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Northland peanut trials 2021–22: final technical report

Trolove S, van der Weyden J, Graham D, Hall G, Johnstone J, Walker G, Tyson JL, Fullerton RA, McIntyre C, Chakwizira E

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Contents

Executive summary

Northland peanut trials 2021–22: final technical report

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August 2022

Growers and manufacturers are interested in the possibility of growing peanuts in New Zealand. Northland growers are keen to explore peanuts as an alternative crop to spread their risk profile, and manufacturers, such as Pic's Peanut Butter, would like to source New Zealand-grown peanuts to promote employment in this country and to reduce its carbon footprint. Small evaluation trials conducted in Northland in the 2020–21 season demonstrated that promising yields were possible with scaled yields of 4–7 t/ha at the most productive site. This yield was estimated to give a gross margin similar to what could be earned from a crop of maize. These trials were sown and weeded by hand and used 1 m row spacing, which is not commercial practice. It was therefore of interest to determine whether peanuts could be successfully grown using commercially available equipment and agrichemicals[1]. It was also of interest to identify what pest and disease problems may be encountered, and how these might be managed. In addition, the peanut butter produced from these nuts did not taste as good as that produced from imported peanuts, and it was suspected that the nuts were slightly immature. So it was of interest to investigate whether alternative cultivars may produce better tasting peanut butter.

Northland Inc. is leading the current 2-year project of the feasibility of growing high-oleic peanuts on a larger scale in Northland, supported by The New Zealand Institute for Plant and Food Research Limited (Plant & Food Research), Manaaki Whenua – Landcare Research and Picot Productions who are able to offer both scientific and commercial knowledge/expertise to the project. Five trials were established in Northland; three near Dargaville and two north of Kaitaia. The sites were sprayed with glyphosate and then worked with a power harrow once the pasture had begun to die. Eight breeding lines from ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) were sown on 11 November 2021 at the Dargaville sites and 25 November in the sites near Kaitaia. Seeds were sown using commercial maize drills in rows 75 cm apart, with approximately 6.7 cm spacing between plants within the row. Lines with larger seeds were difficult to sow using a conventional maize drill.

Peanut establishment was generally poor, being typically below the value of 80% often achieved in Australia. Crops near Dargaville were monitored fortnightly, but only monthly near Kaitaia, because of labour challenges. Weed control was a challenge during the trial. This was largely because of the short time frame between project approval and sowing, which did not give the opportunity for an early spray and a fallow period to produce a stale seedbed. Invertebrate pests and diseases required monitoring and the occasional spray (fungicide) but did not cause significant yield losses. All sites were harvested in early May because air temperatures were dropping towards 9°C, slightly before maturity targets had been reached. Yields across the sites ranged from nothing at the Greenhill site, up to 5.3 t/ha for the highest yielding breeding line at Te Kōpuru. The very low yields at the Greenhill and Kai Iwi sites were due to small animals (pūkeko, turkeys, rabbits and hares) eating the trials. The

[1] Note that there are no agrichemicals registered for use on peanuts in New Zealand, so any chemicals used will be residue tested to determine concentrations are below minimum residue limits prior to consumption.

better performing breeding lines yielded approximately 2–2.5 t/ha at the Ngāi Takoto and Water Trust sites.

Key learnings from the 2021–22 growing season were:

- Two sprays of glyphosate applied prior to sowing give much better weed control than the single glyphosate spray.
- A period of perhaps 4–6 weeks between spraying and cultivating existing pasture and re-spraying then sowing peanuts would have several benefits. This would allow for clods and turf to be broken down (which is important if kikuyu is present), allow weeds to emerge and be sprayed, and provide a period of solarisation, which can reduce the number of grass grub/black beetle larvae in the soil.
- Improved pre-emergent weed control is required to aid peanut establishment. This may include the use of a stale seedbed. A different pre-emergent herbicide should be trialled, e.g. trifluralin plus Linuron.
- A commercial maize drill is likely to require modifications if used to sow peanuts, particularly if a large seeded peanut variety is sown.
- Control weeds early when they are still small, to minimise the use of higher spray rates, which may cause minor damage to the peanut crop.
- The season length was approximately 1700 growing degree days (GDD; base temperature of 10°C) in the Kaipara, or 1850 GDD in the Far North, which suggests that short season cultivars should be sown. That being said, good tasting peanut butter was produced by the breeding lines sown, which apparently required 1785–1975 GDD to reach maturity according to ICRISAT.
- To ensure peanuts reach maturity, sowing should occur no later than late October in the Kaipara or early November in the Far North, or earlier if the soil temperature rises above 18°C for three days. This is based on weather from the 2021 season and the use of a peanut cultivar that requires 1785 GDD.
- The number of GDD to maturity in New Zealand may differ from that calculated in countries where they are bred. Hence, new cultivars should be trialled before growing on a large scale.
- It is important to check the irrigation at all sites, to ensure that it is working and delivering the correct amount of water.
- Root chewing insects, such as black beetle larvae, may potentially be important pests in some areas. These pests must be minimised by pre-sowing management such as an extended fallow.
- Birds (pūkeko and turkeys) and rabbits can cause severe damage to small trial plots.
- Yields of up to 5 t/ha were achieved, which is similar to those achieved in Australia.
- No agrichemical residues or aflatoxins were detected in the peanuts.
- Great tasting peanut butter can be made from New Zealand-grown peanuts.

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1 Background

Peanuts have been grown by home gardeners in New Zealand since as early as the 1960s, with a number of trials taking place over the years, e.g. New Zealand Department of Agriculture (1967/68), Dawbin (1980), Anderson & Piggot (1981). These trials have taken place primarily at locations across Northland, Auckland and Hawke's Bay, as it was identified early on that only the northern areas of New Zealand would be suitable for commercial production, because of the warmer climate.

In the small peanut evaluation trials conducted in the 1980s by Anderson & Piggot (1981), average yields were around 1–2 t/ha. Since then, genetics and management practices have improved. Yields in Australia currently average 2.5 t/ha non-irrigated crops in New South Wales (Wright et al. 2017) or 5 t/ha for irrigated crops in Queensland (GRDC 2017). When those small New Zealand trials occurred in the 1980s, a limiting factor for growing larger-scale crops (>0.2 ha) was that adequate harvesting equipment was not available in New Zealand, so growers were unable to successfully harvest larger-scale crops by hand in the limited time they had available. Other challenges included the lack of an industry infrastructure and problems with weed control (Griffiths et al. 2003). Thus a New Zealand peanut industry did not come to fruition.

In 2012, New Zealand imported approximately 12,000 t of shelled peanuts and other peanut products. Based on Australian farmer returns, a yield of 4 t/ha could have a gross income of around $5000 per ha, although it is possible that there could also be a grower premium associated with New Zealand-grown peanuts. Growing areas in traditional production countries, including Australia, are becoming marginalised as a result of climate change; and the per tonne price is expected to increase over time. More recently, the idea of commercialising peanut crops in New Zealand has come back into focus. This is based upon growing demand from the private sector, especially Picot Productions (Pic's Peanut Butter), to source inputs locally, to diversify and to provide greater security from a supply chain perspective. Farmers are also keen to explore peanuts as an alternative land-use option to pastoral agriculture, kumara, maize or avocados, to spread their risk profile. With climate change, new cultivars, and commercial demand, there is interest in reviewing the commercial feasibility of growing peanuts in Northland. As a result, in 2020/21 Picot Productions secured partnership funding through the SFFF to undertake a range of small-scale trials in the Kaipara District. Northland Incorporated, through the Kaipara Kai Project, managed the trials with help from The New Zealand Institute for Plant and Food Research Limited (Plant & Food Research).

These trials (Trolove et al. 2021) demonstrated that promising yields were possible (scaled yields of 4–7 t/ha at the most productive site), which was predicted to give a gross margin similar to what could be earnt from a crop of maize. The conclusion of this research was that it was worth conducting further trials, to try to address some of the challenges identified. These included poor crop establishment, highly variable yields among sites, and that the nuts tasted slightly immature, which was not the taste profile that Pics were wanting for their peanut butter. There was also a need to understand how to grow peanuts using commercially available agrichemicals and equipment, with commercial row spacing. There is also little knowledge of the pest and disease issues that might be encountered in growing peanuts in New Zealand, and how these issues might be addressed.

This current trial builds upon the findings of the previous one, with a view to test whether some varieties can be grown on a larger scale, especially as local production of peanuts will provide the opportunity for new locally produced processed foods. For this year's trial (Year 1), the inability to source and import a large quantity of seed in the required timeframes has offered an opportunity to trial a larger range of high-oleic peanut cultivars instead. This provides an opportunity to test whether other cultivars grow well and if their nuts have good taste for peanut butter. Another reason for broadening the range of cultivars is because the project includes trial sites in the Far North District as well this year, which has a slightly warmer climate and more growing degree days (GDD). In the Year 1 trial of this current project, eight breeding lines were trialled, with some newly selected lines included. Plot sizes ranged from 0.02 to 0.5 ha, with plots of up to 1 ha planned for next year.

This Final Technical Report covers the agronomy, harvesting and processing of the peanuts into peanut butter. Associated work on finding suitable *Rhizobium* inoculum for New Zealand-grown peanuts is covered in a separate report by Bevan Weir from Manaaki Whenua – Landcare Research (Weir et al. 2022).

