NIS yields for mature farms from 2009–2019

For the eleven years from 2009–2019 average saleable kernel productivity for the top 25% of the benchmark sample (1.46 t/ha) was more than four times higher than the bottom 25% (0.34 t/ha).

Figure 29 compares the average tonnes of saleable kernel (SK) per bearing hectare for the top 25%, bottom 25% and all mature farms in the benchmark sample for each year from 2009–2019. Yield increases and decreases were generally more pronounced in the top 25% of the sample. Average SK productivity of the top 25% was over four times that of the bottom 25% over the 11-year period shown.



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	09–19
Top 25%	1.50	1.42	1.13	1.33	1.14	1.46	1.53	1.53	1.39	1.76	1.37	1.46
All mature farms	0.91	0.87	0.66	0.84	0.67	0.88	0.94	0.95	0.85	1.05	0.87	0.87
Bottom 25%	0.36	0.38	0.26	0.37	0.25	0.32	0.39	0.42	0.36	0.42	0.40	0.34

Figure 29: Top 25%, bottom 25% and average saleable kernel yields for mature farms from 2009–2019

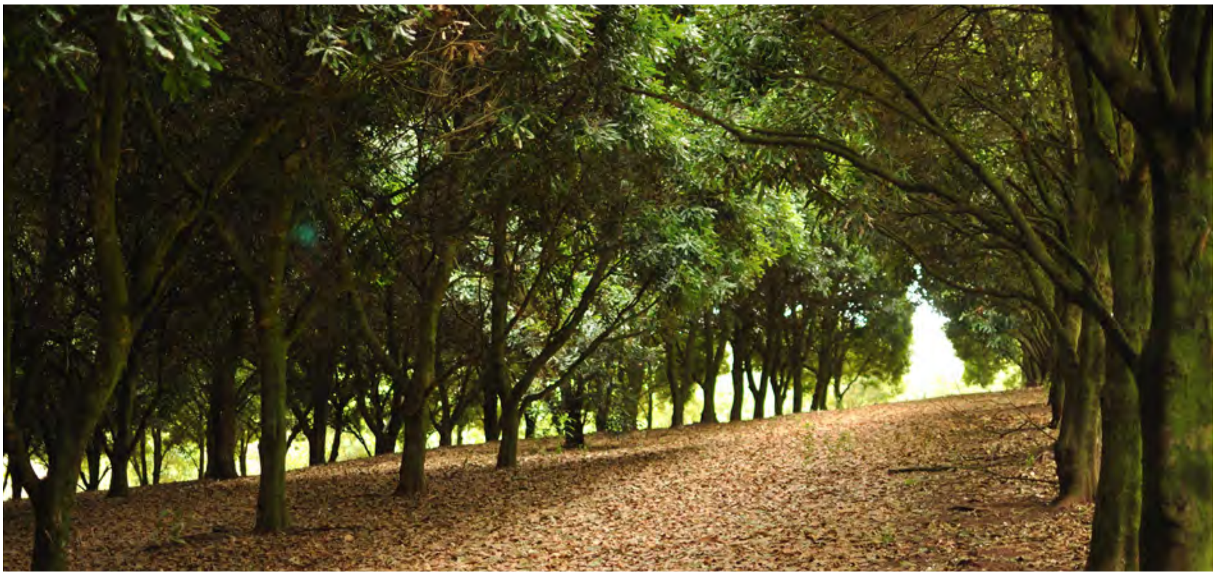
Regional results and trends

In this section regional yield and quality trends are compared for each of the four major production regions of Central Queensland, South East Queensland, Northern Rivers of NSW and the Mid North Coast of NSW.

When considering regional performance it is important to understand the underlying differences between farms in each region in terms of orchard characteristics, management approach and environment.

The **Central Queensland (CQ)** region includes the significant production areas in and around Bundaberg and Childers. It also includes currently outlying production areas such as Mackay, Rockhampton and Emerald. A total of 49 of the 264 farms in the benchmark sample are in the CQ region. Almost half of these farms (22) provided cost data in 2019. The majority of farms in this region are located in and around Bundaberg and over two-thirds are managed. CQ has the youngest average tree age of all regions (15 years) and includes some young farms that are yet to reach full maturity. While CQ accounts for just 19% of farms in the benchmark sample, the larger median farm size in this region (61.1 hectares) means that it represented 52% of the sample for both production and planted area in 2019. The Bundaberg region is typically hotter and drier than the more southern macadamia production areas and all farms from this region within the benchmark sample are irrigated.

In 2019 a total of 52 farms participated from the **Southeast Queensland (SEQ)** region, which includes the two main production areas of the Glass House Mountains (24 farms) and Gympie (28 farms). The SEQ region represents approximately 20% of the benchmark sample by number of farms and 15% by production. SEQ has the oldest average tree age of all regions (25 years in 2019). Approximately 40% of the farms in this region are not irrigated, most of which are located in the Glass House Mountains area. Annual rainfall has been somewhat unreliable in this region in recent years resulting in dry conditions in some seasons. Approximately 90% of participating farms in SEQ are owner operated. Only 9 of the 52 farms in this region (17%) contributed cost data in 2019.



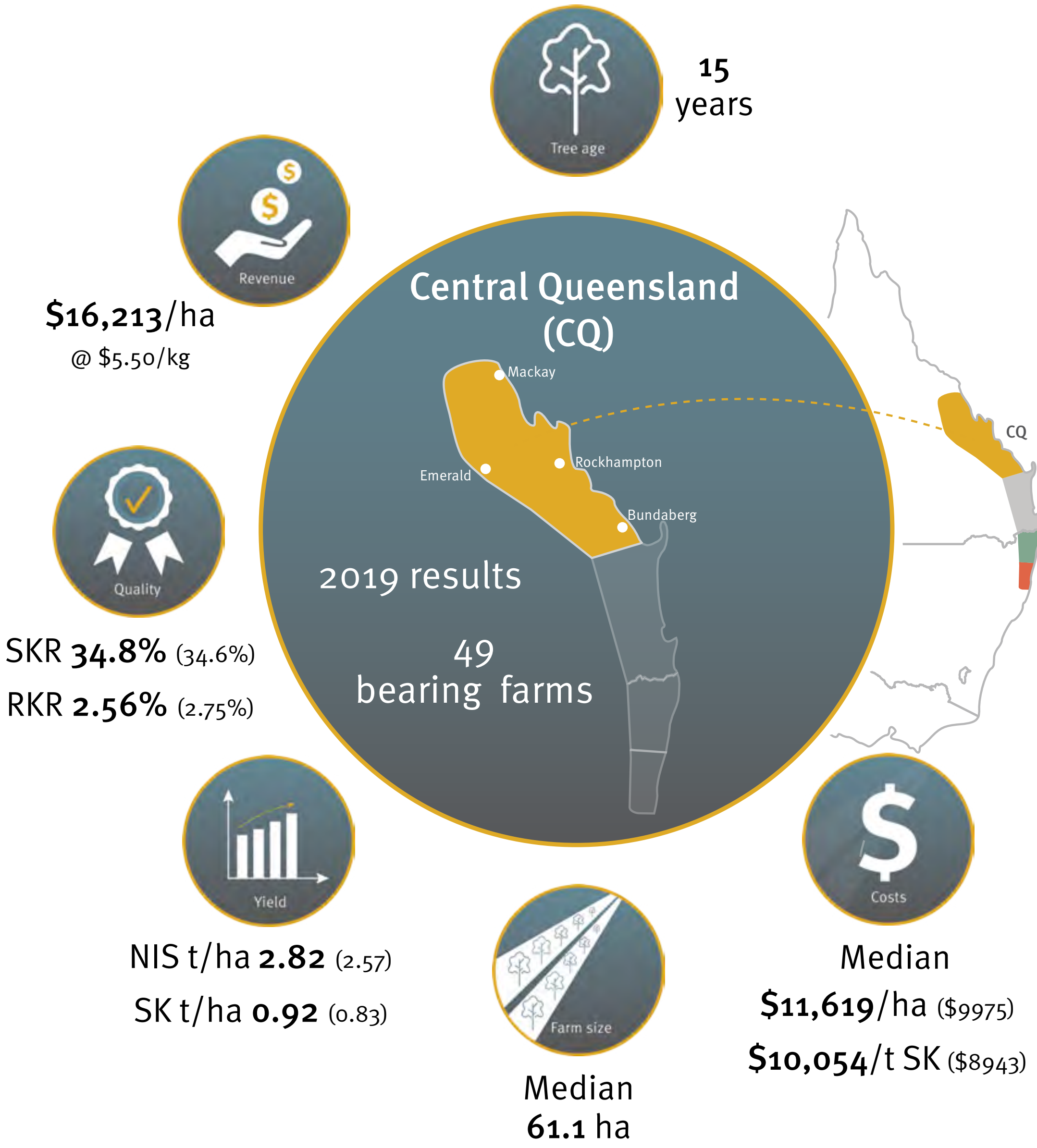
The **Northern Rivers of NSW (NRNSW)** region is predominantly represented by farms on the plateau and coastal areas surrounding Lismore, Alstonville, Clunes, Newrybar and Knockrow. This region comprises the largest proportion of the benchmark sample by number of farms (135 farms, 51%). As median farm size (17.6 ha) is relatively smaller than CQ, NRNSW represented just 30% of the sample by production in 2019. Approximately 80% of farms are owner-operated, with an average tree age of 24 years. Average rainfall has historically been sufficient to support production in this region without widespread reliance on irrigation. Over one-third of participating farms in NRNSW (52) provided cost data in 2019.

The **Mid North Coast NSW (MNNSW)** region includes areas in and surrounding Valla, Nambucca Heads, Macksville and Yarrahapinni. This region is relatively smaller than others in terms of the number of farms participating (28 farms, 11% of sample), median farm size (8.6 ha) and proportion of sample production (3% in 2019). The average age of trees planted in this region is 20 years. A relatively high proportion of "A" series varieties in this region contributes to higher average kernel recovery than other regions. Approximately 7% of farms in this region are irrigated and two-thirds are owner-operated. Similar to NRNSW, this region usually receives sufficient rainfall to support production without widespread use of irrigation. Almost half of participating farms in MNNSW (13) provided cost data in 2019.

Central Queensland region

Figure 30 shows a summary of the 2019 season for the CQ region with corresponding long-term averages or medians shown in brackets. Long-term figures span 2009–2019 for yield and quality and 2013–2019 for costs.

2019 was generally an above-average season for farms in CQ, with seasonal average NIS and SK slightly higher than long-term averages. This followed high average yields for the region in 2018. SKR was close to the long-term average and RKR was slightly lower than the long-term. Median costs per hectare and per tonne of SK in 2019 were both higher than the long-term medians.



Central Queensland (CQ)

2019 results

49 bearing farms

15 years

$16,213/ha
@ $5.50/kg

SKR 34.8% (34.6%)
RKR 2.56% (2.75%)

NIS t/ha 2.82 (2.57)
SK t/ha 0.92 (0.83)

Median
61.1 ha

Median
$11,619/ha ($9975)
$10,054/t SK ($8943)

Figure 30: Summary of the 2019 season for the CQ region

Figure 31 shows monthly climate data for Bundaberg for 2018/19 and compares this with long-term averages for 1999–2019. The three sections include monthly rainfall, maximum temperature and the corresponding soil water index values. For more information see the *Analyses and methods* section. In each case the seasonal values (gold lines) are compared with long-term averages for 1999–2019 (grey dotted lines).

Environmental conditions in the CQ region leading into the 2019 season were characterised by below-average rainfall and above-average maximum temperatures. Rainfall only exceeded the long-term average during the month of October 2018, which coincided with flowering and early nut development. Conditions remained dry and hot during the remaining nut development period.

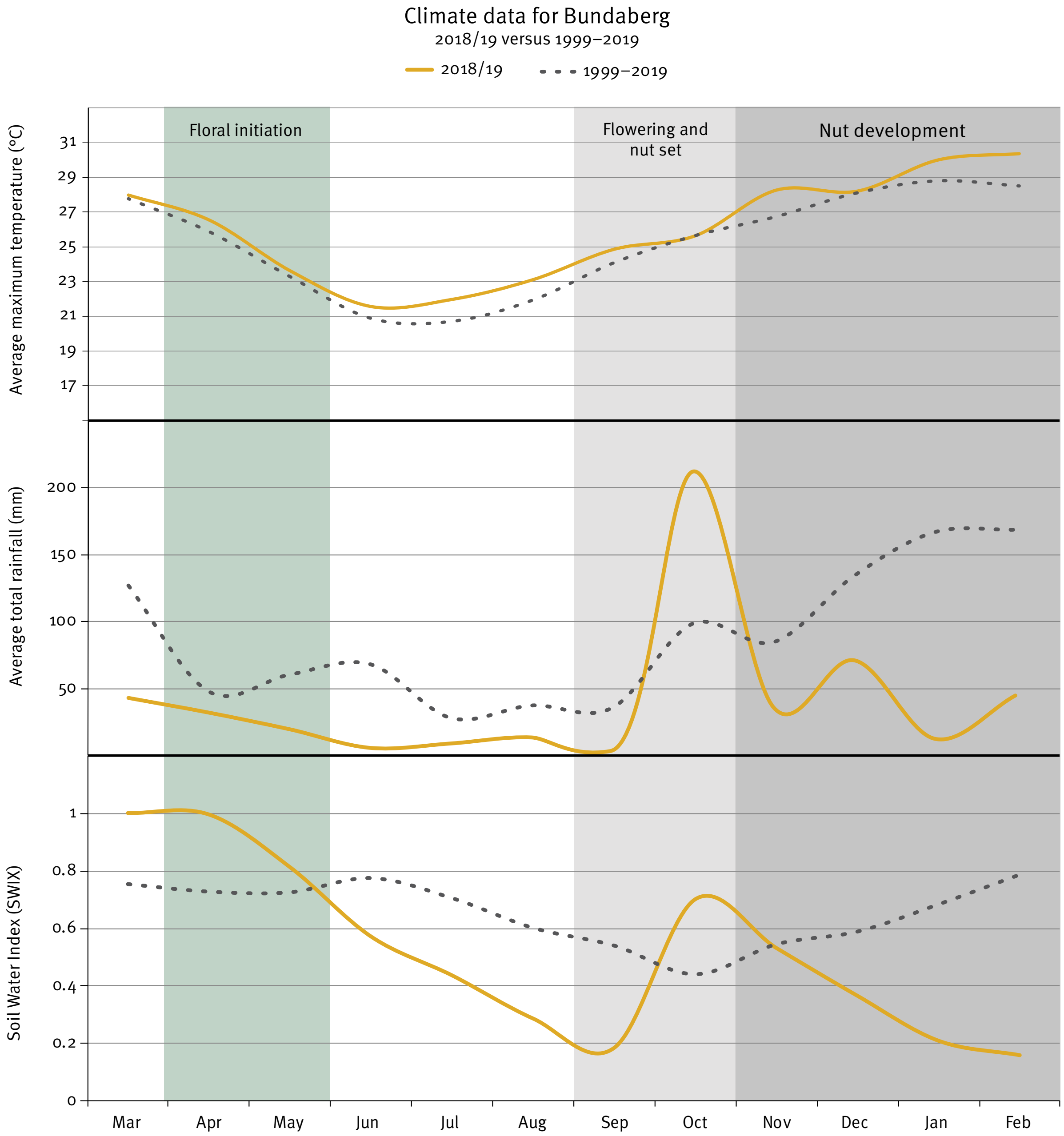


Figure 31: Seasonal average climate data for Bundaberg for 2018/19 versus 1999–2019

Figure 32 shows the most reported pests, diseases and general factors limiting production in the CQ region for 2019. Dry weather, pests and soil or tree health were the dominant factors limiting productivity. Fruit spotting bug was the major limiting pest reported by participants, followed closely by Macadamia nut borer and rats. Husk spot and Phytophthora root rot were the most commonly reported diseases limiting production.

