Update of new research in peanuts to assist in-field decision making

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peanut, Kairiⓓ, plant population, row configuration, nutrient management, rotations

GRDC code

DAQ00204

Take home message

- Target plant populations of 180,000 plants/ha to improve the productivity and profitability of peanut variety Kairiⓓ
- Peanut variety Kairiⓓ does not need a different nutrient management plan than current commercial varieties.

Introduction

Grain legume rotations are an essential component of sustainable sugarcane farming systems of the Coastal Burnett. Research conducted by the Sugar Yield Decline Joint Venture (SYDJV) demonstrated a 20% yield improvement in sugarcane productivity by breaking the monoculture with a legume crop. Factors such as the close proximity of Bundaberg and Childers to Kingaroy; access to irrigation water to ensure cropping reliability; depressed sugarcane prices and grower adoption of SYDJV recommendations to include legumes in the farming system has seen an expansion of peanut production in the Coastal Burnett. In the years 2010 – 2020, 52,584 tonnes of peanuts were grown in the Coastal Burnett and delivered to the Peanut Company of Australia, representing $46,331,102 in gross crop value being fed back into the economies of the Bundaberg, Childers and to a lesser extent, Maryborough farming communities.

Peanuts are viewed as a 'high input' crop requiring irrigation of up to 50 mm/week, regular fungicide applications (8 or more per crop) and soil sampling to apply the correct ameliorants to maximise productivity. The high reliance on protective fungicide applications in a high rainfall environment can be problematic in La Niña years, when access to the paddock can be limited by high rainfall. The National Peanut Improvement Program has improved foliar disease resistance traits as a major foci in the breeding program. Kairiⓓ (previously D281-p40-236A) has high foliar disease resistance to rust.

Initial field trials conducted by DAQ00184 and DAQ00204 highlighted the superior rust resistance of Kairiⓓ over Holtⓓ with the relative disease score ratings highlighted in Figures 1 and 2 for Kairiⓓ and Holtⓓ respectively.

Treatments detailed in Figures 1 and 2, are labelled as follows:

ES= early start to fungicide (four weeks after sowing) program. LS= late start (eight weeks after sowing) of fungicide program. 14 DBS= there were 14 days between fungicide sprays. (21 DBS = 21 day spray intervals). Commercial means Initial fungicide application four weeks after sowing with sprays on a 10-14 day basis with two Bravo® sprays replaced by Amistar Xtra® and ES + Monitor = early start then re-initiate spray program once disease is detected. Please note that the fungicide applied in all treatments was Bravo Weather Stick® with the exception of the 'Commercial' treatment where two of the Bravo® applications were swapped out with Amistar Xtra®

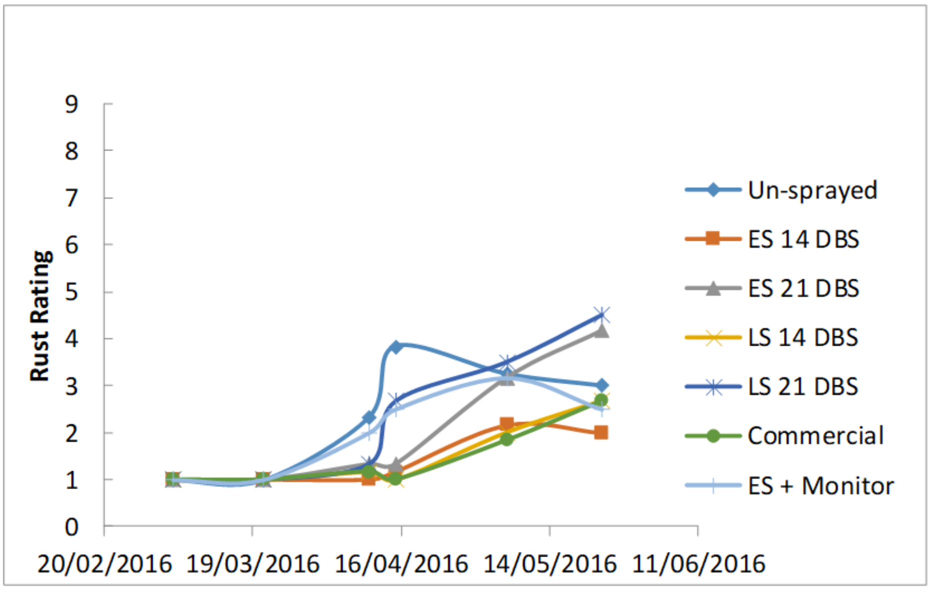

Figure 1. The impact of fungicide application strategy on the incidence of rust (*Puccinia arachidis*) on peanut variety Kairi⁽ᵇ. (Rust rating where 0 = no evidence of disease 9 = complete infection resulting in defoliation)

