DAQ2111-005RTX: Agronomic practices to maximise peanut kernel quality and yield

Milestone Progress Report 2021-22

Peanut agronomy experiments with five varieties in the Bundaberg and Kingaroy regions in the 2021-22 season

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Executive summary

Peanut is an important grain legume crop due to its intrinsic value as nutritious food and its contribution to the sustainability of farming systems. In Australia, peanut has become an important rotational crop. The Australian peanut industry has recently bred several high-yielding peanut varieties for irrigated production systems. These varieties have created an excellent opportunity to support the development of best management strategies to increase the production of high-quality grade peanut kernels to meet the growing market demand. The project 'Agronomic practices to maximise peanut kernel quality and yield (DAQ2111-005RTX)', supported by the Grains Research and Development Corporation and the Department of Agriculture and Fisheries, aims to achieve this goal.

This report summarises the results of the peanut agronomy experiments conducted at Bundaberg and Kingaroy during the 2021-22 season as part of the above project. The experiments were laid out in a split-plot design with three replications at each location. Five peanut varieties, including Holt, Alloway, Kairi, Wheeler and P85-p112-151 (P85), were assigned to main plots, and four plant populations, 6, 12, 18, and 24 plants per m^2, were assigned to subplots. All varieties were runner types except Wheeler, which represented a 'Virginia' type. Planting was done by the precision planting 20/20® and vSet® electronic seed metering system. The experiments were irrigated using irrigation scheduling software Aquaman via the web-based 'Yield Prophet'.

Observations included monitoring crop phenology, flower counts, canopy cover, crop growth and dry matter partitioning into pods and kernel quality. We used the Canopeo app on iPhone at Kingaroy to analyse the canopy cover. Nut-in-shell (NIS) yield was estimated from a quadrat of 14 m^2. Yield samples were processed using a KEW cleaner. Kernels were then categorised into jumbos, ones, twos, manufacturing, split, and oil categories following the shelling of a 1 kg pod sample. The shelling percentage was calculated as the ratio of kernels to NIS weight. Gross crop value (GCV) was computed by multiplying different grades with their commercial value. Data were analysed using GENSTAT 22nd edition.

The growing season was wetter than average, resulting in significant disease pressure in both environments. The plant population attained varied between 80 and 89% at Bundaberg and 80 and 94% at Kingaroy of the target plant population.

Biomass accumulation in stems and pods and the partitioning efficiency (the ratio of pod dry weight to total biomass in each sampling) on a thermal time scale were generally similar in the two environments. At Bundaberg, Kairi and Alloway and at Kingaroy, Alloway was the top dry matter producing variety. The dry matter accumulation in pods was fastest in Wheeler at Bundaberg and Alloway at Kingaroy. Partitioning efficiency followed the trend of pod dry matter production.

The NIS yield averaged 4.51 t/ha at Bundaberg and 3.6 t/ha at Kingaroy. The lower yields at Kingaroy were partly due to the variety Wheeler losing its leaf canopy just before harvest due to late infection by the net blotch disease. The plant population and type of disease severity differences were generally non-significant at Bundaberg. The NIS yield differed significantly

due to the plant population at Bundaberg and the varieties at Kingaroy. The interaction between variety and plant population was not significant in any environment.

The effect of three plant populations, five varieties and their interactions were significant for the percentage of Jumbo kernels at Bundaberg, but at Kingaroy, only the variety effects were significant. At Kingaroy, the differences in canopy cover, mainly due to variety, became more strongly associated with the NIS yield with time, alluding to the importance of the trait. There was no apparent effect of the rate of phenological development on NIS yield.

Although a direct association with NIS yield could not be established, the frequency of flowers being formed was substantially more in the lowest plant population than in the higher plant population. This difference in frequency is a new finding from this work. This aspect will be further investigated to determine implications for its use as a selection trait for new variety development and improved agronomic management of peanuts.

The first season experiments have provided some interesting agronomic and variety information on peanuts grown in irrigated systems. The 2022-23 experiments will confirm the findings of the first season experiments. In addition to determining the effects of plant population, variety and their interactions on NIS yield and its quality, the investigations will focus on measurements of canopy cover, rate of phenological development and frequency of flowers and their impacts on NIS yield and quality.

The extension activities were undertaken by Peanut Company of Australia through the regular release of videos as Covid-19 issue prevented face-to-face interaction in the experimental field and other venues. The grower response to the videos was very positive with around 45% of 2021/22 growers viewing each update. Peanut Company of Australia representatives were also able to provide a face-to-face update on the trial at grower meetings in July 2022. Meetings were held at Kingaroy, Bundaberg and Atherton and were well attended, with up 40 growers at each meeting. Overall, there is good feedback from growers on the project, and they look forward to improving agronomic practices to improve crop yield and quality.

Background

Peanuts are an important crop due to their intrinsic nutritional food value and positive role in the sustainability of farming systems. The Australian demand for peanuts is growing, with around 60% of the market requirement currently being met from imports. There is considerable scope to increase production in Australia due to its rotational benefits in the farming systems and increasing domestic market demand. In recent years, the Australian peanut industry has released several high-yielding peanut varieties. Growers, industry representatives and researchers have identified an opportunity to further support the continued development of best management strategies to increase the production of high-quality grade peanut kernels to meet the growing market demand. The project, 'Agronomic practices to maximise peanut kernel quality and yield (DAQ2111-005RTX)', supported by the Grains Research and Development Corporation, aims to achieve this. This report summarises the results of the peanut agronomy experiments conducted at Bundaberg and Kingaroy during the 2021-22 season, which is the first season for the project.

Experimental protocol

We conducted two experiments, one at the Kingaroy Research Facility in the South Burnett and another at Peter Russo's Farnsfield property in the Bundaberg district. The experimental design of both experiments was a split plot with five varieties, including Holt, Alloway, Kairi, Wheeler and P85-p112-151 (P85), assigned to the main plots and four plant populations (6, 12, 18, and 24 plants/m^2 assigned to the subplots. There were three replications. The crop was sown on 8 December 2021 at Bundaberg and 14 December 2021 at Kingaroy using a precision planting 20/20® and vSet® electronic seed metering system, which in a single run sowed two rows spaced at 85 cm apart on 180 cm beds. This sowing configuration resulted in slightly more space (95 cm) between two rows of adjacent beds than within a bed (85 cm) to reduce the effect of compaction from tractor tyres. Each plot consisted of three beds that were 25 m long. The crop was irrigated three times at Kingaroy and four times at Bundaberg using sprinklers when the Aquaman program (www.yieldprophet.com.au) suggested that the crop needed irrigation. The total irrigation applied at each location was 135 mm.

The crop was kept relatively weed-free with the help of pre-and post-emergence herbicides. High rainfall during the season created ideal conditions for rust, leaf spots, and net blotch diseases and required frequent fungicide sprays. Three sprays were applied at Kingaroy and four sprays at Bundaberg.

In-season and final yield observations were taken on the middle bed of each plot. Plant samples for biomass and pod yield estimation were drawn from the edge of the plot leaving some area to minimise the border effect. The in-season observations included observations on crop phenology and four biomass samples. The canopy cover was measured using Canopeo software developed by Oklahoma State University App Centre at Kingaroy. The app can also score for disease effects on foliage while computing canopy cover. The app analyses pictures taken 1 m above the crop canopy using an iPhone mounted on a selfie stick and the field view covered roughly 1 m2 area. Canopeo converts the green area into white pixels to compute crop cover and accounts for leaf area that has been discoloured due to blotched or rust. Development of foliar diseases was scored on a 1-9 scale at Bundaberg. About 14 m^2 area was harvested at maturity to assess pod yield and quality (kernel grades and shelling percentage etc.). At Bundaberg, the reproductive stage (R-Stage) was measured using the Bootee et al. (1982) method. Flowers developing on the crop were counted weekly on three plants at Bundaberg. At Kingaroy, observations on flower count were made on plants in a randomly selected 1 m running the length of rows. For both locations, a cumulative flower count was then calculated.

The crop was dug on 6 May 2022 at Bundaberg (Wheeler was dug on 21 April 2022) and on 3 June 2022 at Kingaroy. All varieties except Wheeler accumulated 2300 °Cd at Bundaberg and 2000 °Cd by harvest at Kingaroy. At Kingaroy, the early onset of the winter season prevented the crop from reaching full maturity leading to a slightly earlier harvest.

After harvesting and drying, peanut samples from all three field trials were processed in an identical manner - namely: The samples were put over a 'KEW peanut cleaner' at DAF Kingaroy Research Facility to remove soil and extraneous matter. The sample was then weighed. A 1,000 g sub-sample was then hulled and hand shelled to remove peanut shell. The kernels were then placed over the 'KEW peanut grader' to determine treatment impact on grade/quality using the following sieves:

Oil = kernels that passed through a 21/64th round sieve

Split = kernels that passed through a 16/64th slotted sieve

MFG = kernels that passed through a 22/64th round sieve

2's = kernels that passed through a 24/64th round sieve

1's = kernels that passed through a 25/64th round sieve

J's = kernels that passed over the 25/64th round sieve.

The per hectare grades were calculated my multiplying the NIS yield with proportion of particular grade. For example, if the NIS yield was 4.8 t/ha and the Jumbo proportion 0.39, then the Jumbos per hectare will be 1.87 t/ha. Gross crop value (GCV) was computed from the 2021 peanut supply contract for runner peanuts at: $1,775/t for J's; $1,775/t for 1's; $1,775/t for 2's; $1,775/t for splits; $535/t for MFG; $150/t for oil's. The $/t was computed by multiplying GCV with NiS.