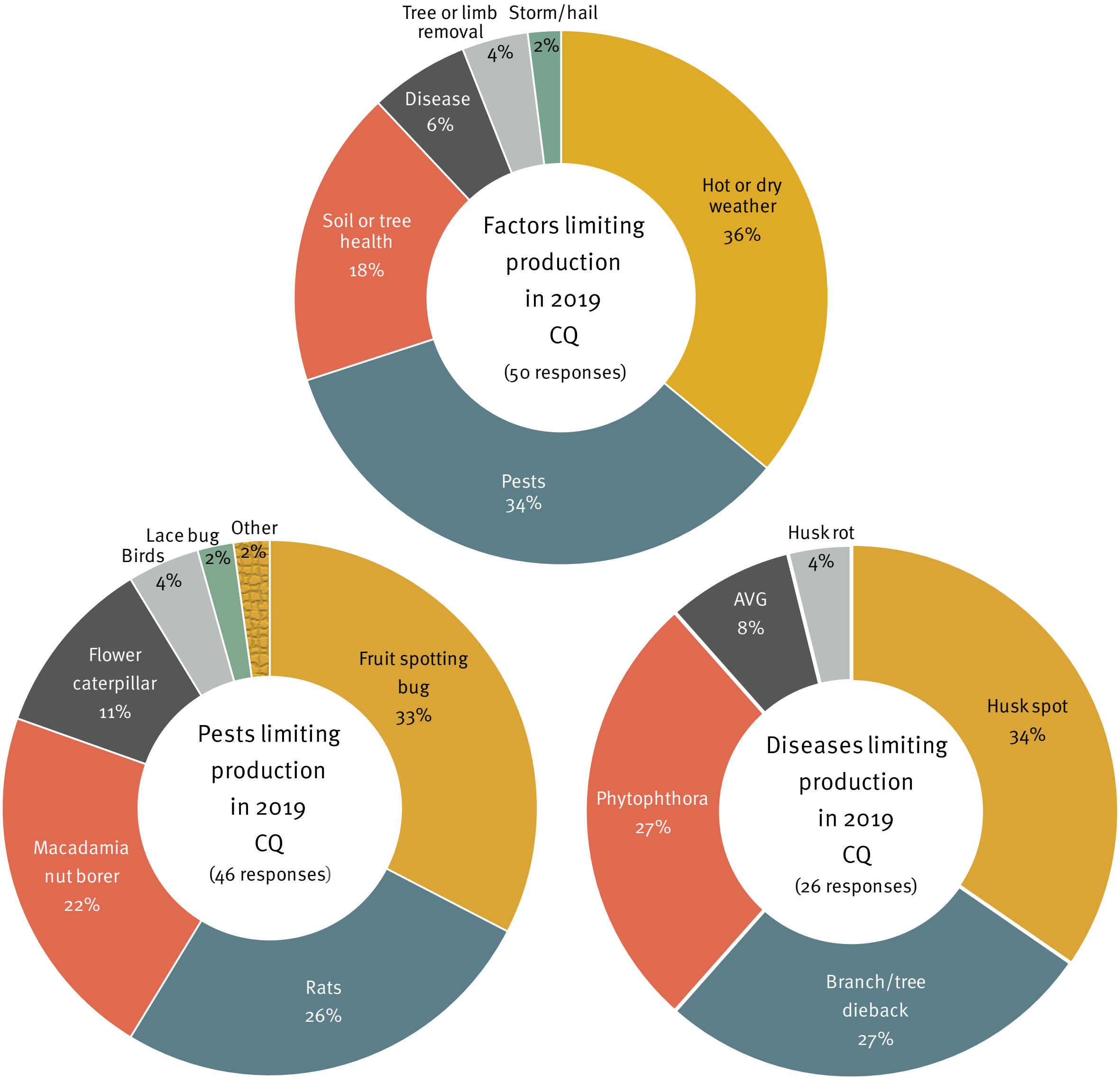


Figure 32: Major factors, pests and diseases limiting production in 2019 for the CQ region

South East Queensland region

Figure 33 shows a summary of the 2019 season for the SEQ region with corresponding long-term averages or medians shown in brackets. Long-term figures span 2009–2019 for yield and quality and 2013–2019 for costs.

2019 was generally an average season for farms in SEQ, with seasonal average NIS, SK and SKR close to long-term averages. This followed record high yields for the region in 2018. The figure below does not include cost information for 2019 as insufficient farms supplied cost data from this region. All analyses presented in this report are based on a minimum of ten farms to safeguard the confidentiality of individual farm data.

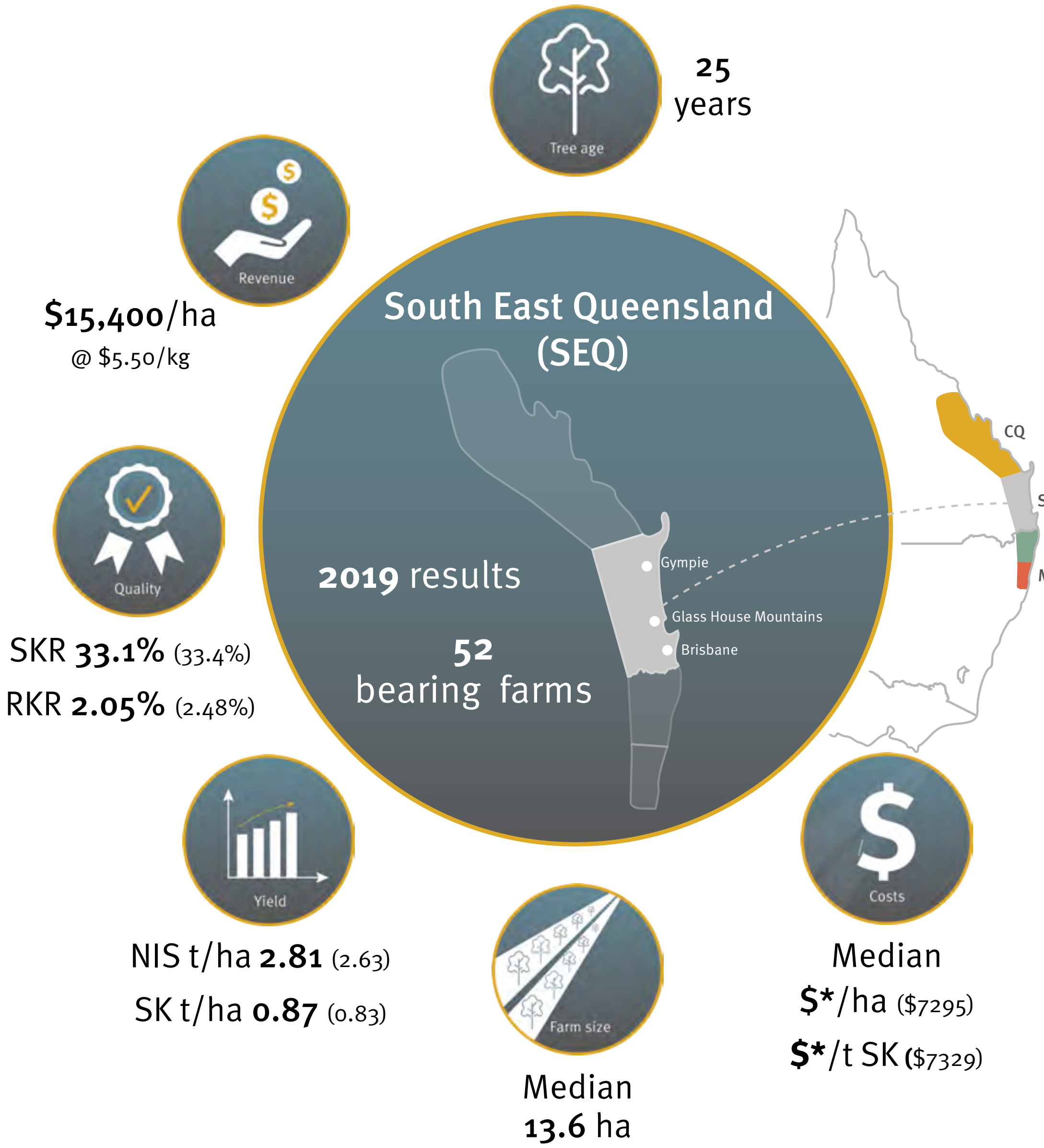


Figure 33: Summary of the 2019 season for the SEQ region
(* indicates insufficient data)

Climate data for the SEQ region includes the two localities of Gympie and Glass House Mountains. **Figure 34** shows monthly climate data for Gympie for 2018/19 and compares this with long-term averages for 1999–2019. The three sections include monthly rainfall, maximum temperature and the corresponding soil water index values. For more information see the *Analyses and methods* section. In each case the seasonal values (gold lines) are compared with long-term averages for 1999–2019 (grey dotted lines).

Below-average rainfall and above-average temperatures during the winter months resulted in below-average SWIX during flowering in September. Significant rainfall in October resulted in above-average SWIX during nut set and early nut development. Temperatures fluctuated above and below the long-term average during summer. When combined with limited rainfall in January and February this resulted in below-average SWIX values in the latter stages of nut development.

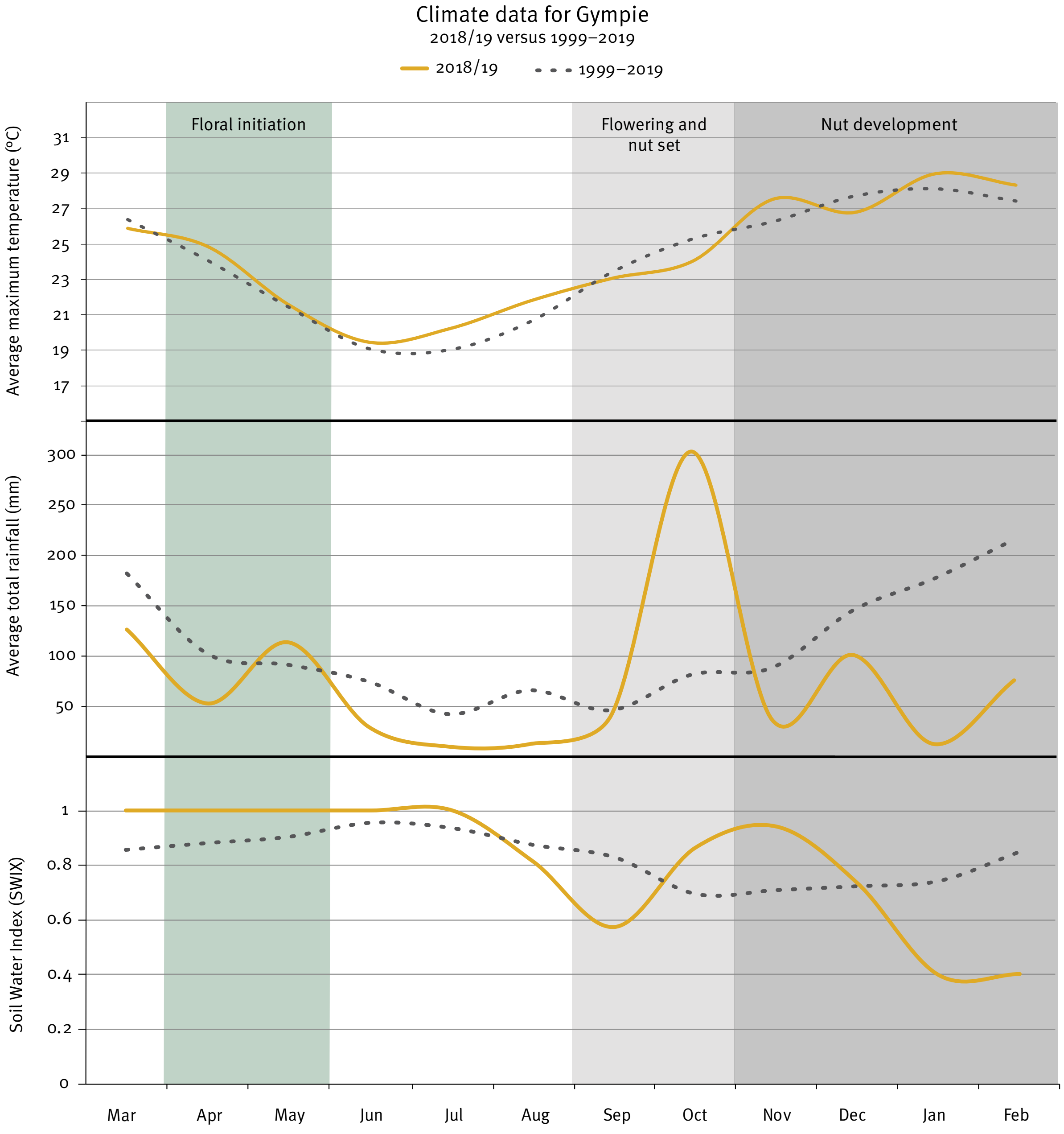


Figure 34: Seasonal average climate data for Gympie for 2018/19 versus 1999–2019

Figure 35 shows monthly climate data for Glass House Mountains for 2018/19 and compares this with long-term averages for 1999–2019. The three sections include monthly rainfall, maximum temperature and the corresponding soil water index values. For more information see the *Analyses and methods* section. In each case the seasonal values (gold lines) are compared with long-term averages for 1999–2019 (grey dotted lines).

Similar to the Gympie region, Glass House Mountains recorded a warmer and drier winter than average, resulting in below-average SWIX during flowering. Rainfall in October and December helped maintain above-average SWIX during nut set and early nut development. A reduction in SWIX during the latter stages of nut development was again influenced by very low rainfall and above-average temperatures in January and February.

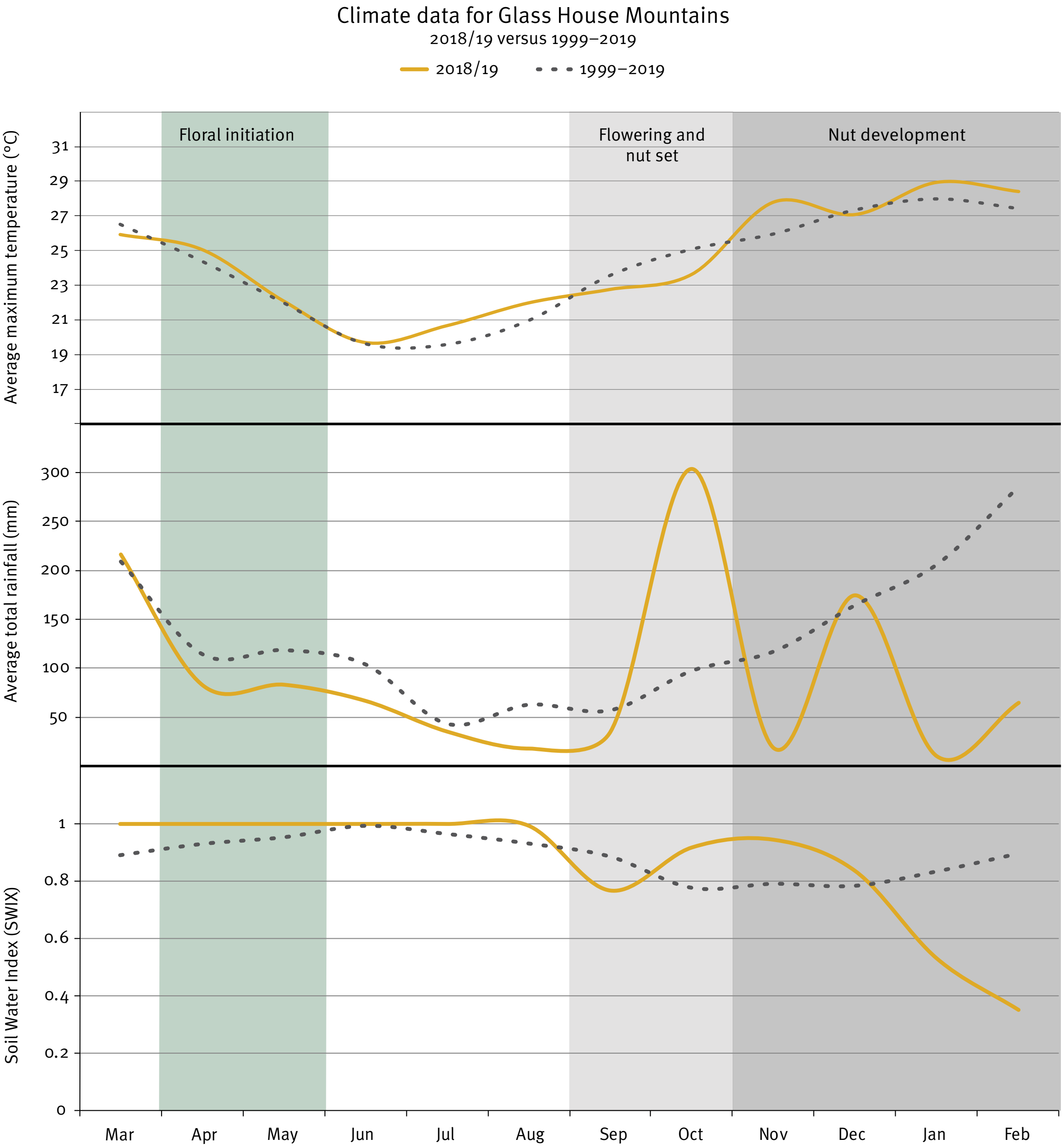


Figure 35: Seasonal average climate data for Glass House Mountains for 2018/19 versus 1999–2019

Figure 36 shows the most reported pests, diseases and general factors limiting production in the SEQ region in 2019. Hot or dry weather was the most reported limiting condition for SEQ, followed by pests and storm or hail. Other limitations included thrips, feral pigs and cockatoos. Fruit spotting bug was reported as the most limiting pest followed by birds and rats. Phytophthora root rot was reported as the most common limiting disease, however this was based on responses from a relatively small number of farms.