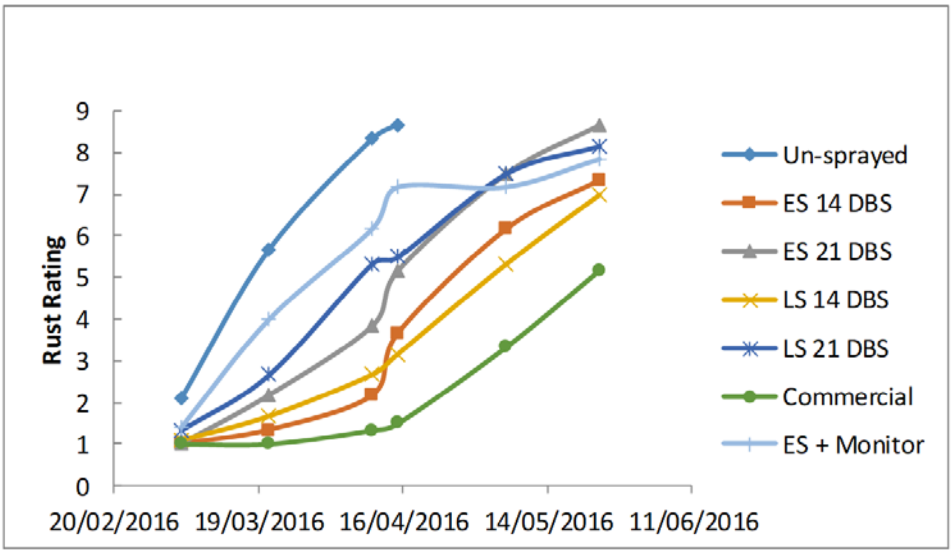

Figure 2. The impact of fungicide application strategy on the incidence of rust (*Puccinia arachidis*) on peanut variety Holt⁽ᵇ. (Rust rating where 0 = no evidence of disease 9 = complete infection resulting in defoliation)

To better illustrate the foliar disease resistance of Kairi⁽ᵇ to leaf rust, Figures 3 and 4 are pictures from the late start (eight weeks after planting) and 21 days between fungicide application treatment for Kairi⁽ᵇ and Holt⁽ᵇ plots respectively. This high resistance to rust resulted in a 44.8% increase in productivity of Kairi⁽ᵇ over Holt⁽ᵇ in this fungicide application timing experiment.

Figure 3. Leaf canopy in the Late start, 21 days between sprays treatment in variety Kairi

Figure 4. Leaf canopy in the Late start, 21 days between sprays treatment in variety Holt

The soil at the end of a cane cycle (plant cane crop and three ratoons) typically is acidic and low in potassium and nitrate nitrogen. It is not uncommon for the application of 2t/ha of lime and a basal fertiliser containing 30kgN/ha, 20kgP/ha and 100kgK/ha incorporated pre-plant for peanut production in the Coastal Burnett. Natural gypsum at 1t/ha and foliar applications of boron, zinc and magnesium are generally applied in-crop.

Peanuts are unique in that the calcium and boron needed for kernel development is absorbed through the pod wall, necessitating the pod zone to have adequate calcium and boron levels. Figure 5 is a drawing of a peanut bush demonstrating above and below-ground components.