2 Peanut varieties used in the trial

The objective was to access seed of peanut varieties that showed promise in the trials the previous season. However, it was almost impossible to access high-oleic peanut seed of any variety for this trial because of a worldwide shortage of peanut seed. The only means of accessing high-oleic peanut seed was to join ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) and access their breeding lines. ICRISAT sent eight breeding lines; all were Spanish bunch type lines except ICGV 181037, which was a Virginia bunch type. The lines had moderate maturity times (see Section 13.1), and were reported to have good agronomic performance based on multi-environment testing conducted over several years in India as well as resistance/tolerance to late leaf spot and rust diseases.

3 Description of sites

Five sites with sandy soils were selected for field trials, at locations shown in Figure 1. Information on their climate and paddock history is shown in Table 1. Three were located west of Dargaville, and two north of Kaitaia. All sites had a similar annual median rainfall, and the northern sites averaged a greater number of GDD. All sites had a history of being in pasture, although the Kai Iwi Lakes site had been sown in peanuts last season.

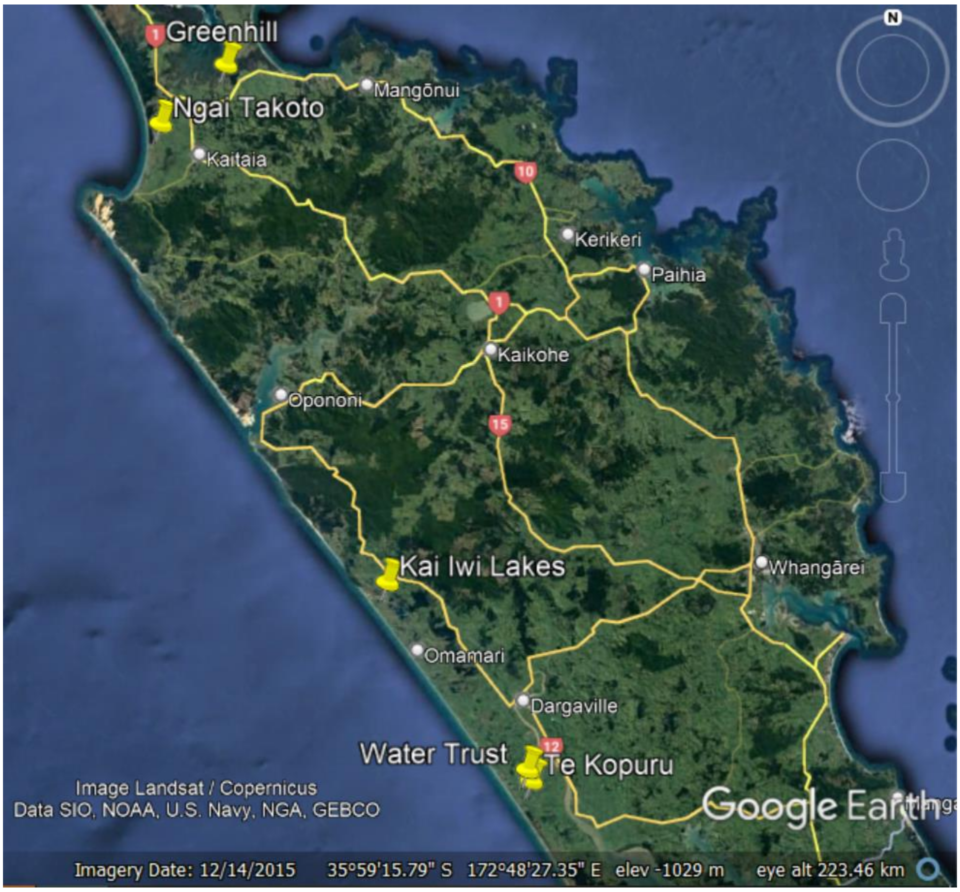

Figure 1. Location of the five trial sites.

Table 1. Climate and soil data for the sites. Growing degree days[2] (GDD) over a base temperature of 10°C are shown for Kaitaia and Dargaville. Source for rainfall and GDD: Chappell (2013).

Name	Nearest town	Median annual rainfall (mm)	Average GDD (1 Nov–30 Apr)	Paddock history
Water Trust	Dargaville	1100–1200	1925	Dairy pasture
Ngāi Takoto	Kaitaia	1100–1200	2086	Dry stock pasture (long-term kikuyu)
Te Kōpuru	Dargaville	1100–1200	1925	Dairy pasture
Kai Iwi Lakes	Dargaville	1200–1300	1925	Long-term kikuyu pasture, sown in peanuts last season
Greenhill Farm	Kaitaia	1100–1200	2086	Sheep and beef pasture

[2] For more information on growing degree days for peanuts, see Section 12.2

4 Plant nutrition

Soil tests were taken prior to sowing at all five sites to the standard depth of 15 cm. Samples were sent immediately to a commercial laboratory for analysis, and the results are provided in Table 2. Fertiliser recommendations (Table 3) were made based on the soil test values and recommendations for peanuts in Australia (GRDC 2017), leguminous crops in New Zealand (Reid & Morton 2019) and knowledge of agronomist Emmanuel Chakwizira.

Soil pH at all sites was within the range of 5.5–7.0 recommended for peanuts (GRDC 2017). Application of phosphorus is recommended when Olsen P concentrations are below 20, indicating that three of the sites were low for phosphorus (Table 2). Potassium was low at Te Kōpuru and Greenhill Farm, and these sites received additional K fertiliser (Table 3). Calcium was particularly low at the Ngāi Takoto site, so this site received an application of gypsum at sowing. Peanuts have particularly high requirements for calcium at pegging, so all sites received an application of gypsum at flowering (Table 3). Sulphur was low at the Ngāi Takoto, Te Kōpuru and Greenhill Farm sites (Table 2), this was supplied in the nitrophoska at sowing, and additional sulphur was also supplied when gypsum or superphosphate was applied at sowing (Table 3**)**. Starter nitrogen was supplied in the nitrophoska fertiliser, and the remainder of the nitrogen for peanut growth was supplied by mineralisation over the growing season, as indicated by anaerobically mineralisable nitrogen test values of 150 kg N/ha or more (Table 2), or possibly from nitrogen fixation.

Table 2. Soil test results for 0–15 cm depth samples taken prior to sowing at the five trial sites.

Name	pH	Olsen P	K	Ca	Mg	Na	S-SO4	Org S	AMN
		mg/L	me/100 g				mg/kg	mg/kg	kg/ha
Water Trust	6.5	22	0.78	13.6	2.42	0.2	34	12	158
Ngāi Takoto	5.7	38	0.24	1.9	0.89	< 0.05	3	3	181
Te Kōpuru	6.3	13	0.19	10.5	1.44	0.19	6	7	150
Kai Iwi Lakes	6.1	13	0.61	9.9	1.84	0.13	23	9	171
Greenhill Farm	6.1	19	0.16	11	0.82	0.09	4	6	215

Table 3. Fertiliser recommendations for the different trial sites.

Name	Fertiliser at sowing	Fertiliser at flowering
Water Trust	333 kg/ha of Nitrophoska® extra	Broadcast 400 kg/ha gypsum
Ngāi Takoto	333 kg/ha of Nitrophoska extra Broadcast 400 kg/ha gypsum	Broadcast 400 kg/ha gypsum
Te Kōpuru	333 kg/ha of Nitrophoska extra 325 kg/ha 30% potassic super	Broadcast 600 kg/ha gypsum
Kai Iwi Lakes	333 kg/ha of Nitrophoska extra	Broadcast 600 kg/ha gypsum
Greenhill Farm	385 kg/ha of Nitrophoska extra 92 kg/ha of muriate of potash	Broadcast 600 kg/ha gypsum

5 Sowing

Sites were sprayed with glyphosate and worked with a power harrow once the pasture had begun to die. Commercial maize drills were used to sow the trials. The Water Trust, Te Kōpuru and Kai Iwi Lakes sites were sown on 11 November 2021 using a Vaderstad Tempo F8 drill. The Ngāi Takoto and Greenhill Farm sites were sown on 25 November 2021 using an Amazone EDX 6000 TC drill. The drills were setup with the standard maize spacing (76 cm between rows) and targeted a 6.7 cm spacing between plants within the row (15 plants/m). The targeted sowing depth was 5–7 cm. Starter fertiliser was applied next to the seed using the drill.

At the Water Trust site, an eight-row drill was used, with four rows per variety. There were two passes of each variety giving two blocks of 90 m long, except for ICGV 16668, which repeatedly blocked up the drill and so it was only used in a single plot. The Vaderstad Tempo F8 maize drill was suitable for sowing seven breeding lines, but not for ICGV 16668. This was because the seed was larger than that of the other breeding lines, being approximately 12–15 mm long, and kept blocking up the drill when the seed was pushed into the tube down to the foot of the drill. If seeds of similar size are to be sown in future, new vacuum plates and a larger exit pipe would need to be purchased and fitted.

The Kai Iwi Lakes and Te Kōpuru sites were sown with one row of each breeding line in rows 30 m long, since these were small sites with limited space available. The cultivated area at the Kai Iwi Lakes site was larger than anticipated, so to fill the empty space and try to reduce weed pressure another pass of the drill (eight rows) was made using breeding line 181031. It was unsuitable to do all breeding lines again as rows 7 and 8 would be in uncultivated ground.

For the Ngāi Takoto site, each breeding line was planted in blocks eight rows wide by 45 m long. This was because the drill only had a single seed chamber. The drum design used to pick up seed under vacuum for sowing struggled to cleanly distribute the seed, resulting in numerous blockages. This was most evident on the lines with larger seeds (ICGV 181037 and ICGV 16700), where the operator had to stop numerous times to unblock the drill. Therefore, it was decided that the largest variety (ICGV 16668) was unsuitable for the drill and could not be planted at this site. As time for the drill operator was now becoming limited it was decided to plant out the remainder of the cultivated area with a line that had a small seed size. Line ICGV 181029 was selected and three further passes with the drill were made.