Results

Seasonal conditions

The total in-season rainfall was 676 mm at Bundaberg and 446 mm at Kingaroy (Fig. 1). The high rainfall conditions were conducive to the development of foliar diseases, despite recommended fungicide treatments being applied. At Kingaroy, the variety Wheeler was particularly affected by net blotch caused by the pathogen *Didymosphaeria arachidicoladue* in the late stages of development (Fig. 2 and 3). These diseases resulted in severe defoliation towards maturity. The average temperature at Kingaroy was 21 °C, and at Bundaberg, 24.9 °C. The average daily radiation was 17.1 MJ/m^2 at Bundaberg and 15.7 MJ/m^2 at Kingaroy.

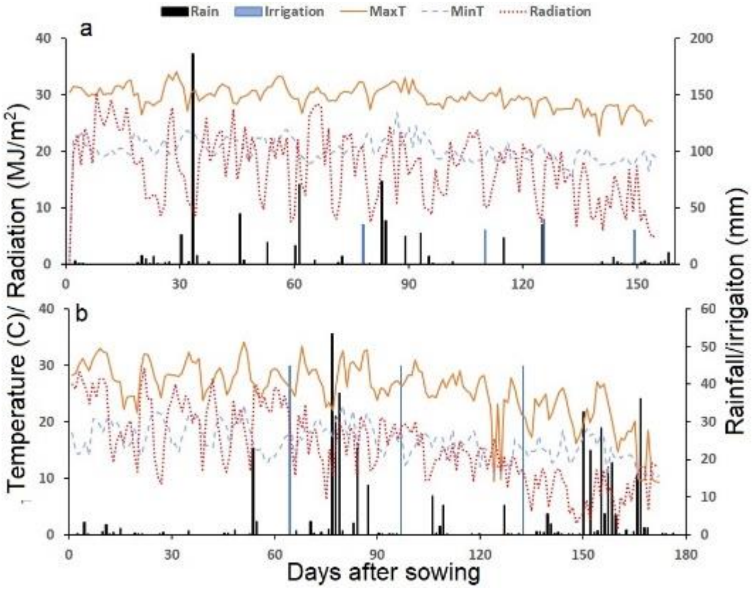


Fig. 1. Bundaberg (a) and Kingaroy (b) weather during the 2021-22 summer season

Fig. 2. The images of peanut crops at Bundaberg (top rows) and Kingaroy (bottom rows) early in the season (left column) and at close to maturity (right column), respectively. The crop at Kingaroy was affected due to net blotch losing entire foliage (in Wheeler – bottom right image), and waterlogging caused by incessant rains towards maturity, 2021-22.

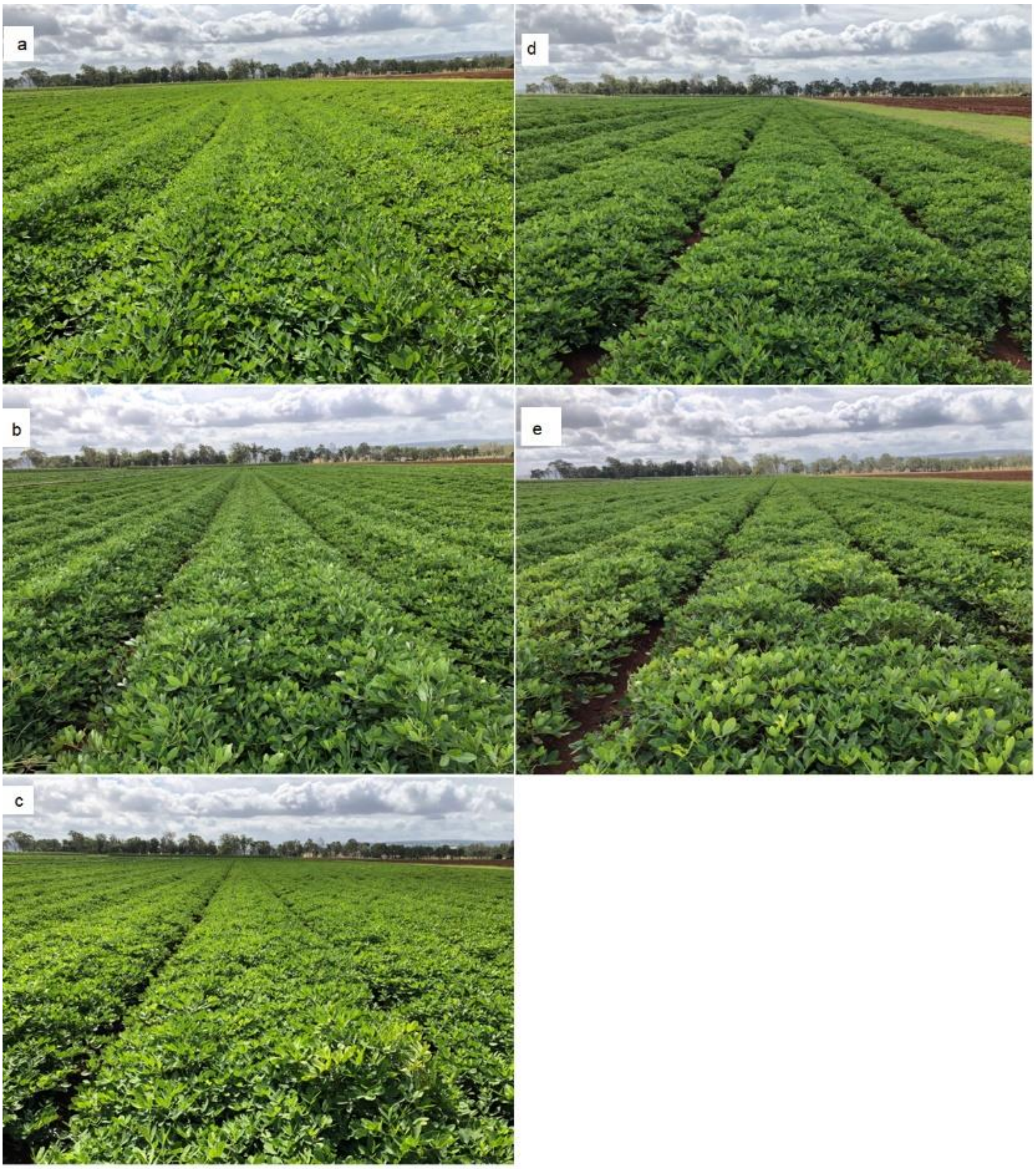


Fig. 3. Images of varieties Alloway (a), Holt (b), Kairi (c), P85 (d) and Wheeler (e) on 22 April 2022 at Kingaroy, 2021-22.

The images of peanut crops at Bundaberg (top rows) and Kingaroy (bottom rows) early in the season (left column) and at close to maturity (right column), respectively. The crop at Kingaroy was affected due to net blotch losing entire foliage (in Wheeler – bottom right image), and waterlogging caused by incessant rains towards maturity, 2021-22.

Plant population and canopy cover

Although the target plant population was 6, 12, 18 and 24 plants/m^{2,} the final population varied between 80 to 89% at Bundaberg and 80 to 94% at Kingaroy. Generally, the crop's establishment was reduced as the plant population increased due to increased inter-plant competition.

The Canopeo readings were reasonably precise, as reflected in a very low CV% (Table 1). Generally, the variety effects were significant throughout crop growth, with plant population effects only being significant in the early stages. The interaction between these two factors was not significant at any stage. The observations revealed that all varieties achieved up to 99% canopy cover by 90 days after sowing (Fig. 4). There was a decline in the canopy cover after that time, which was more prominent in Kairi and Wheeler, which had slightly higher disease pressure. There were differences in the canopy cover due to plant population, which disappeared by the 87th day after sowing, suggesting that plant population did not increase disease severity as disease pressure was minimal until this time. Our plot-wise Canopeo observations were highly correlated ($r > 0.54$, $p < 0.01$) with pod yield from about 107 days onward. The correlation increased as the season progressed at the final reading done 156 days after sowing. The coefficient of variation for Canopeo reading was very low, suggesting that the software helps pick varietal differences in development more precisely. As this only requires an iPhone or Android phone, it could be cheaper to assess canopy health and quantify disease pressure.

Table 1: The coefficient of variation (CV%) and the significant differences in the canopy cover measured using the Canopeo app on iPhone. *, **, and NS represent significant at 5%, 1% and not significant effects, respectively.