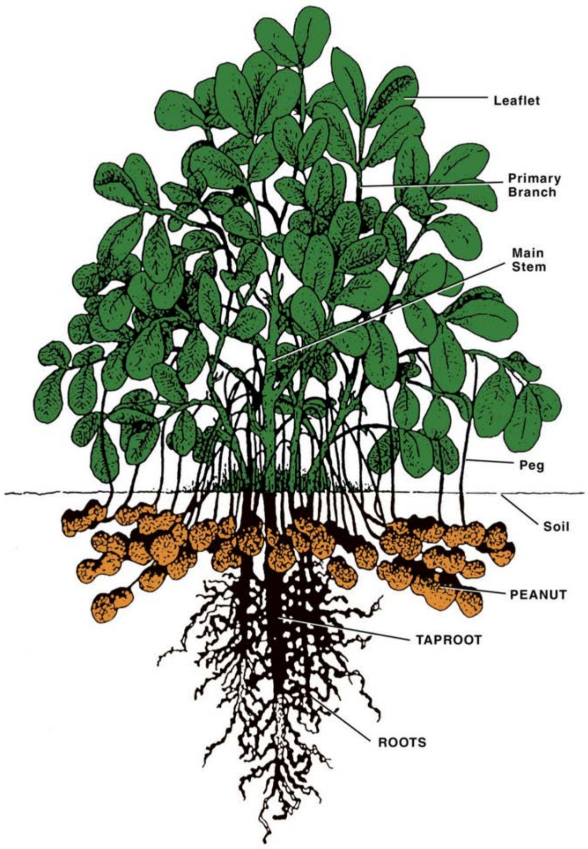

Figure 5. Drawing of a peanut plant structure

Grower experience of Kairi⏀ on release was marred with poor grades and yields not meeting grower expectation. The Coastal Burnett Regional committee of the GRDC Growers Solution Project for Coastal/Hinterland Queensland and NSW North Coast project identified and prioritised field trials to evaluate strategies to maximise the productivity of Kairi⏀.

To provide information for growers a number of field trials were established over 17/18 and 18/19 growing seasons.

Materials and methods

This paper focuses on three field trials conducted over two years.

The first field trial was established in the 2017/18 peanut season a factorial trial of two populations (120,000 and 240,000 plants/ha), by two row configurations (single or twin rows), by three nutrition regimes (standard practice, extra Ca & B, and extra nutrition based on commercial agronomic lab 'Hortus' recommendations). Treatments were replicated four times in a randomised complete block (RCB) design. The trial was planted on 10/10/17. The Hortus treatment was a flexible nutrition program based on petiole sap tests. Please note that the 'single' row configuration refers to two rows 85cm apart on a 1.8m bed; whereas the 'twin' row configuration refers to four rows planted on the 1.8m bed, with the outside-most rows being 85cm apart with a 36cm gap between the innermost rows as in Figure 6. All plots received the standard fertiliser application (listed below) and the soil was conventionally tilled and beds were formed. The plots were three beds wide by 25m length. The soil type was a yellow dermosol (sandy-loam top soil, over a light clay sandy loam) in the Farnsfield district south of Bundaberg.

Figure 6. Twin row configuration in the background and single row configuration in the foreground

The standard fertiliser recommendations were to apply sufficient lime to push the pH up to 6.5 (~4 t lime/ha); 20 kgN/ha; 18 kgP/ha; 97 kgK/ha; 5 kgS/ha. There were also in-crop additions of manganese and boron. The extra Ca & B treatment had an extra tonne of gypsum applied pre-flowering and boron as Solubur® @ 2 kg/ha. The crop was irrigated with a high pressure travelling irrigator and weeds and foliar diseases (mainly late leaf spot) were controlled with herbicides and fungicides respectively.

The crop was dug on 20/3/18 (161 DAP), a yield quadrat of 14.4m^2 was marked out of each plot. The crop was field dried for about seven days. The yield samples were then threshed using a 'KEW' self-propelled small-plot thresher with the pods collected in labelled hessian bags that were placed into a tobacco barn with only the fan running. The yields and grades were determined by the method outlined below.

The data was analysed by ANOVA for an RCB design with a factorial treatment structure using the Genstat® computer package version 16.1. Pairwise testing of means was conducted using a protected LSD test at P=0.05.

The second field trial was implemented in the following 2018/19 season. The trial design was changed to a randomised complete block consisting of eight replicate blocks each with eight plots randomly allocated to two row configurations (single or twin) by four target populations (60,000, 120,000, 180,000, or 240,000 plants per hectare) See Table 1. The trial was planted on the 4th October 2018.