The Greenhill Farm site was sown just after completing Ngāi Takoto, and because of the issues previously described it was decided to do a single strip, eight rows by 30 m, of the same breeding line used to complete the sowing at Ngāi Takoto (ICGV 181029). There was poor establishment in this trial, so it was resprayed with glyphosate and planted using a hand seeder on 21 December 2021. This drill had a much lower within-row plant spacing of approximately five plants per m. The same between-row spacing was used of 0.75 m. Four rows of ICGV 16700 were planted.

Irrigation was installed at each site.

6 Monitoring equipment

A 5TM probe (Decagon Devices, Inc., WA, USA) was installed at sowing to monitor soil temperature and soil moisture in the top 5 cm at each site. These data indicated that soil temperatures were above the recommended temperature of 18°C for germination of peanuts (GRDC 2017) in both regions. For example, the soil temperature at 9 a.m. for the week near sowing averaged 18.5°C at Kai Iwi Lakes (12–18 November) and 20.3°C at Ngāi Takoto (19–25 November). Soil moisture was adequate for germination, with the 5TM probes giving a volumetric soil water reading of >20% in the top 5 cm at all sites. Soil moisture probes (10HS, Decagon Devices, Inc.) were also installed at 10 cm depth.

Weather stations to monitor rainfall, humidity and air temperature, were intended to be installed at sowing at two sites, but this was delayed because of supply issues. Data for the Water Trust site were collected from 23 March 2022 and at the Ngāi Takoto site from 7 April 2022. The sensors appeared to be working well, but this was too late in the season to be of much use, so data from the NIWA cli-flo database were used instead. These weather stations will be re-installed ready for the 2022–23 season.

7 Crop establishment

Higher plant establishment percentages were achieved at Te Kōpuru than at the other sites (Table 4). This site appeared to have the most favourable seedbed. One reason for the poorer establishment at some sites may be the rapid seedbed preparation, which did not allow time for the breakdown of clods and pasture (Figure 2). Seedbeds were not prepared well in advance this season because growers were reluctant to spray out paddocks several months early with there being uncertainty around when the seed would arrive, the timing of the funding coming through and unfavourable weather conditions. Difficulties with the Amazone drill may explain the lower establishment for most breeding lines at Ngāi Takoto. Peanut seed is fragile (GRDC 2017) so it is possible that the commercial maize drills used may have caused some seed damage. Different seed lines may have been more damaged than others during sowing, particularly given the difficulties sowing ICGV 16668.

There were large differences in establishment of the different breeding lines. Across the four sites, ICGV 16700 had a higher average establishment percentage than all the other breeding lines (Table 4). ICGV 181029 had extremely poor establishment at all sites (Table 4). A germination test was conducted on the seed to determine whether seed quality may have been a factor in the poor germination of some breeding lines. The seed had been stored in a temperature-controlled room at 20°C from sowing until testing in March. This is above the recommended temperatures of <16°C (Morton et al. 2008), so germination percentages recorded may have dropped somewhat since sowing. However, the differences in germination percentages among breeding lines evident from this germination test (Table 4) were similar to the differences observed in the field, suggesting that differences in seed quality may be a major factor in explaining the poor germination of some breeding lines. Typical establishment rates in Australia are close to 80% (GRDC 2017). Only three breeding lines achieved this at Te Kōpuru, and only ICGV 171051 at Kai Iwi Lakes.

Table 4. Peanut germination percentages for the ICGV breeding lines at the different sites. Measurements were taken 22 days after sowing at all sites except Ngāi Takoto, where measurements were made 41 days after sowing. A germination test was conducted on the seed, stored at 20°C from sowing until testing in March 2022.

Site	16668 RP20 /21 RP 2b	16688	16700	171051	181008	181029	181037	181031 PR 20 /21 RP 2B
Te Kōpuru	60	67	>100	100	80	7	53	40
Kai Iwi Lakes	40	47	60	80	33	0	20	40
Water Trust	10	28	70	43	27	8	30	60
Ngāi Takoto	-	0	60	7	3	0	17	11
Germination test	35	59	84	99	72	41	39	94

Figure 2. Peanut establishment at Kai Iwi Lakes, 3 December 2021. Note the presence of trash on the surface.

8 Weed control

All trial sites received a pre-emergent spray of Strada® herbicide at 3 L/ha – the label rates recommended for Australia. This gave poor weed control, with large numbers of both broadleaf and grass weeds emerging with the peanuts. The main weed species present were wild portulaca, redroot and summergrass. These grew faster than the peanuts, and by the time the peanuts had reached the two- to three-leaf stage when they could tolerate sprays, the weeds were too big to be effectively controlled by herbicides without causing some damage to the peanuts. This was particularly the case at the Water Trust site (Figure 3), where wild portulaca and redroot began to cover the peanuts and had to be controlled by hand weeding. The weed control programme at the five sites is described below.

Figure 3. Weed control challenges in parts of the Water Trust site, 10 December 2021.

Water Trust: This site was weeded by hand in late-December (Figure 4), since weeds had become large and required immediate removal. Cletho was applied at 375 mL/ha + oil at 1 L/ha on 14 January 2022, and at the higher rate of 2 L/ha on 4 February 2022. Valdo® (flumetsulam 800 g/kg) at 100 g/ha and Troy® (480 g/L bentazone) at 2 L/ha + oil (1 L/ha) were applied on 13 December and 2 February 2022 to control broadleaf weeds.

Te Kōpuru: Cletho (clethodim 240 g/L) at 375 L/ha + oil at 1 L/ha was applied on 13 December 2021 and 14 January 2022 to control grass weeds. This rate was increased to 2 L/ha + oil at 1 L/ha on 3 February to control kikuyu encroaching from the side of the trial site (Figure 5). The kikuyu may have affected growth to some extent for the seed lines growing on this side. Valdo® (flumetsulam 800 g/kg) at 100 g/ha and Troy® (480 g/L bentazone) at 2 L/ha + oil (1 L/ha) were applied on 13 December and 2 February 2022 to control broadleaf weeds. By 16 February, peanuts showed some yellowing of younger leaves, which may have been signs of oxidative stress damage from bentazone herbicide application at this site (Figure 5).

Figure 4. Hand-weeded rows at the Water Trust site.

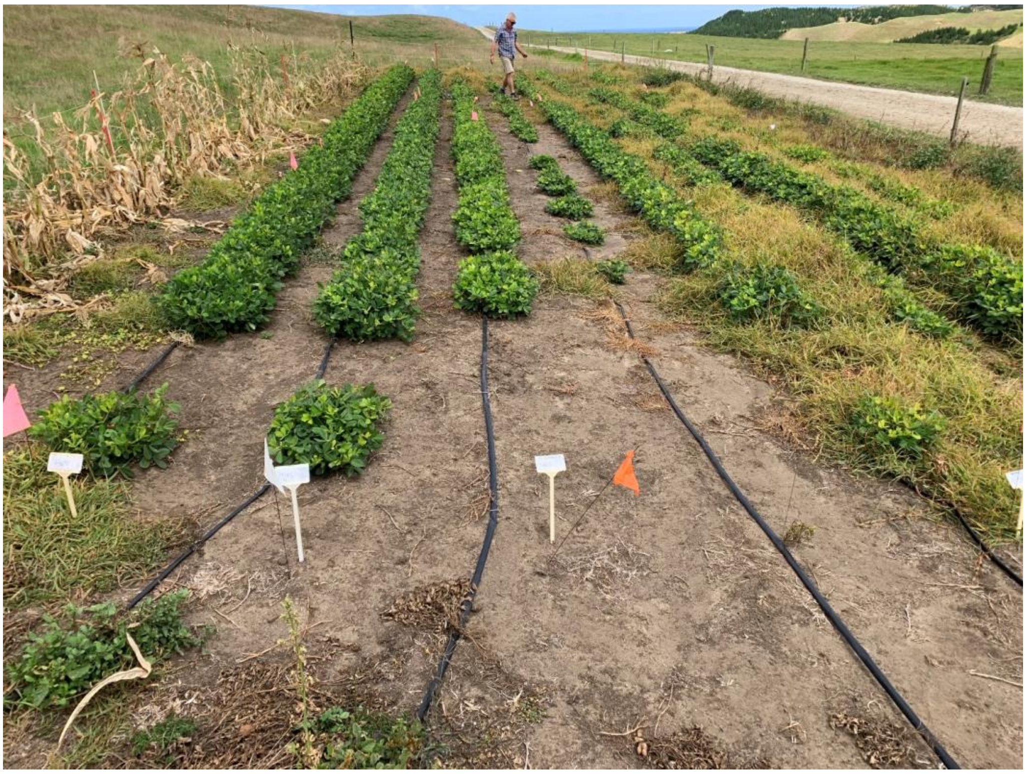

Figure 5. Peanuts at Te Kōpuru on 16 February 2022. The kikuyu, which is particularly evident on the right side of the site, is showing the effects of being sprayed by Cletho at 2 L/ha on 3 February 2022.

Kai Iwi Lakes: Cletho at 375 L/ha + oil at 1 L/ha was applied on 13 December 2021 and 14 January 2022 to control grass weeds. The rate of Cletho was increased to 2 L/ha + oil at 1 L/ha on 3 February as the grass weeds were larger. There was some yellowing of younger peanut leaves, which may have been signs of oxidative stress damage from herbicide application at this site. Valdo® (flumetsulam 800 g/kg) at 100 g/ha and Troy® (480 g/L bentazone) at 2 L/ha + oil (1 L/ha) were applied on 13 December 2021 and 2 February 2022 to control broadleaf weeds.

