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Collaborative Research Towards Best Practice Nitrogen Management in Asparagus Cropping

Building understanding of nitrogen pools and dynamics

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Executive Summary

Project aim:

To collaborate with growers across the growing regions to collect data upon which we can build understanding of nitrogen pools and dynamics, and together determine what Best Practice should be.

Team:

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Key findings:

- Current nitrogen fertiliser recommendations are based on limited trial work.
- Nutrient deficiency symptoms are not common and careful fern and root testing are needed to see if they exist
- While analysis of fern growth to assess nutritional status is recommended, little guidance on interpretation is given
- Soil testing should take in the whole root depth, but there are few guidelines to establish fertiliser rates
- While sufficient nitrogen fertiliser to grow healthy fern should be applied during the establishing years, once established application, if any, should be based on replacing nutrients removed during harvest
- Research showed 75 kg-N/ha could support a crop for three years without a detectable change in fern nitrogen concentration
- Fertiliser should be applied close to fern growth which is when uptake occurs. This will minimise leaching risk, especially on shallow or low water holding soil types
- Fresh root mass is highly variable with a minimum at the end of harvest, and a maximum at the end of fern growth. We found the root mass in summer at the end of harvest was 26,300 kg/ha, increasing to 91,700 kg/ha in winter after fern growth
- At the end of fern growth, about 80% or more of the nitrogen in the system was found in the roots
- Data we collected are generally in line with published research

The project faced several challenges due to the late start and because it was a very difficult season for growers who experienced collapsed markets, poor weather and a severe shortage of labour.

We established and monitoring trials in five crops, but data has gaps where growers did not collect yield information and in two cases did not apply alternative fertiliser treatments. This is understandable when severe pressure such as experienced in the 2021-22 season impacts growers and they are forced to prioritise and make compromises. The growers through the New Zealand Asparagus Council have committed to continuing this trial post-project, and data will be collected from at least three crops where alternative fertiliser treatments were applied.

The data we did collect increased our understanding of nitrogen pools, finding they are generally in line with other reports in literature.

We found a wide range of nitrogen management practices, not indicative of a single agreed industry best practice. In general, fertiliser if any is applied at the end of harvest just before fern growth.

Surveys showed growers do not prepare formal documented nutrient budgets, but they do consider some relevant variables when determining how much (if any) fertiliser to apply. Preparing a pre-harvest nutrient budget for nitrogen would require careful sampling of the storage root mass. To get robust estimates, a reasonably large number of samples is required, and extracting and cleaning roots is a time consuming process. Given the very low nitrate requirements, typically low additions, and low soil nitrate levels, it may not be considered worthwhile. Preparation of a summary budget post-season is similarly difficult as virtually all the nitrate is held in the roots.

Limited yield data have collected so far for this project. The yield data to be collected during the 2022-23 season are relevant to alternative fertiliser treatments applied in 2021-22. The limited data we collected in 2021-22 and reported typical yields from our grower surveys are generally similar to those reported by Hunt, Dellow, and Sinton (2019).

While Drost and Wilson (2003) found roots to at least 80 cm depth, most of the soils in our trials had limitations from wetness or stones at about 45 cm. The average 91,700 kg/ha fresh root mass measured at the end of fern growth is generally at the higher end of root masses in literature reports (Drost, 2013). The average concentration of NO3-N in root tissue was 1.38% of dry mass which is similar to German research that found about 1.78% N in dry matter (Hartmann, Hartmann, & Altringer, 1990).

When we review the data collected and the amounts of nitrogen determined in the key pools as the crop proceeds from spring through summer to winter, the overpowering influence of the nitrate levels in the massive storage root system is apparent, especially in winter when more than 80% of identified NO3-N was in the storage roots.

While there is support for application of nitrogen in the establishment phase, the need for additions to mature crops is not clear. Growers have a wide range of fertiliser policies, some applying no nutrients at all, and others applying at rates much higher than exported in the harvested crop. From the total season yield information supplied and the laboratory test data obtained, the amount of NO3-N exported in the harvested crop is about 12 – 13 kg NO3-N/ha. Of the trial growers that report applying nitrogen fertilisers, the rates were 24, 55 and 69 kg NO3-N/ha. This is similar to the rates reported by the wider group that responded to the NZAC survey.

Introduction

Project Deliverables

1. Preview work by others
    a. "Asparagus Manual" Sarah Sinton, 2010. Crop & Food.
    b. Survey of Waikato growers. Adrian Hunt, 2019. P&FR (and NZAC survey data on other growers)
    c. Interview with Dr Peter Falloon, Aspara Pacific (Deceased 2021)
    d. European and USA recommendations
2. National Current Practice Survey
    a. Survey I: Project growers
        i. Current fertiliser application rates
        ii. Methods used to determine crop/soil status and fertiliser application
    b. Survey II: Collect current practice from most NZ growers (> 90% total area)
3. Research Plan
    a. Design simple research to address key gaps
        i. How much N is cycling in the system?
        ii. How much is exported?
        iii. How much is typically added?
        iv. What is the maximum biomass and how much N does it contain?
        v. What are typical soil N levels in root zone through the season?
4. Grower as a Researcher Training Workshops
    a. Representative soil and plant sampling
    b. Nitrate Quick Test
5. Data collection
    a. Soil sampling – Farms in key growing regions: Hawke's Bay, Manawatu, Horowhenua, Canterbury
        i. 0-15 cm, 15-30 cm, 30-x cm
        ii. Nitrate Quick test (grower activity)
        iii. Lab tests in October, December (pre main fertiliser application), and May (fern removal)
    b. Crop sampling
        i. Spear production weekly
        ii. Above ground biomass (end of fern)
        iii. Below ground biomass from roots caught during soil sampling
        iv. Lab tests October, December and May
6. Analysis
    a. Basic nutrient balances
    b. Apparent nutrient flows
    c. Crop effects
    d. Benchmarking tables
7. Post Project Work: following season yield monitoring as the 9 month time frame does not allow for impact on following crop performance. This will be monitored by industry and incorporated into a follow-up addendum

Project rationale

Through the MPI SFF project "Future Proofing Vegetable Production", LandWISE and vegetable growers learned to use the Nitrate Quick Test and a Nutrient Budget template to improve management of nitrogen, with significantly reduced risk of leaching. The process has become a tool for demonstrating application of Best Practice.

Asparagus growers expressed interest in this methodology, but there is a lack of scientific knowledge around nitrogen pools and dynamics upon which to build target levels and provide guidance for and justification of supplementary nitrogen applications.

Asparagus production is spread across New Zealand from Waikato to Canterbury. About 520 ha produce about 2000 tonnes per year. Annually, $9.1 M is sold within NZ and $0.1 M is exported (Anonymous, 2020).

Anecdotally asparagus has been considered a low nitrogen crop however grower practices are not always reflecting this. A 2019 survey of grower practice in Waikato suggested an extremely wide range of application rates and that typical applications exceeded crop exports, but there has been minimal in-field validation.

Industry reinvigoration and an increase in planted area is expected with the commercialisation of robotic technology and the sustainable growing of New Zealand grown asparagus is pivotal in its brand story to consumers. As a potential crop for more sustainable land-use, better knowledge and grower best practice is required.

The existing science supporting best practice for nitrogen management of asparagus in New Zealand is sparse. We aimed to address the lack of base data, the lack of reliable decision support tools, and to develop a new understanding among growers and new best practice guidelines, based on nationwide collaborative research with the overall goal of maximising nitrogen use efficiency and crop quality.

Our proposal was to collaborate with growers across the growing regions to collect data upon which we could build understanding of nitrogen pools and dynamics, and together determine what Best Practice should be. Engaging growers intimately in the process would both collect more data, and develop on-farm trial skills and knowledge, enabling them to undertake trial work to resolve future issues as they are identified.