Figure 36: Major factors, pests and diseases limiting production in 2019 for the SEQ region

Northern Rivers of NSW region

Figure 37 shows a summary of the 2019 season for the NRNSW region with corresponding long-term averages or medians shown in brackets. Long-term figures span 2009–2019 for yield and quality and 2013–2019 for costs.

Average NIS and SK yield in 2019 were above long-term averages, making 2019 the fourth successive year of stable productivity for the region. Median expenditure for NRNSW farms providing cost data in 2019 was above the long-term median. More than half of these farms indicated an above-average season for spending. More than a third of those farms indicated they were undertaking some form of orchard rejuvenation.

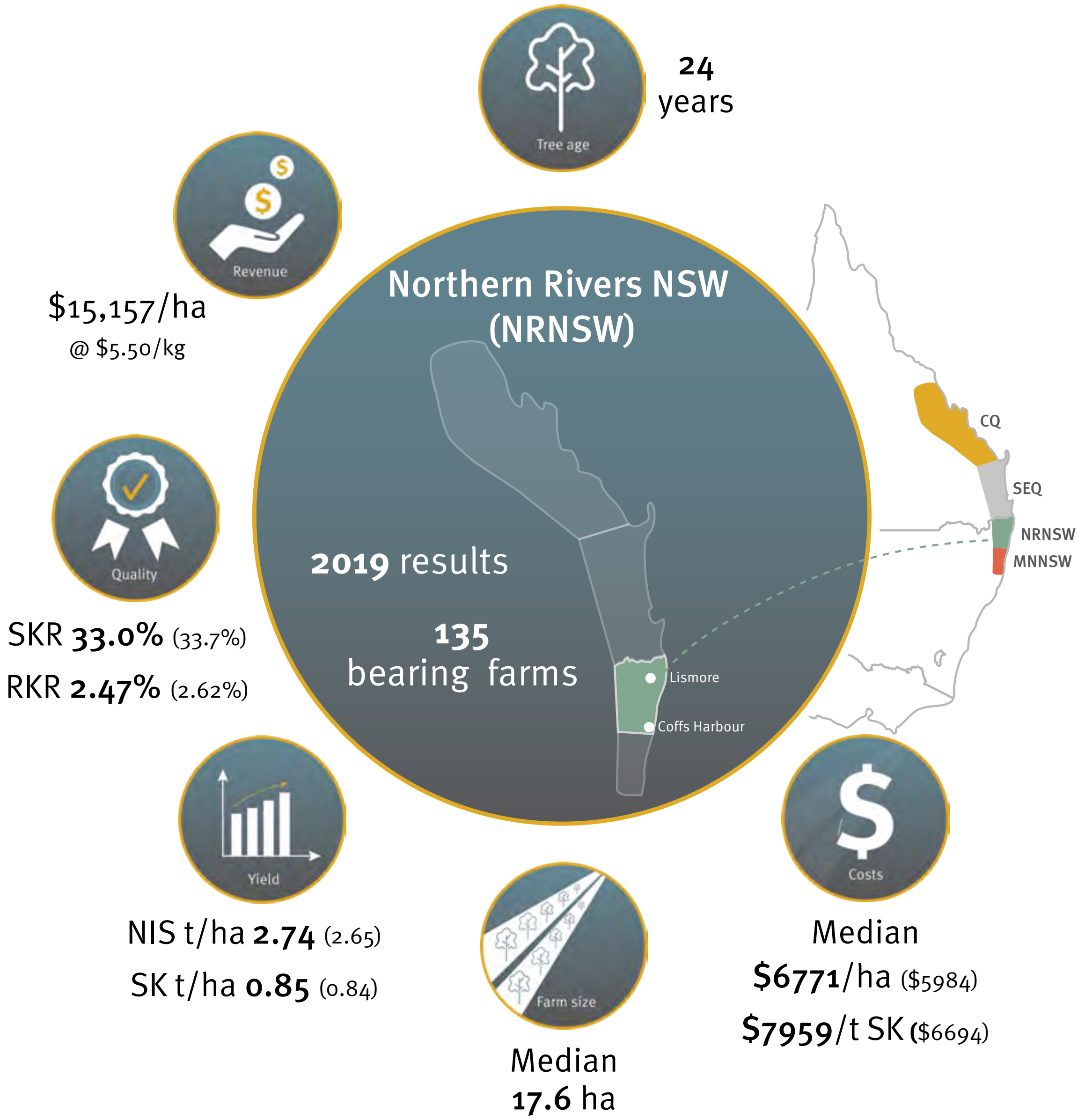


Figure 37: Summary of the 2019 season for the NRNSW region

Figure 38 shows monthly climate data for NRNSW plateau area for 2018/19 and compares this with long-term averages for 1999–2019. The three sections include monthly rainfall, maximum temperature and the corresponding soil water index values. For more information see the *Analyses and methods* section. In each case the seasonal values (gold lines) are compared with long-term averages for 1999–2019 (grey dotted lines).

NRNSW plateau experienced a hotter and drier autumn and winter when compared to the long-term average. This resulted in below-average SWIX leading into flowering. Above-average rainfall during flowering and nut set impacted productivity in the region, with 15% of responses indicating wet weather as a major limitation in the 2019 season. Above-average maximum temperatures and below-average rainfall resulted in a significant reduction in SWIX, especially in the latter stages of nut development.

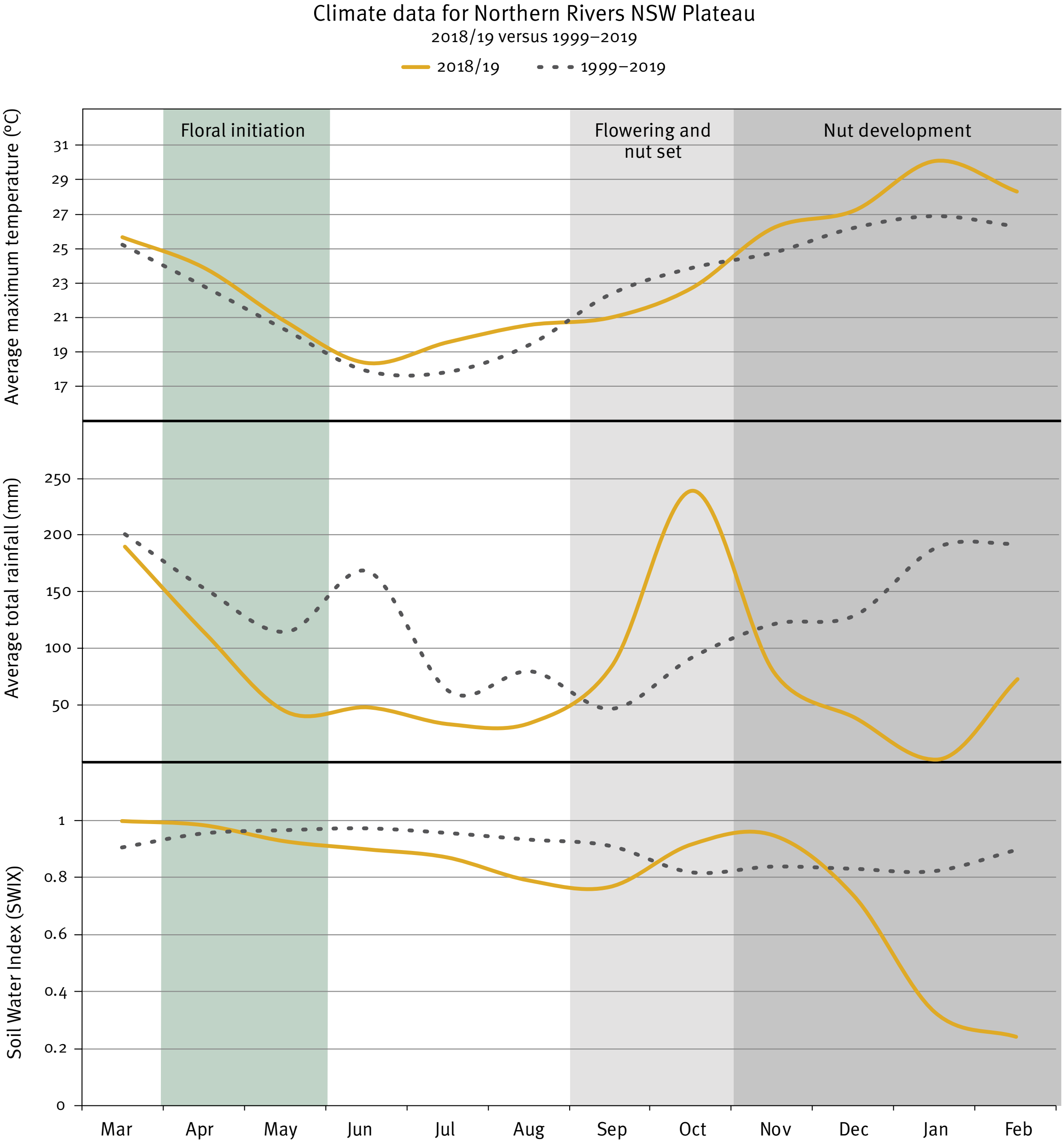


Figure 38: Seasonal average climate data for NRNSW for 2018/19 versus 1999–2019

Figure 39 shows the most reported pests, diseases and general factors limiting production in the NRNSW region in 2019. Hot dry weather was the most commonly reported limiting factor for NRNSW followed by wet weather, pests and disease. Fruit spotting bug was the most reported pest followed closely by rats and Macadamia seed weevil. Flower diseases were the most reported limiting disease, possibly influenced by wet weather at flowering. Other high ranking diseases included Phytophthora root rot, branch or tree dieback and husk spot.

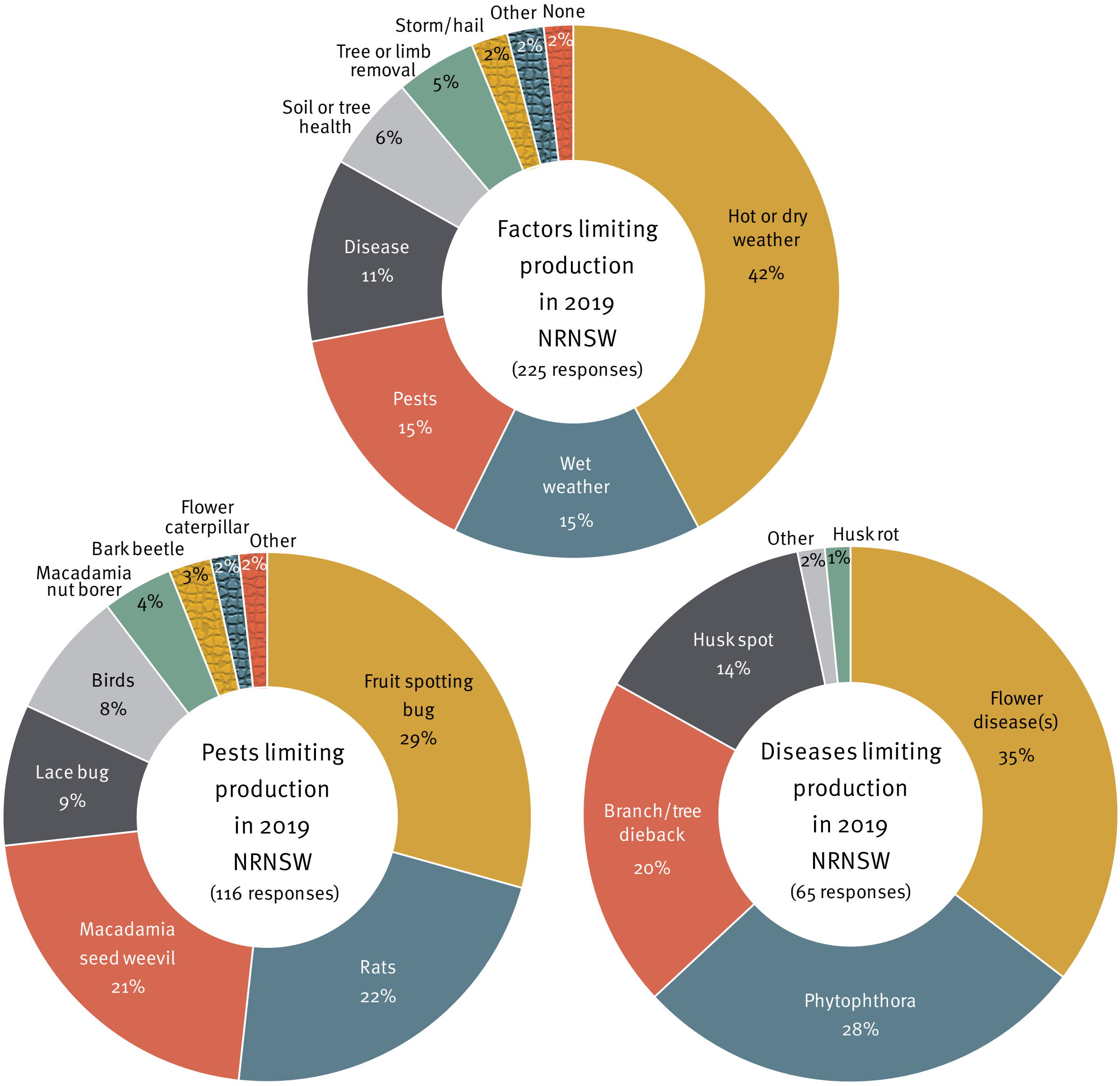


Figure 39: Major factors, pests and diseases limiting productivity in 2019 for the NRNSW region

Mid North Coast of NSW region

Figure 40 shows average yield, quality and costs for the 28 bearing farms in the MNNSW region that submitted data in 2019. Corresponding long-term averages, medians or totals are shown in brackets. These figures span 2009–2019 for yield, quality and planting information and 2013–2019 for costs.

Average productivity in 2019 was consistent with the long-term average (2.24 NIS t/ha). SK yield and SKR in 2019 were also similar to long-term averages. Median expenditure per hectare and per tonne of SK in 2019 were higher than long-term medians.

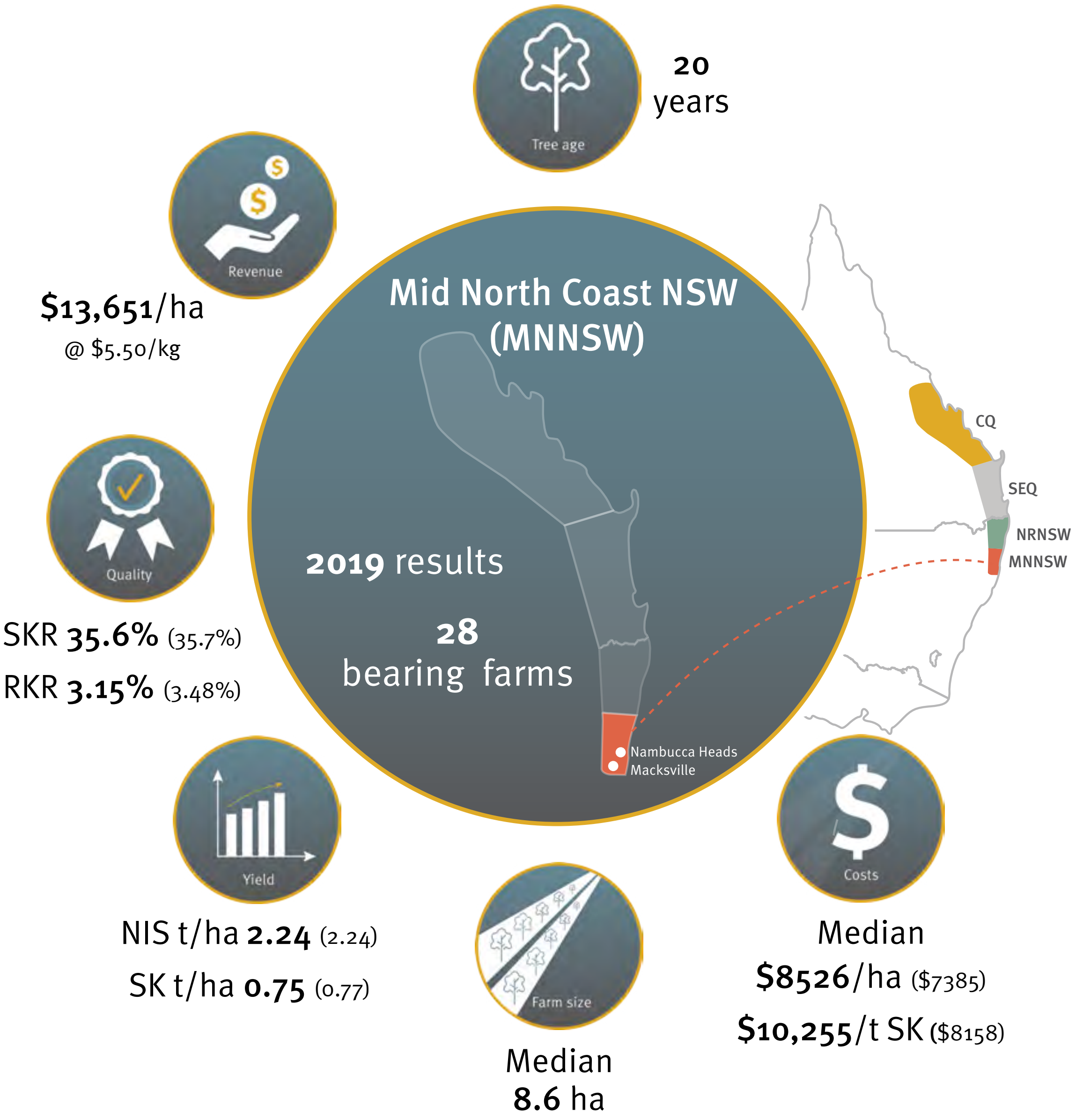


Figure 40: Summary of the 2019 season for the MNNSW region

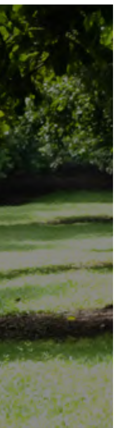


Figure 41 shows monthly climate data for Macksville for 2018/19 and compares this with long-term averages for 1999–2019. The two sections include monthly rainfall and maximum temperature. For more information see the *Analyses and methods* section. In each case the seasonal values (gold lines) are compared with long-term averages for 1999–2019 (grey dotted lines). SWIX values are unavailable for this locality.