Days after sowing	CV%	Variety (V)	Population (P)	V x P
37	11.2	NS	**	NS
45	12.2	nS	N	NS
52	8.3	**	**	NS
66	6.5	**	**	NS
79	3.6	*	NS	NS
87	1.4	**	NS	NS
94	1	NS	*	NS
107	1.3	*	NS	NS
115	2.4	**	NS	NS
129	2.7	**	NS	NS
141	4.5	**	NS	NS

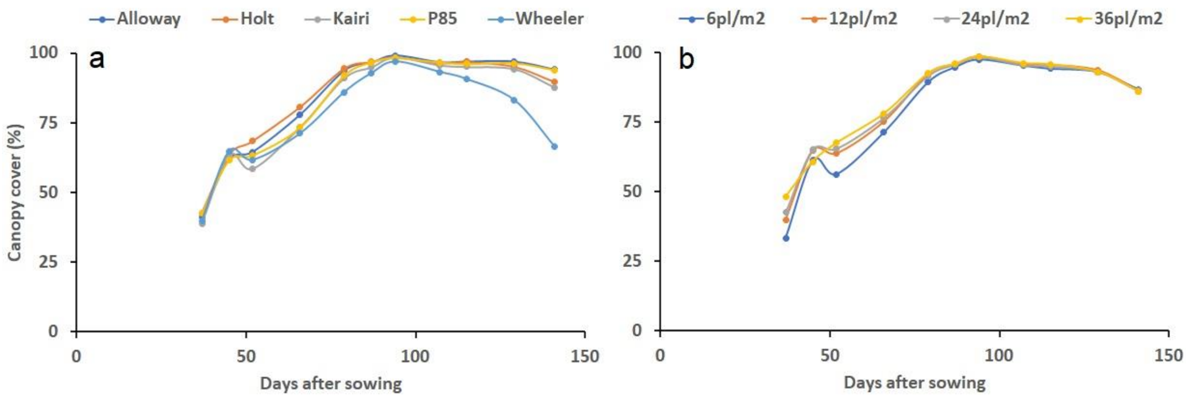


Fig. 4. The variety (a) and population (b) effects in canopy cover assessed using the Canopeo app**.**

Phenology

At Bundaberg, where detailed phenological development was monitored, the effect of plant population was non-significant at every observation date. Variety differences were significant at 105 and 112 days after sowing. Thermal time accumulated during the R-stage monitoring dates varied from 960 to 1962 °Cd. When the individual variety R-stage was plotted against the accumulated thermal time, the faster development of cv. Wheeler became more conspicuous (Fig. 5). The progression of the R-stage appeared fastest for Wheeler and slowest for Alloway; the other three varieties were similar and were intermediate between Wheeler and Alloway.

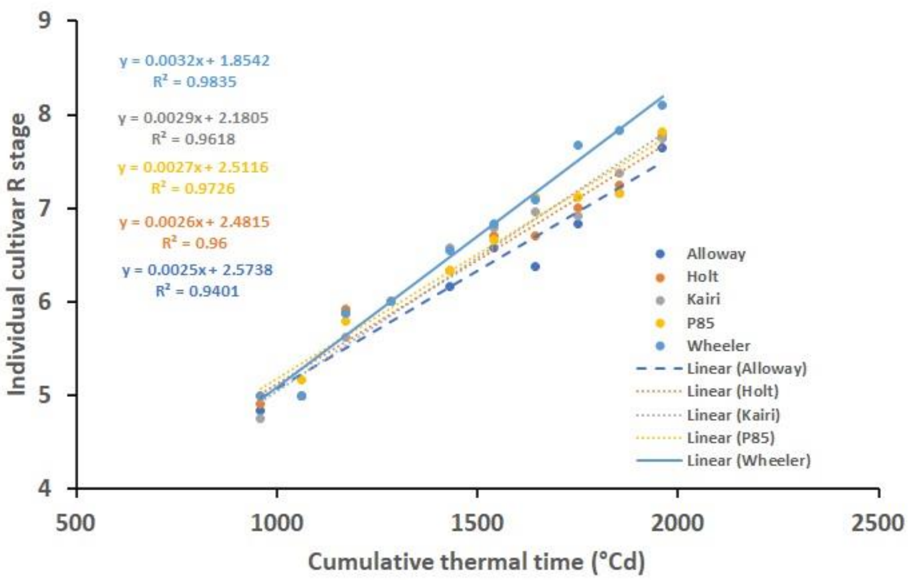


Fig. 5**.** Relationship of R-stage of development with thermal time at Bundaberg, 2021-22.

These thermal times accounted for 94 to 98% of the variation in the R-stage in different varieties. The slope of the relationship between accumulated thermal time and the R-stage was indicative of the rate of R-stage progression. The slope value was highest (0.0032) for

Wheeler and lowest (0.0025) for Alloway. The slope values were 0.0026 for Holt, 0.0029 for Kairi and 0.0027 for P85. The slopes of Wheeler and Alloway differed significantly, but differences among other varieties were not significant. The cumulative number of flowers was highest at six plants /m^2 and lowest at 18 plants/m^2. Variety Kairi, followed by P85, produced the highest number of cumulative flowers and Holt the lowest number of flowers (Fig. 6).

At Kingaroy, the crop started flowering 28 days after sowing (DAS) and reached 50% flowering 35 days after planting at Kingaroy. The first quantifiable pods were measured at around 80 days after sowing. The counting of flowers revealed some exciting information. From two months after sowing, the effects of variety, plant population and the interactions between them were generally significant (Fig. 7). Most increases in flower number occurred between 49 DAS and 85 DAS at Kingaroy. Here also, the lowest density produced the maximum number of flowers on an area basis, and the cumulative number of flowers declined as the plant population increased. Variety P85, followed by Holt, had the highest number of flowers and Wheeler the lowest.

In both environments, pods were assessed for maturity using a hull-scrape method (Fig. 8). While full maturity was achieved at Bundaberg, at Kingaroy, full maturity was not reached due to cooler and wet conditions leading to early termination of the crop.

At both locations, the number of flowers produced plateaued around 100 days after sowing.

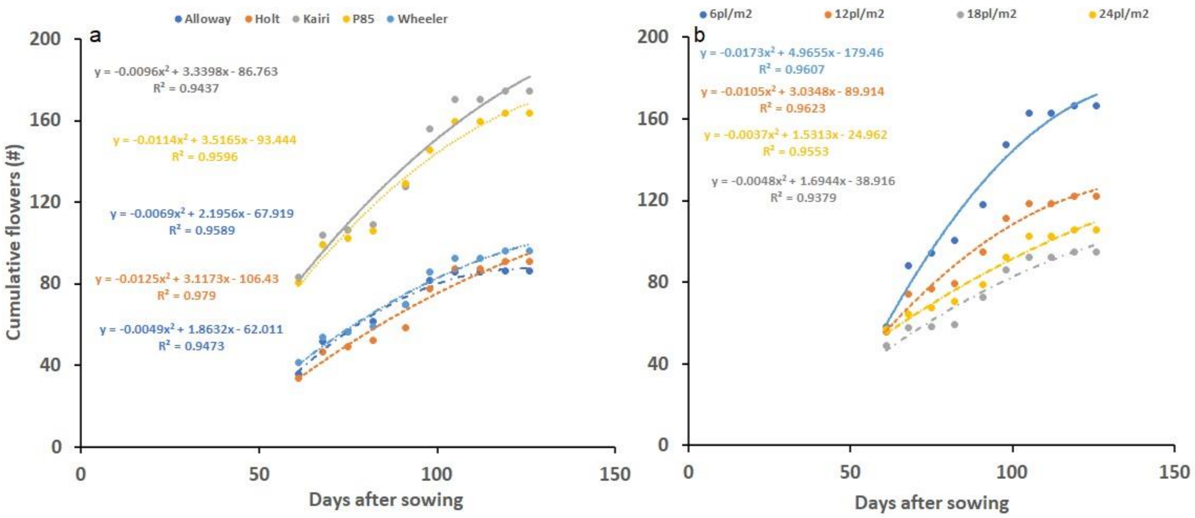


Fig. 6.The effect of variety (a) and plant population (b) on cumulative flower numbers on different days after sowing at Bundaberg, 2021-22.

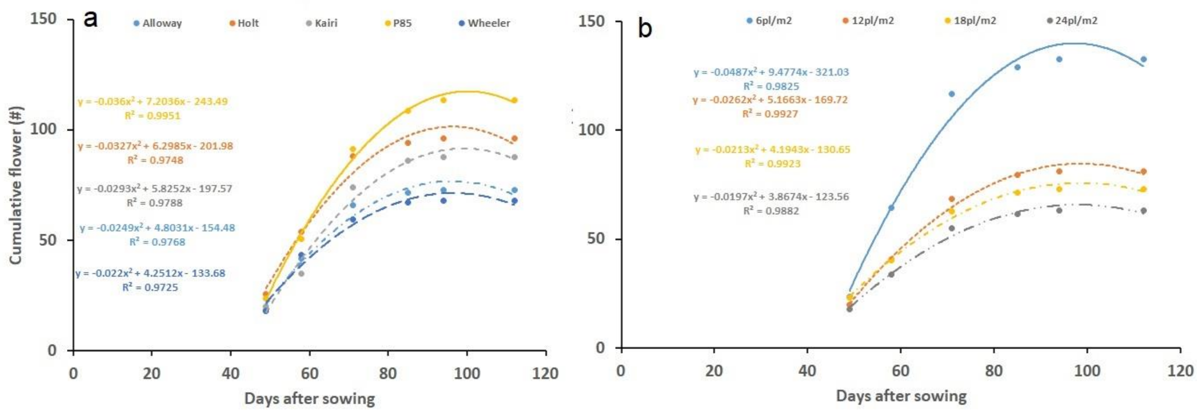


Fig. 7. The effect of variety and plant population on cumulative flower numbers on different days after sowing at Kingaroy, 2021-22.

Fig. 8. The assessment of peanut maturity at Bundaberg using the hull-scrape method.