The work is to continue post-project so growers can collect yield data from the crop following application of different treatments. This will complete the picture by adding to the baseline data have been collected.

Literature Review

The asparagus plant

Asparagus plants have an underground rhizome or crown and a mass of fleshy roots (Figure 1). After a winter dormant phase, spears emerge as shoots or spears once soil temperatures reach 8-10 °C. Uncut spears develop into asparagus fern over summer recharging storage roots, before senescing and dying in autumn (Douglas, 2005 (Brash et al., 2005).

Figure 1 Asparagus crown consisting of rhizome, bud clusters, buds, fleshy storage roots and fine feeder roots. Copied from Drost (2013) Fig 1

Figure 2 Asparagus fern in mid-January, two months after close-up at the end of the harvest period

Asparagus establishes its root system during the first few seasons of growth. The root system of asparagus is fully developed at the end of the fourth year (Bennison, Parker, & Drost, 2014) or fifth year (Drost, 2013) after the asparagus has been planted. While percentage biomass increase is greatest in the first two or three years, the greatest increase in total below-ground biomass occurs during the third and fourth years after planting (Hunt et al., 2019)

Spear production relies on carbohydrate reserves stored during fern growth the previous season as represented in Figure 3.

Reported critical times in the plant growth cycle are near the beginning and end of harvest, after fern establishment, during mid and late fern growth, and during early winter (Wilson et al. 2002). Asparagus storage roots contain soluble carbohydrates which accumulate during fern growth and are utilised in spring to foster spear growth. This also means the pool of nitrogen in roots is depleted to grow spears in spring and accumulates when fern growth refills the storage roots (DR Wilson et al., 2005).

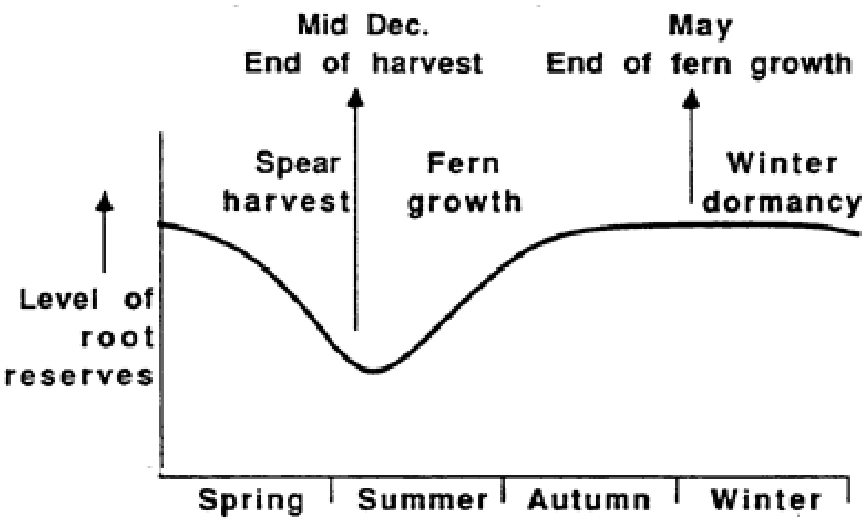

Figure 3 The depletion and rejuvenation of root carbohydrate reserves in asparagus through one annual cycle. [reproduced from Douglas, in Brash et al 2005]

Nitrogen pools

Nitrogen is present in the soil solution and soil organic matter, and in roots, shoots and fern, measured as soil mineral nitrogen, anaerobically mineralisable nitrogen and nitrogen in plant biomass respectively. Plant take-up from the soil pool occurs from the end of November to the beginning of March[1] (P.-J. Paschold, Artelt, & Hermann, 1996).

Roots

Roots are a major store of nitrate in the system, with the amount of nitrogen a function of root mass and root nitrogen concentration.

Determination of root mass in a field is difficult. Simmons, De Baets, Niziolomski, and Maskova (2018) recommend taking about 10 cores randomly along the top of the ridge, the side and into the wheel track. In a detailed root study, Drost and Wilson (2003) took 55 mm diameter core samples at three distances from the row at four random locations.

Simmons (2021) took root cores on the crown zero line (CZL) from between two plants in the row. Cores were also taken subsequently, away from the CZL, but in line with the crown at distances of 0.3 m, 0.6 m and 0.9 m. Root cores were extracted from the following soil depths: 0.00 -0.15 m, 0.15-0.30 m, 0.30-0.45 m and 0.45-0.6 m (Figure 4).

Fleshy asparagus roots can be found to at least 80 cm depth. Investigations showed roots grew deeper in a sandy soil than in a silt soil, had higher dry matter content in silt than in sandy soil, and greater root length in a silt compared to a sandy soil. Fibrous root length density was greater during fern growth than during harvest, in a sandy versus a silt soil and at shallow versus deep sampling depths (Drost & Wilson, 2003).

[1] Adjusted for Southern Hemisphere - originally from end of June to beginning of October.

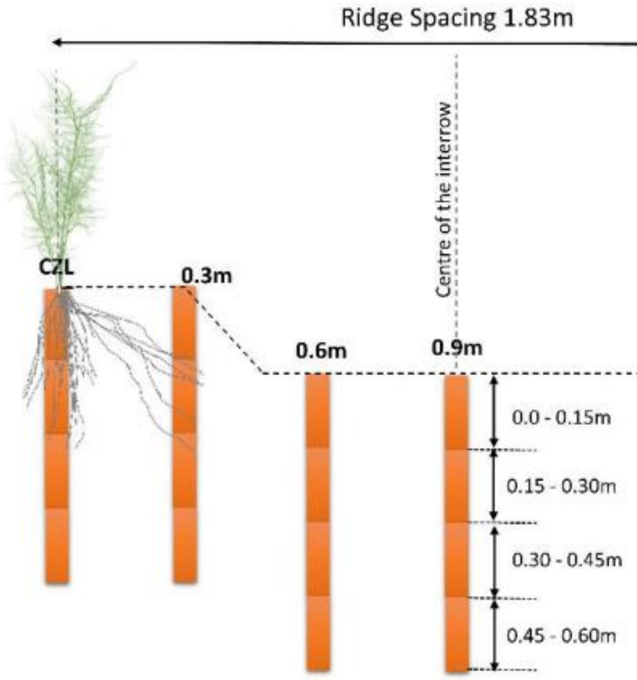

Figure 4 Root coring protocol adopted for asparagus. [Reproduced from Simmons (2021) Fig 3]

Fresh root mass is highly variable with a minimum at the end of harvest, and a maximum at the end of fern growth. With adequate nutrition, fresh root mass five years after planting can be 70,000-80,000 kg/ha (Drost, 2013).

The dry matter of root biomass in NZ asparagus fields can vary greatly from between 0.12-1.2kg per plant. Typical asparagus production systems have populations of around 20,000 plants meaning root dry weight per hectare can vary from between 2,400 to 24,000 kg (DR Wilson et al., 2005).

In a model study, German research testing asparagus roots from 24 different commercial asparagus fields covering a broad range of soil types found asparagus roots contained between 0.26 and 1.44% N in dry mass, with average field values of 1.72% nitrogen on a dry matter basis (Hartmann et al., 1990). Drost (2013) reports typical storage in fleshy roots of 300-500 kg N/ha.

Figure 5 Fleshy asparagus roots at 40 cm depth

Shoots/fern

In a commercial setting, fern growth begins at the end of the harvest period typically in December, and continues until it senesces in winter, typically in May.

The nitrogen content of asparagus shoots is reported as about 0.5% of fresh weight or 5kg/tonne of yield, so about 25 kgs of nitrogen are removed from the system with an asparagus yield of 5 tonnes per hectare, or 5 kg N/tonne exported (Brash et al., 2005).