Macksville experienced higher-than-average maximum temperatures and below-average rainfall during floral initiation and the months leading into flowering. Above-average rainfall and below-average temperatures were present during flowering and early nut set. Average maximum temperatures remained above the long-term average during nut development. Monthly rainfall totals only exceeded the long-term average once during nut development period, with no rainfall recorded in January.

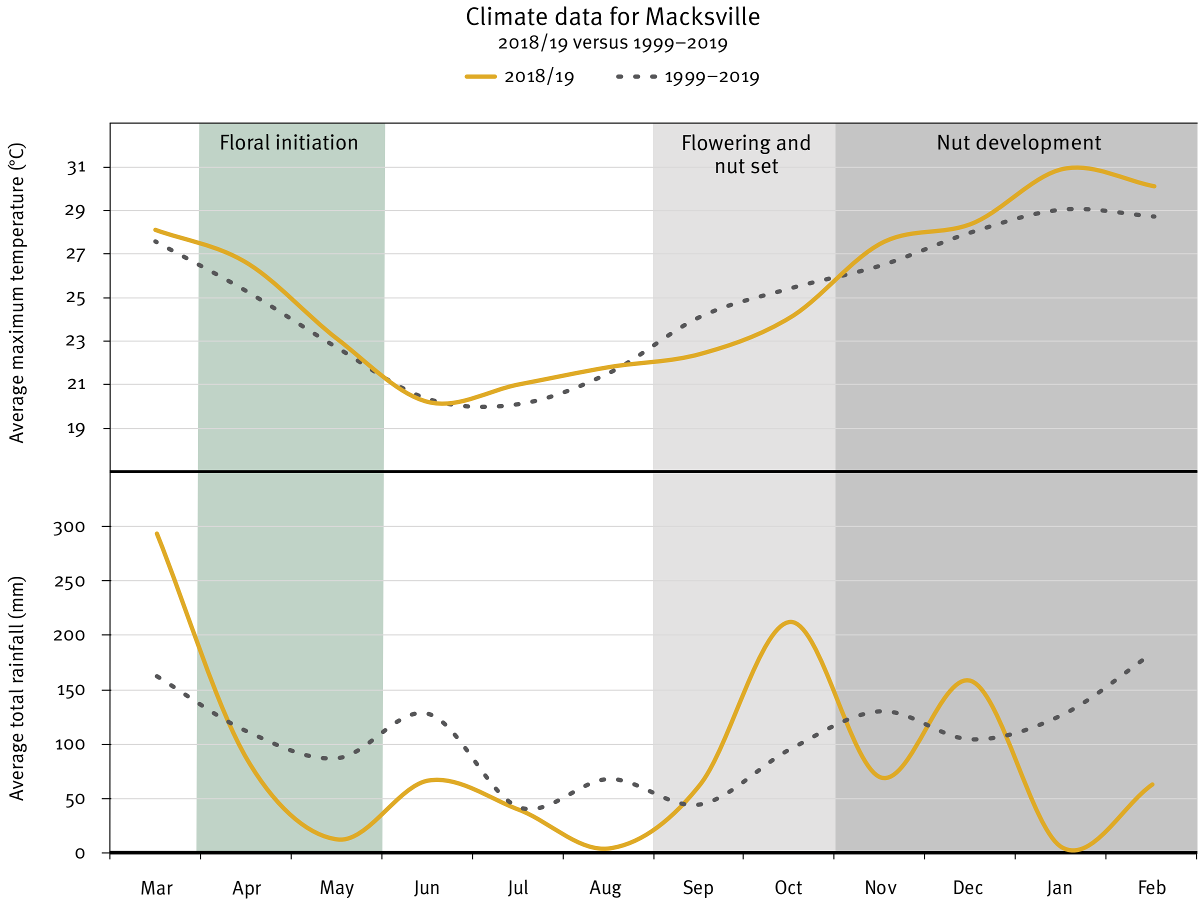


Figure 41: Seasonal average climate data for MNNSW for 2018/19 versus 1999–2019

Figure 42 shows the most reported pests, diseases and general factors limiting production in the MNNSW region in 2019. Hot or dry weather was the most commonly reported limiting condition followed by wet weather and pests. The “other” category included frost and timing of sprays. Fruit spotting bug and birds were reported as the main pests limiting production. Other pests that impacted the 2019 season included pin hole borer, Hairyline blue butterfly, deer and rats. Phytophthora root rot was reported as the most common disease limiting production in 2019.

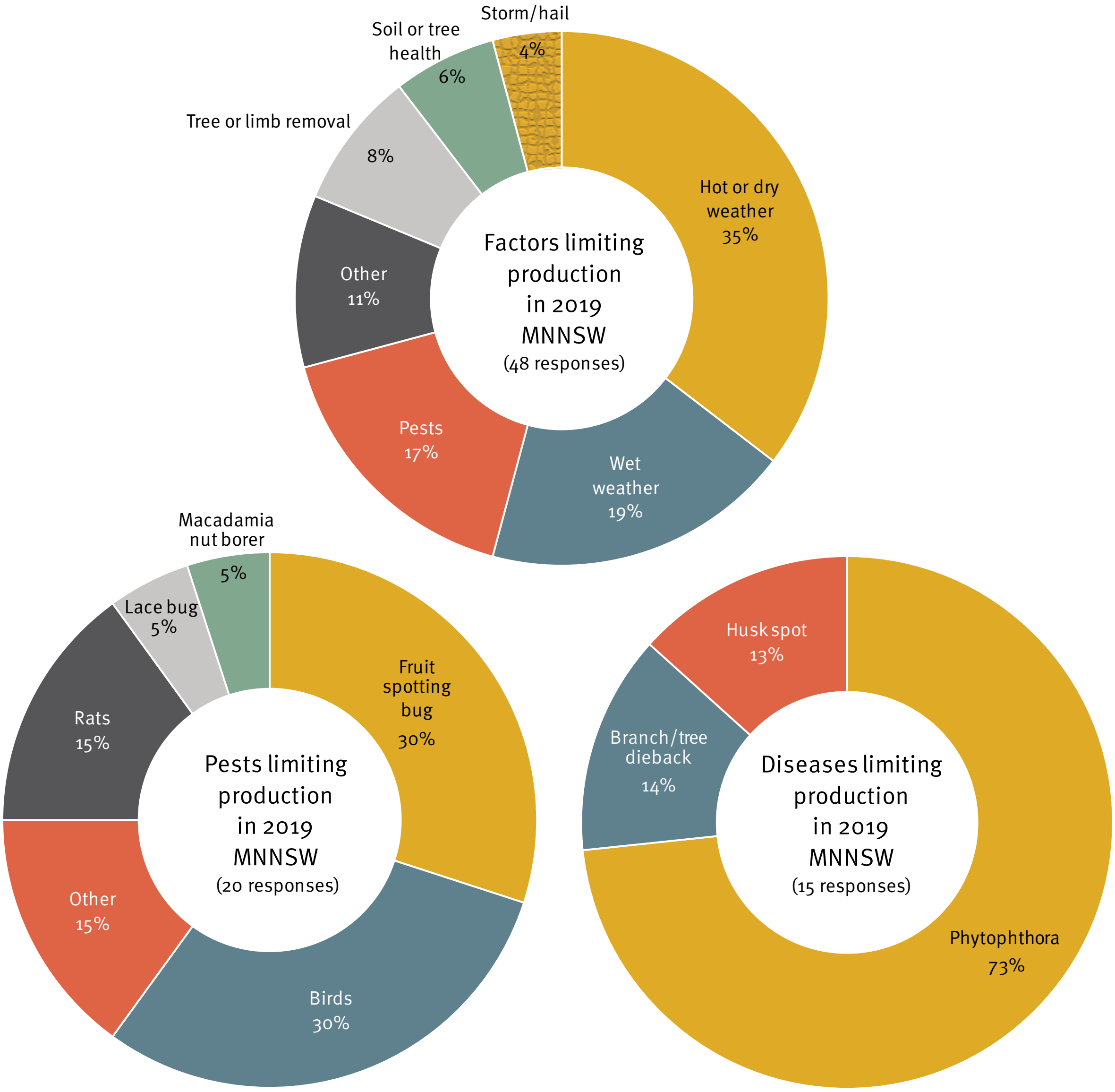
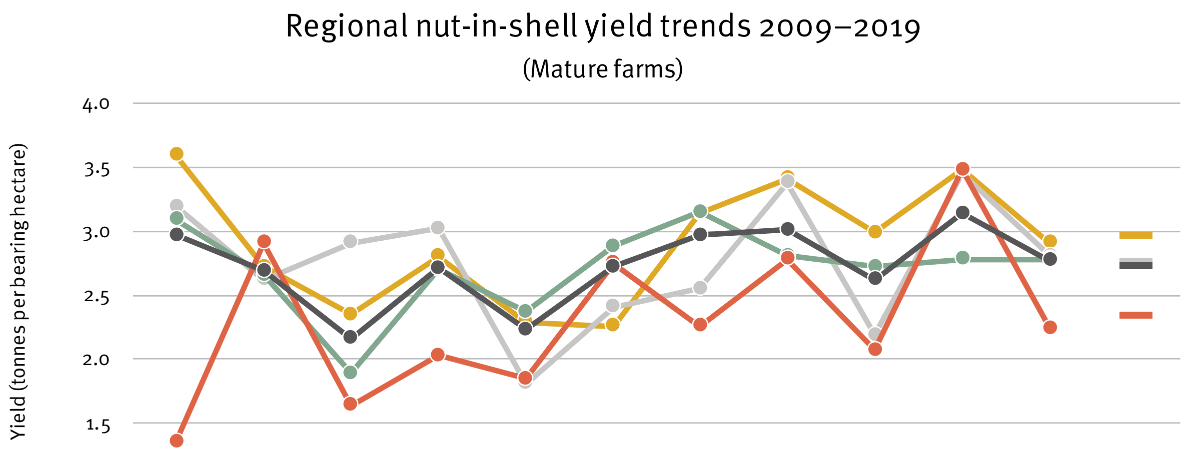


Figure 42: Major factors, pests and diseases limiting production in 2019 for the MNNSW region

Regional trends

Figure 43 compares average annual nut-in-shell (NIS) yield per bearing hectare for mature farms (10+ years old) in each production region from 2009–2019. These averages are unweighted, meaning all farms exert equal influence regardless of their size.

Over the last 11 years the average yield of mature farms in CQ (2.96 t/ha) was significantly higher than the other three regions ($P<0.05$). The long-term averages for SEQ and NRNSW (2.76 and 2.73 t/ha respectively) were not significantly different to each other ($P>0.05$). The MNNSW long-term average yield (2.35 t/ha) was significantly lower than the other three regions ($P<0.01$).



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	09–19
CQ	3.59	2.72	2.35	2.8	2.29	2.26	3.14	3.41	2.99	3.48	2.91	2.96
SEQ	3.19	2.62	2.91	3.02	1.81	2.41	2.55	3.38	2.19	3.45	2.81	2.76
NRNSW	3.09	2.66	1.89	2.7	2.37	2.88	3.15	2.81	2.72	2.78	2.78	2.73
MNNSW	1.36	2.91	1.64	2.03	1.85	2.75	2.26	2.78	2.07	3.48	2.24	2.35
All regions	2.97	2.69	2.16	2.71	2.23	2.72	2.97	3.01	2.62	3.14	2.77	2.73

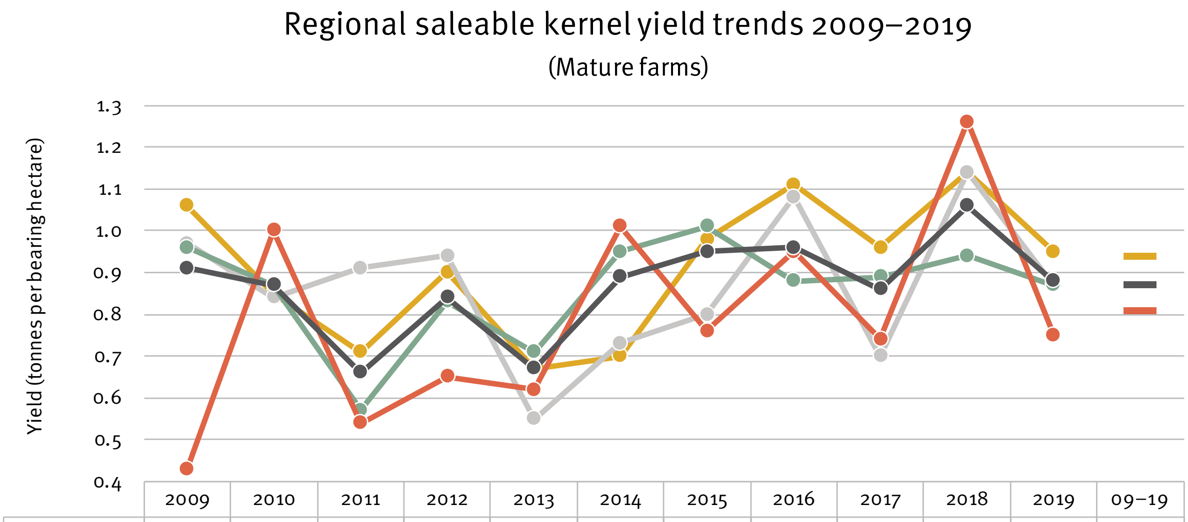
Figure 43: Regional nut-in-shell yields per bearing hectare for mature farms (2009–2019)

Following high average productivity in 2018, most regions had a significant reduction in productivity in 2019. Many growers reported that extended periods of dry weather before and during the 2019 season limited productivity. In NRNSW however, average productivity has not varied substantially over the last four seasons.

Productivity varies significantly between farms in the benchmark sample. Average nut-in-shell productivity for mature farms over the last eleven seasons was 2.73 t/ha with a standard deviation of 1.27 t/ha, or 47% of the average.

Figure 44 compares equivalent average saleable kernel (SK) yield per bearing hectare from 2009–2019 for mature farms in each region. 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 the highest long-term average SK productivity of all regions (0.94 t/ha). Long-term SK productivity was similar in NRNSW and SEQ (both 0.87 t/ha). The MNNSW region had the lowest long-term average SK yield (0.81 t/ha).