Ngāi Takoto: This site was sprayed with SeQuence (240 g/L clethodim) at a low rate of 375 mL/ha + oil (1 L/ha) on 23 December 2021, and again on 25 January 2022, according to the contractors records. This gave poor control of weeds at Ngāi Takoto and weed growth may have affected crop growth. Fusilade (fluazifop-p-butyl 150 g/L) at 2.5 L/ha was applied on 10 February 2022 to control grass weeds, and appears to have been effective, although there did seem to be some oxidative stress damage following Fusilade applications. This was evident by the young peanut leaves being very pale. The site was weeded by hand on 26 February 2022.

Greenhill Farm: Weed control at Greenhill Farm was excellent because it was sprayed out twice with glyphosate, once before the first sowing and again before resowing. No further sprays were applied.

By March, weeds had been brought under control at most sites (e.g. Kai Iwi Lakes, Figure 6), except for some grass regrowth at Ngāi Takoto. There was also one replicate at the Water Trust site that had not been weeded. At the Water Trust site there were some nightshades and other weeds that were quite large and needed to be mown prior to harvest. In future, we recommend that these are managed earlier in the season.

Figure 6. Weeds effectively controlled by Valdo® and Troy® applied in February at the Kai Iwi Lakes peanut trial site. Photograph taken on 16 March 2022.

A better system of weed control will be required for the following season. Several approaches have been suggested. These include:

1. The sowing of a winter crop prior to peanuts. This would allow time for the kikuyu to break down.
2. Spray out the paddock in the autumn with a broadleaf spray, allowing only the grass to persist over winter. Then kill the grass in the spring with glyphosate. This approach is effective if broadleaf weeds are a problem, but gives less time for grasses, particularly kikuyu, to break down.
3. Spray out the paddock in the autumn with glyphosate, then deep plough and leave to fallow over winter. Cultivate again in early spring, and leave several weeks for weeds to germinate. Spray out weeds with glyphosate and drill seeds with minimal disturbance. This approach is effective for breaking down the kikuyu and reducing weed pressure, but has the disadvantage of taking the paddock out of production for longer.

New Zealand research by Trevor James (pers. comm.) in 1990 showed that Treflan™ (active ingredient is trifluralin) at 2.5 L/ha plus Linuron at 3 kg/ha gave good pre-emergent weed control (86% weed reduction) in peanuts with minimal crop damage (<10%). This would be worth trialling to see whether it gives better pre-emergent weed control than Strada. Note that trifluralin is labelled for use in other countries, but Linuron does not appear to be. Trevor James recommended that a similar weed control programme is followed to that used in beans, using regular sprays on very young weeds.

Reducing the inter-row spacing from 75 cm to approximately 40 cm will also assist in closing the crop canopy faster, reducing competition from weeds. A closer row spacing means the crop also intercepts more solar radiation, which is likely to increase yield. The 75 cm spacing was used because a maize seeder was the only drill available, whereas a 40–45 cm row spacing is more common commercial practice for peanuts.

9 Pests

Crops were scouted for the presence of pests every two weeks at the Kaipara sites, and every four weeks at the two sites in the Far North. The farmers kept a regular watch on the crop at the Greenhill Farm site. Birds and small mammals caused much damage at two sites. Rabbits and pūkeko decimated the small peanut trial at the Greenhill Farm site, leaving very few plants and pods, hence yields were not reported for this site. At the Kai Iwi Lakes site, turkeys ate much of the new growth and nuts (see Figure 7), and rabbits and hares were also eating the leaves, which markedly reduced yield (Section 14.1).

Figure 7. Empty peanut shells at the Kai Iwi Lakes trial site – a sign that turkeys have been scratching up the nuts and eating them.

Insect pests were generally of minor importance at all sites. The estimated amount of foliar damage due to insects in late January was 1–2% in the two larger trials, and 4–10% in the three smaller trials (Trolove et al. 2022b). Damage was greater at the smaller sites, which may be because damage tends to be greater on the edges of crops, and smaller sites have a relatively higher proportion of edges than a larger site. A site visit to Kai Iwi Lakes on 16 March 2022 found that insect pests were being controlled by large numbers of spiders of various species. The only concern arising from an insect pest was root damage, which caused serious wilting in some plants from the Greenhill Farm site in late January. Some plants were dug up, and beetle larvae (presumably black beetle – *Heteronychus arator*) were found. This is a potentially serious pest, with little means of control at this growth stage. The best means of control is an extended fallow and solarisation of the soil prior to sowing. The extent of the black beetle damage was not able to be assessed, because of the large amount of damage caused by rabbits.

10 Diseases

Crops were scouted for the presence of diseases every two weeks at the Kaipara sites, and every four weeks at the two sites in the Far North. The farmers kept a regular watch on the crop at the Greenhill Farm site. If any significant signs of disease were observed, crops were sprayed. An application of Balear® (chlorothalonil 720 g/L) fungicide at 1.8 L/ha was applied to the Kai Iwi Lakes and Te Kōpuru sites on 14 January 2022, and to the Water Trust site on 20 January 2022. Samples of the disease were collected and sent to pathologists Joy Tyson and Bob Fullerton at Plant & Food Research, Auckland, for identification and advice. An analysis of the samples delivered is given below.

Between January and May 2022, Plant & Food Research received four sets of symptomatic plant material from the peanut trials (Table 5). The symptoms observed included a rot of the peanut 'seed', leaf spots (Figure 8), and dead or dying plants (Figure 9).

Table 5. Symptomatic peanut plant samples received January – May 2022.

Sample set	Date received	Site	Type of material	Symptoms
1	28 January 2022	Kaitaia	Peanuts, leaves	Peanuts with rots, leaf spots
2	3 February 2022	Water Trust and Kai Iwi	Leaves	Leaf spots
3	17 February 2022	'Water Trust'	Leaves	Leaf spots
4	12 May 2022	Te Kōpuru	Whole plants	Dead and dying stems

For each set of samples, fungal isolations were made from the symptomatic material onto potato dextrose agar (PDA) amended with antibiotics to inhibit bacterial growth. The isolated fungi were identified to genus level using standard morphological techniques.

Figure 8. Peanut leaf spots, ex Kaitaia, 28 January 2022 (sample set 1).

Sample set 1

The most common isolations from the rots on the peanut seed (present on three out of five samples) were *Fusarium* spp. (*F. oxysporum*, *Fusarium* sp.); however, other fungi such as *Penicillium* sp., *Aspergillus* sp. and *Mucor* sp. were also isolated.

The fungi most commonly isolated from the leaf spots were *Fusarium* sp. (present on 7 out of 12 samples) and cf. *Didymella* sp. (present on eight out of twelve samples). In four of the isolations both *Fusarium* sp. and cf. *Didymella* sp. were present. The *Fusarium* sp. isolated from the leaf spots was consistent from all the leaves (i.e. only one species was isolated from the leaf spots).

Figure 9. Peanut stem blight, ex Te Kōpuru, 12 May 2022 (sample set 4).

Sample set 2

Peanut leaves from the Kai Iwi Lakes site yielded *Stemphylium* sp., whereas four out of the five leaves with leaf spots from the Water Trust site (Figure 10) yielded a single *Fusarium* species. The final isolation was a *Phomopsis* sp. The percentage of foliage affected by the leaf spot at the Water Trust site was assessed on 28 January 2022 by observing 50 individual plants in a zig-zag pattern. This indicated that approximately 9% of foliage was affected. This level of infection is considered low, since most crops can usually sustain up to 20% leaf damage before yield is reduced.

Figure 10. Spots on peanut leaves from the Water Trust site, 24 January 2022.

Sample set 3

Three of the four leaves with leaf spots from the Water Trust site yielded *Fusarium* species. The final isolation was a *Stemphylium* sp.

Sample set 4

Sample set 4 comprised a substantial amount of plant material in six paper bags labelled 'dying' 1–4 and 'dead' 1–2. All the bags contained plants with dead and dying stems. The dead stems were found to be filled with mature sclerotia (thin black rind, white inner), while the browning, 'dying' stems were filled with dense fluffy white mycelium and a mixture of mature and immature sclerotia. Sections of the stems were so packed with sclerotia that they became 'shredded' (Figure 9, top right).

The sclerotia were typical of the fungal genus *Sclerotinia* sp.; this was confirmed by fungal isolations. The sclerotia formed within the plant tissues, and on the isolation plates were small, regular and numerous, and this is likely to be *Sclerotinia minor*.

Sclerotinia blight

Sclerotinia minor has been previously recorded from peanuts in New Zealand and two specimens are held in the New Zealand Fungal Herbarium (Table 6). Early trials on the suitability of peanuts as a New Zealand crop found *Sclerotinia* sp. was present at all trial sites (Te Hapua, Kerikeri, Otakanini and Dargaville), although the species was not given (Anderson & Piggot 1981).

Sclerotinia blight, caused by *S. minor,* is a common disease of peanut and is one of the most important diseases of the crop in several states of the USA. The pathogen can be seed dispersed either as sclerotia or as plant debris mixed with seed and also as fungal hyphae in the seed (Akem & Melouk 1990).

The most destructive infections from this pathogen are typically from sclerotia surviving in the soil. As a soil-borne disease it cannot be easily controlled by fungicides and has the potential to limit production in areas where there are high populations of sclerotia in the soil. It is likely to be endemic to the area, possibly being sustained by broadleaf host weeds in pasture and in cropping areas.