Table 1 compares nutrient removal from an asparagus crop with other common vegetable crops including broccoli, cauliflower and buttercup squash. Because of relatively low yields, typical asparagus harvest removes very little nutrients compared to other crop harvests indicating nutrient requirement for asparagus is low compared to other crops.

Table 1 Major nutrients removed by an asparagus crop compared to broccoli, cauliflower and buttercup squash crops (kg/ha). * Retrieved from: (Brash et al., 2005). ** Retrieved from: (Reid & Morton, 2019)

Major Nutrients Removed	N	P	K
Asparagus (5 t/ha) *	25	4	20
Broccoli (16 t/ha) **	67	10	53
Cauliflower (33 t/ha) **	134	20	98
Buttercup squash (28 t/ha) **	103	16	101

Nitrogen concentration found in fern 6-11 weeks after close-up ranges from 2.50 – 4.00%. Dead fern contains between 15-25 kg N/ha. Douglas and Ledgard, in (Brash et al., 2005).

Table 2 shows the common range of nutrients in asparagus fern 6-11 weeks after close-up. Values outside these indicate a nutrient imbalance exists which must be rectified. In the case of nitrogen, low values indicate there is not enough nitrogen available for uptake (Brash et al., 2005).

The majority of N in fern is remobilised and returned to the crown and storage roots as the plant senesces. The remainder is usually returned as part of the incorporated residue when mulched (Drost, 2013). Some growers bale and remove fern, and some graze it with stock.

Table 2 Nutrient concentrations found in asparagus fern, 6-11 weeks after close-up. Retrieved from: (Brash et al., 2005)

Nutrient	**Common range**
Nitrogen (N%)	2.50 -4.00
Phosphorus (P%)	0.20 -0.40
Sulphur (S%)	0.30-0.45
Potassium (K%)	1.90 -3.50
Calcium (Ca%)	0.60 - 1.50
Magnesium (Mg%)	0.14 -0.35
Trace Elements - parts per million (ppm)	
Manganese (Mn)	30 – 160
Zinc (Zn)	20 – 60
Copper (Cu)	5-15
Iron (Fe)	50 – 150
Boron (B)	30 – 150
Molybdenum (Mo)	0.08 -0.40
Foliage Sample: sample the top 30 cm of 8-10 fully expanded ferns taken across a block leaving out immature and diseased fern.	

Soil nitrogen

Mineral Nitrogen (Mineral N or Nmin) is the sum of nitrate and ammonium content in soils, both mineral forms of nitrogen that are immediately available to plants (Reid & Morton, 2019). However asparagus spear production relies on root reserves, and pre-harvest applications of nitrogen fertilisers do not increase spear weight, number or total yield (Drost, 2013).

The mineral nitrogen content in soil under asparagus production fluctuates throughout the year due to uptake, fertiliser applications, and climatic conditions which may affect volatilisation or leaching losses. P. Paschold, Artelt, and Hermann (2001) state the application rate of nitrogen fertiliser should be based on soil-analysis as well to apply the correct amount of nitrogen fertiliser. This is contrary to

Available Nitrogen, otherwise known as Anaerobic Mineralisable Nitrogen (AMN) is a measure of the amount of nitrogen that can potentially become available through biological mineralisation processes throughout a common growing season. This refers to the nitrogen which can be released from breakdown of organic matter (Reid & Morton, 2019). Available nitrogen breaks down to provide mineral nitrogen most rapidly during periods when the soil is warm and moist which occurs during spring and summer; meaning we can expect most of the AMN to be released during spring and summer (Francis & Curtin, 2002).

The common range for AMN found in New Zealand was between 23-144 kg N/ha (Hunt et al., 2019), however this was calculated from a soil test done to a depth of 15cm only.

AMN will become available over the season and should be included when calculating how much fertiliser to apply (Hunt et al., 2019). However, asparagus production fields tend to lose organic matter over time, indicating the AMN value may reduce in long term asparagus fields compared to those coming out of pasture as organic matter reserves are used up (P. Paschold et al., 2001).

Policies

Best Practice

The currently accepted best management practice (BMP) guideline for asparagus production in New Zealand is the “Asparagus Manual, 2005” (Brash et al., 2005). Other useful documentation includes “Asparagus Nutrient Management” (Drost, 2013) and the ADHB Technical Update, “Asparagus root growth patterns” (Simmons et al., 2018).

Nutrient deficiency symptoms are not common and careful fern and root testing are needed to see if they exist (Drost, 2013).

Hunt et al. (2019) state that testing of soil mineral nitrogen, anaerobically mineralizable nitrogen and nitrogen in plant biomass throughout the season is essential to gain insight into the nitrogen balance within the asparagus growing system.

The “Asparagus Manual, 2005” recommends foliage testing during fern growth and soil testing. Foliage testing involves taking a sample of eight to ten fern tips, 300mm long taken diagonally across each asparagus block. Each tip taken must be from different plants and should be taken 6 to 11 weeks after close-up. While a common range for fern nitrogen of 2.50 – 4.00% is given, the manual does not give target levels, noting that it can only provide some guidance as insufficient research has been done.

The Asparagus Guide by Crop Walkers also recommended fern nutrient analysis as the most accurate way of finding out the nutrient status of asparagus plants (Bennison et al., 2014).

The “Asparagus Manual, 2005” also recommends soil sampling to a depth of 30cm for pre planting and to a depth of 15cm in an established block (Brash et al., 2005). However, there is only a blanket recommendation, apparently not related to current soil nitrogen levels.

Shallow testing is likely to underestimate the soil nitrogen supply available to asparagus, because most of the root mass and nutrient uptake will be below 15cm (Hunt et al., 2019). They recommend soil testing for mineral nitrogen close to fertiliser application time, and that nitrogen fertiliser, if necessary, should be applied shortly before the most rapid growth phase of fern.

Nitrogen application

Drost (2013) recommends against applying fertiliser before the start of fern growth, the main period of nutrient uptake. Nitrogen uptake is likely to be highest if applied at close-up provided conditions allow fertiliser N to move into the rootzone. Sufficient nitrogen fertiliser to grow healthy fern should be applied during the establishing years. Once established, application if any, should be based on replacing nutrients removed during harvest.

Hunt et al. (2019) state that nitrogen fertiliser recommendations are based on limited trial work (details not reported). The research suggests applications on 100 kg-N/ha can be profitable on high yielding varieties, but recommends rates based on fern analysis.

UK research showed that if soil mineral nitrogen in the upper 0 – 30 cm layer was greater than 120 kg N/ha, and the total in the rootzone was more than 160 kg N/ha, no fertiliser was required. If soil mineral N was less than 160 kg N/ha, adding sufficient to increase the upper 30 cm to 120 kg N/ha was recommended (Drost, 2013).

Developing new crop

Asparagus crops during their establishment phase have a net underground biomass accumulation till the fourth year after planting with the greatest increase in biomass being evident in the third and fourth year after planting. Due to this, allowance must be made for the nitrogen requirement to support this net increase in biomass. This nitrogen requirement could be up to 63 kg N/ha on top of the amount of nitrogen which is removed due to spear harvest (Hunt et al., 2019).

Brash et al. (2005) note that asparagus planted in a field out of an extended period of permanent pasture will receive sufficient nitrogen from organic matter breakdown to meet establishment needs without additional fertiliser.

It is recommended to minimise or avoid asparagus picking during the establishment phase as this can have a detrimental effect on establishment. Common practice in Europe is to avoid all picking during the first establishment year, however this is not common in New Zealand (D Wilson & Sinton, 2005). If picking is not done during the first year, this decrease in nitrogen export should be incorporated in the nitrogen balance.