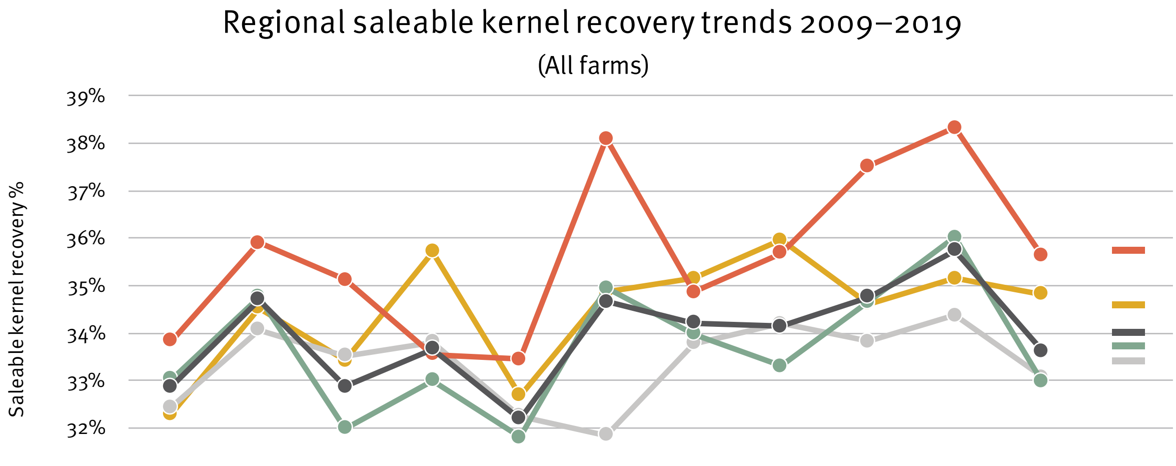
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	09–19
CQ	1.06	0.85	0.71	0.90	0.67	0.70	0.98	1.11	0.96	1.14	0.95	0.94
SEQ	0.97	0.84	0.91	0.94	0.55	0.73	0.80	1.08	0.70	1.14	0.87	0.87
NRNSW	0.96	0.87	0.57	0.83	0.71	0.95	1.01	0.88	0.89	0.94	0.87	0.87
MNNSW	0.43	1.00	0.54	0.65	0.62	1.01	0.76	0.95	0.74	1.26	0.75	0.81
All regions	0.91	0.87	0.66	0.84	0.67	0.89	0.95	0.96	0.86	1.06	0.88	0.87

Figure 44: Regional saleable kernel yields per bearing hectare for mature farms (2009–2019)

Figure 45 compares average regional saleable kernel recovery (SKR) for farms in each major production region from 2009–2019. SKR is the sum of premium kernel recovery (PKR) and commercial kernel recovery (CKR).

In 2019 average SKR across all regions was more than 2% lower than 2018. The biggest SKR declines were evident in NSW where the average fell by almost 3% in 2019. By comparison the CQ region had the smallest decrease in 2019 (less than 0.3%)

The MNNSW region had significantly higher long-term average SKR (35.74%) compared to other regions (P<0.01). The high average SKR in MNNSW is influenced by the high percentage of "A" series cultivars grown in this region, which tend to have high kernel recoveries.



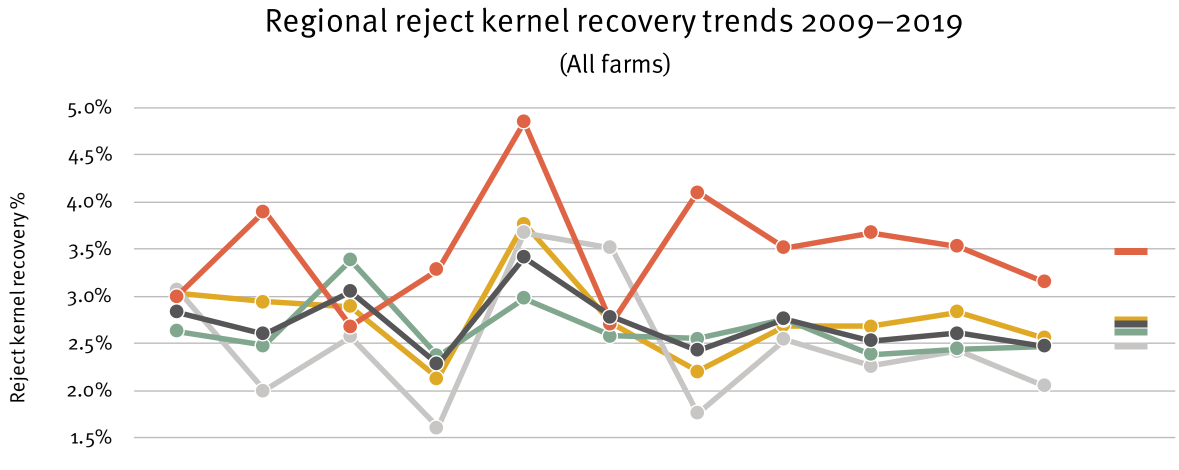
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	09–19
CQ	32.30	34.53	33.42	35.72	32.69	34.86	35.16	35.96	34.62	35.16	34.83	34.59
SEQ	32.44	34.07	33.52	33.81	32.26	31.86	33.79	34.20	33.83	34.37	33.08	33.41
NRNSW	33.04	34.76	32.00	33.00	31.81	34.95	33.98	33.31	34.66	36.02	32.98	33.74
MNNSW	33.85	35.91	35.12	33.56	33.45	38.10	34.87	35.69	37.52	38.33	35.63	35.74
All regions	32.88	34.71	32.88	33.67	32.20	34.67	34.22	34.15	34.76	35.75	33.62	34.01

Figure 45: Regional saleable kernel recoveries for all farms (2009–2019)

Figure 46 compares average reject kernel recovery (RKR) for each region from 2009–2019.

The 2019 season recorded the lowest average RKR since 2015 across all regions except NRNSW and was lower than the long-term averages for all regions.

The long-term average RKR for the MNNSW region (3.48%) was significantly higher than other regions (P<0.01). It's important to note that average TKR is also significantly higher in MNNSW than other regions (39.2% 2009–19). The next highest was CQ (2.75%) followed by NRNSW (2.62%). SEQ had the lowest long-term average RKR (2.48%).

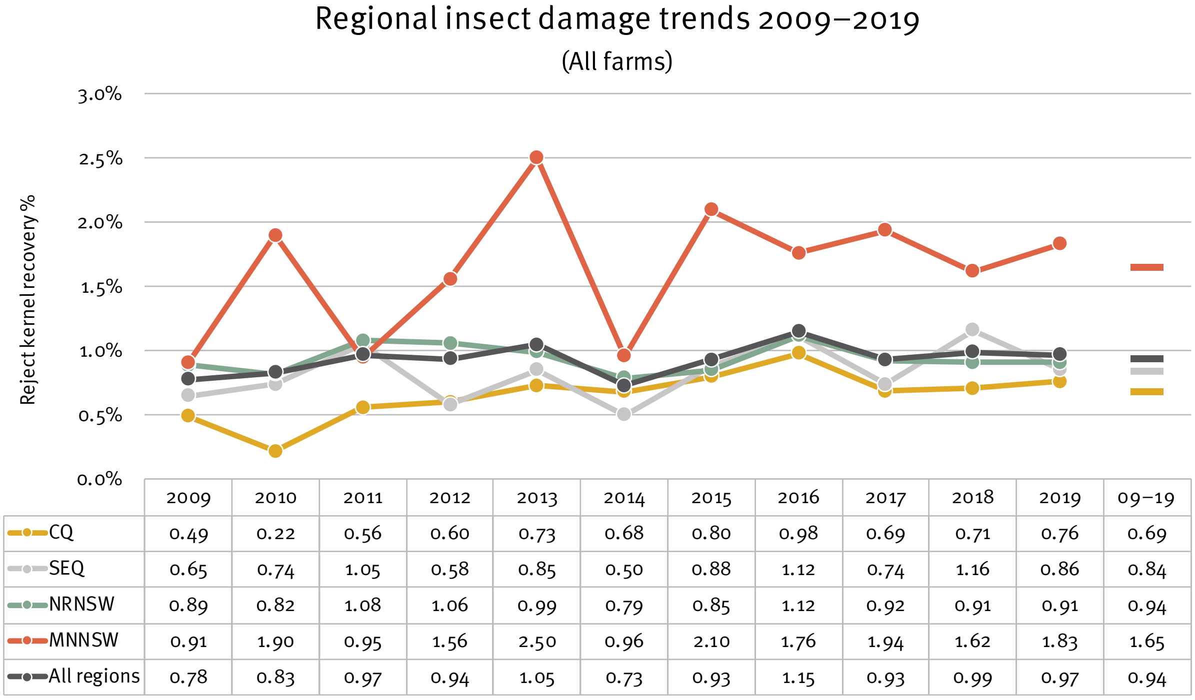


	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	09–19
CQ	3.03	2.94	2.89	2.13	3.77	2.72	2.20	2.69	2.68	2.83	2.56	2.75
SEQ	3.07	2.00	2.57	1.61	3.67	3.51	1.76	2.54	2.26	2.42	2.05	2.48
NRNSW	2.63	2.48	3.38	2.37	2.98	2.58	2.55	2.75	2.38	2.44	2.47	2.62
MNNSW	3.00	3.90	2.68	3.28	4.85	2.71	4.10	3.51	3.67	3.53	3.15	3.48
All regions	2.83	2.60	3.05	2.28	3.41	2.78	2.43	2.76	2.53	2.61	2.47	2.70

Figure 46: Regional reject kernel recovery trends (2009–2019)

Figure 47 shows average factory rejects due to insect damage for participating farms in each of the four major production regions from 2009–2019.

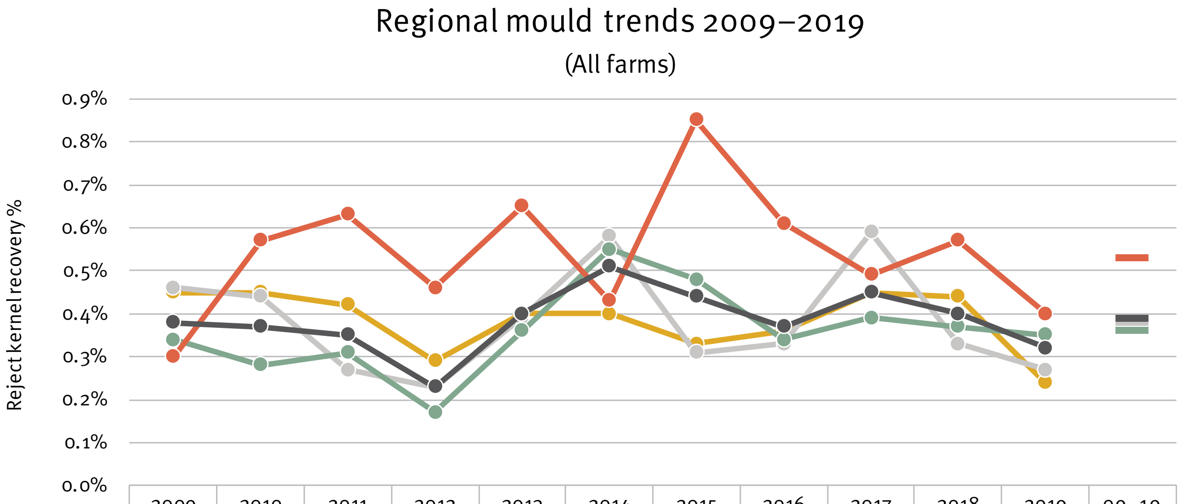
Average insect damage levels were significantly higher in MNNSW (1.65%) than in all other regions over the 2009–2019 period (P<0.01). Long-term insect damage levels were similar in NRNSW and SEQ (0.94% and 0.84% respectively). The CQ region had the lowest long-term average insect damage levels over this period (0.69%).



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	09–19
CQ	0.49	0.22	0.56	0.60	0.73	0.68	0.80	0.98	0.69	0.71	0.76	0.69
SEQ	0.65	0.74	1.05	0.58	0.85	0.50	0.88	1.12	0.74	1.16	0.86	0.84
NRNSW	0.89	0.82	1.08	1.06	0.99	0.79	0.85	1.12	0.92	0.91	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	1.83	1.65
All regions	0.78	0.83	0.97	0.94	1.05	0.73	0.93	1.15	0.93	0.99	0.97	0.94

Figure 47: Regional insect damage rejects (2009–2019)

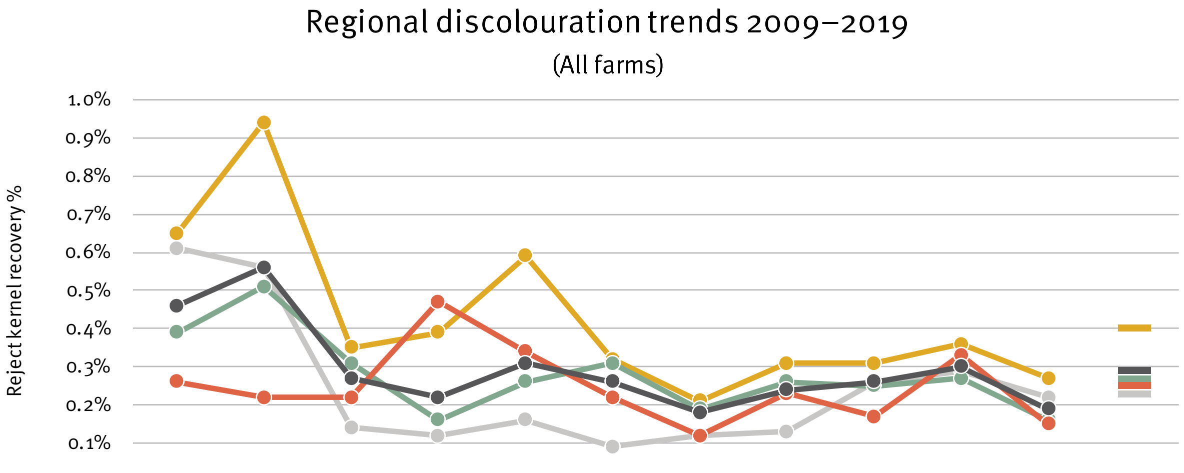
Figure 48 shows average factory rejects due to mould from 2009–2019 for each of the four regions in the benchmark sample. MNNSW had significantly higher long-term average levels of mould rejects (0.53%) than all other regions ($P<0.01$). Average mould reject levels were very similar in all other regions over this period.



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	09–19
CQ	0.45	0.45	0.42	0.29	0.40	0.40	0.33	0.36	0.45	0.44	0.24	0.38
SEQ	0.46	0.44	0.27	0.23	0.39	0.58	0.31	0.33	0.59	0.33	0.27	0.38
NRNSW	0.34	0.28	0.31	0.17	0.36	0.55	0.48	0.34	0.39	0.37	0.35	0.36
MNNSW	0.30	0.57	0.63	0.46	0.65	0.43	0.85	0.61	0.49	0.57	0.40	0.53
All regions	0.38	0.37	0.35	0.23	0.40	0.51	0.44	0.37	0.45	0.40	0.32	0.39

Figure 48: Regional mould rejects (2009–2019)

Figure 49 shows factory rejects due to discolouration over the period 2009–2019 for each of the four regions in the benchmark sample. Long-term average discolouration rejects were similar in SEQ, NRNSW and MNNSW but significantly higher in CQ over this period (P<0.01).



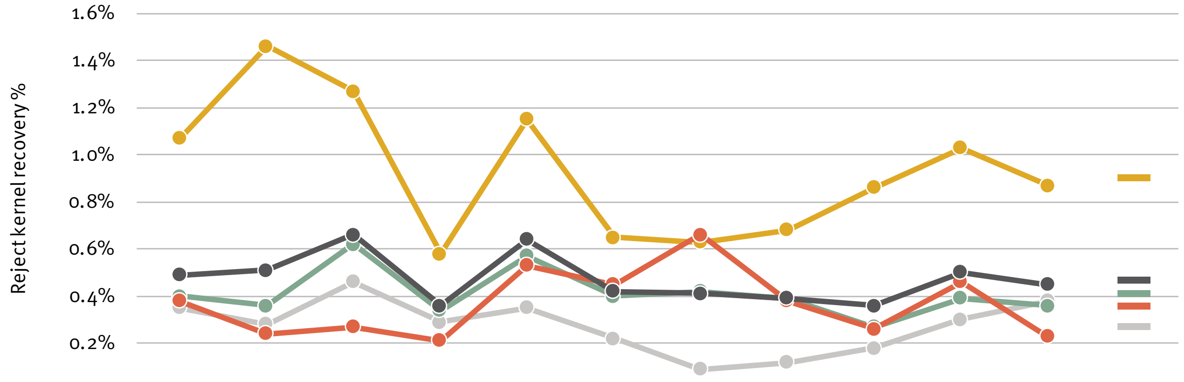
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	09–19
CQ	0.65	0.94	0.35	0.39	0.59	0.32	0.21	0.31	0.31	0.36	0.27	0.40
SEQ	0.61	0.56	0.14	0.12	0.16	0.09	0.12	0.13	0.26	0.29	0.22	0.23
NRNSW	0.39	0.51	0.31	0.16	0.26	0.31	0.19	0.26	0.25	0.27	0.16	0.27
MNNSW	0.26	0.22	0.22	0.47	0.34	0.22	0.12	0.23	0.17	0.33	0.15	0.25
All regions	0.46	0.56	0.27	0.22	0.31	0.26	0.18	0.24	0.26	0.30	0.19	0.29

Figure 49: Regional discolouration rejects (2009–2019)

Figure 50 shows factory rejects due to brown centres from 2009–2019 for each of the four regions in the benchmark sample.

In most seasons, farms in the CQ region have had significantly higher average rejects due to brown centres than those in other regions (P<0.01). This was followed by NRNSW (0.41%) and MNNSW (0.36%). Long-term average levels of brown centres were lowest in SEQ over this period (0.27%).

Benchmark data has shown that CQ farms are typically 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.