Dry matter production and partitioning

Dry matter sampling was generally done in the linear phase of growth except for the last sample at Kingaroy, where dry matter production declined due to inclement weather, which induced leaf diseases and waterlogging (Fig. 9). The increase in the total dry matter as a function of thermal time was similar at two locations. The rise in pod dry matter was identical in the two environments, whereas, at Bundaberg, the partitioning of dry matter decreased in the later stages.

At Bundaberg, differences in total dry matter due to plant population were significant in the first two sampling (60 DAS and 82 DAS) dates, which disappeared at the third and fourth sampling (105 and 126 days after sowing) dates (Table 2). The variety x plant population interaction was significant only in the first sampling. The plant population effects on pod weight were substantial at the second and the third sampling and the interaction between plant population and variety was not significant at any sampling date (Table 2). The effects of plant population on dry matter partitioning into pods were significant in the second and third sampling dates (Table 2). Dry matter accumulation as a function of days after sowing was fastest in Kairi and slowest in Alloway (Fig. 10). At the final sampling date, dry matter partitioning into pods was highest in Wheeler and lowest in P85, although differences were not significant. Our study found that P85 produced the highest number of flowers at Kingaroy and was also the second highest flower-producing variety at Bundaberg. In both environments, it yielded well.

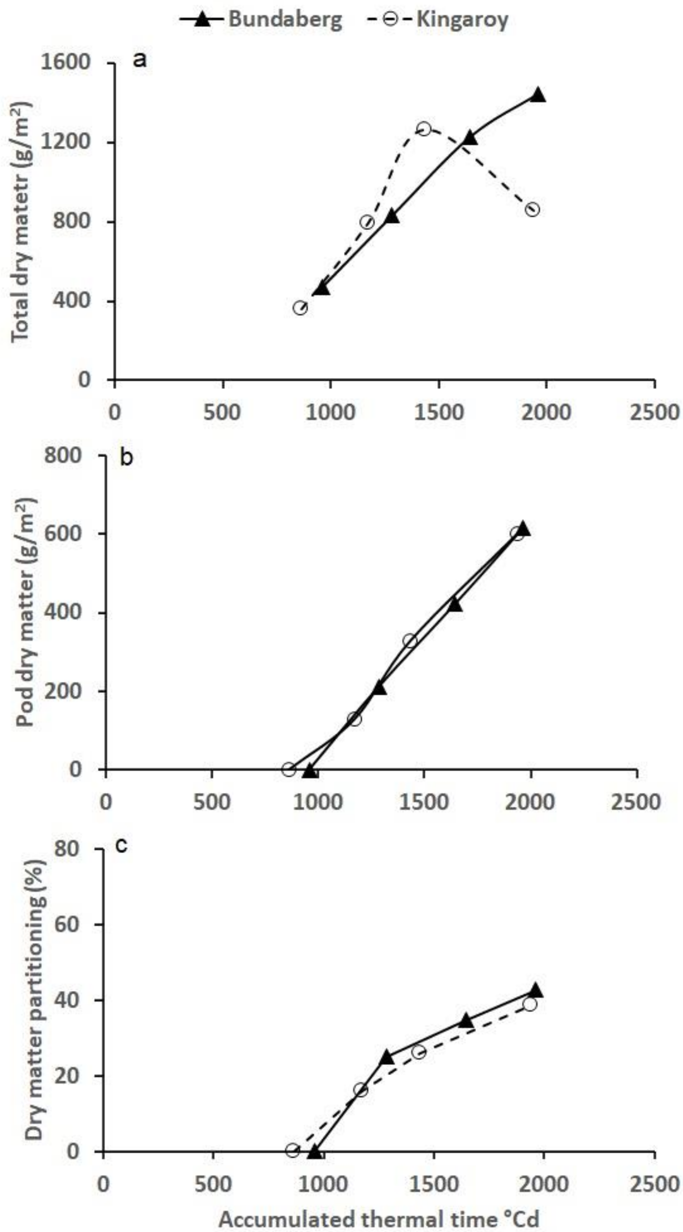


Fig. 9. Accumulation of total pod dry matter and its partitioning as a function of thermal time at Bundaberg and Kingaroy, 2021-22.

Table 2. The coefficient of variation (CV%) and the significant effects of variety (V), plant population (P) and their interactions (P x V) in different samplings on different days after sowing (DAS). * Significant at 5%, **, significant at 1% probability and NS, not significant.

	Biomass				Pod				Partitioning			
DAS	CV%	V	P	VxP	CV%	V	P	VxP	CV%	V	P	VxP
					Bundaberg							
61	22.7	NS	**	*								
82	21.5	NS	**	NS	32.1	NS	**	NS	12.1	NS	**	NS
105	47.1	NS	NS	NS	31.3	NS	**	NS	14.6	NS	**	NS
126	20.3	NS	NS	NS	22.3	NS	NS	NS	11.7	NS	NS	NS
					Kingaroy							
64	9.9	NS	**	NS								
86	14.4	NS	*	NS	23.1	*	**	NS	13.8	**	**	NS
107	12.3	NS	NS	NS	13.0	*	NS	*	5.3	**	*	NS
156	12.6	NS	NS	NS	13.2	NS	NS	NS	3.3	NS	NS	NS

At Kingaroy, there were significant differences in dry matter accumulation due to plant population in the first two sampling (64 and 86 DAS) dates, which disappeared in the third and fourth sampling (105 and 156 DAS) dates (Table 2). The varietal differences were generally not significant for biomass production but were significant for pod dry weight and its partitioning efficiency. As expected, dry matter accumulation was higher in the highest plant population and lowest in the lowest plant population at both locations (results not shown). The varietal differences in total dry matter accumulation were apparent when regressed over four samplings. Still, differences in pod dry matter appeared smaller (Fig. 11). The dry matter partitioning was fastest in Wheeler, as found at Bundaberg. The interaction between plant population and variety was not significant at any sampling date.

At the final harvest, dry matter partitioning into pods was highest in variety Wheeler and lowest in varieties Alloway and P85, with insignificant differences in any environment. Part of the high partitioning in Wheeler at Kingaroy could be due to a confounding effect of net blotch diseases reduced leaf dry matter.

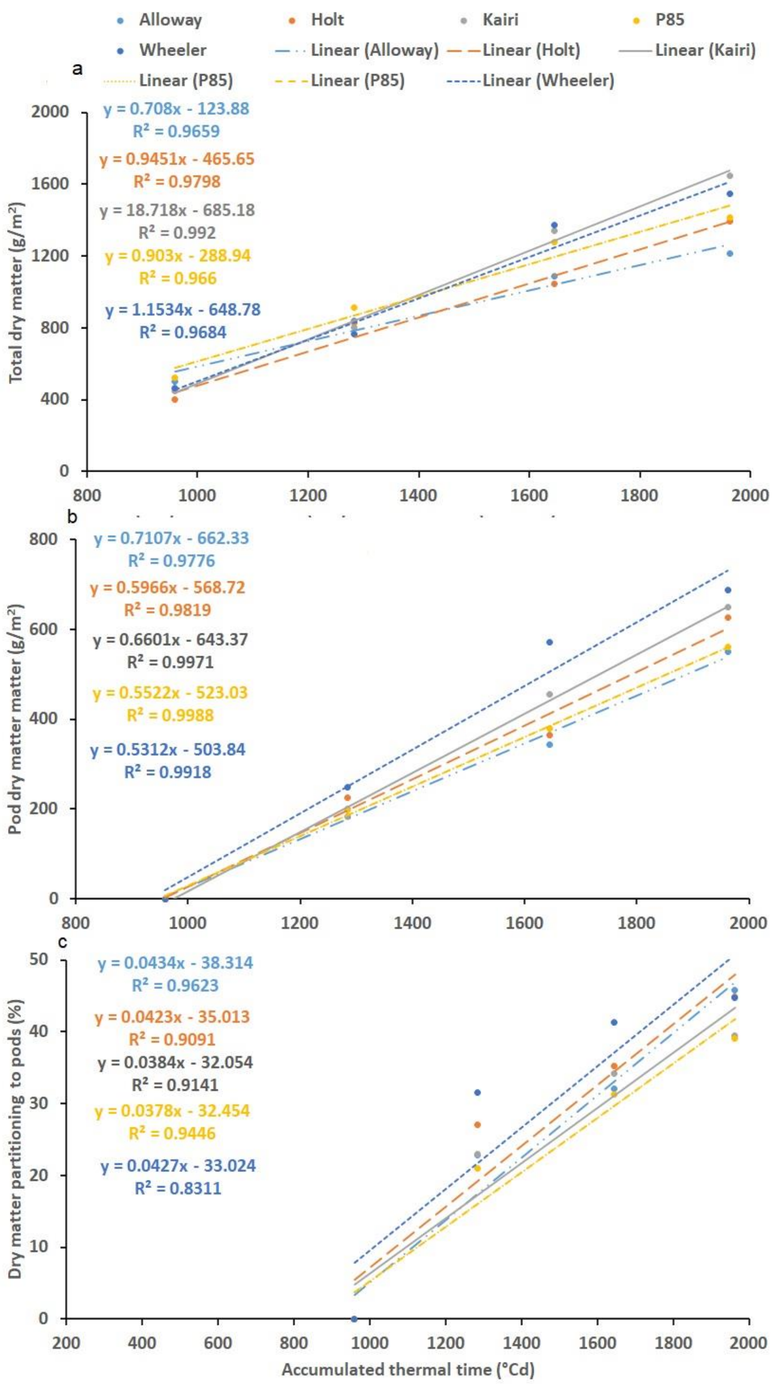


Fig. 10. Total dry matter (a) and pod dry matter (b) accumulation (g/m^2) and partitioning (c) between them at different thermal times from sowing in five different peanut varieties at Bundaberg, 2021-22.