Maintenance of an established crop

Established asparagus crops grow a large amount of fern biomass every year. Common practice is to mulch fern at the end of the season. It will rot down and will subsequently remineralise the nitrogen it contains, returning between 15-25 kg of N/ha back into the soil and must be taken into consideration when calculating the nitrogen requirements of the established asparagus crop.

The "Asparagus Manual, 2005" recommends applying between 50-100 kg N/ha depending on crop yield (Brash et al., 2005). By comparison, those authors report that 25 kg/ha of nitrogen are removed from the system with an asparagus yield of 5 tonnes per hectare.

P. Paschold et al. (2001) recommended testing for soil nitrogen before applying any fertiliser as the mineral nitrogen content of soils fluctuates due to climatic conditions stimulating mineralisation. Their German research found an optimum soil mineral nitrogen level of 90 kg N/ha to a depth of 90 cm. There was no significant difference in yield from target levels of 30, 60, 90 and 120 kg N/ha but a level of 90 kg N/ha gave a slightly higher number of marketable spears than other treatments.

Hunt et al. (2019) reported a case where a single application of 75 kg N/ha supported asparagus for three years without any significant change in fern nitrogen concentration indicating that fern analysis is an essential part of analysing whether an asparagus crop is deficient of nitrogen or not. In contrast, Hartmann et al. (1990) state that nutrient status can be evaluated only on the basis of root analyses and not by analyses of above ground parts.

D Wilson and Sinton (2005) were unable to find consistent productivity responses to applied N and concluded that there was no benefit to applying high rates of N and in some cases rates of 200 kg N/ha may have suppressed yields. Nutrient applications before or during harvest have little impact on present years productivity as spear growth is dependent on the prior year’s nutrient storage (Drost, 2013).

Minimising losses

The main losses of nitrogen which can occur in asparagus production systems include volatilization and leaching (Hunt et al., 2019).

Asparagus is commonly grown on sandy, free draining soil which further exacerbates the risk of leaching (Hunt et al., 2019). Furthermore, as asparagus only takes up nitrogen during the active fern growing period, all nitrogen outside of this active fern growing period is at a high risk of leaching (P.-J. Paschold et al., 1996).

The first strategy is to apply the correct amount of nitrogen the crop needs by calculating a nitrogen balance based on the net nitrogen loss from the system as well as the AMN and mineral nitrogen content of the soil. Recommendations for an establishing crop will include the increase of nitrogen in the increasing plant biomass. For an established crop, there is debate if any further fertiliser nitrogen is required.

Application of any nitrogen supplements should be made as close to the time of nutrient uptake (the end of November to the beginning of March) as possible to reduce the risk (Brash et al., 2005). Volatilization that occurs when urea is applied during hot, dry weather may result in up to 30% of the applied nitrogen can be lost into the air as ammonia, especially if rates higher than 100 kg N/ha are applied. However, rain or irrigation within 12 hours may greatly reduce volatilization loss. Applying nitrogen as liquid urea or ammonium nitrate containing 35% urea can result in a 48% reduction in volatilization of the urea content under field conditions (Grant et al. 1996 in (Bishop & Manning, 2010).

Douglas and Ledgard (Brash et al., 2005), suggested splitting fertiliser into two applications in dry areas, half at pre-harvest and half at close-up to ensure some has reached the root zone before fern growth starts. Drost notes this will increase the risk of loss through leaching.

Grower Surveys

Grower practices

Hunt et al. (2019) through Horticulture New Zealand surveyed asparagus growers in the Waikato to gain insight into common asparagus management strategies. The survey covered 303 ha of the total 520 ha of asparagus production in NZ. Survey questions and exemplar responses are presented in Table 3.

After removal of extreme yield values such as those under 1 tonne/ha, the average gross yield was found to be 4.4 t/ha. The dominant soil type was light textured ranging from sandy through to sandy loam. Due to their free draining nature these soils are susceptible to nitrogen leaching.

Anaerobic mineralisable nitrogen (AMN) content of soils ranged from 23 to 144 kg/ha, however most growers only soil tested to a depth of 15cm deep. The median AMN value was 69 kg N/ha in the top 15cm of soil. Average nitrogen fertiliser application ranged from 0 to 137 kg N/ha. They report that common nitrogen fertiliser application rates vary from anywhere between 0 to 209 kg N/ha/yr.

Table 3 Survey questions in and exemplar responses to a survey used by Horticulture NZ to gather data on current grower management practice for Asparagus production in the Waikato region. (Reproduced from Hunt et al, 2019)

Question	Example response
Name/Grower ID	*Frank Smith (Name to be retained by HortNZ and substituted for an anonymised grower id e.g. "Grower A")*
Region	*Hamilton*
Dominant soil type	*Soil texture as a minimum (sandy loam) but ideally New Zealand soil classification from Smap*
Area under production (establishing < 3 years	*2 ha establishing*
old, established >3 years old)?	*5.5 ha established*
Oldest established crop	*10 years old*
How often do you soil test for N, what analysis and to what depth?	*Mineral nitrogen (N), in spring, to a depth of 15 cm*
Last 3 years' soil tests	*Attached reports from Hill Laboratories Limited*
How much irrigation is applied and when?	*15 mm per week during summer*
Gross yield harvested (removed from the field)	*7 t/ha*
Fertiliser practice on establishing crops	*50 kg of urea in November*
Fertiliser practice on established crops	*100 kg of urea in January*
Any additional inputs containing N?	*2 t/ha compost, 4% N*
How do you manage fern trash?	*Mulch in April*

LandWISE survey 1

The first LandWISE survey was completed through a questionnaire distributed by the New Zealand Asparagus Council, with responses received from ten growers, eight not triallists in our project. A summary is presented as Table 4.

The area of crop represented was about 330 ha. While new crops are still being planted and some blocks replanted, most are more than three years old. The oldest crop was reported to have been established in 1976, and another reported to be 25 years old.

Five growers soil test annually to 15cm depth, one every two years, one not in the last three years and two never test. The two growers that irrigate do so based on soil moisture monitoring results.

Based on grower responses, average yields range from about 3 to possibly 6.4 t/ha. Calculated nitrogen application rates to developing crops range from 0 kg/ha (four growers) to 74 kg/ha. On established crops, application rates range from 0 kg/ha (three growers) to 75 kg/ha.

Six growers report mulching fern residues, two cultivating it into the ground and one reports 90% is cut and removed from the paddock.

Two Canterbury growers prepare nutrient budgets based on the Asparagus manual and one Waikato grower prepares a budget with their fertiliser company representative. Seven growers, one a Canterbury grower who does not apply any nutrients to the crop, do not prepare any nutrient budget.