Table 6. *Sclerotinia minor* accessions from peanuts held in the New Zealand Fungarium.

Accession#	Name	Collector	Year	Country	District	Host
PDD 26219	*Sclerotinia minor*	W. Stacey	1968	New Zealand	Northland	*Arachis hypogaea*
PDD 39112	*Sclerotinia minor*	R.A. Fullerton	1979	New Zealand	Auckland	*Arachis hypogaea*

In summary, there was a minimal amount of fungal disease observed, and it was late in the season, so this had little effect on yield. *Sclerotinia* was observed in small patches in one replicate at the Water Trust site only.

11 Irrigation

Irrigation was set up at all sites. Drip tape was used on the Greenhill and Te Kōpuru Sites.

At the Te Kōpuru site, a 1 m^3 pod was set on pallets and filled with water from the trough each time we visited, so approximately 950 L (5.3 mm) was applied by gravity every 7–10 days depending on local rainfall. At the Greenhill site the landowners supplied water twice a week, based on visual observations. No measurements taken. Sprinklers were used on Water Trust, Kai Iwi and Ngāi Takoto sites. The sprinklers were set through Hunter Controllers to irrigate three times per week for one hour in the early morning. This was altered to every second day at the Kai Iwi Lakes site on 16 March 2022 and at Ngāi Takoto on 24 March 2022.

There were no water meters installed to measure water flow, so the application rate was based on time and soil moisture levels from the data loggers, which were read each time the sites were visited.

Soil moisture probes were installed to monitor surface soil moisture (top 5 or 10 cm at the different sites). Problems were encountered with the dataloggers, and so only data for the start of the season was collected. The irrigation appears to have been working poorly at the Kai Iwi Lakes and Ngāi Takato sites, since the surface soil moisture dropped markedly between rainfall events (Figure 11 and Figure 12). This agrees with visual observations that the soil surface at Kai Iwi Lakes was dry in March. It is therefore important to ensure that the irrigation system is working and delivering the correct amount of water.

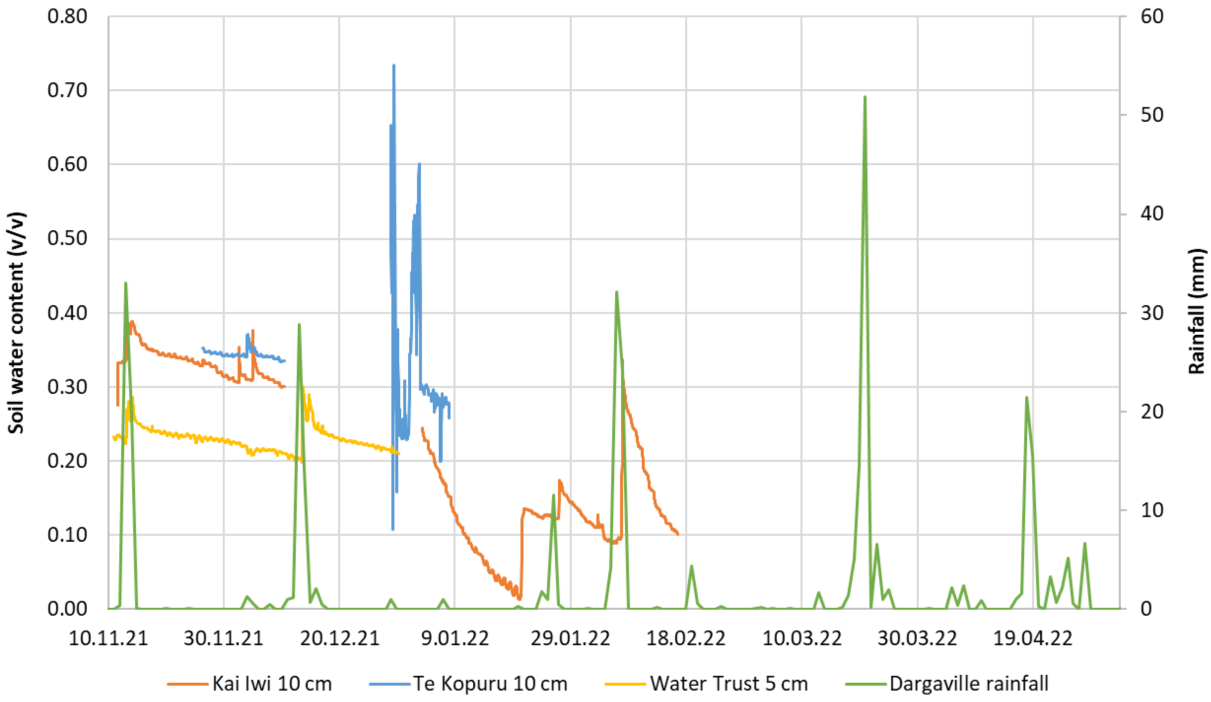

Figure 11. Moisture content of the top 5 or 10 cm of soil and rainfall at the Kaipara sites.

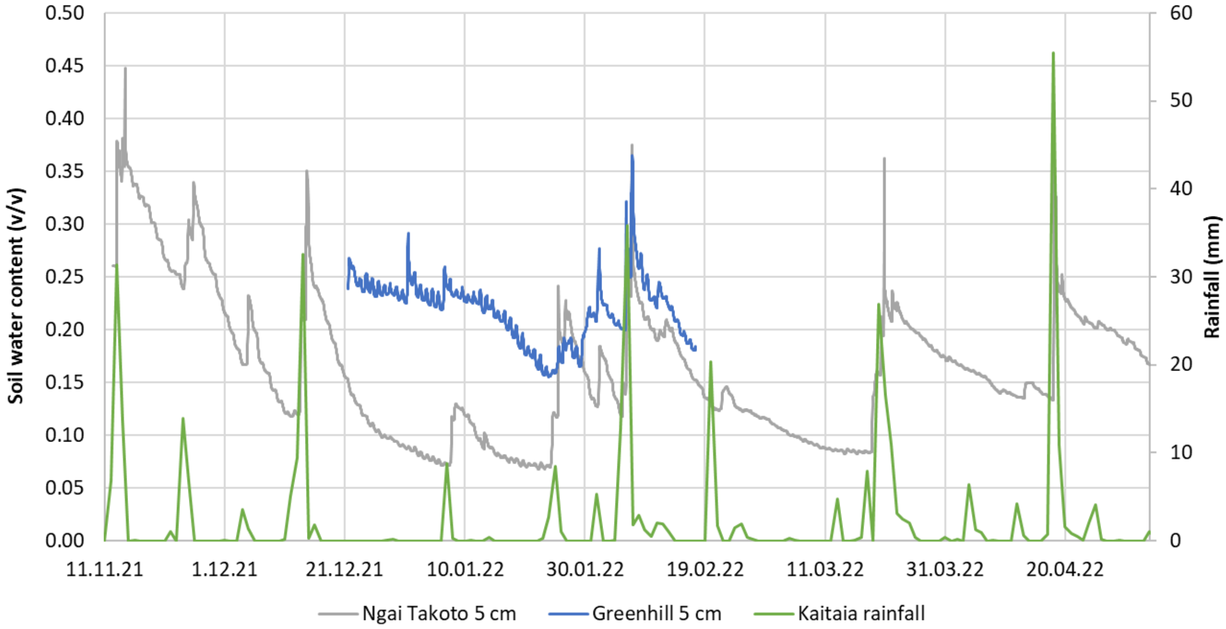

Figure 12. Moisture content of the top 5 cm of soil and rainfall at the Far North sites.

12 Temperatures

12.1 Soil temperatures

The recommended soil temperature for sowing peanuts is >18°C at 9 a.m. at a sowing depth of 5–7 cm (GRDC 2017). Soil temperatures in the 0–5 cm depth at 9 a.m. rose above 18°C at both sites in late October, although they dipped below this value soon afterwards, then rose above 18°C again in early to mid-November, depending upon the site (Figure 13). Soil temperatures averaged 1.1 degree warmer at the Ngāi Takoto site, which was over 100 km further north. Soil temperatures were well above 18°C when the Ngāi Takoto site was sown, and mostly above 18°C after the Water Trust site was sown, apart from a three-day period, when they just dipped to less than 1 degree below (Figure 13).

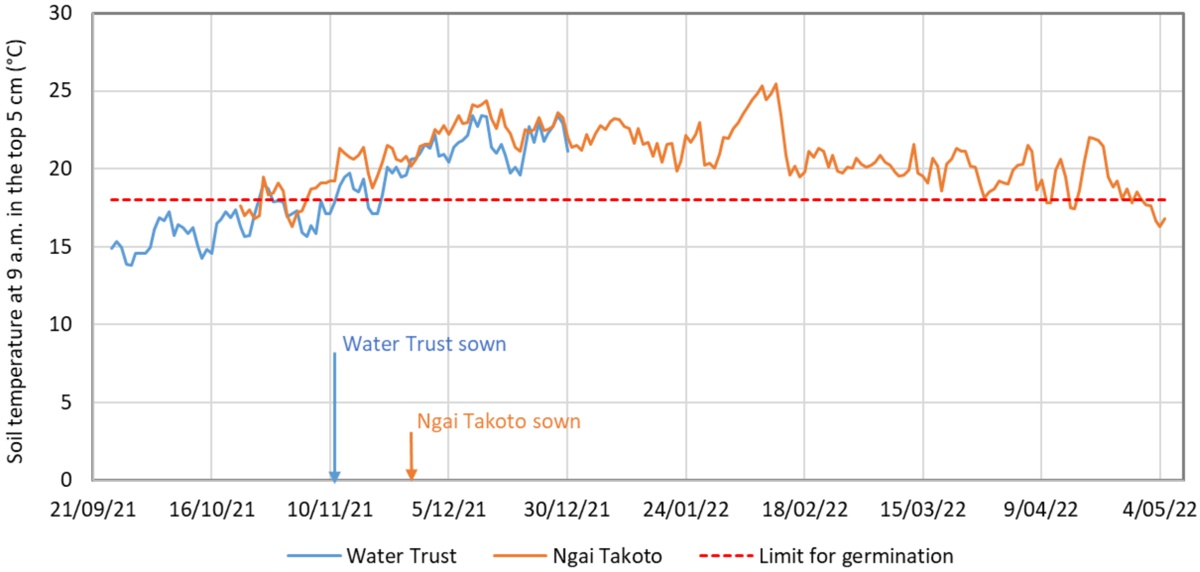

Figure 13. Soil temperatures at 9 a.m. in the top 5 cm at the Water Trust and Ngāi Takoto sites. The limit above which peanut germination is reliable is shown in red.