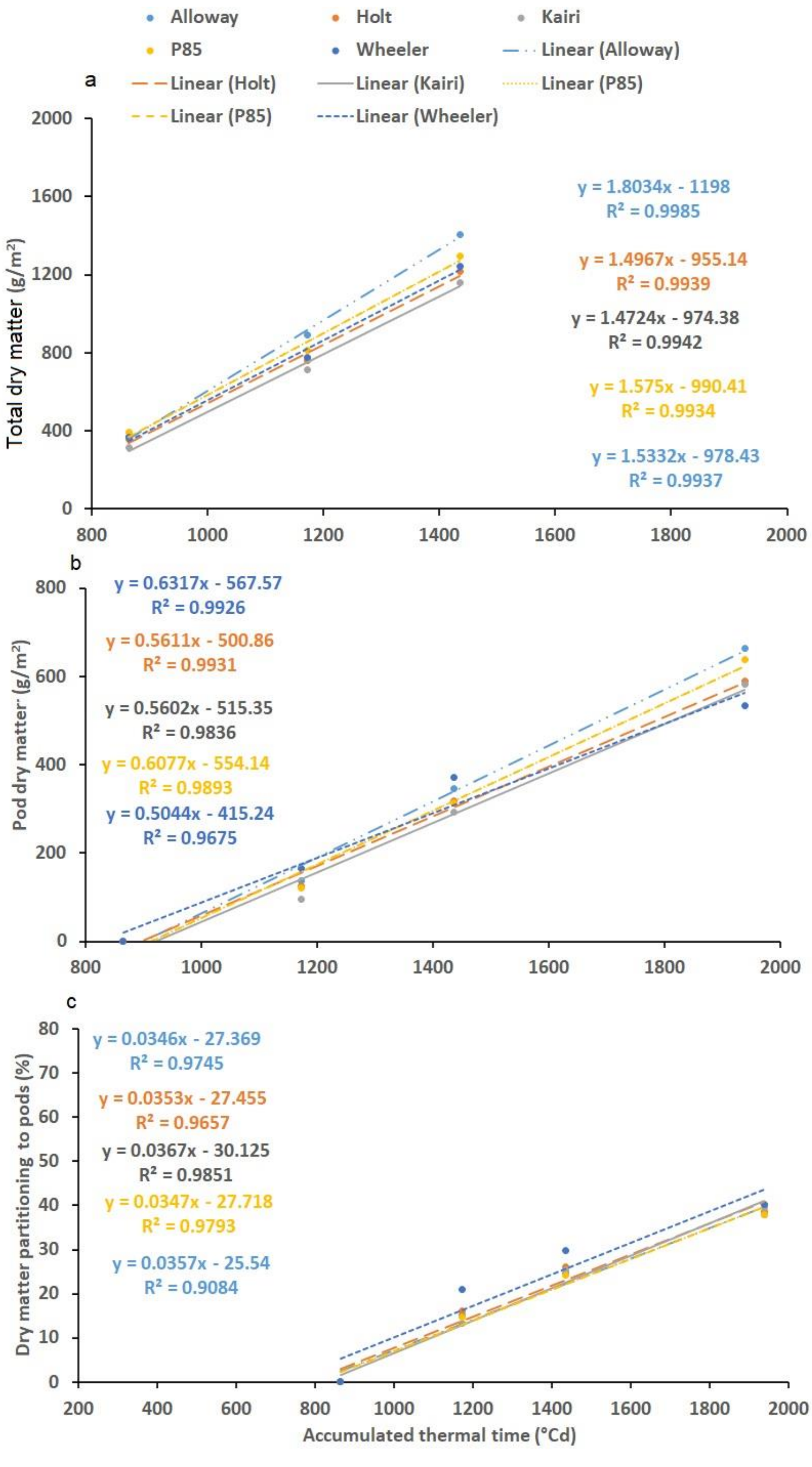


Fig. 11. Total dry matter (a) and pod dry matter (b) accumulation (g/m^2) and partitioning (c) between them at different times from sowing in five different peanut varieties at Kingaroy, 2021-22.

Disease development

There was an appreciable presence of leaf rust and late leaf spot at Bundaberg (Fig. 12). The foliar disease development was scored on a 1 to 9 scale at Bundaberg. There, rust and late leaf spots developed in the 5 to 7 scores on a 1 to 9 scale, with severity increasing with the score. The effects of plant population, variety and interaction between them were non-significant (data not shown).

Although rust development was not apparent at Kingaroy, the development of leaf spots and net blotch was severe (Fig. 13 & 14). We believe these effects could be well captured by Canopeo readings, as apparent by the significant correlation in the final yield and canopy cover reading (see next section).

Fig. 12**.** A view of disease incidence in the peanut experiment at Bundaberg on 6 May 2022

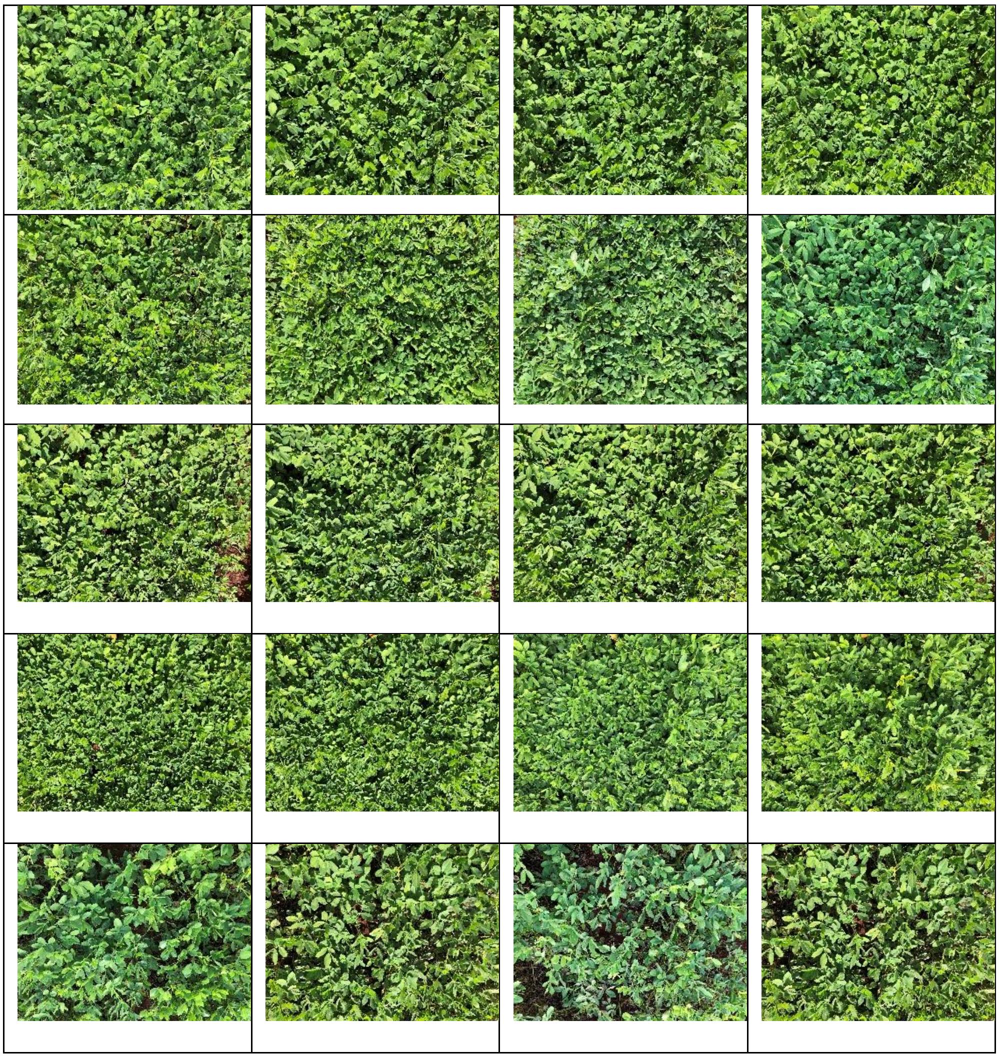


Fig. 13. Images of four plant populations x five varieties combinations at Kingaroy taken at 1 m height on 22 April 2022. The varieties in the image rows from top to bottom are Alloway, Holt, Kairi, P85 and Wheeler, and plant populations in columns from left to right are 6, 12, 18 and 24 plants/m^2.