Table 1. The treatment list for the Kairi population by row configuration field trial (second field trial)

Treatment #	Target population (Plants/ha)	Row configuration
1	60,000	Single
2	60,000	Twin
3	120,000	Single
4	120,000	Twin
5	180,000	Single
6	180,000	Twin
7	240,000	Single
8	240,000	Twin

The trial was established on a sandy-loam soil (yellow dermosol) at Farnsfield. The previous cane crop was harvested and trash baled prior to the cane stool being removed with conventional tillage. At least one month prior to planting, 4t lime/ha was applied to correct soil pH and ensure an adequate soil calcium status. A fertiliser blend containing 20kgP, 30kgN and 100kgK/ha was broadcast and incorporated with a rotary hoe prior to 1.8m beds being formed.

The peanuts were planted using a 'Monosem™' vacuum plate planter. The seeding rate was electronically altered at each plot. The rate of seed supplied was calibrated to allow for 90% germination and 90% establishment. The planting furrow was opened with a double disc opener and then rhizobia inoculant (Group P) as a peat slurry was water injected onto the seed in the planting furrow.

Each plot was 30m long and three cane rows wide. The site was kept weed-free with combinations of pre and post emergent herbicides (Dual Gold®, Flame®, Blazer®, Verdict® and 2,4 – DB) applied at registered rates. Fungal pathogens such as white mould and late leaf spot were controlled with prophylactic applications of registered fungicides. The crop was grown using supplementary irrigation supplied via a low-pressure over-head centre pivot that delivered approx. 30mm every 7 to 10 days.

The crop was dug on 12/3/19 (160 days after planting (DAP)), the crop was then field dried for about seven days. A yield quadrat of 14.4m^2 was marked out of each plot and threshed using a 'KEW' self-propelled small-plot thresher. Pods were collected in labelled hessian bags that were placed into a tobacco barn with only the fan running. The yields and grades were evaluated with the method outlined below.

Actual plant populations were estimated from plant counts. Populations were variable and did not reflect the target populations. As a result, measured plant populations were considered as a continuous variable in the analysis rather than using the categorical target populations.

A linear fixed model was fitted to the data with fixed effects of row configuration (Rows-factor) and the continuous variable of actual plant population and interactions between these terms. Where there was evidence of curvature across population, a quadratic fit was applied to the population variable. Replicate block was fitted as a random effect. A parsimonious model was achieved by sequentially removing non-significant terms from that model but always retaining the main effects terms, including the linear population term.

Data were analysed using GenStat 19th edition (VSN International, 2015) Significance tests were performed using a LSD at 5% level.

The <u>third</u> field trial came about because agribusinesses were approaching peanut growers offering a range of calcium products as an alternative to gypsum. A trial was implemented at the request of the growers to determine the efficacy of these alternative products. The experiment design was a randomised complete block consisting of 10 replicate blocks each with four treatments randomly allocated; see Table 2. The trial was co-located beside the Kairi⦶ population by row configuration experiment and was established on 2/11/18.

Table 2. The treatment list for the 'Kairi⦶' population by row configuration field trials

Treatment #	Calcium fertilisation strategy
1	Nil
2	Natural gypsum (1t/ha)
3	Micro-fine prilled gypsum (200kg/ha)
4	Liquid gypsum (20L/ha)

The peanuts were planted using a 'Monoson™' vacuum plate planter. The planter was calibrated to establish 180,000 plants/ha. The planting furrow was opened with a double disc opener and then rhizobia inoculant (Group P) as a peat slurry was water injected onto the seed in the planting furrow.

Each plot was 30m long and three cane rows wide. The various calcium treatments were applied on 12/12/19 (40 DAP). Product for each plot (natural and fine-prilled gypsum) were weighed out for each individual row and were applied by hand. The liquid gypsum was applied by a three-point linkage mounted spray rig using 'twin cap' 02 'Drift Guard' nozzles calibrated to supply 280L water volume/ha.

The site was kept weed-free with combinations of pre and post emergent herbicides (Dual Gold®, Flame®, Blazer®, Verdict® and 2,4 – DB) applied at registered rates. Fungal pathogens such as white mould and late leaf spot were controlled with prophylactic applications of registered fungicides. The crop was grown using supplementary irrigation supplied via a low-pressure over-head centre pivot that delivered approx. 30mm every 7 to 10 days.