Regional brown centres trends 2009–2019

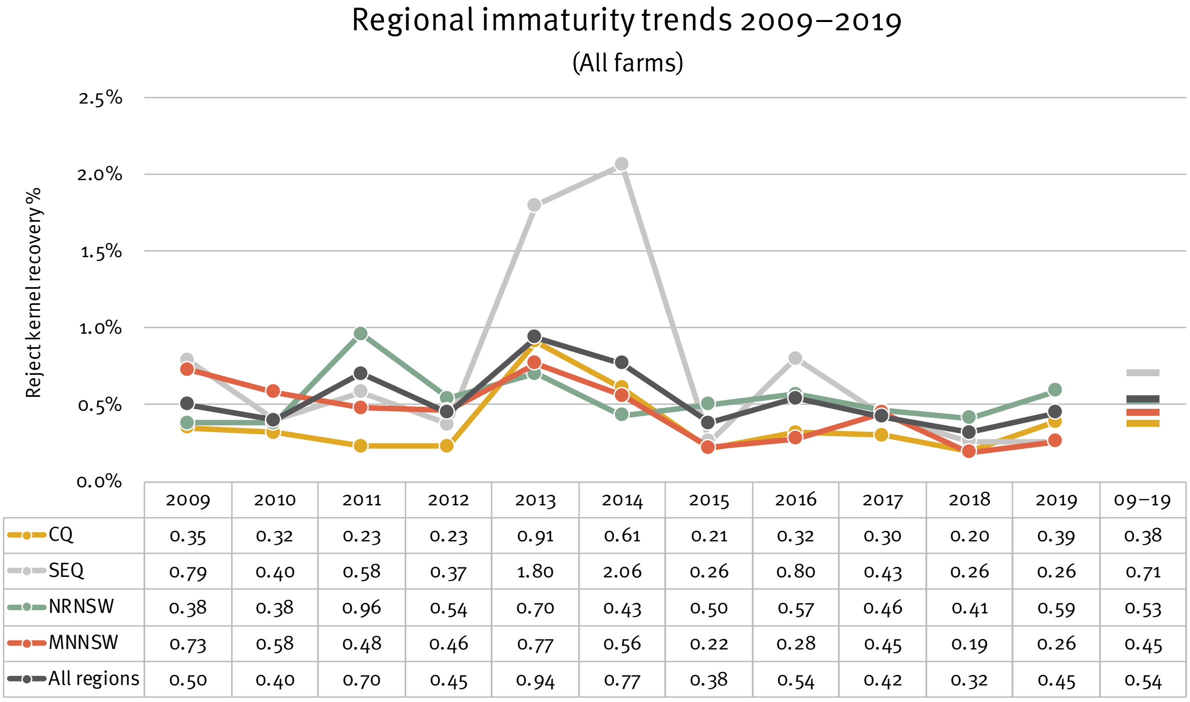
(All farms)

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	09–19
CQ	1.07	1.46	1.27	0.58	1.15	0.65	0.63	0.68	0.86	1.03	0.87	0.90
SEQ	0.35	0.28	0.46	0.29	0.35	0.22	0.09	0.12	0.18	0.30	0.38	0.27
NRNSW	0.40	0.36	0.62	0.34	0.57	0.40	0.42	0.39	0.27	0.39	0.36	0.41
MNNSW	0.38	0.24	0.27	0.21	0.53	0.45	0.66	0.38	0.26	0.46	0.23	0.36
All regions	0.49	0.51	0.66	0.36	0.64	0.42	0.41	0.39	0.36	0.50	0.45	0.47

Figure 50: Regional brown centres rejects (2009–2019)

Figure 51 shows factory rejects due to immaturity from 2009–2019 for each of the four regions in the benchmark sample.

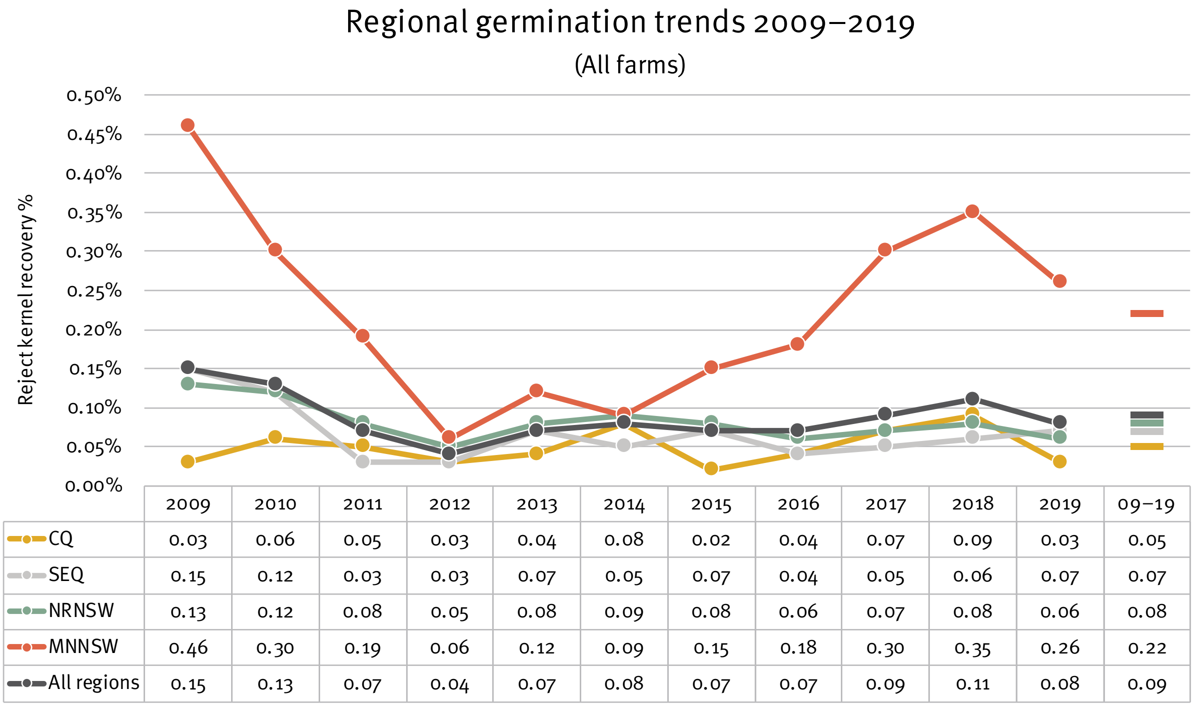
SEQ had significantly higher levels of immaturity over this period than other regions in the sample ($P<0.01$). Previous high immaturity levels in SEQ in 2013 and 2014 have largely been attributed to very dry conditions leading to moisture stress during nut growth and oil accumulation stages. Prior to 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 2019 and was not considered a major cause of immaturity in these seasons.



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	09–19
CQ	0.35	0.32	0.23	0.23	0.91	0.61	0.21	0.32	0.30	0.20	0.39	0.38
SEQ	0.79	0.40	0.58	0.37	1.80	2.06	0.26	0.80	0.43	0.26	0.26	0.71
NRNSW	0.38	0.38	0.96	0.54	0.70	0.43	0.50	0.57	0.46	0.41	0.59	0.53
MNNSW	0.73	0.58	0.48	0.46	0.77	0.56	0.22	0.28	0.45	0.19	0.26	0.45
All regions	0.50	0.40	0.70	0.45	0.94	0.77	0.38	0.54	0.42	0.32	0.45	0.54

Figure 51: Regional immaturity rejects (2009–2019)

Figure 52 shows factory rejects due to germination from 2009–2019 for each of the four regions in the benchmark sample. MNNSW had significantly higher long-term average levels of germination (0.22%) than other regions (P<0.01). Average germination rejects have remained low across most other regions since 2011, making germination the least prevalent type of reject across the benchmark sample from 2009–2019.



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	09–19
CQ	0.03	0.06	0.05	0.03	0.04	0.08	0.02	0.04	0.07	0.09	0.03	0.05
SEQ	0.15	0.12	0.03	0.03	0.07	0.05	0.07	0.04	0.05	0.06	0.07	0.07
NRNSW	0.13	0.12	0.08	0.05	0.08	0.09	0.08	0.06	0.07	0.08	0.06	0.08
MNNSW	0.46	0.30	0.19	0.06	0.12	0.09	0.15	0.18	0.30	0.35	0.26	0.22
All regions	0.15	0.13	0.07	0.04	0.07	0.08	0.07	0.07	0.09	0.11	0.08	0.09

Figure 52: Regional germination rejects (2009–2019)

Trends for top performing farms

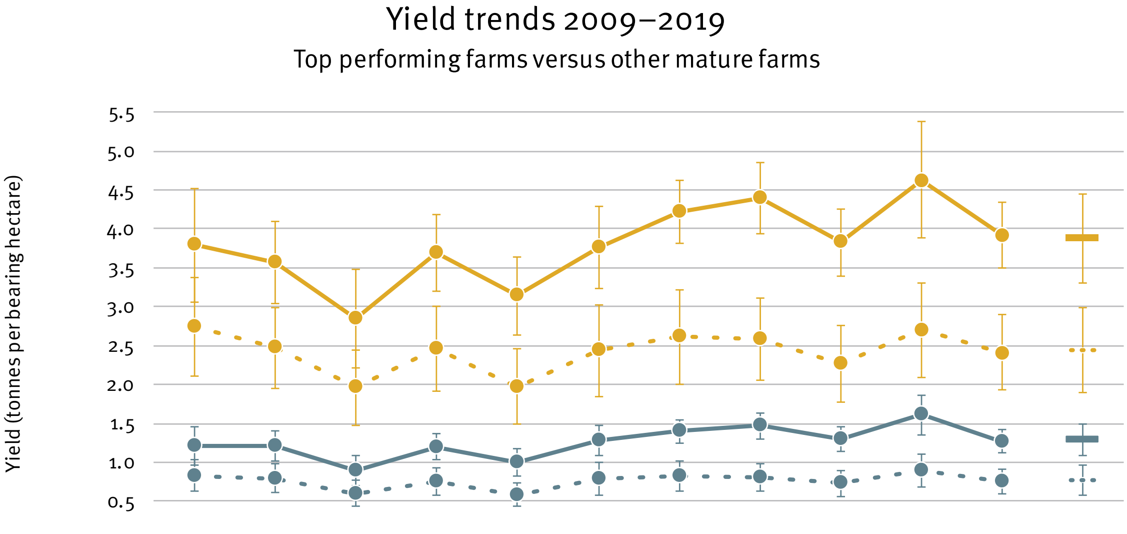
The benchmarking study has revealed high variability in productivity between farms and also between seasons for individual farms. Analysis of the top performing farms provides insight into trends associated with sustained high orchard productivity.

To be regarded as a “top performing farm”, high orchard productivity must be sustained over a minimum of four seasons, including the most recent season. These farms are then ranked according to their long-term average saleable kernel productivity (t/ha). 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 any one particular season.

A total of 58 top performing farms were identified in 2019. All regions were proportionately represented within this group based on the total number of farms participating in each region (CQ 14%, SEQ 22%, NRNSW 53%, MNNSW 10%). The median farm size for top performing farms was around 13 ha, however this varied considerably within each region (CQ 99 ha, SEQ 12 ha, NRNSW 12.4 ha, MNNSW 9.7 ha).

Weighted average tree age for the sample ranged from 20 years in CQ to 29 years in SEQ. More than half of the planted area for all top performing farms in the sample had an average tree age less than 15 years. Over 11% of top performing farms had an average tree age of 30 years or more, which clearly shows that high productivity is being maintained in some older orchards. Most of these older top performing farms are in SEQ and NRNSW.

Figure 53 shows yearly average nut-in-shell (NIS) and saleable kernel (SK) yield per bearing hectare for the top performing farms and compares these with other mature farms in the benchmark sample. The error bars show the standard deviation from these average yields.



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	09–19
NIS yield (Top)	3.79	3.57	2.85	3.69	3.14	3.76	4.22	4.39	3.83	4.63	3.92	3.88
NIS yield (Other)	2.74	2.47	1.96	2.46	1.97	2.44	2.61	2.58	2.26	2.70	2.41	2.44
SK yield (Top)	1.21	1.21	0.90	1.20	1.00	1.28	1.40	1.47	1.30	1.61	1.27	1.29
SK yield (Other)	0.83	0.79	0.60	0.75	0.58	0.78	0.82	0.80	0.73	0.89	0.75	0.77

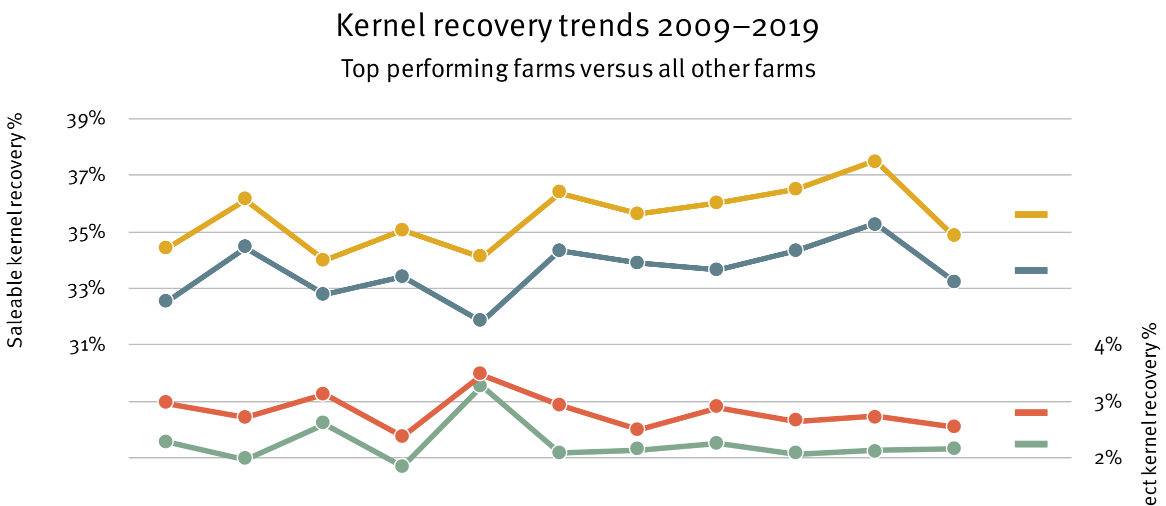
Figure 53: Saleable kernel yield for top performing farms versus other mature farms in the benchmark sample (2009–2019)

The chart confirms that top performing farms, much like the broader benchmark sample, experience substantial 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 seasonal yields per hectare for top performing farms rarely overlap with those of other mature farms in the benchmark sample.

The top performing farms averaged 1.29 t of SK per bearing hectare over the 11 years from 2009–2019, more than 60% higher than the long-term average for other mature farms in the benchmark sample (0.77 t/ha). Average long-term NIS yield was similarly higher for top performing farms (59%).

Figure 54 compares average saleable and reject kernel recovery trends for top performing farms with other farms in the benchmark sample from 2009–2019. Over this period top performing farms averaged approximately 2% higher saleable kernel recovery and 0.55% lower reject kernel recovery than other farms in the benchmark sample.

As top performing farms achieved higher average SKR over this period they also received a higher average price per kilogram of nut-in-shell (NIS) each season compared with other farms in the benchmark sample.



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	09–19
SKR% (Top)	34.41	36.14	33.98	35.04	34.09	36.37	35.61	36.01	36.49	37.50	34.87	35.62
SKR% (Other)	32.53	34.44	32.77	33.41	31.82	34.31	33.89	33.65	34.31	35.29	33.25	33.64
RKR% (Top)	2.28	1.98	2.60	1.84	3.27	2.08	2.15	2.26	2.07	2.13	2.17	2.25
RKR% (Other)	2.97	2.71	3.12	2.37	3.47	2.93	2.50	2.89	2.65	2.74	2.56	2.80

Figure 54: Kernel recovery for the top performing farms versus all other farms in the benchmark sample (2009–2019)

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 2019.

Figure 55 shows the average factory rejects by category for top performing farms compared with other farms in the benchmark sample from 2009–2019. These averages are unweighted, which means that each farm in the sample exerts equal influence on the average, regardless of size or amount of production.

Over this period top performing farms had significantly lower rejects due to insect damage, mould, discolouration, brown centres and immaturity than other farms (P‹0.01). The only reject category that did not differ significantly between the two groups was germination (P›0.05).