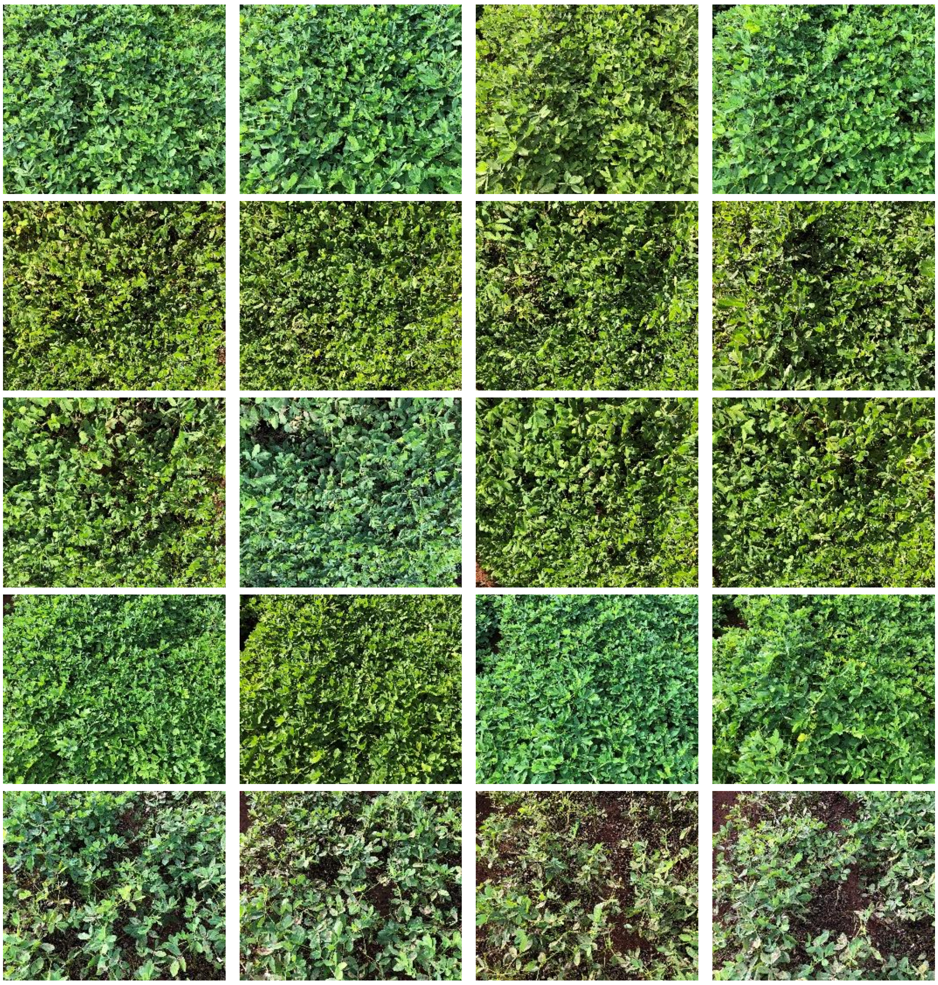


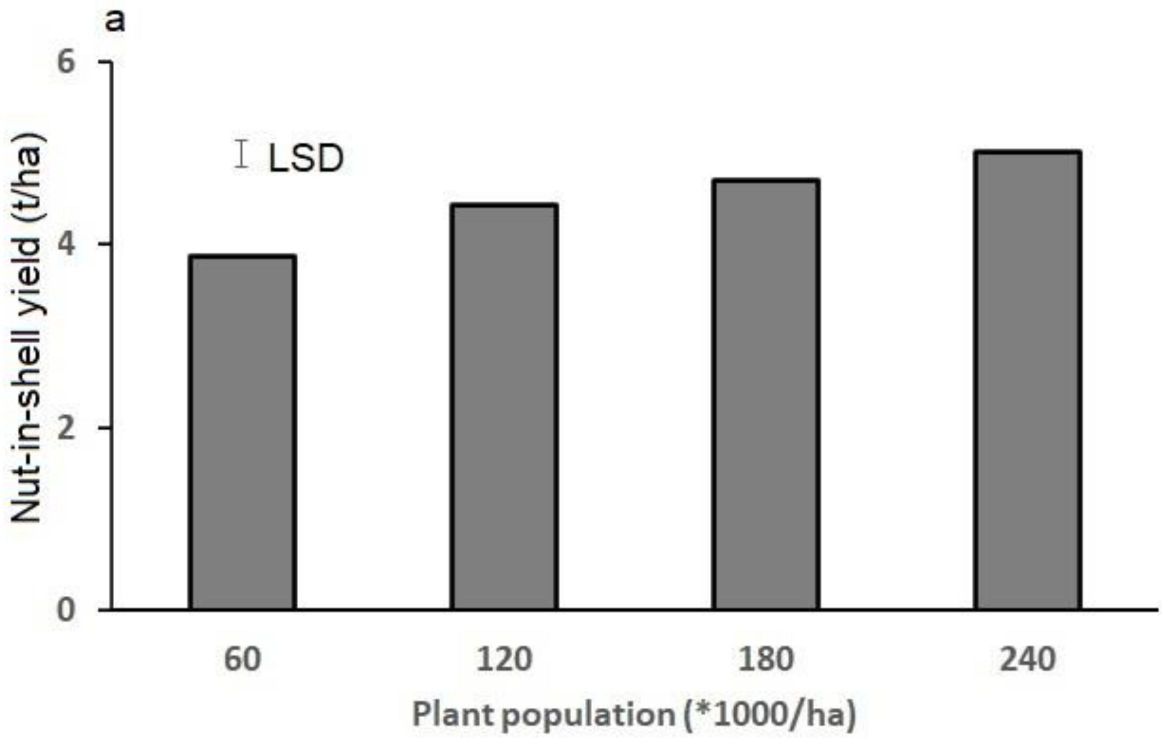
Fig. 14. Images of 4 plant populations x 5 variety combinations at Kingaroy taken at 1 m height on 4 May 2022. The individual varieties in the image rows from top to bottom are Alloway, Holt, Kairi, P85 and Wheeler, and plant populations in columns left to right are 6, 12, 18 and 24 plants/m^2.

Nut-in-shell yield

The average NIS (nut-in-shell) yield was 4.51 t/ha at Bundaberg and 3.66 t/ha at Kingaroy. At Bundaberg, the effect of plant population was highly significant, but the effect of variety and its interaction with plant population were not significant (Table 3). These NIS yields are consistent with the general commercial yields achieved in the respective regions. The NIS yield harvested at the highest population of 24 plants/m^2 was about 29% more compared to that at six plants/m^2 (Fig. 15a). NIS yield was positively and linearly related to the actual plant population ($r=0.55$, $p<0.05$).

Table 3. The coefficient of variation (CV%) and the significant effects of variety (V), plant population (P) and their interactions (V x P) in different yield and quality traits, including nut-in-shell (NIS) and quality traits at Bundaberg and Kingaroy.* significant at 5%, **, significant at 1% and NS, not significant.

	Bundaberg				Kingaroy			
Trait	CV%	V	P	V x P	CV%	V	P	V x P
NIS yield	8.4	NS	**	NS	16.9	**	NS	NS
Jumbo's %	12.7	**	**	**	7.9	**	NS	NS
One's %	24.1	**	NS	NS	17.7	**	NS	NS
Two's %	15.1	**	**	NS	23.6	**	*	NS
Splits %	19	**	**	NS	30	**	*	NS
MFG's %	20.6	**	**	NS	21.2	*	*	NS
Oil %	30.4	NS	**	*	35.3	**	NS	NS
Shell %	7.1	**	**	NS	12.8	**	NS	NS
Jumbo's t/ha	17.9	**	**	**	18.6	**	NS	NS
One's t/ha	29.5	**	NS	NS	40.0	**	NS	NS
Two's t/ha	16.6	**	NS	NS	34.5	NS	*	NS
Splits t/ha	25.1	*	**	NS	37.5	*	NS	NS
MFG's t/ha	17.7	**	NS	NS	29.3	**	NS	NS
Oils t/ha	23.4	NS	**	NS	33.3	**	NS	NS
GCV	13.8	NS	**	NS	17.9	**	NS	NS
$ /t	7.5	*	**	*	6.1	NS	NS	NS
Population	14.8	NS	**	*	19.1	NS	**	NS