The crop was dug on 4/4/19 (154 DAP). A yield quadrat of 14.4m^2 was marked out of each plot. Yields and grades were determined by the method outlined below

The kernels from the grading sample were then processed in a food blender and passed through a 2mm sieve. Samples were sent to Queensland Department of Environment and Science – Chemistry Centre in Brisbane to determine treatment effect on kernel calcium concentration using Plant Elements nitric microwave digest ICP technique.

Treatment effect of measured parameters were determined via ANOVA using Genstat 19th edition (VSN International, 2015) Significance tests were performed using a 'Fischer Protected LSD' at 5% level.

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 1,000g 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 percent of each grade was determined by dividing the weight of each grade (in grams) by the original 1,000g sample. Shell percentage was determined by the difference of the sum of all the grades from the original 1,000g sample. Gross crop value was calculated from the 2017 peanut supply contract for runner peanuts at: $1,650/t for J's; $1,500/t for 1's; $1,300/t for 2's; $1,200/t for splits; $450/t for MFG; $150/t for oil's. Gross margins were calculated using the Farm Economic Analysis Tool (FEAT) and PCA indicative gross margin; with individual plot yield, grade and seed and fertiliser inputs accounted for.

Results and discussion

Results from the first field trial, demonstrated that Kairi did not have a different nutritional requirement to that of Holt as there was no difference in yield or grade (or any other measured parameter) between the standard, extra calcium and boron or the 'Hortus' treatment. Similarly, row configuration offered no yield improvements.

However, increasing the target population from 120,000 plants/ha to 240,000 plants/ha significantly (P=0.002) improved nut-in-shell yield by 6%. More importantly, increasing the population significantly increased the percentage of high value 'Jumbo' kernels and decreased the percentage of worthless shells. The combination of improved yield and grade offered by the higher population significantly increased gross crop value by $754/ha; representing a 13% improvement. Peanut seed is expensive, so increasing population means increased input costs. To account for these variables a crop gross margin was calculated and statistically analysed. Increased planting population significantly (P=0.010) improved gross margin by $515/ha. This increase is gross margin means that the 240,000 plant/ha treatment had a 24% higher gross margin than the 120,000 plants/ha treatment. There were no treatment interactions, see Table 3.

Table 3. The effect of population, row configuration and nutrition on peanut productivity, grade-out, gross crop value, payment price and gross margin. Means within a column not followed by a common letter are statistically different (P=0.05).

	NIS (t/ha)	J's (%)	1's (%)	2's (%)	Split (%)	MFG (%)	Oil (%)	Shell (%)	GCV ($/ha)	$/t	Gross Margin ($/ha)
Population (P)											
120K	6.72 ^{b}	41 ^{b}	3 ^{a}	6	9 ^{b}	4 ^{a}	6 ^{a}	32 ^{a}	5,840 ^{b}	866.3 ^{b}	2,128 ^{b}
240K	7.19 ^{a}	45 ^{a}	2 ^{b}	5	10 ^{a}	3 ^{b}	5 ^{b}	30 ^{b}	6,594 ^{a}	917.1 ^{a}	2,643 ^{a}
P value	0.002	0.010	0.048	0.057	0.024	0.011	0.024	0.004	<0.001	0.003	0.010
LSD	0.28	2.8	0.4	-	1.2	0.7	0.1	1.2	384	31.8	383.7
Row Config (R)											
Single	7.03	43	3	5	9	3	5	31	6,306	894.0	2,428
Twin	6.88	43	3	5	10	3	5	31	6,128	889.4	2,344
P value	0.262	0.852	0.440	0.731	0.752	0.797	0.319	0.708	0.351	0.771	0.657
Nutrition (N)											
Std	6.98	43	3	5	10	3	5	31	6,201	887.3	2,521
Extra Ca&B	6.92	44	3	5	10	3	5	30	6,258	902.3	2,308
Hortus	6.96	43	3	5	9	3	5	31	6,192	885.5	2,328
P value	0.947	0.704	0.849	0.924	0.943	0.392	0.841	0.668	0.953	0.633	0.602
Interaction P values											
P * R	0.712	0.350	0.254	0.722	0.519	0.756	0.481	0.097	0.348	0.242	0.565
P * N	0.956	0.302	0.180	0.393	0.724	0.156	0.394	0.855	0.735	0.432	0.942
R * N	0.857	0.584	0.488	0.572	0.567	0.409	0.766	0.795	0.841	0.905	0.964
P * R * N	0.302	0.907	0.434	0.968	0.577	0.416	0.952	0.693	0.702	0.903	0.880

Poor seed quality and potential planter calibration issues resulted in the target populations not being achieved in the second field trial.