Table 4 Summary of grower responses to survey distributed by the New Zealand Asparagus Council

Grower ID	Grower 1	Grower 2	Grower 3	Grower 4	Grower 5	Grower 6	Grower 7	Grower 8	Grower 9	Grower 10
2. Region	Waikato	Wanganui/ Manawatu	Canterbury	Hawke's Bay	Canterbury	Canterbury	Waikato	Waikato	Horowhenua	Mid Canterbury
3. What is your dominant soil type?	sandy loam	Stoney Silt loam	Waimakariri loam	Medium Sandy Loam	Stony silt loam	Deep sandy Loam	Sandy Loam	Horotu Sandy Loam	Sandy Loam	Lismores
4. Area under production (establishing < 3 years old, established >3 years old)?	13 ha	25ha 55ha	1980	1 Ha 25 years old, 3Ha 10 years	62 hectares	1.5 Ha established <3 years	>3 years - 7ha's	42 ha >3 yr	83ha >3 yr	3 ha 2.5 yrs 4 ha 1.5 yrs
5. Oldest established crop?	12 yrs	16yrs	1976	25 yrs	17 yrs	12 years	8 years	2015	2012	As above
6. How often do you soil test for N, what analysis and to what depth? (e.g., in spring, to a depth of 15 cm)	not in last 3 yrs	Annually early Spring, 150mm	Never	Nil	Late winter to 15cm	~every 3 years spring 15cm	2 years, 15cm	Annually, winter 15cm	Annual, Depth 15cm	Soil test yearly. 15 cm samples
7. How much irrigation is applied and when? (e.g., 15mm per week during summer)	nil	None	Nil	Nil	dependent on neutron probe	None	Nil	Nil	None	Dec on depending on soil moisture.
8. Gross yield harvested (removed from the field)	35 t	5t	6.7	12 Ton	12 tonnes	6 T	45t	5 ton hectare net	4.1-5.1 T/ha Paid. + 30% for gross	NA yet
T/ha [calculated DJB]	3.7	5	*?	3	12*?	4	6.4	5	4.6	

Grower ID	Grower 2	Grower 3	Grower 4	Grower 5	Grower 6	Grower 7	Grower 8	Grower 9	Grower 10	Grower 11
9. Fertiliser practice on establishing crops (e.g., 40kgs of NPK/ha in December)	seaweed, fish fert,	40kgs N, P, K on <3yr old blocks early spring	Nil	May/June - 250 kg/ha pot 30, 100 kg/ha Urea in Sep	Nov- Dec 300 kg 8-11-20 Dec 50kg N Feb 50kg N	currently N.A	Spring as per recs based on soil tests	Nil fertiliser for the last 3 years		Apply fert as per recs from consultants.
kg N/ha [calculated DJB]	5	5	0	46	74	0		0	0	28.5
10. Fertiliser practice on established crops	as above	Minimal in recent years	Nil	May/June - 250 kg/Ha pot30, 100 kg/ha Urea in Sep	December 250 kg KS 50kg N	December 75kg/ha N, 37 kg/ha P, 108kg/ha K	As above	Nil	Units/ha N=55, P=24, K60, S=29, Ca=67, Mg=33 B=?	As per recommend ation. As above
kg N/ha [calculated DJB]	5	0	0	46	50	75		0	55	
11. Any additional inputs containing N?	nil	no	No	Nil	No	Aug/Sep 1% N mushroom compost	Nil	No	None	Only during Fertigation
12. How do you manage fern trash?	disc in	Mulch	Mulch	Mulched into ground	Mulch and bury	90% is cut and carried of paddock	Harrow back into soil	Mowed and mulched	Cut onto ground	Mulch it in.
13. Do you prepare a nutrient budget? If so, is it written and where do you get the information from?	no	No	No	Nil	Yes; written to FEP asparagus manual annual soil tests yields	The nutrient budget is based on information found in the asparagus manual.	Yes, work with fert company	No	No	Not as yet.

LandWISE Survey 2

The second survey was a detailed questionnaire based on the Fertiliser Association Nutrient Management Code of Practice. Results are presented below as a series of tables.

Undertaken only with the trial site growers, there were six main sections: Risk Assessment, Nutrient Budgeting, Nutrient Records, Fertiliser Use, Application Rate and Application Technique. Rather than a Yes/No answer, growers were asked to respond “Always”, “Usually”, “Sometimes” or “Never” about each recommended practice. In some cases, the practice did not apply and was recorded as N/A.

Note that while five blocks were included, there were only four growers because the cancelled Waikato trial was relocated to an additional Hawke’s Bay paddock at short notice. The survey represents a small sample, but of larger growers with strong involvement in sector governance. Combined they produce on 130 ha of asparagus beds, 25% of the national total.

Risk management

Responses to the Risk Assessment questions (Table 5) show little common practice and suggest formal farm plan checklists are absent.

Table 5 Summary of grower management practices: Risk Assessment

Risk Assessment						
Management Practices	Never	Sometimes	Usually	Always	N/A	TotCheck
Land Management Units (LMUs) are identified for all farmed blocks	50	0	0	50	0	100
Surface water bodies that may be affected are identified for all blocks	25	0	0	75	0	100
The current nutrient load status in surface water is checked	100	0	0	0	0	100
Ground water bodies that may be affected are identified for all blocks	50	0	0	50	0	100
The current nutrient load status in ground water is checked	50	0	0	25	25	100
A nutrient management plan is prepared for each LMU	25	0	0	25	50	100
A nutrient risk assessment is completed for each LMU	25	0	0	25	50	100
Risk assessment considers contamination of surface and ground waters	50	0	0	50	0	100
Risk assessment considers undesired changes in soil nutrient status (+)	25	0	0	75	0	100
Risk assessment considers fertiliser application to non-target land	25	0	0	75	0	100
Risk assessment considers accumulation of non-nutrient impurities in soil	75	0	0	25	0	100
A sediment management plan is completed for each LMU	0	0	0	50	50	100
A sediment risk assessment is completed for each LMU	0	0	0	25	75	100

Nutrient budgeting

In this survey, a nutrient budget was defined as a documented set of calculations to determine a justified nutrient management response. Because there is minimal formal documentation, the overall assessment is the sector does not complete nutrient budgets (Table 6). However, note that in the Fertiliser Rate section, most growers do report taking relevant variables into consideration when determining how much fertiliser (if any) to apply.

Table 6 Summary of grower management practices: Nutrient Budgeting

Nutrient Budgeting						
Management Practices	Never	Sometimes	Usually	Always	N/A	TotCheck
A nutrient budget is prepared	75	25	0	0	0	100
Nutrient budget is supported by soil testing	75	0	25	0	0	100
Nutrient budget includes nutrients in mineral fertilisers	75	0	0	25	0	100
Nutrient budget includes nutrients in organic fertilisers or amendments	75	0	0	0	25	100
Nutrient budget includes nutrients in crop and/or stock returns	75	0	25	0	0	100
Nutrient budget includes nutrients from soil fixation and mineralised OM	75	0	25	0	0	100
Nutrient budget includes nutrients in irrigation and rainfall	100	0	0	0	0	100
Nutrient budget includes nutrients in produce leaving the block	75	0	25	0	0	100
Nutrient budget includes nutrients leaching below the root zone	100	0	0	0	0	100
Nutrient budget includes nutrients in runoff including sediments	100	0	0	0	0	100
Nutrient budget includes nutrients fixed or immobilised in soil	75	0	25	0	0	100
Nutrient budget includes nutrients lost to the atmosphere	100	0	0	0	0	100

Nutrient records

By contrast, formal records of nutrient management including fertiliser type, application rates, and timing of application are maintained by all growers (Table 7). Test results for soil, herbage, surface, and ground water measurements are not widely kept.

Table 7 Summary of grower management practices: Nutrient Records

Nutrient Records						
Management Practices	Never	Sometimes	Usually	Always	N/A	TotCheck
Nutrient management records are kept	0	0	0	100	0	100
Nutrient management records cover fertiliser types	0	0	0	100	0	100
Nutrient management records cover application rates	0	0	0	100	0	100
Nutrient management records cover timing of application	0	0	0	100	0	100
Nutrient management records cover non-fertiliser additions	25	0	0	25	50	100
Nutrient management records cover untreated areas (buffer zones, headlands)	75	0	0	0	25	100
Nutrient management records cover soil and herbage test results	50	0	0	50	0	100
Nutrient management records cover surface water measurements	50	0	0	25	25	100
Nutrient management records cover ground water measurements	75	0	0	0	25	100
Nutrient management records cover risk factors – irrigation, rainfall	25	0	0	75	0	100
GPS and GIS technology are used for precise recording	25	25	0	50	0	100

Fertiliser use

Management practices about fertiliser use (Table 8) is generally in line with the Code of Practice for factors such as transport, storage, and handling. The grower responding "never" to storage does not store fertiliser on-site, therefore should be regarded as "not applicable".