12.2 Air temperatures

The optimum air temperature for vegetative growth of peanuts is approximately 25–30°C, whereas the optimum temperature for reproduction is approximately 22–24°C (GRDC 2017). Average temperatures at Dargaville (Figure 14) and Kaitaia (Figure 15) were typically just below the optimum range for reproduction. Night temperatures below 9°C can cause leaf damage, evident as leaf yellowing between the veins, and growth rate is halved (GRDC 2017). Night temperatures were often below 9°C at Dargaville after early May (Figure 14), which was when the crops were harvested, suggesting that this was effectively the end of the growing season. At Kaitaia, night temperatures only dropped briefly below 9°C during May (Figure 15), indicating the potential for a longer growing season this Far North.

The length of the peanut growing season can be taken from the date that the soil temperature was reliably over 18°C, until the air temperature dropped regularly to <9°C. For the Water Trust site, this can be taken as being from 11 November 2021 until 5 May 2022, which was very close to the actual sowing and harvest dates of 11 November 2021 until 2 May 2022. For the Ngāi Takoto site, the potential growing season was longer, starting from 5 November 2021 until temperatures dropped below 9°C on 10 May 2022. There is potential that the growing season could have been longer, since temperatures rose above 9°C five days later, and remained above 9°C for the rest of the month (Figure 15). The actual sowing and harvest date was 25 November 2021 until 5 May 2022.

The peanut growing season is measured using GDD. The number of GDD accumulated on any given day is calculated as the (maximum temperature + minimum temperature)/2 minus a base temperature, i.e. the average temperature minus a base temperature. The base temperature for peanuts is commonly 9°C (GRDC 2017) or 10°C (Dr Janila Pasupuleti, ICRISAT, pers. comm.). The number of GDD is then summed over all the days from sowing until harvest, to give the number of GDD for the peanut growing season. For the sites near Dargaville, the potential growing season (using a base temperature of 10°C) was 1707 GDD long, and 1857 GDD (or longer) for the warmer sites near Kaitaia. The actual number of GDD from sowing until harvest for each site, based on Dargaville and Kaitaia temperature data, are given in Table 7.

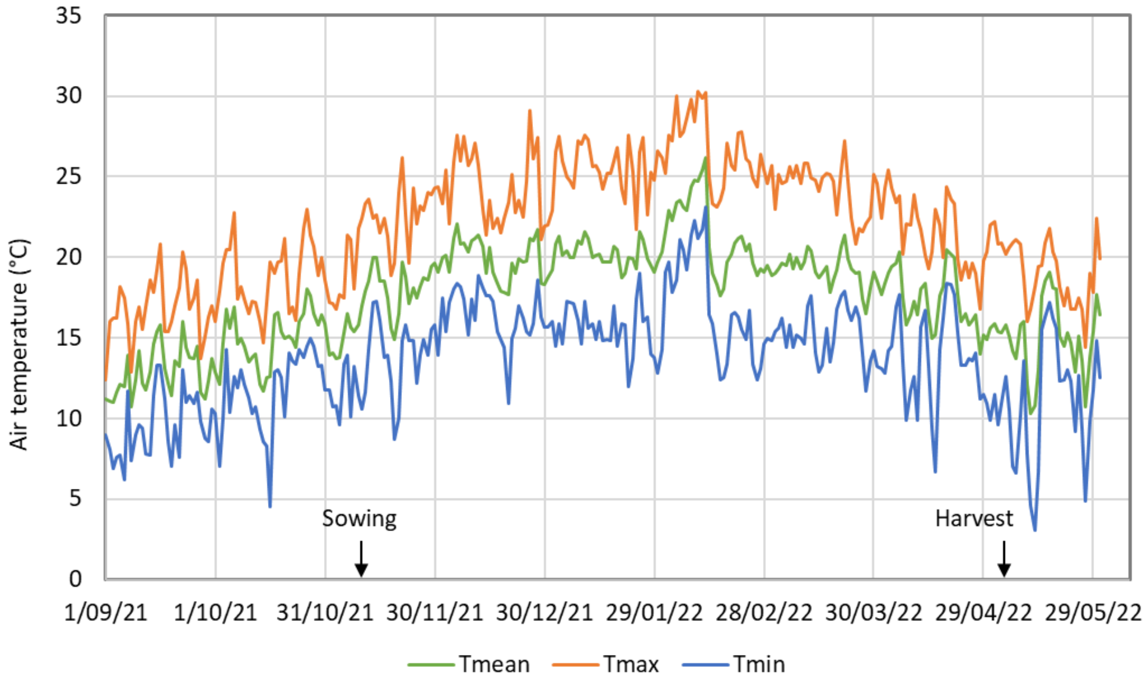

Figure 14. Mean, maximum and minimum air temperatures at Dargaville. Source: NIWA cli-flo database.

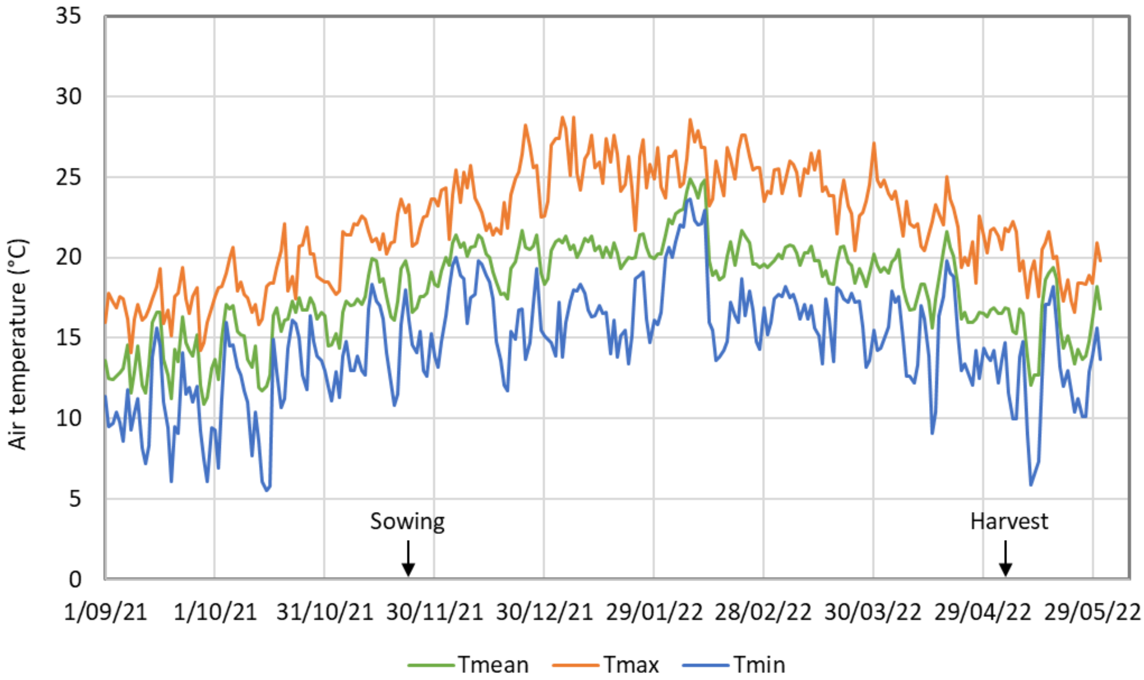

Figure 15. Mean, maximum and minimum air temperatures at Kaitaia. Source: NIWA cli-flo database.

Table 7. Growing degree days (GDD) from sowing until harvest for the five sites. GDD were calculated as (maximum temperature + minimum temperature)/2−10, summed daily from sowing until harvest.

	Water Trust	Te Kōpuru	Kai Iwi	Ngāi Takoto	Greenhill
Sown	11.11.21	11.11.21	11.11.21	25.11.21	21.12.21
Harvested	2.5.22	3.5.22	4.5.22	5.5.22	5.5.22
GDD	1689	1694	1700	1661	1411

13 Maturity testing

13.1 Differences among the breeding lines

The main difference among the breeding lines was that ICGV 16700 and ICGV 181037 were slower maturing than the other lines (Figure 16). This differs from the information received from ICRISAT (Table 8), which suggests that ICGV 16700 should be one of the faster maturing lines. This highlights the importance of testing varieties in the environment in which they will be grown. The ICRISAT information also suggests that the lines grown would require 1785–1975 GDD to reach maturity, which is longer than the c.1700 GDD in this trial. This explains why none of the breeding lines reached the target maturity of 65% brown + black by the end of April (approximately harvest time), although ICGV 181029 was close. To reach 1785 GDD (the shortest maturity time of the breeding lines provided, Table 8) by harvest (5 May), peanuts would need to have been planted by 28 October 2021 in the Kaipara, and by 10 November 2021 in the Far North. Soil temperatures at 9 a.m. were above 18°C on 28 October in the Kaipara, but then they dropped one or two degrees below this temperature for two weeks. At temperatures below 18°C emergence will be slow and the seedlings more susceptible to disease (GRDC 2017).