However, there was a significant effect of population on nut-in-shell yield, with an established population of 180,000 plants/ha having the highest yield of 6.16t/ha. This yield was nearly 50% better than the lowest population and 7% higher than the yield at 150,000 plants/ha. This is an important finding as current recommendations for the industry standard variety Holt⒫ is to establish 150,000 plants/ha, see Figure 7.

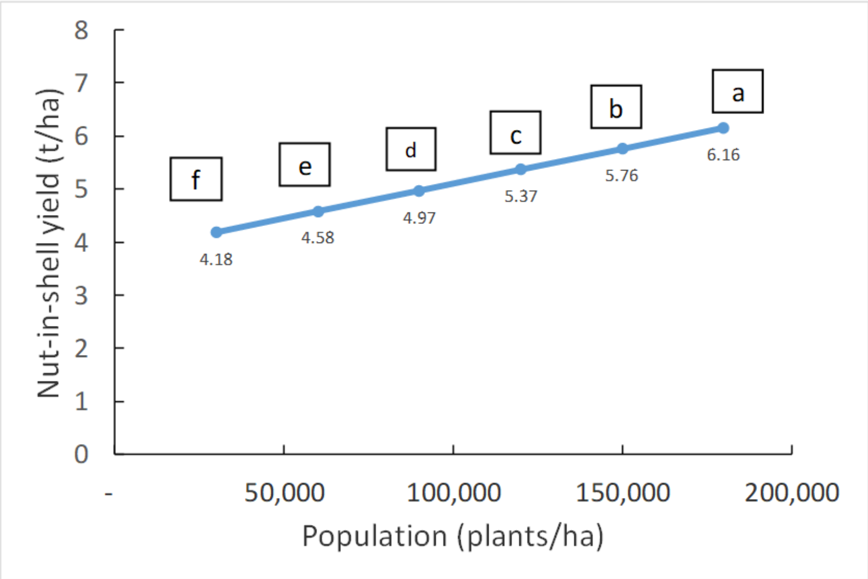

Figure 7. Population effect on nut-in-shell yield of peanut variety 'Kairi⒫' for the second field trial 2018/19. Data points with the same letter are not statistically different (P=0.05)

Importantly, population had a significant effect on grades. The payment price to a grower depends on the crop grade (or quality), with jumbo kernels (Figure 8) being the most valuable, oil grade kernels the least valuable and shells worthless (Figure 9).

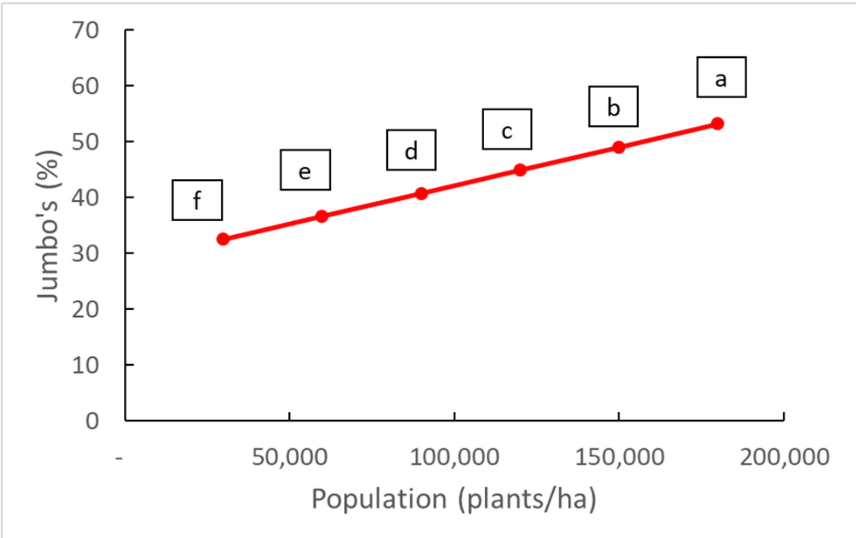

Figure 8. Population effect on Jumbo grade peanuts for variety 'Kairi⒫' in the second field trial. Data points with the same letter are not statistically different (P=0.05)