Table 8 Summary of grower management practices: Fertiliser Use

Fertiliser Use						
Management Practices	Never	Sometimes	Usually	Always	N/A	TotCheck
Fertiliser is fully contained during transport, storage and handling	0	0	0	100	0	100
N, P and soluble fertilisers contained within storage area on impervious floor protected from rain	0	0	0	100	0	100
Storage facilities >50m from waterways, avoiding areas subject to slope failure or significant flood risk	25	0	0	75	0	100
All storm water discharges are collected and diverted away from the storage area	25	0	0	75	0	100
The storage facility is designed to effectively contain stored fertiliser	25	0	0	75	0	100
Fertiliser loading sites >50m from any open waterway or wetland on areas not susceptible to flooding	25	0	0	75	0	100
Vegetated riparian buffer strips of sufficient width (10m – adjust for slope) to filter any run-off are maintained adjacent to all waterways	25	25	0	50	0	100
Fertiliser spills on the loading area are collected and returned to the storage facility	0	0	0	75	25	100
Excess or unwanted fertiliser is spread onto suitable land or crops	0	0	0	75	25	100
Selected fertilisers best meet identified nutrient needs while minimising environmental risks	0	0	0	100	0	100

Application rate

Responses to questions about management practices for application rates and timing show that while formal nutrient budgets may not be prepared, consideration is given to relevant factors when rates and timing are decided.

Table 9 Summary of grower management practices: Application Rate

Application Rate						
Management Practices	Never	Sometimes	Usually	Always	N/A	TotCheck
Fertiliser application rate for situation based on rate of nutrient required by the plants	0	0	25	75	0	100
Application rate considers soil and plant tissue analysis results	0	75	0	25	0	100
Application rate considers nutrient budget reports	25	0	25	0	50	100
Application rate considers crop type, yield and quality targets	0	0	25	75	0	100
Application rate considers maintenance or capital needs	0	0	25	75	0	100
Application rate considers local fertiliser trials	50	25	0	25	0	100
Application rate considers local land manager experience	25	0	25	50	0	100
Application rate considers previous crop and fertiliser history on-site	0	0	25	75	0	100
Application rate considers difference LMU requirements	0	0	25	25	50	100
Application rate is limited where groundwater underlies permeable soil	25	0	25	0	50	100
Application rate is limited where there is a high water-table	25	0	25	0	50	100
Application rate is limited on areas with mole and tile drainage	25	0	25	25	25	100
Application frequency matches nutrient availability to plant demand	0	0	50	50	0	100
Mobile nutrients are applied in split applications	0	0	50	50	0	100
Highly mobile nutrients are applied when plants are actively growing	0	0	25	75	0	100
Nitrogen fertilizer is applied in split dressings of 50 kg N/ha when 200 kg N/ha is required	0	0	25	0	75	100
Nitrogen is applied in proportion to other nutrients according to plant requirements	0	0	25	75	0	100
Soluble P fertiliser applied in split dressings if single application rate >100kg P/ha	0	0	25	0	75	100
Phosphate is applied in proportion to other nutrients, according to plant requirements	0	0	25	50	25	100

Application technique

All growers report their application equipment is sufficiently accurate for its purpose. Two are always accuracy certified, one usually and the other sometimes. The one machine we tested using the FertSpread (www.fertspread.nz) protocols and calculation website was performing well.

Table 10 Summary of grower management practices: Application Technique

Application Technique						
Management Practices	Never	Sometimes	Usually	Always	N/A	TotCheck
The selected application method applies nutrient sufficiently accurately for its purpose	0	0	0	100	0	100
Application method is suitable for the terrain and soil conditions	0	0	0	100	0	100
Application method is suitable for the fertilizer type	0	0	0	100	0	100
Application method is certified to meet accuracy requirements	0	25	25	50	0	100
Application timing considers rainfall forecasts and irrigation plans	0	0	0	100	0	100
Nitrogen is not applied when 10cm soil temperature at 9am is less than 6ºC and falling	25	0	0	25	50	100
GPS and GIS technology are used for precise application	25	0	25	50	0	100
Non-target application is avoided by direct placement	25	0	25	50	0	100
Non-target application is avoided by application in bands when sowing	25	0	25	25	25	100

On-farm trials

Methods Used

A matrix of data collection points across space and time was developed, representing different regions, soil types, varieties, and ages.

Soil sampling

Soil was collected in three layers, 0-15cm, 15-30 cm and 30cm to the bottom of the rooting zone, with multiple samples from the centre of the ridge/planting line in steps to the centre of the wheel track. Initial sampling was spread across the plot to establish a mean value for the area to harvested. Final samples were taken from a smaller area that was the area from which final herbage (fern and weed) samples were collected.

Multiple cores were collected depending on the size of auger used. Early sampling was by 20 mm diameter straight tube corer and at least 12 cores in each plot. Later sampling used a 55 mm twist auger with at least eight cores in each plot.

For nitrates, both laboratory and Nitrate Quick Test analyses were undertaken.

For laboratory testing, samples for each depth were from each plot were combined and a sub-sample of the composite sent for analysis from mineral nitrogen (six samples per block).

Figure 6 Head of 55 mm diameter twist auger used to collect soil and root samples

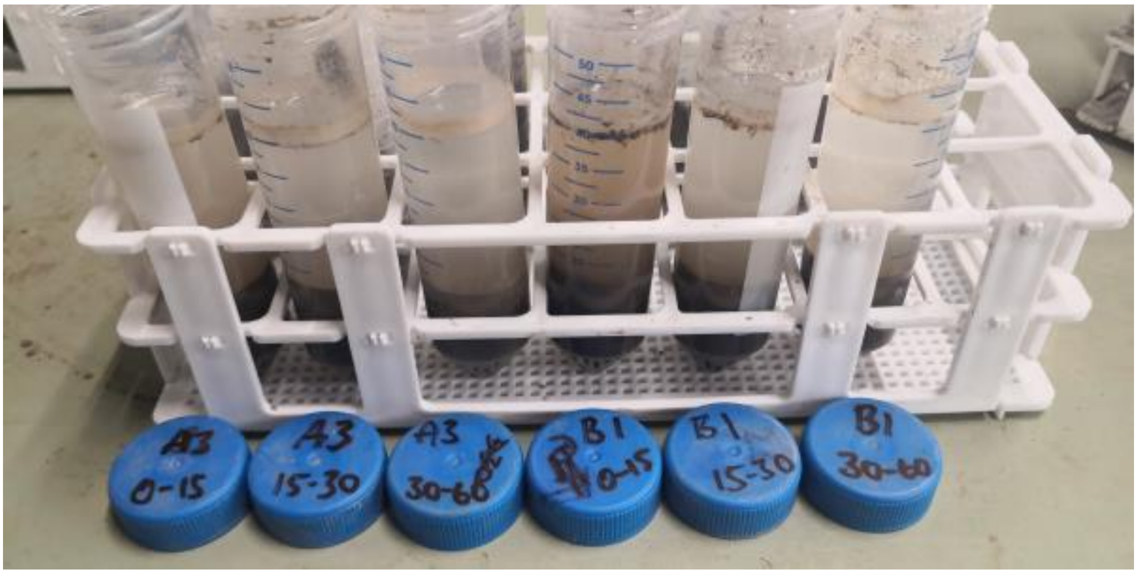

Figure 7 Rack of soil samples prepared for Nitrate Quick Testing show soil settled in test tubes and a clear extract solution ready for strip dipping

Nitrate Quick Test analyses were made for each depth in each plot (18 samples per block). The Nitrate Quick Test (NQT) involved extracting the sample, testing with the Merck test strip, and converting the concentration to kg NO3_N/ha using the FAR calculator (https://far-qttool.shinyapps.io/shinyapp/).