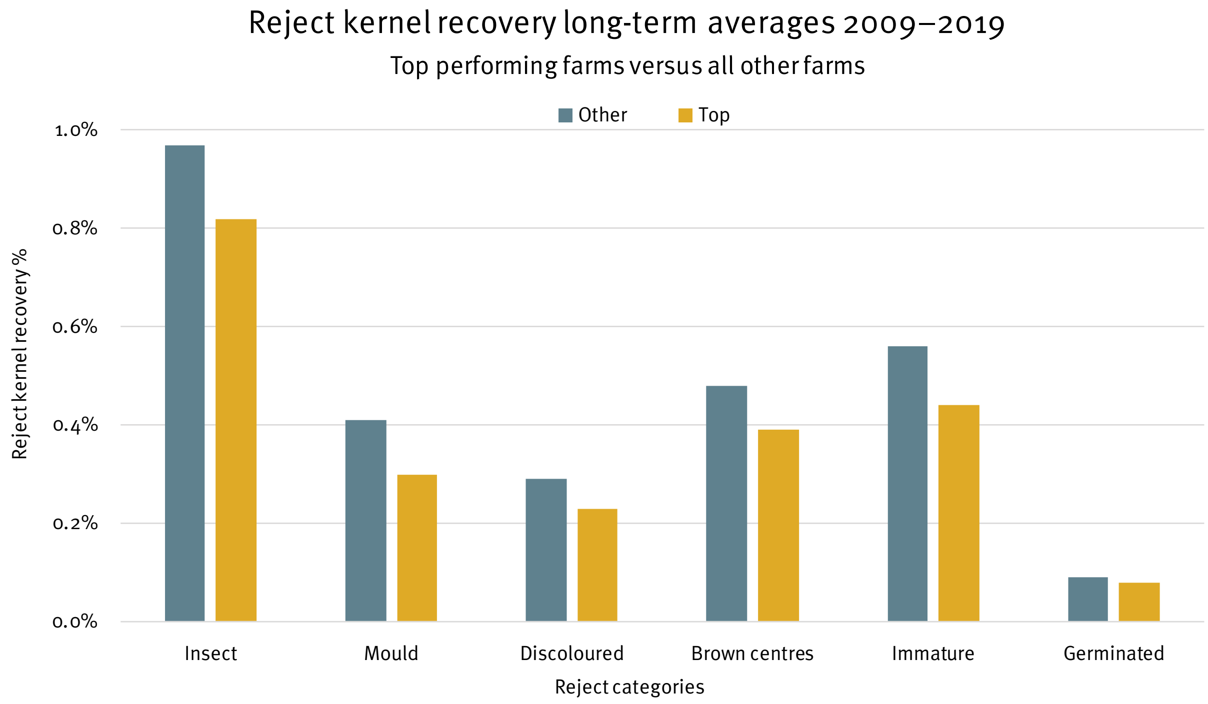
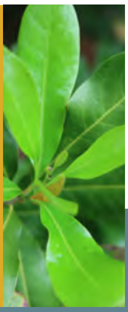


Figure 55: Reject breakdown for top performing farms versus all farms (2009–2019)

> *"Being pro-active in the orchard, having a plan of what you are going to do, having the infrastructure to perform tasks when they need to be done and spending money on inputs to make the orchard run as well as the weather conditions of that year allow".* Anonymous



A survey of top performing farms in 2019 identified common approaches to orchard management that contributed to the high productivity of this group. Attention to detail was the most common response, which included ensuring timeliness and forward planning of important tasks including pest management, nutrition and harvesting. Regular monitoring and observation were also key components of this.

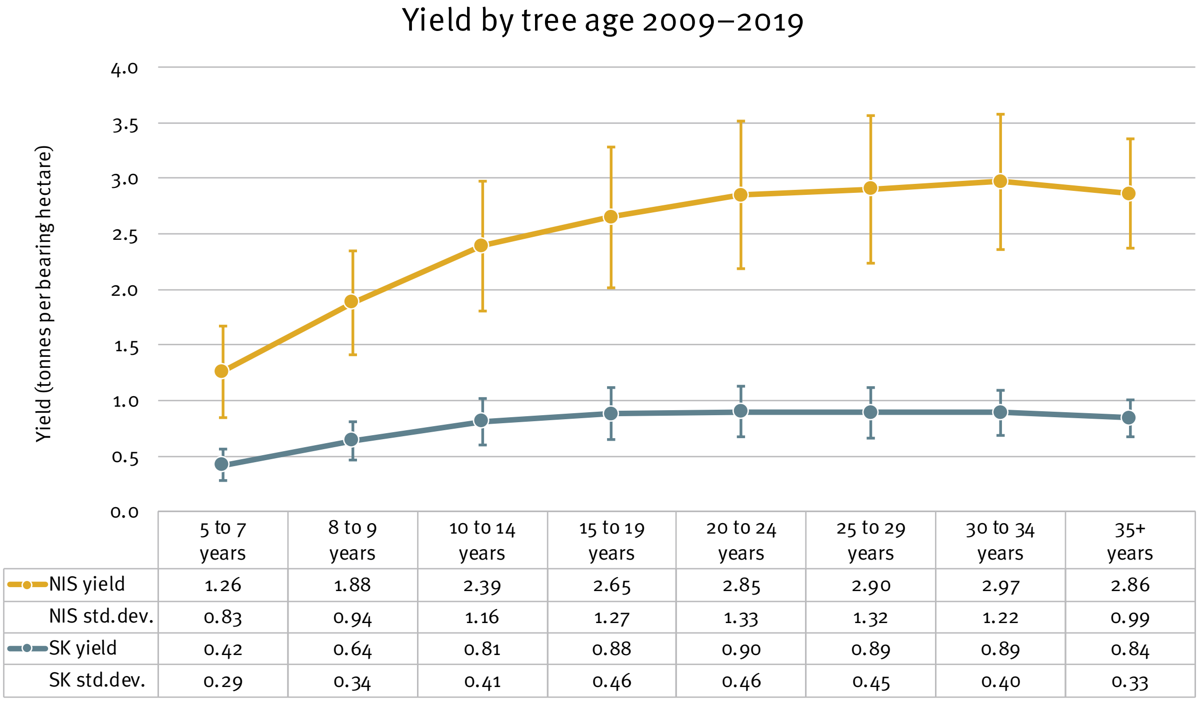
Trends by tree age

Yield and quality were plotted by tree age to identify any age-related trends in orchard performance. It is important to note that this analysis is based on weighted average tree age, as very few farms harvest by individual block or tree age group. Some farms have a mixture of tree ages, so a weighted average tree age is calculated for each farm. Tree age categories are then used to identify and compare data from farms with similar weighted average 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 56 shows average nut-in-shell (NIS) and saleable kernel (SK) yield per bearing hectare for all years from 2009–2019 for farms of various weighted average tree ages. Results are presented only where sufficient data exists to maintain individual farm confidentiality (i.e. more than 10 data points).

Average NIS yield increased with tree age up to the 30 to 34 years category ($P<0.01$) while SK yield plateaued at age 20 to 24. At average tree ages greater than 25 years there is no significant correlation between tree age and either NIS or SK yield ($P>0.05$). While there appears to be some decline in both NIS and SK yield beyond age 35, it's important to note that there are relatively fewer farms on which to base an average in this age group (<10% of sample). The error bars show that some farms within this group are clearly achieving higher (and lower) productivity. As some older farms may also have larger trees, any decline in productivity could also potentially be related to factors other than tree age, such as canopy architecture, tree health, erosion or accessibility during wet weather.



	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	1.26	1.88	2.39	2.65	2.85	2.90	2.97	2.86
NIS std.dev.	0.83	0.94	1.16	1.27	1.33	1.32	1.22	0.99
SK yield	0.42	0.64	0.81	0.88	0.90	0.89	0.89	0.84
SK std.dev.	0.29	0.34	0.41	0.46	0.46	0.45	0.40	0.33

Figure 56: Average yield of nut-in-shell and saleable kernel across tree age groups 2009–2019

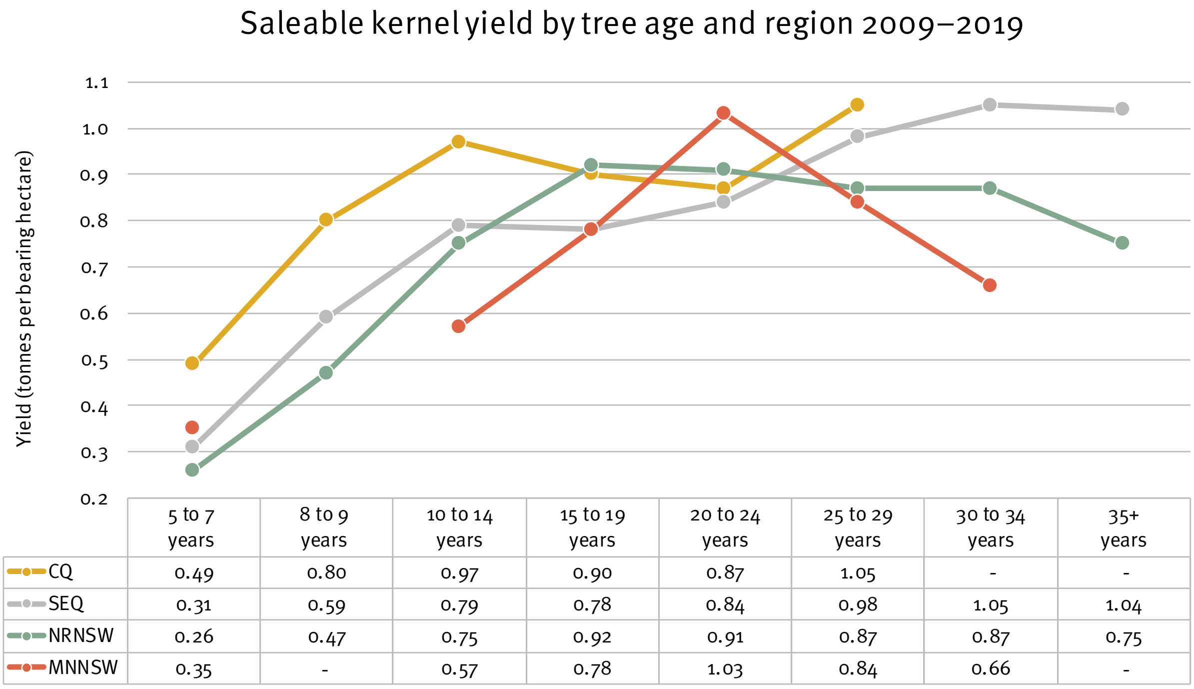
Figure 57 shows a regional breakdown of average SK yield per bearing hectare by tree age category for 2009–2019. Missing values on the chart and in the table indicate that there was insufficient data available for specific tree age categories in some regions.

CQ farms with an average tree age of 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 shows that while there is a significant positive correlation between tree age and yield across all age groups, these relationships are complex and other regional, genetic or management factors can influence the performance of orchards.

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 potentially be related to external factors such as those mentioned above.

In SEQ there is a significant positive correlation between tree age and SK yield per hectare across all age groups up to 30–34 years ($P<0.01$).

In MNNSW SK yields appeared to peak in the 20 to 24 years age group. It's important to note that there are fewer farms from the MNNSW region in the benchmark sample than other regions, so specific age categories may potentially be more heavily influenced by individual farm attributes than in regions with more available data.

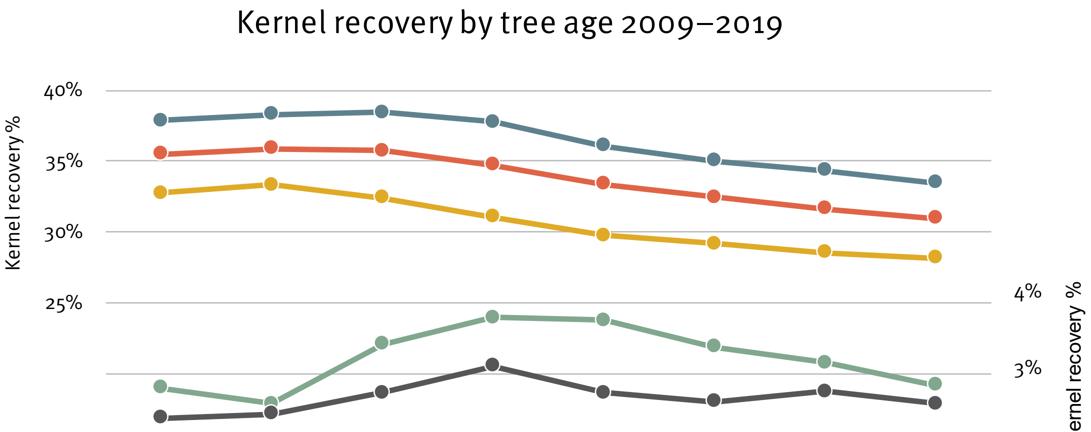


	5 to 7 years	8 to 9 years	10 to 14 years	15 to 19 years	20 to 24 years	25 to 29 years	30 to 34 years	35+ years
CQ	0.49	0.80	0.97	0.90	0.87	1.05	-	-
SEQ	0.31	0.59	0.79	0.78	0.84	0.98	1.05	1.04
NRNSW	0.26	0.47	0.75	0.92	0.91	0.87	0.87	0.75
MNNSW	0.35	-	0.57	0.78	1.03	0.84	0.66	-

Figure 57: Saleable kernel productivity by tree age and region 2009–2019

Average nut-in-shell yield generally increases with tree ages up to 34 years. Lower average saleable kernel recovery among older farms means that this relationship is less obvious for saleable kernel production per hectare.

Figure 58 shows long-term average kernel recoveries by tree age category from 2009–2019. These include 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.



	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%	37.86	38.28	38.42	37.75	36.07	35.02	34.34	33.49
Saleable KR%	35.51	35.88	35.74	34.71	33.39	32.46	31.64	30.96
Premium KR%	32.77	33.34	32.43	31.05	29.76	29.17	28.57	28.17
Commercial KR%	2.74	2.54	3.31	3.66	3.63	3.28	3.07	2.78
Reject KR%	2.35	2.40	2.68	3.03	2.68	2.56	2.70	2.54

Figure 58: Average total, saleable, premium, commercial and reject kernel recovery by tree age category 2009–2019

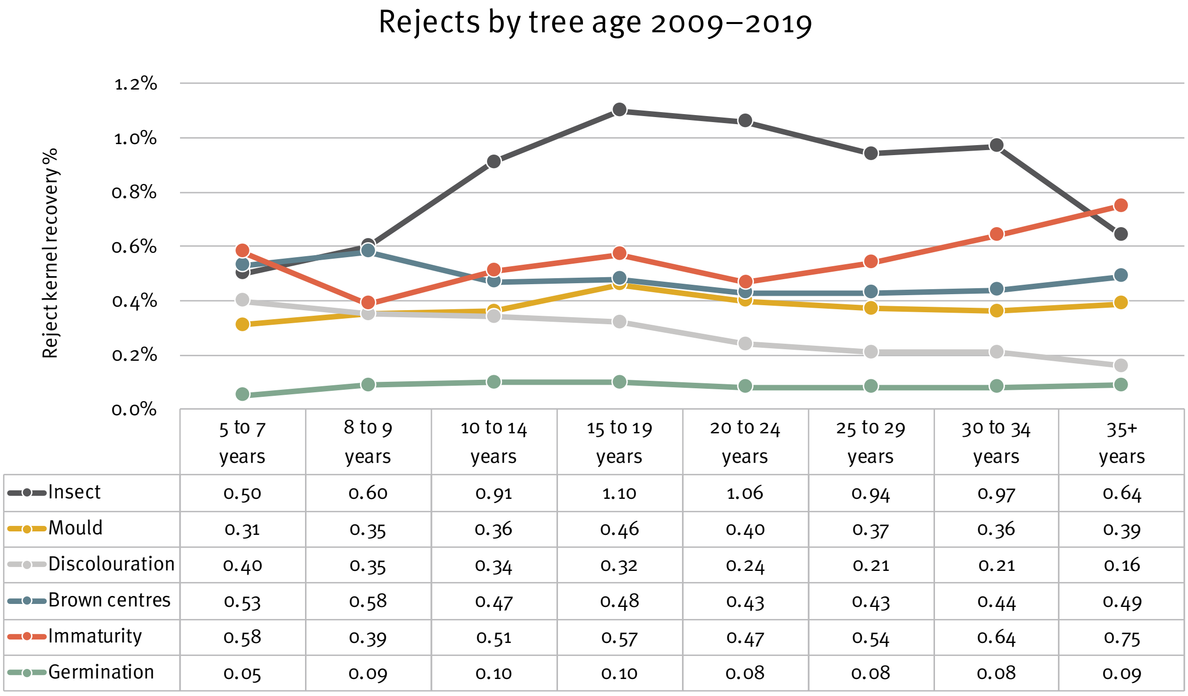
In mature trees (10+ years) there is a general trend towards lower average total kernel recovery in older trees. It's important to note that many factors other than tree age may also influence kernel recovery in older trees such as variety, canopy architecture and tree health.

There is no significant correlation between tree age and CKR indicating that on average CKR is not strongly associated with tree age (P>0.05).

Figure 59 shows a breakdown of individual factory reject categories by tree age from 2009–2019.

Insect damage was the major reject category for most age groups. 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 *Trends by farm size* section for more information.

Average immaturity levels increased steadily beyond age 20. 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.