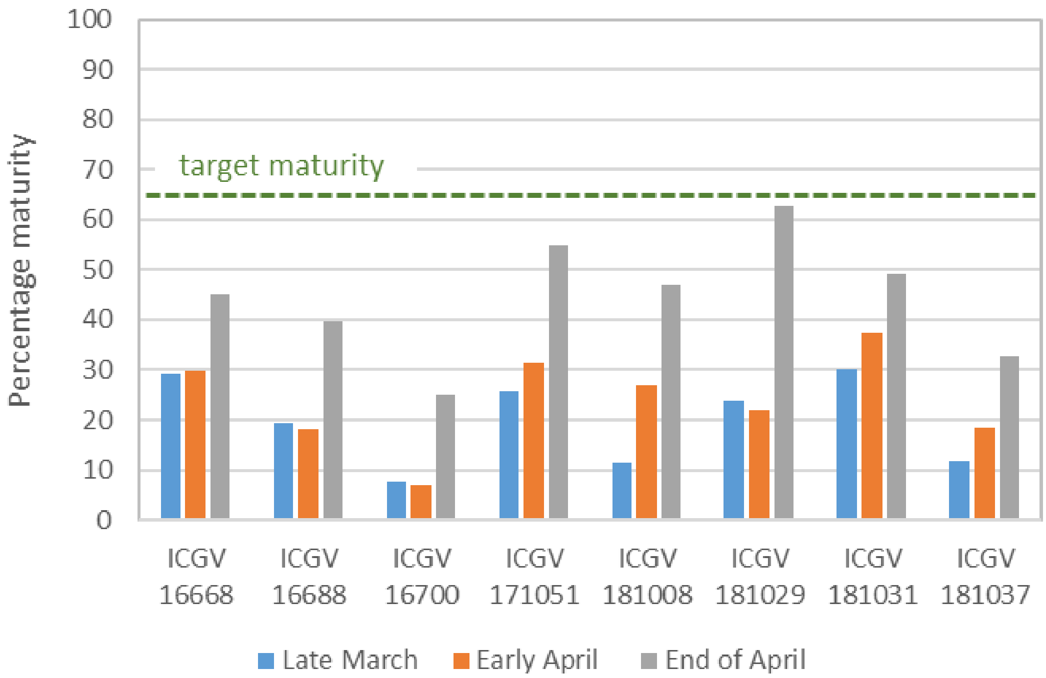

Figure 16. Percentage maturity for the different breeding lines, from late March to the end of April. Data are averaged across four trial sites, with the Greenhill site excluded since it was sown very late.

Table 8. Growing degree days [calculated as (maximum + minimum temperature)/2 − 10°C] required for key growth stages for the eight breeding lines used in this trial, according to ICRISAT India, where the lines were bred.

Breeding line	Emergence	Days to 50% flowering	Maturity
ICGV 16668	150-200	410	1975
ICGV 16688	150-200	425	1975
ICGV 16700	150-200	460	1860
ICGV 171051	150-200	590	1945
ICGV 181008	150-200	575	1785
ICGV 181029	150-200	575	1945
ICGV 181031	150-200	505	1945
ICGV 181037	150-200	575	1975

13.2 Differences among sites

Peanuts matured earlier at the Te Kōpuru, Kai Iwi Lakes and Water Trust sites (Figure 17). These were planted two weeks earlier than the Ngāi Takoto site, and almost six weeks earlier than the Greenhill site, since this site had to be replanted because of poor establishment (see Milestone Report 1, Trolove et al. 2022a). The Te Kōpuru and Kai Iwi Lakes sites matured earlier than the Water Trust site, even though all were planted at the same time (Figure 17). This is probably because of warmer soil temperatures at the Te Kōpuru and Kai Iwi Lakes sites. Soil temperature data during establishment showed that temperatures in the top 5 cm were 1.2°C warmer at Kai Iwi Lakes and 1.8°C warmer at Te Kōpuru than at the Water Trust site from 26 November to 10 December 2021.

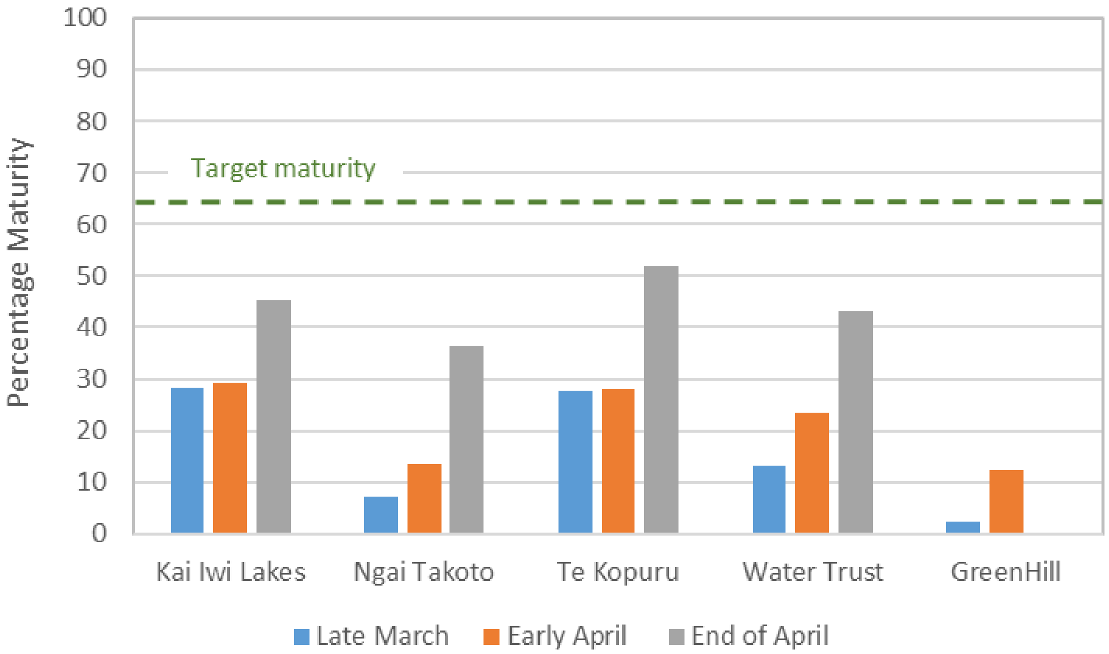

Figure 17. Changes in peanut maturity from late March to the end of April at the five trial sites. Data are averaged across breeding lines.

14 Harvesting

14.1 Yield differences among the sites and breeding lines

The sites were harvested in early May 2022: the Water Trust site on the 2nd, Te Kōpuru on the 3rd, Kai Iwi on the 4th, and the two sites in the Far North on the 5th. There were clear differences between the sites in yields. The highest yields were recorded at Te Kōpuru, which was true for all breeding lines (Figure 18). The higher yields were probably because of better weed control at this site and a higher soil moisture content (based on limited data, Figure 11). Very poor yields were measured at the Kai Iwi Lakes site, because of damage from turkeys and rabbits.

Breeding lines 181037, and particularly 181029, yielded poorly at all four sites (Figure 18). Differences were smaller among the other breeding lines. ICGV 171051 produced consistently high yields across all four sites compared with the other breeding lines. Despite the meagre yields at Kai Iwi Lakes, the yield differences among the cultivars followed a similar pattern to the other sites. The yield of ICGV 16700 was very small at Ngāi Takoto, compared with those at the Water Trust and Te Kōpuru sites; this was largely the result of difficulties sowing this cultivar with the drill used at the Ngāi Takoto site.

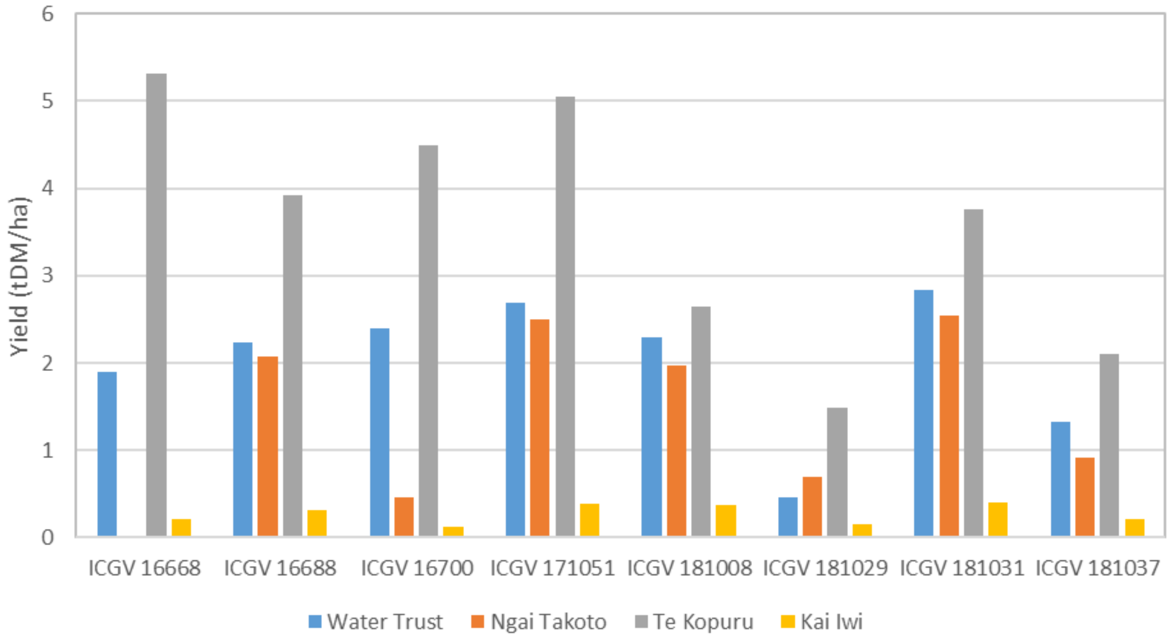

Figure 18. Yield of shelled peanuts across four of the five sites in 2022. The Greenhill site was planted late and was severely damaged by rabbits, so the data are not included.