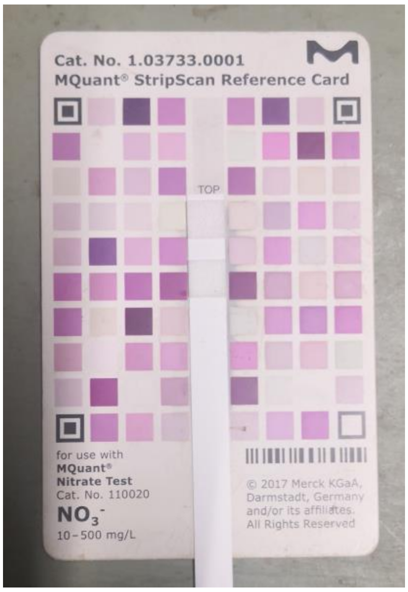

Figure 8 Test strip set on Reference Card allowing nitrate concentration to be determined using a smartphone application

Roots were collected by sieving the soil samples through a 5 mm garden sieve and collecting the root fragments (Figure 9). Some very fine roots will have been missed, but the bulk is in the storage roots which were reasonably easy to identify and remove. Dirty roots were combined for each plot and sent fresh to Eurofins who washed, weighed, and analysed the mineral nitrate content.

Spears were collected weekly by the growers, harvesting all spears in each plot. Spear number and weight were recorded, and a representative fresh sample sent to Eurofins for dry matter and nitrate content analyses.

At the end of fern growth, the senescent fern and any weed material was collected from 1 m of bed length, extending from the centre of one row to the centre of the adjacent row (Figure 10). Mass was recorded, and a sub-sample from each plot sent to Eurofins for mineral nitrogen analysis (six samples per block).

Figure 9 Roots were sifted from the soil samples using a 5 mm sieve, and sent to laboratory for washing and analysis

Figure 10 Fern and weed material collected prior to mulching for determination of biomass and nitrate concentration

Results

With the 2022 harvest yet to take place, this is in some senses a progress report. However, pooling all data from the various sites establishes baseline values that can be compared to other published information. Because fertiliser rate relevant yield data has yet to be collected, we have not completed statistical analyses such as ANOVA to assess significance of measured responses.

A series of charts are presented, displaying measured nitrate levels as either concentrations or mass per hectare by season. The terminology used and corresponding growth phase, is spring (early to mid-harvest), summer (end of harvest at close-up before fern growth), and winter (the end of fern growth). A fourth measurement at the point of maximum fern fresh mass may have been useful but was not collected.

Soil nitrate levels

Soil was collected in three layers, 0-15cm, 15-30 cm and 30cm to the bottom of the rooting zone. In three cases this was around 45 cm due to soil limitations from stones or wetness. The soil in Hastings was more than 90 cm, but few significant roots were found below about 45 cm, so for consistency, data presented here are for the upper 45 cm of soil profile for all the blocks.

Soil nitrate nitrogen

Measured soil nitrate nitrogen (NO3-N) levels ranged from about 0 – 169 kg NO3-N/ha in the 45 cm rooting profile. The lab data show little difference in NO3-N between spring and summer (Figure 11 and Figure 12). The spring NQT and lab data were very similar but the NQT averages in summer and winter were lower than the laboratory analysis averages. The residual NO3-N in the soil at fern mulching in winter was very low by either test method. The annual fertiliser application for most blocks occurred after summer measurements were made at close-up prior to fern growth. On one block nitrogen fertiliser had been applied pre-harvest, some three months before measurements began at that site.

In these trials, only about half the NO3-N measured was in the upper 15 cm, the remainder in the rest of the profile between 15 cm and (typically) 45 cm.

There is greater variation in the NQT data (Figure 11) than in the laboratory NO3-N analyses (Figure 12). The NQT was performed in each plot in each block, whereas the laboratory data represent composite samples for each treatment in each block. The summer and winter readings include some tests of very moist soil and the conversion in the FAR calculator is highly dependent on the input moisture content. The choices are relative broad (dry, moist-dry, moist, moist-wet, wet) and are particularly sensitive in wetter soil because the dilution effect is pronounced. At lower levels of nitrate, the NQT is also limited by the resolution of 0 – 500 ppm the test strips which have a lower range of about 10 ppm. In general, however, the similarities between the NQT and lab results are pleasing, and if attention is paid to soil moisture, the results useful for farm decision making.

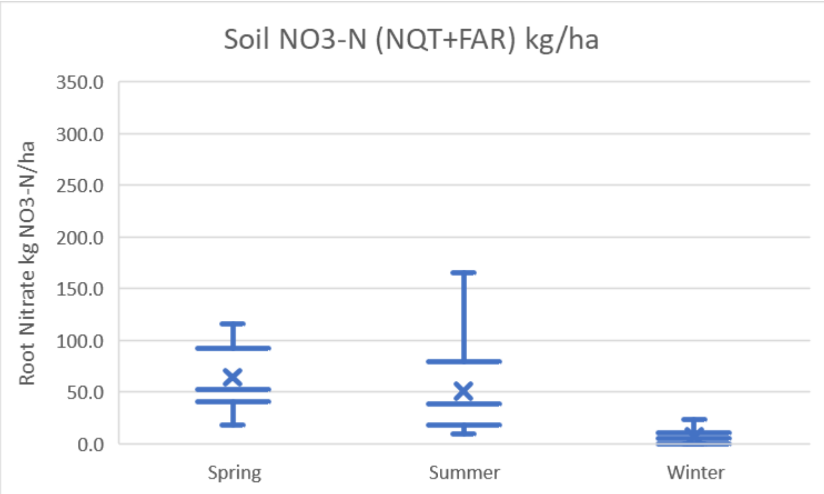

Figure 11 Soil nitrate levels (kg NO3-N /ha) in upper 45 cm of profile by season as determined by the Nitrate Quick Test and FAR conversion

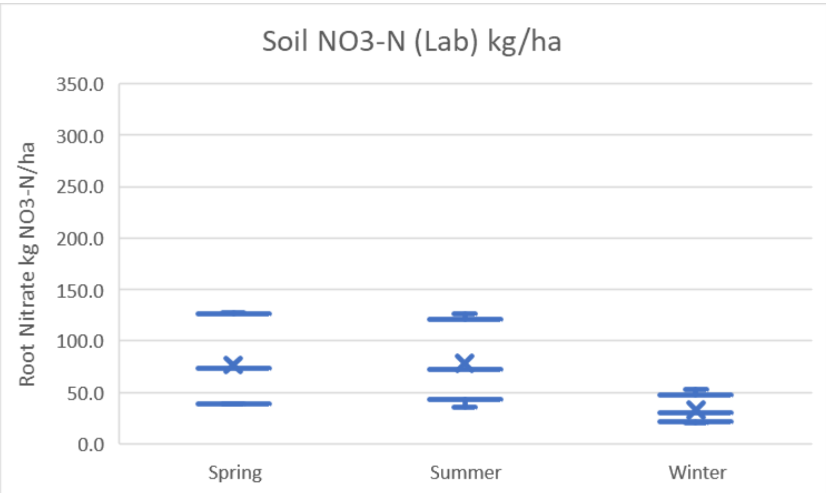

Figure 12 Soil nitrate levels (kg NO3-N /ha) in upper 45 cm of profile by season as determined by laboratory analysis

Root nitrate levels

Root fresh mass

Determining a sampling protocol was one aspect of the project, and several auger sizes were tried. The final sampling protocol used was to take one transect of eight 50 mm diameter cores across a transect from the centre of one bed to centre of the next in each trial plot. Positioning followed the pattern suggested by Simmons (2021). The average root mass during harvest in spring was 50,850 kg/ha, reducing to 26,300 kg/ha in summer at the end of harvest. After fern growth, the winter root mass was 91,700 kg/ha (Figure 13).