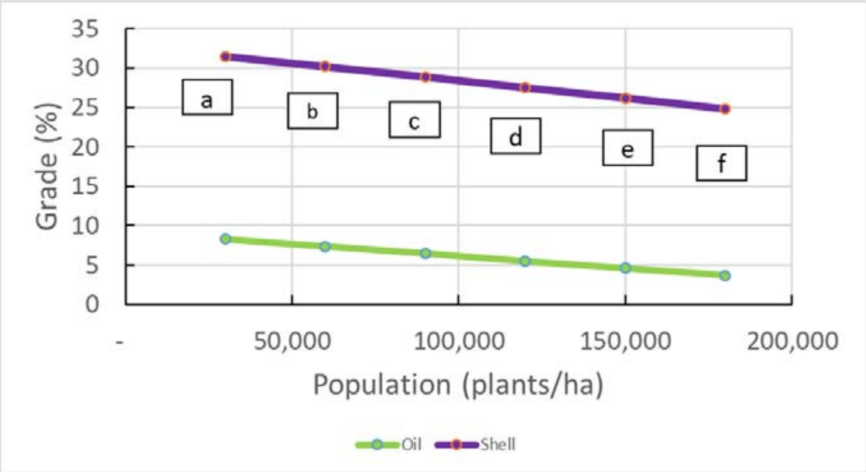

Figure 9. Population effect on oil grade kernels and shell percentage for peanut variety 'Kairi⁽ᴰ⁾' in the second field trial. Data points with the same letter are not statistically different (P=0.05)

Grades are a measure of crop quality and growers are paid accordingly on a $/t basis. The improvement in jumbo's and reduction in oil's and shell's results in a payment price of $1,014/t for the highest population which is $41/t and $82/t more than the 150,000 plants/ha and 120,000 plants/ha respectively. The 180,000 plants/ha treatment had the highest gross crop value of $6,167/ha. This value is $555/ha and $1,109/ha more than the 150,000 plants/ha and 120,000 plants/ha treatments respectively (Table 4).

Table 4. Population effect on payment price and gross crop value.
Values in columns with the same letter are NOT statistically different (P=0.05).

Population	Payment price ($/t)	Gross crop value ($/ha)
30,000	809 [f]	3,395 [f]
60,000	850 [e]	3,949 [e]
90,000	891 [d]	4,503 [d]
120,000	932 [c]	5,058 [c]
150,000	973 [b]	5,612 [b]
180,000	1,014 [a]	6,167 [a]
P Value	<0.001	<0.001
LSD (P=0.05)	463	45

Please Note: Gross crop value (GCV) is an economic measure that is a multiplication of the yield by payment price. Please do not confuse GCV with a crop gross margin, as a GCV does not take into consideration the extra cost of seed for the different treatments.

The twin-row configuration did not offer any improvement in yield or grade. Commercially the twin-row configuration would require capital investment into different planters or planting the paddock twice; these data would suggest that such investment is not warranted.

The third field trail demonstrated that there were no calcium fertilisation treatment effects on peanut yield (P=0.127). The commercial practice of applying gypsum in-crop resulted in a yield of

5.11t/ha which was not different to the control (5.07t/ha) where no gypsum was applied, see Figure 10.