14.2 Statistical analysis of the Water Trust site yields

The Water Trust site was replicated, which enabled the data to be analysed for statistical differences among breeding lines. A detailed discussion of differences among cultivars at the Water Trust site is provided below.

The ICGV breeding lines 171051 and 181031 produced the highest average yield at the Water Trust site (Figure 19). ICGV181029 yielded significantly less than all the other breeding lines. There was a large amount of variability in the growth of the peanuts across the site, which meant it was not possible to say with confidence that one breeding line was better than the other, apart from the poor performance of 181029. The variability mainly arose from variable weed pressure across the site. Irrigation may also have varied across the site, which may have explained why yields were generally higher from the lower part of the trial than from the higher part. There were also differences in topsoil thickness across the site. To a lesser extent there was some variability in fungal disease across the site.

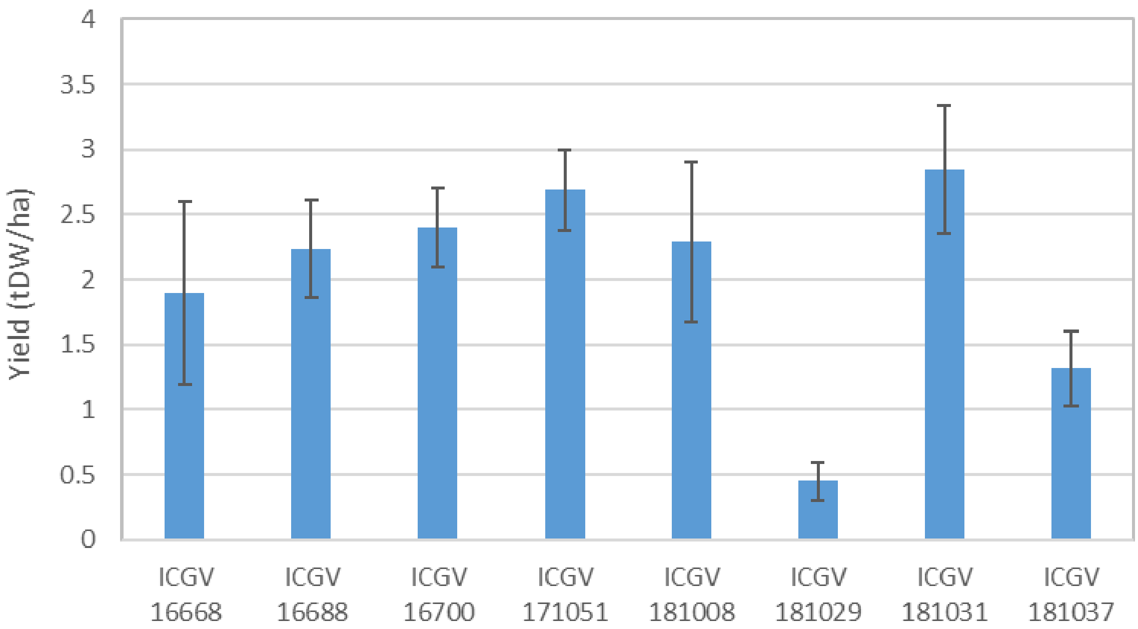

Figure 19. Yield of shelled peanuts at the Water Trust site. The bar is the standard error of the mean. The least significant difference at the 5% probability level is 1.6 t DW/ha.

14.3 Yield discussion

Average yields at the Te Kōpuru site for the four better performing breeding lines ranged from 3.9 to 5.3 t DW/ha, which are similar to the adjusted yields of 4.1–7.4 t DW/ha recorded the previous season (Trolove et al. 2021). The maximum yield recorded at any individual 1-m^2 quadrat at the Water Trust site was 5.1 t/ha, which was produced by line 181008. This suggests that these average yields for the Water Trust site may be higher in future if weed and disease management is improved. A closer row spacing is also likely to increase yields, since this will result in more sunlight being captured by the crop, which would drive more yield (Gardner & Auma 1989). We plan to use 38-cm row spacing next year, which will be achieved by offsetting the maize drill to plant in between the 76-cm rows.

15 Soil nutrient concentrations at sowing and harvest

Growing a peanut crop generally resulted in a decrease in soil pH (Table 9). This is because leguminous crops release acidity from their roots when they fix nitrogen. This drop in pH is likely to be only temporary, and should rise to close to the original values if the shoot residue is allowed to decompose in the soil, because this releases the alkalinity (Yan et al. 1996). Sulfate concentrations rose as a consequence of the large application of gypsum (calcium sulfate) at all sites (Table 9). The application of potassium fertiliser increased soil potassium at Te Kōpuru and Greenhill Farm, and superphosphate increased soil phosphorus at the Kai Iwi Lakes site. The cation exchange capacity (CEC) – which is a measure of the soil's capacity to hold positively charged nutrients, such as calcium, magnesium and potassium – decreased at the Kai Iwi Lakes and Water Trust sites. This is probably the result of the decrease in soil pH in these soils. A change in pH does not affect CEC in all soil types. The CEC is also influenced by the concentration of charged nutrients in the soil (ionic strength). The large increase in sulfate in the Greenhill Farm soil may explain the increase in CEC at this site. The amount of potentially available nitrogen (measured by the Anaerobically Mineralisable Nitrogen test) is governed by the amount of organic matter that is broken down by microbial processes in the soil, and this changed little over the five-month period of a peanut crop. Nitrogen released by microbial processes in the soil (ammonium- and nitrate-nitrogen) was rapidly taken up by the higher yielding peanut crops, so soil concentrations at the end are low (Table 9). The low yielding crops at Kai Iwi Lakes and Greenhill Farm had high soil nitrate-nitrogen concentrations, which may reflect some nitrogen return to the soil from animal excreta during grazing by pests, and less nitrogen uptake from the soil by these poorer performing crops.

Table 9. Soil test results from the start and end of the peanut crop.

Site	Time	Depth	pH	Olsen P	SO4	K	Ca	Mg	Na	CEC	NH4	NO3	AMN*
				mg/L	mg/kg	me/100g	me/100g	me/100g	me/100g	me/100g	mg/kg	mg/kg	kg/ha
Te Kōpuru	Start	0–15	6.3	13	6	1.1	62	8.5	1.1	17	2	5	150
	Start	15–30									2	3	-
	End	0–15	6.3	12	17	1.9	63	8.6	0.8	17	< 1	12	148
	End	15–30									< 1	7	
Kai Iwi	Start	0–15	6.1	13	23	0.61	9.9	1.84	0.13	21	2	7	171
	Start	15–30	-	-	-	-	-	-	-	-	< 1	3	-
	End	0–15	5.6	19	86	0.59	8.4	1.32	0.18	19	4	97	205
	End	15–30	-	-	-					-	1	24	-
Water Trust	Start	0–15	6.5	22	34	0.78	13.6	2.42	0.2	22	3	11	158
	Start	15–30									< 1	2	
	End	0–15	6.2	18	60	0.41	10.9	0.94	0.14	18	1	17	151
	End	15–30									< 1	28	
Ngāi Takoto	Start	0–15	5.7	38	3	0.24	1.9	0.89	< 0.05	6	4	4	181
	Start	15–30									3	1	
	End	0–15	5.0	58	51	0.2	2.4	0.71	0.08	7	7	14	172
	End	15–30									1	3	
Greenhill	Start	0–15	6.1	19	4	0.16	11	0.82	0.09	17	5	1	148
	Start	15–30									5	< 1	
	End	0–15	5.4	18	133	0.43	14.6	1.62	0.21	26	15	73	230
	End	15–30									7	18	

*AMN = Anaerobically mineralisable nitrogen

16 Pesticide residue and aflatoxin test results

Four peanut samples of 100 g were sent to AsureQuality for aflatoxin analysis, and a 500 g sample to check for residues of 486 different agrichemicals, from both the Te Kōpuru and Ngāi Takoto sites. No agrichemical residues or aflatoxins were detected. The detection limit for aflatoxin was 2.0 µg/kg, and 0.010 mg/kg for the agrichemical residues.

17 Production of peanut butter

A sample of 18 kg of peanuts was sent to Nelson to be made into peanut butter. There the skins were rubbed off, the nuts roasted and ground into peanut butter. Stuart Macintosh of Pic's Peanut butter considered the end result a success, saying "We tasted it. We're pretty happy it compares equally to what we currently have" (Ridout 2022).

It is interesting to note that the taste was good, despite not quite meeting the maturity targets. This indicates that the cultivars tested were suitable, and that the maturity targets may have been unnecessarily high. It may also indicate that the taste might have been even better, had the maturity targets been met.

18 Acknowledgements

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