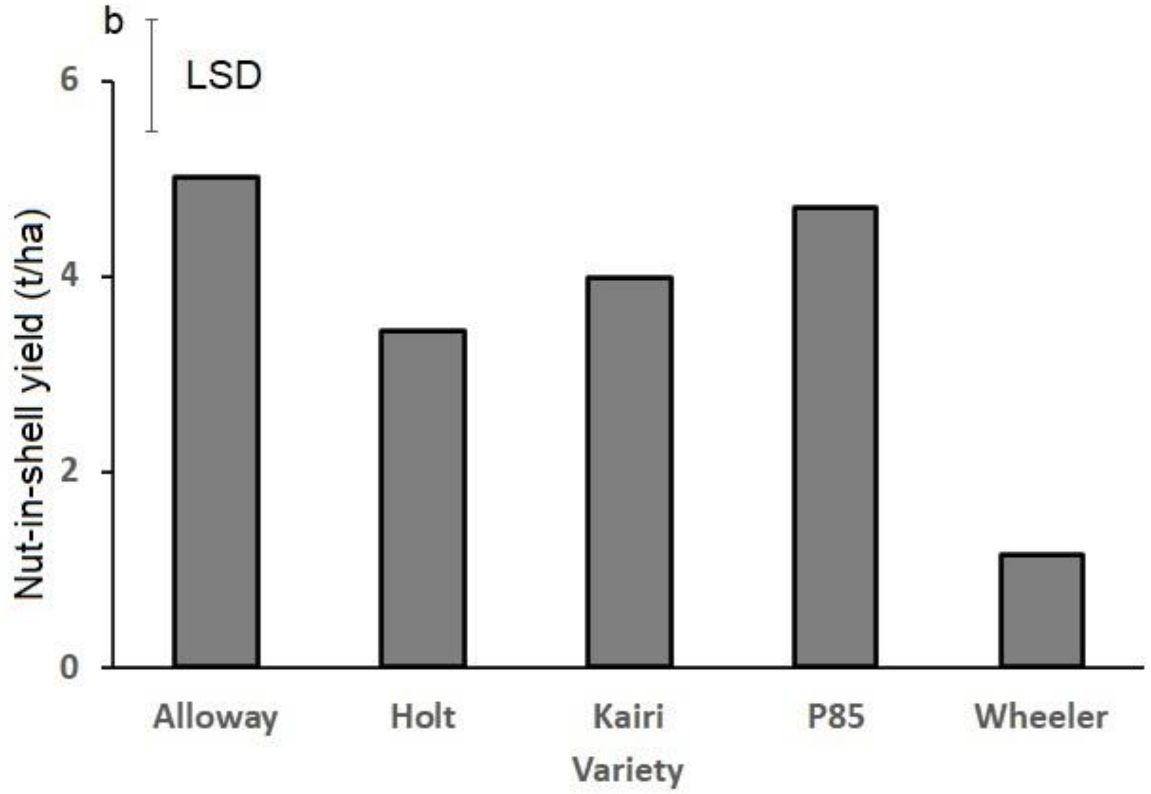


Fig. 15 Significant effects in nut-in-shell yield due to plant population at Bundaberg (a) and due to variety at Kingaroy (b), 2021-22.

At Kingaroy, varietal differences in NIS yield were significant, but the plant population and its interaction with variety was not significant (Table 2). Wheeler was the lowest yielding (1.15 t/ha), and Alloway was the highest yielding (5.01 t/ha) variety (Fig. 15 b). P85 was the next best (4.71 t/ha) yielding variety (Fig. 15b). Alloway was 46%, and P85 was 37% superior yielding compared to the check variety Holt.

At Kingaroy, the NIS yield in individual plots was significantly related to Canopeo readings from 87 DAS. The correlation between the canopy cover readings and NIS yield increased linearly from the first measurement day (Fig. 16).

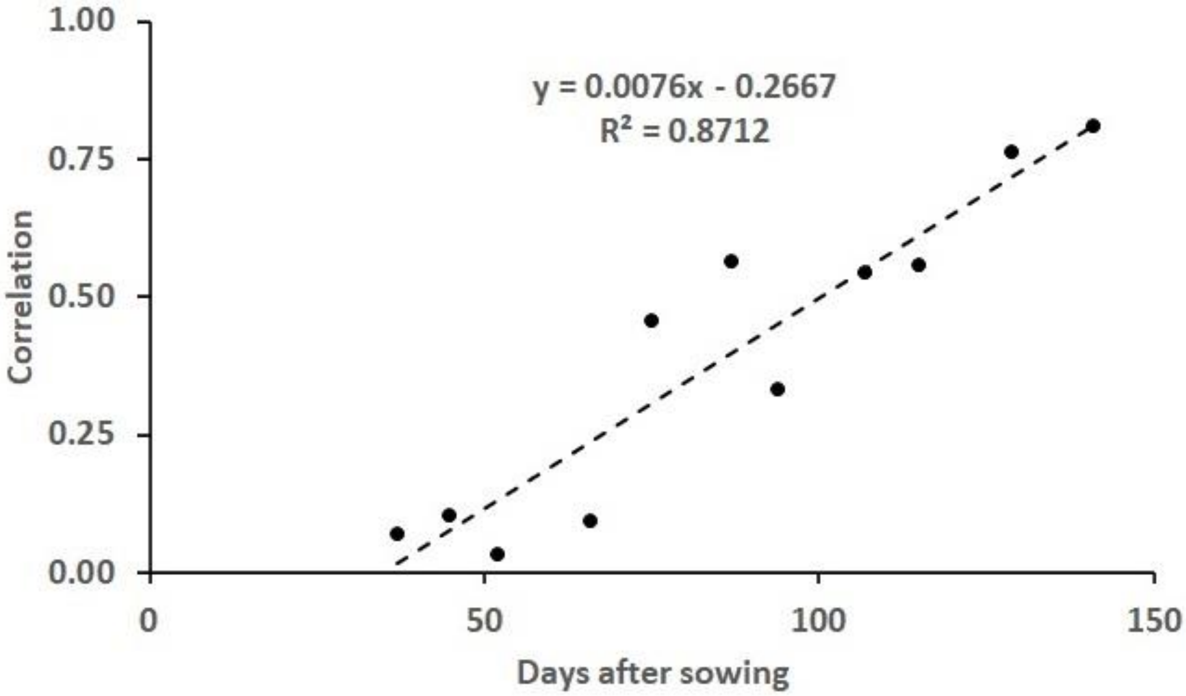


Fig. 16. Correlation between Canopeo readings at different times of measurements and NIS yield at Kingaroy, 2021-22.

Kernel quality

Nearly 68% and 71.2% of NIS yield at Bundaberg and Kingaroy, respectively, was of Kernels and the proportion was shells. The effects of plant population and variety on shell percentage were significant at Bundaberg, but only variety effects at Kingaroy (Table 3). At Kingaroy, NIS yield was lowest for Wheeler and Kairi, which were affected by leaf spot and net blotch diseases (results not shown). The interaction between variety and plant population was absent in both environments.

The effects of plant population, variety and their interaction on jumbo Kernels were significant at Bundaberg (Table 3, Fig. 17). However, at Kingaroy, only the variety effects were significant.

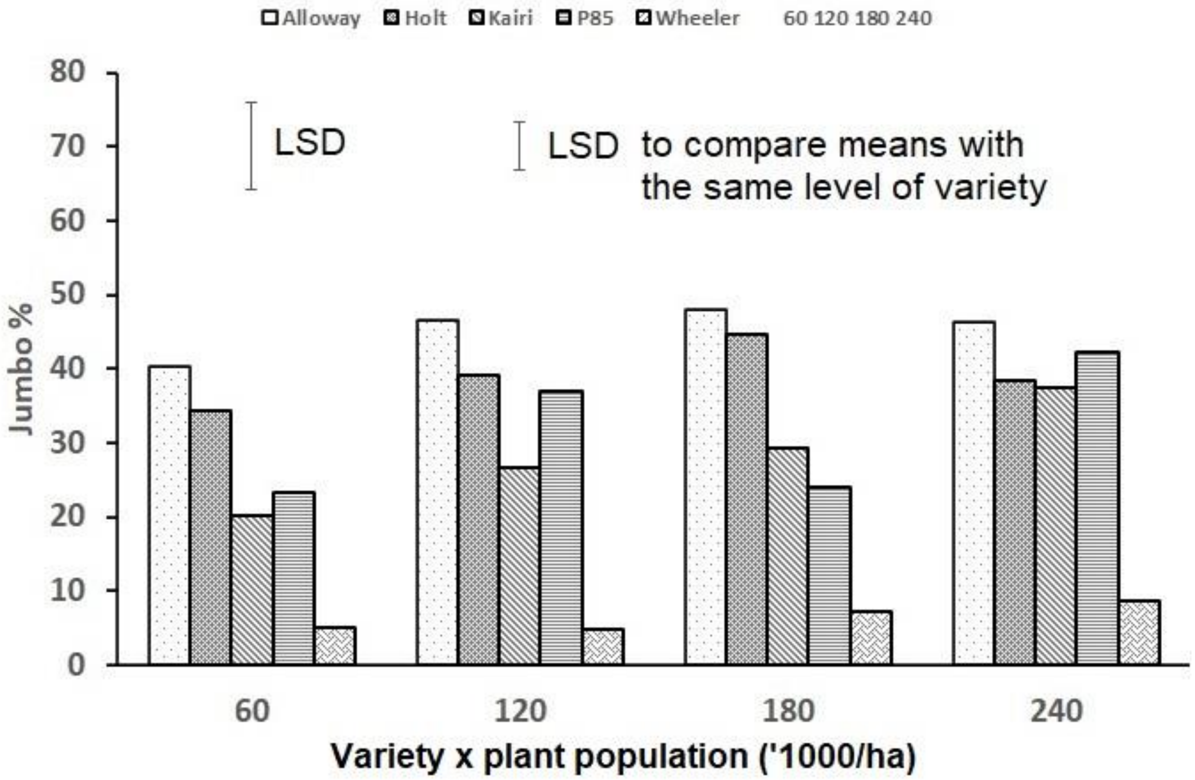


Fig. 17. Plant population x variety interaction in Jumbo kernels at Bundaberg, 2021-22

The effects on One's were largely due to variety, but twos, splits, and manufacturing grades were affected by both variety and plant population in both environments (Table 3). Conversion of grades in terms of per hectare values obtained by multiplying NIS yield affected significance to some extent as it was not the same as when the trait values were expressed on a percentage basis (Table 3). The GCV and Dollar/t, the two other economic indicators of quality, were significantly affected by plant population at Bundaberg (Fig. 18) but not at Kingaroy. At Kingaroy, only the varietal effect on GCV value was significant. It should be noted that at this location, while GCV was 9% lower, the $/ha realised were slightly higher (11%) as compared to at Bundaberg.