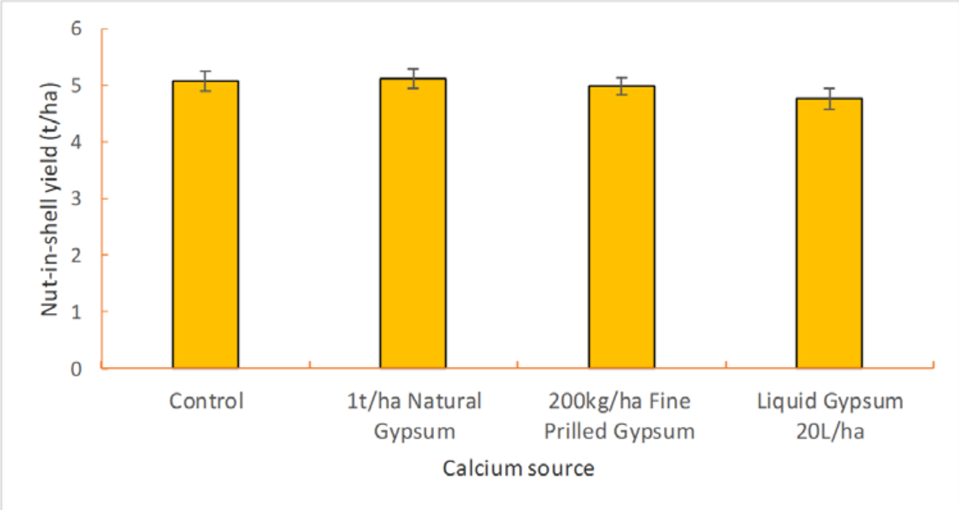

Figure 10. The effect of in-crop calcium fertilisation strategy on peanut variety 'Kairi⁽ᐟ⁾' yield. *Error bars are +/- standard error of treatment mean.*

From a kernel quality perspective, there was no effect of in-crop calcium fertilisation strategy on the percentage of the high value jumbo kernels (P=0.245); the low value oil grade kernels (P=0.114) or the worthless shell percentage (P=0.471) (data not shown).

Due to the lack of treatment effect on yield and/or grade there were no statistically significant calcium fertilisation effects on gross crop value (GCV) or payment price, refer to Table 5.

Table 5. The effect of in-crop calcium fertilisation strategy on gross crop value and payment price.

Treatment #	Gross crop value ($/ha)	Payment price ($/t)
Nil	4,569	899
Natural gypsum (1t/ha)	4,651	904
Micro-fine prilled gypsum (200kg/ha)	4,357	870
Liquid gypsum (20L/ha)	4,095	851
P Value	0.100	0.326
LSD (P=0.05)	-	-

Whilst in-crop calcium fertilisation strategies failed to have an impact on yield, grade and ultimately GCV, there was an effect on kernel calcium status. The application of natural gypsum at 1t/ha significantly increased the kernel calcium concentration by 31% over the control treatment. However, there was no evidence that the application of the micro-fine prilled product or the liquid product had an effect on kernel calcium concentrations applied at the rates used in this experiment.

The range of calcium treatments had some interesting interactions on some other kernel cation concentrations. For example, the kernels in the liquid gypsum treatment had very similar calcium, magnesium and sodium concentrations to the control. However, the application of gypsum at 1t/ha significantly improved kernel calcium status yet significantly reduced kernel magnesium and sodium concentrations relative to the control. Whilst the micro-fine prilled gypsum treatment did not have an effect on the kernel calcium concentrations, it did have significantly lower magnesium and sodium kernel concentrations relative to the control (Table 6). These findings could be of interest if there is a market for peanuts with increased calcium levels.

Table 6. The effect of in-crop calcium fertilisation strategy on peanut calcium, magnesium and sodium concentrations.
Values in columns followed by the same letter are NOT statistically different (P=0.05)

Treatment #	**Calcium %**	**Magnesium %**	**Sodium %**
Nil	0.0456 [b]	0.1739 [a]	0.0326 [a]
Natural gypsum (1t/ha)	0.0599 [a]	0.1589 [b]	0.0220 [c]
Micro-fine prilled gypsum (200kg/ha)	0.0467 [b]	0.1605 [b]	0.0289 [b]
Liquid gypsum (20L/ha)	0.0445 [b]	0.1706 [a]	0.0334 [a]
P value	<0.001	<0.001	<0.001
LSD (P=0.05)	0.0032	0.0069	0.0019

Conclusion

Data from these field trials highlights that the yield, grade and therefore profitability of recently released peanut variety Kairi⊕ is improved by establishing 180,000 plant/ha. Whilst there is increased cost to the grower from increasing seeding rates, the improvement in yield, grade and in-turn gross margin, more that justifies the extra seed cost incurred.

Despite the fact that Kairi⊕ has a larger kernel size than Holt⊕, we could not find any evidence that Kairi⊕ has a requirement for a different nutrient management strategy than what is typically 'industry practice' for high-input peanut production in coastal environments. However, it is also evident that peanut growers' profitability would benefit from a calcium fertilisation decision support tool. The calcium trial (third field trial) backed up previous research that demonstrated that if a paddock has lime applied to ameliorate pH then the in-crop application of gypsum offers no improvement in yield or grade.

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