	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	0.50	0.60	0.91	1.10	1.06	0.94	0.97	0.64
Mould	0.31	0.35	0.36	0.46	0.40	0.37	0.36	0.39
Discolouration	0.40	0.35	0.34	0.32	0.24	0.21	0.21	0.16
Brown centres	0.53	0.58	0.47	0.48	0.43	0.43	0.44	0.49
Immaturity	0.58	0.39	0.51	0.57	0.47	0.54	0.64	0.75
Germination	0.05	0.09	0.10	0.10	0.08	0.08	0.08	0.09

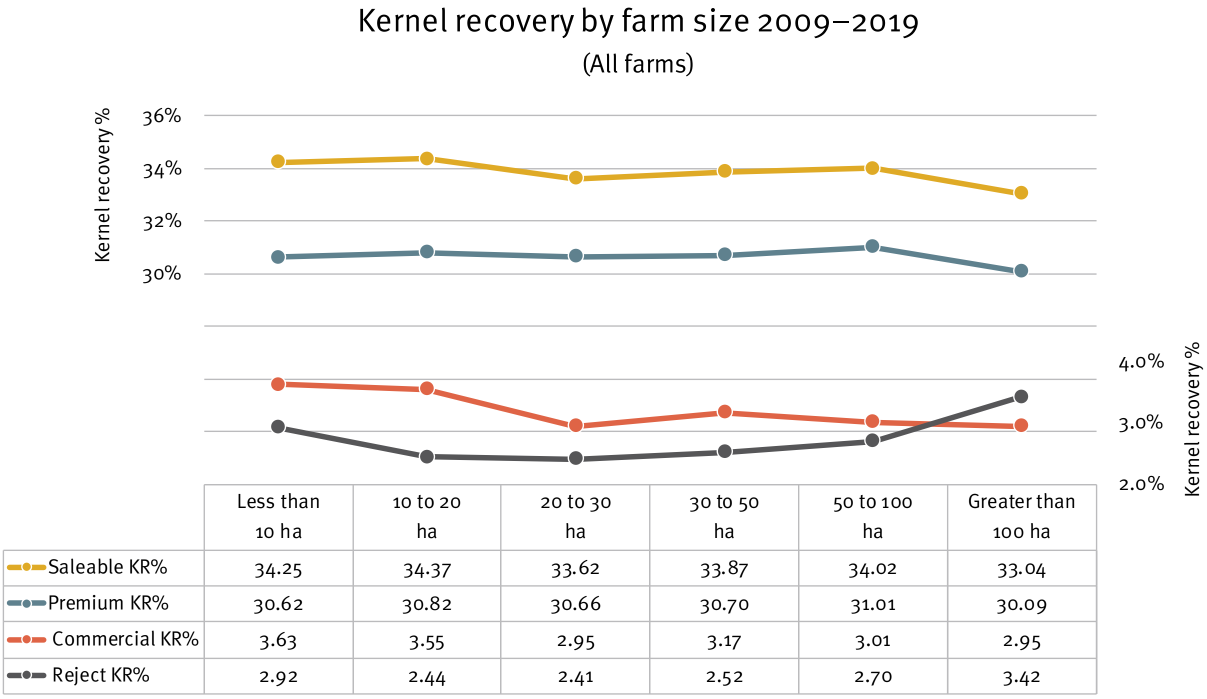
Figure 59: Reject kernel recovery by reject category and tree age 2009–2019

Trends 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.

Analysis of long-term yield trends from 2009–2019 revealed no significant correlation between yield and farm size (P>0.05). There is high variability in both NIS and SK yield around the sample average regardless of total bearing hectares.

Figure 60 shows long-term average saleable kernel recovery (SKR), premium kernel recovery (PKR), commercial kernel recovery (CKR), and reject kernel recovery (RKR) for 2009–2019 by farm size category.



Kernel recovery by farm size 2009–2019

(All farms)

	Less than 10 ha	10 to 20 ha	20 to 30 ha	30 to 50 ha	50 to 100 ha	Greater than 100 ha
Saleable KR%	34.25	34.37	33.62	33.87	34.02	33.04
Premium KR%	30.62	30.82	30.66	30.70	31.01	30.09
Commercial KR%	3.63	3.55	2.95	3.17	3.01	2.95
Reject KR%	2.92	2.44	2.41	2.52	2.70	3.42

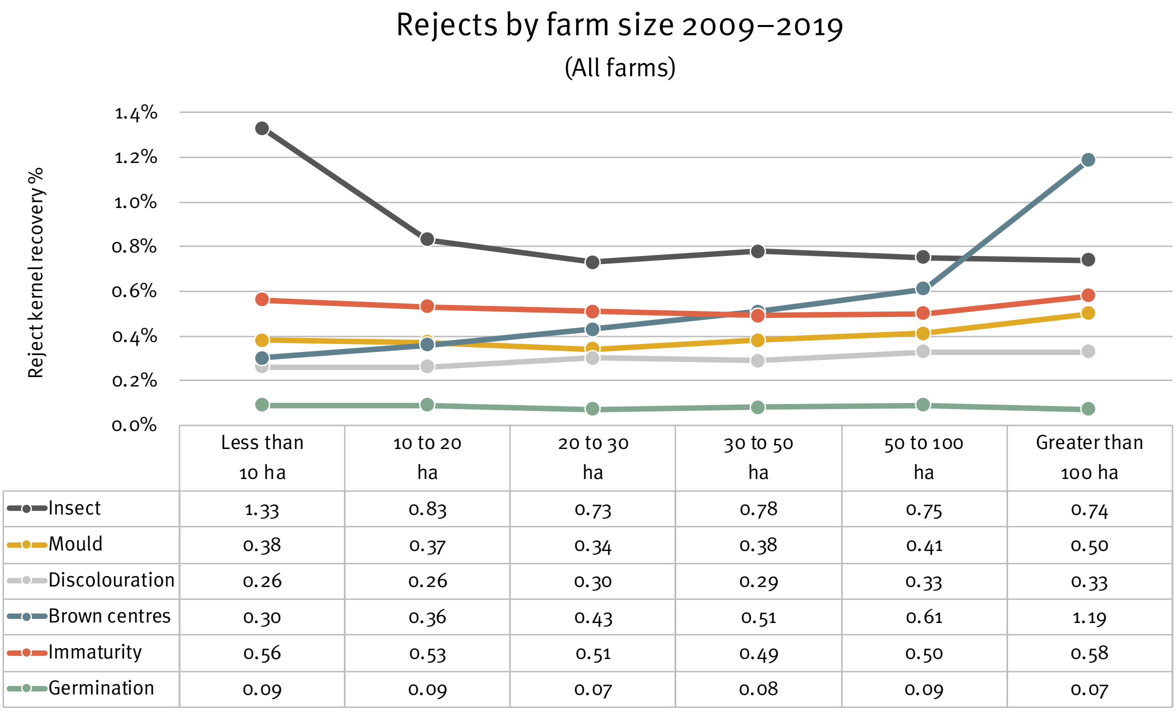
Figure 60: Saleable, premium, commercial and reject kernel recovery by farm size category 2009–2019

There is no significant correlation between farm size and SKR or RKR (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). RKR is significantly positively correlated with farm size indicating that on average RKR increases with farm size (P<0.01). Farms greater than 100 hectares have significantly higher average RKR than all other farm sizes (P<0.01).

Figure 61 shows a breakdown of long-term average factory rejects by farm size for 2009–2019.

Brown centres rejects are directly correlated with increasing farm size (P<0.01). Farms larger than 100 hectares had significantly higher average levels of brown centres reject than all other farm sizes (P<0.01).

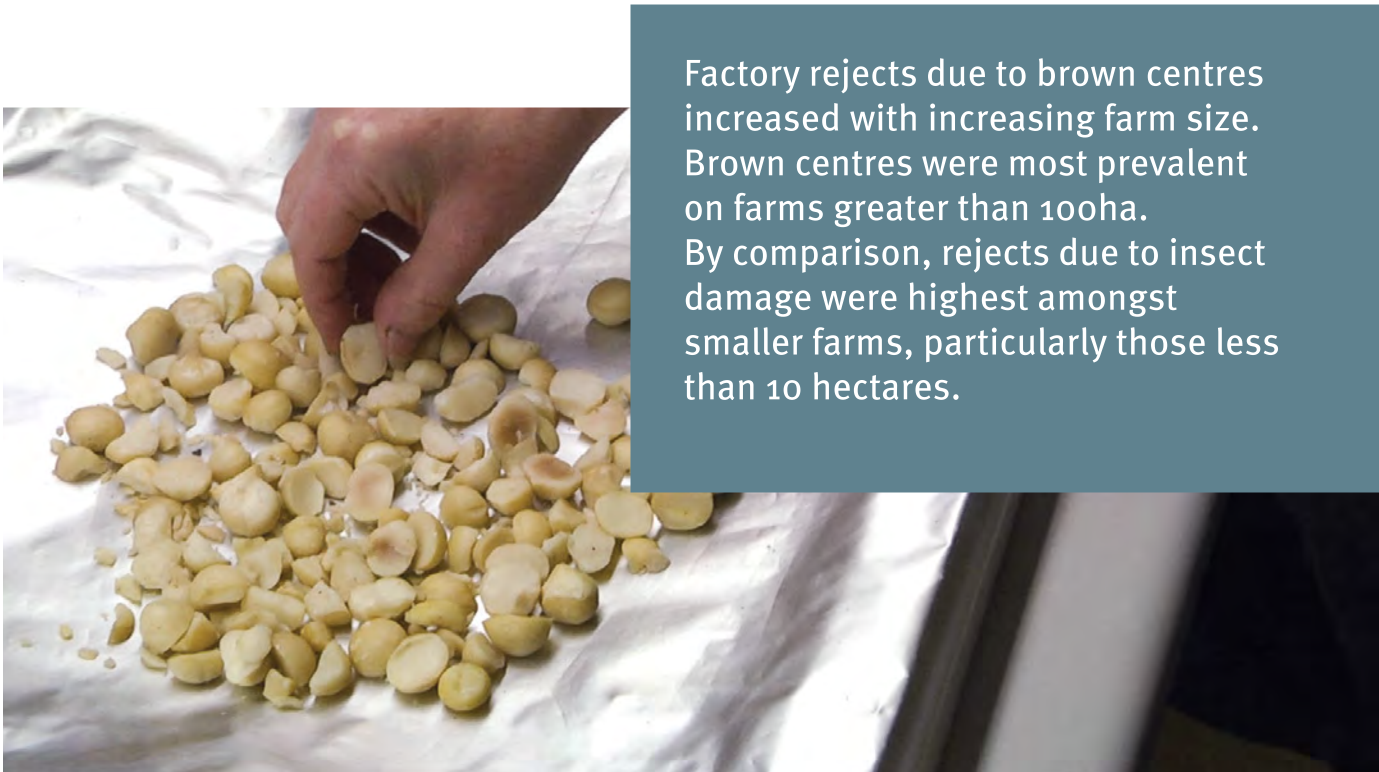
Rejects due to insect damage were inversely correlated with farm size (P<0.01), with significantly higher average insect rejects on farms less than 10 hectares than all other farm sizes (P<0.01). There was no correlation between farm size and other factory rejects including mould, discolouration, immaturity and germination.



	Less than 10 ha	10 to 20 ha	20 to 30 ha	30 to 50 ha	50 to 100 ha	Greater than 100 ha
Insect	1.33	0.83	0.73	0.78	0.75	0.74
Mould	0.38	0.37	0.34	0.38	0.41	0.50
Discolouration	0.26	0.26	0.30	0.29	0.33	0.33
Brown centres	0.30	0.36	0.43	0.51	0.61	1.19
Immaturity	0.56	0.53	0.51	0.49	0.50	0.58
Germination	0.09	0.09	0.07	0.08	0.09	0.07

Figure 61: Factory rejects by farm size 2009–2019

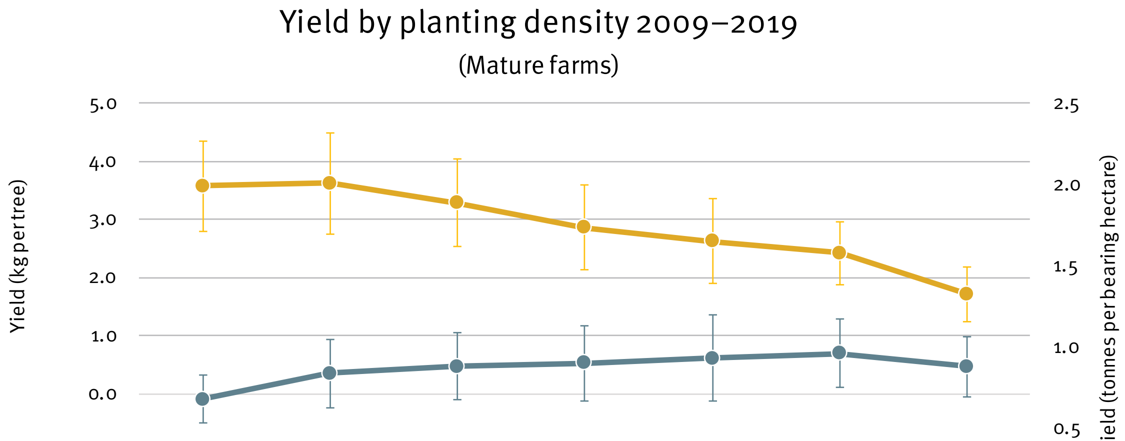
Factory rejects due to brown centres increased with increasing farm size. Brown centres were most prevalent on farms greater than 100ha.
By comparison, rejects due to insect damage were highest amongst smaller farms, particularly those less than 10 hectares.



Trends by planting density

Figure 62 shows average saleable kernel (SK) productivity for mature farms at a range of planting densities. Yield is shown as both tonnes per bearing hectare and kilograms per tree. 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 326 trees per hectare.

SK productivity per tree is significantly inversely correlated with planting density (P<0.05), with yields generally declining above 250 trees per hectare. Conversely, yield per hectare is directly correlated with planting density with average yields increasing up to 450 trees 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)	3.57	3.62	3.28	2.85	2.63	2.42	1.71
SK std.dev. (kg/tree)	1.54	1.74	1.51	1.46	1.47	1.08	0.93
—●— SK yield (t/Ha)	0.68	0.84	0.88	0.90	0.93	0.96	0.88
SK std.dev. (t/Ha)	0.30	0.42	0.41	0.46	0.53	0.42	0.37

Figure 62: Saleable kernel (SK) productivity by planting density 2009–2019

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.
- Top Performing Farms are chosen based on sustained high SK productivity over a minimum of four seasons, including the most recent season.
- 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.
- We aim to use widely recognised terms to describe kernel recovery and reject analysis categories, although some processors may sometimes use different terminology to describe similar reject categories or have their own additional reject categories.
- Unless otherwise stated, 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 2018/19). 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 is imputed at a nominal rate of $30 per hour to derive a more complete picture of true labour costs, 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).
- Where potential for significant skewing of a data occurs (seasonal costs) medians rather than averages may be presented to provide an understanding of the mid-point of the sample.

Analyses and 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

Unweighted averages or arithmetic means 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.

For weighted averages each item is multiplied by a number (weight) based on the item's relative importance. All results are then totalled and divided by the sum of the weights. For example, to calculate average rejects weighted by production individual reject results are multiplied by production for each farm. The sum of these results is then divided by the sum or production for all farms to derive a weighted average. This means that some farms will have more influence on the average than others based on the weighting factor used. In this example farms with more production have a bigger influence on the average. This approach is important analysing results and trends on a whole industry or a whole region basis.

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 and therefore how well the average represents the sample.

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% ($P<0.05$).

Soil water index

The amount of water stored in the soil profile can be estimated by calculating a Soil Water Index (SWIX). This has been provided by the Macadamia Crop Forecasting Project team (MC18003). The index ranges between 0 (dry) to 1 (saturated) and can provide a measure of potential moisture stress at specific points during the season. Average soil-water-index has been calculated from a hydrological ‘typical’ macadamia-farm model using the simulation model GRASP, which is a soil-water, pasture-growth model developed for northern Australia and rangeland pastures. Soil water index incorporates changes in soil water content as the difference between inputs (rainfall) and outputs (runoff, drainage, soil evaporation and tree water use). The soil water index does not account for irrigation, therefore water inputs are purely the result of rainfall.

Rainfall and temperature data

Regional rainfall and temperature information has been compiled by the Macadamia Crop Forecasting Project team (MC18003) using BOM and Long Paddock data. In most cases regional data is derived from a single weather station that was identified as the most representative of each region. Rainfall, temperature and SWIX will vary greatly between farms and may not be representative of the geographical spread of farms in each region. This information should therefore be used as a guide only and should not be used to inform management decisions. Weather station locations for each region are listed below.

Region	Weather station location
CQ	Hinkler Park
SEQ (Gympie)	Wolvi
SEQ (Glass House Mountains)	Beerwah
NRNSW	Average of Alstonville, Clunes, Dunoon and Lismore
MNNSW	Macksville

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2009 to 2019 seasons

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