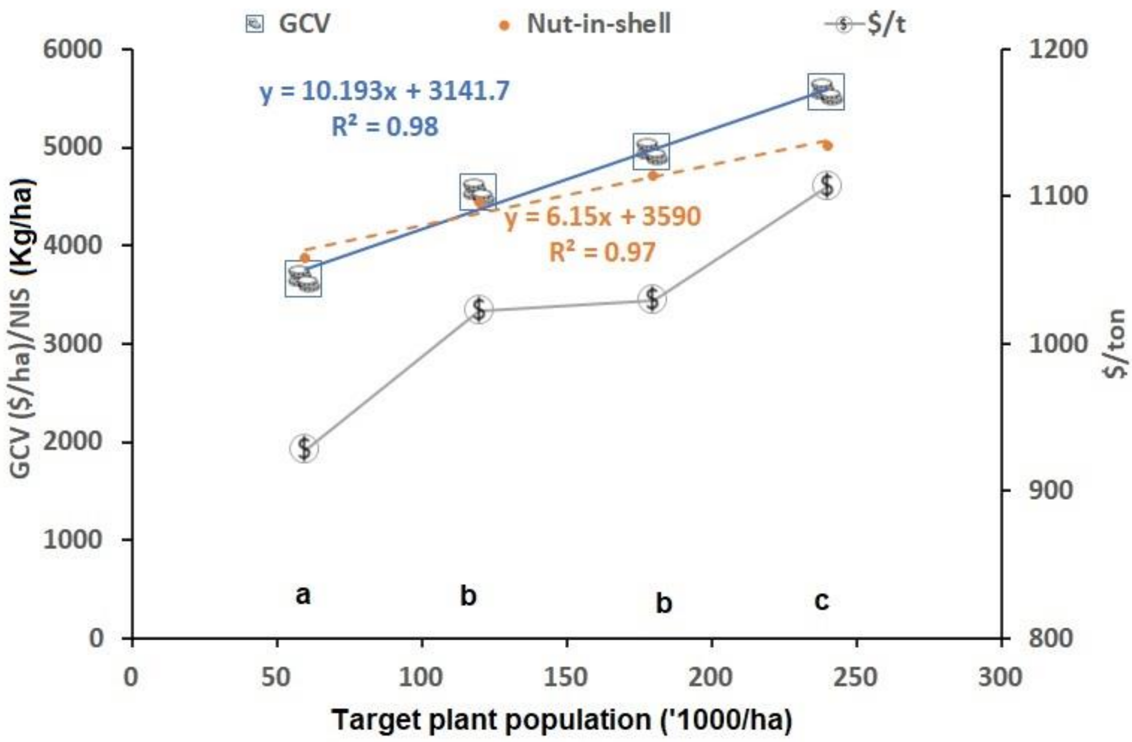


Fig. 18. Gross crop value ($/ha), nut-in-shell yield (Kg/ha) and $/t at Bundbaberg. For all three parameters values with the same letter (given parallel to x-axis) were not significantly different.

Discussion

This study provided an improved understanding of whether peanut yield and its quality can be increased by enhanced agronomic management in Bundaberg and Kingaroy environments. Despite the seasons in both locations being wetter than usual, creating disease pressure as wet soil conditions machine operations a bit more complicated, the NIS yield was representative of commercial yields in the respective environments.

Based on the 2021-22 season, the study showed that the NIS yield increased 7 to 29% by increasing the plant population from 6 to 24 plants/m^2 at Bundaberg. In a previous GRDC project on Grower Solution, yield response of up to 18 plants/m^2 was noted at this location. However, varietal differences were not significant, suggesting that increases in plant population could be the primary avenue for increasing NIS yield at this location. If we can verify this in the following season experiments, we could make plant population recommendations to growers.

The plant population effects were not significant at Kingaroy. Lack of response to plant population is consistent with a previous study at this location, albeit with shorter season varieties (Chauhan et al. 2022). Also, consistent with this earlier study, varietal differences contributed most to the observed NIS yield variability. The new varieties Alloway and P85 appeared 37 to 46% better yielding than the check variety Holt. Wheeler is particularly unsuitable for the Kingaroy environment due to its high susceptibility to the net blotch disease.

Different factors contributing to yield variability in the two environments were interesting, given that the rate of dry matter accumulation at the two locations was similar on a thermal time basis. Bundaberg climate was warmer with higher night temperatures compared to Kingaroy, which may increase radiation use efficiency (Bell et al. 1992) but decrease dry matter partitioning (Bell and Wright 1998b). Bell and Wright (1998a) noted a difference of 4 to 5% in the harvest index of peanuts grown at Kingaroy compared to Bundaberg. This effect may be mediated through the relationship between the photothermal quotient (PTQ) and harvest index (Bell and Wright 1998b). The Kingaroy climate was 4 degrees cooler, although it also had slightly lower radiation due to the unusually high number of overcast days.

The greater response to plant population in the Bundaberg environment needs further examination. Bell and Wright (1998a) indicated that plants respond to closer density in warmer tropical climates due to shorter duration resulting in smaller individual plant sizes. In our study, however, plant size at Bundaberg, where we got a bigger response to plant population, was not necessarily due to smaller plants as the crop accumulated more dry matter by maturity than at Kingaroy. One of the reasons could be the dynamics of flower production related to the plant population. Our study suggested that in Kingaroy and Bundaberg environments, the number of flowers produced at the lowest population was 2 to 4.7 folds more at Kingaroy and 0.9 to 3.2 folds more at Bundaberg than in the higher plant populations (Figs. 6 & 7).

Why should plants growing at lower density produce more flowers but still not yield higher? This hitherto unreported trend suggests that inter-plant competition could affect flower production. Likely, it may also affect the conversion of flowers into pegs and pods. This aspect needs further investigation as up to 29% higher NIS yield being achieved in Bundaberg due to higher plant population may justify the higher seed rate used by growers. Alternatively, more flowers being produced at a lower population in the Kingaroy environment could be converted into pods; it may improve gross margins as variable costs related to seed will be reduced. This response could also lead to this trait being used to develop higher-yielding peanut varieties. In the Kingaroy environment, the ratio of the total number of flowers produced between the lowest and highest population within each variety was negatively related to NIS yield variation. This may suggest that this trait could be of some physiological significance and therefore merits further investigation. No such relationship was evident at Bundaberg, where varietal differences in NIS yield were non-significant as the range of differences in the NIS and ratio were probably not large enough. There appeared to be some association between the maximum number of cumulative flowers in different plant populations and NIS yield at this location.

At Bundaberg, visual scores of disease development were not affected by variety and plant population or their interactions, nor was there any relationship with NIS yield. This observation may indicate that NIS differences due to plant population may not be due to differences in disease development under the different population treatments. One interesting observation related to varietal performance at Kingaroy was the significant relationship between canopy cover and NIS yield, which became closer as the crop grew. This software can capture the variation in leaf colour that a disease could cause or the extent of canopy cover due to inherent differnecs in varieties. This free-to-use software developed by Oklahoma State University, USA, could even be used by growers to assess crop performance in their fields. If the threshold for canopy cover could be determined for optimum yield, growers could strive to achieve it by plant population increase, irrigation, or fungicide sprays.

The other finding was that R-stage development was significantly related to thermal time. By plotting these scores against the accumulated thermal time, we could pick differences in the development rate of individual varieties. This relationship is important as being a subterranean crop, visual assessment pod stage development or hull-scrape method (Santos et al. 2019) is quite tedious and not practical in most circumstances. Further, with the slopes of R-stages, it should be possible to characterise the relative phenological development of different varieties. For example, the variety Wheeler had the fastest pod development and Alloway slowest (Fig. 5). These crop specific development coefficients will also be useful for improving crop model prediction.

In summary, the increase in plant population increased NIS yield at Bundaberg. It also increased the proportion of Jumbo peanuts and hence overall quality and GCV value (Fig. 18). The $/ha value also increased with an increase in plant population. These responses were consistent with the observations made on variety Kairi made in the 2017/18 trial at Bundaberg (https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2020/08/update-of-new-research-in-peanuts-to-assist-in-field-decision-making.). Even the decreases in the proportion of manufacturing and oil grade kernel were similar to that has been observed previously. The response to plant population at Kingaroy was marginal and only in the proportion of two's and splits which declined significantly with an increase in plant population while GCV and $/t were not impacted by plant population.

Extension activities

In view of Covid-19 scare, the digital platform was used to stay in touch with growers. Regular videos of trials were shared through vimeo.com website by Dan O' Conner of Peanut Company of Australia, partners in the project. The grower response to the videos was very positive with around 45% of 2021/22 growers viewing each update. The updates gave an overview of the project, the collaborators involved and viewing of the experimental sites. Please follow the links given below for the videos at Kingaroy and Bundaberg. A further video will be provided to growers and the industry to summarise the results for 2021-22, and the plans for the 2022-23 trial program. Peanut Company of Australia representatives were also able to provide a face-to-face update on the trial at grower meetings in July 2022. Meetings were held at Kingaroy, Bundaberg and Atherton and were well attended, with up 40 growers at each meeting. Overall, there is good feedback from growers on the project, and they look forward to improving agronomic practices to improve crop yield and quality.

Video 1

GRDC DAF Population Kingaroy

https://vimeo.com/681145594

January 2022

66 grower views

Video 2

GRDC DAF Population Childers

https://vimeo.com/697610411

March 2022

64 grower views

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