The crops in this trial are established, so limited increase in bulk biomass is expected from season to season, although previous years' harvest management and fern development could have a significant impact. Pre-harvest in spring, the root mass should be the same as the end of fern mass, as the plants have stored resources through fern growth, then stayed in hibernation until spring.

With our late project start, harvest was already underway, so some of those reserves had been utilised for spear growth and removed from the paddock as harvest. We have slightly lower confidence in our spring assessments due to the sampling methodology. Our first approach (spring measurements) was to use a 20 mm corer to extract soil and roots through the profile. While we took at least 10 cores, it is still a relatively small volume of material extracted. In later sampling we took eight cores using a 50 mm corer giving five times the volume of material.

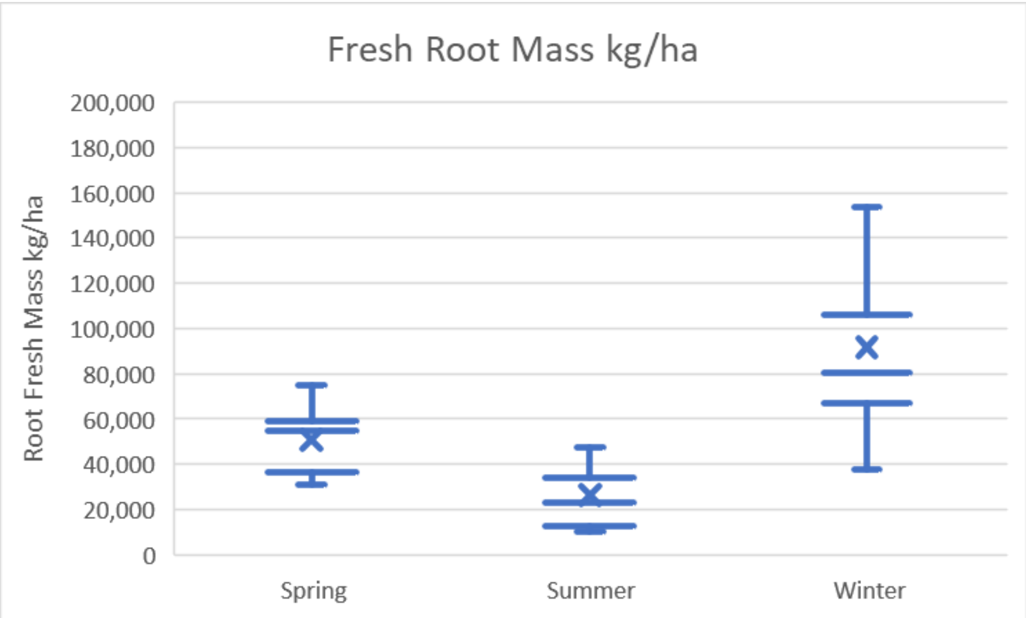

Figure 13 Mass of fresh root material (kg/ha) present in the 45 cm root profile

Root nitrate nitrogen

The laboratory measured nitrate content in the roots remained reasonably consistent across the seasons (Figure 14).

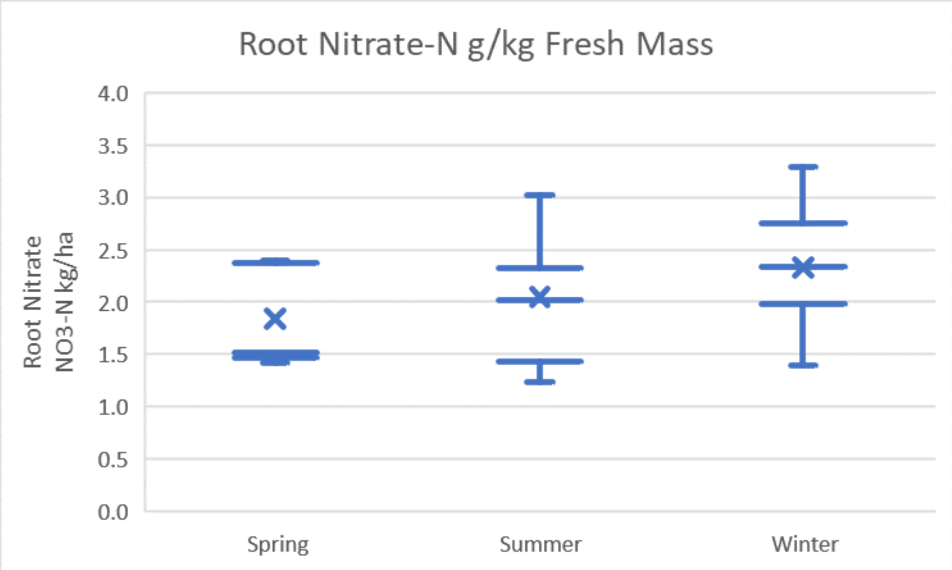

Figure 14 Nitrate concentration g/kg fresh mass) in root material recovered from the rooting profile by season

Root nitrate per hectare derived from the root nitrate concentration and root mass per hectare combined shows a wider variation (Figure 15). In general, the trend follows the changes in total root biomass with the maximum in winter (196 kg N/ha), followed by spring (77 kg N/ha) and summer (47 kg N/ha). However, some of the spring root measurements are thought to underestimate the mass, due to the use of a small corer for soil and root sampling.

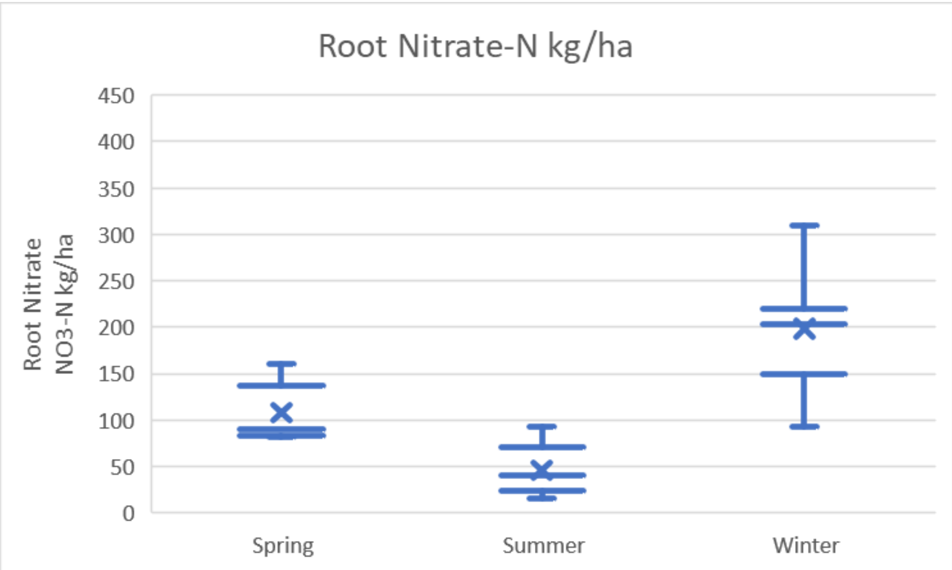

Figure 15 Nitrate nitrogen (kg N/ha) in root material recovered from the total soil rooting profile by season

Above ground biomass nitrate levels

The nitrate content in the above ground plants is presented as “spring” (spears during harvest), and “winter” being the fern and any weeds present at fern mulching (Figure 16). The spring value represents only three cases for which sufficient data were collected for confident calculation. The winter data points with high nitrate concentrations included a high proportion of green weed material with the dried fern residue. The weeds were included in analyses to account for their nitrate contribution.

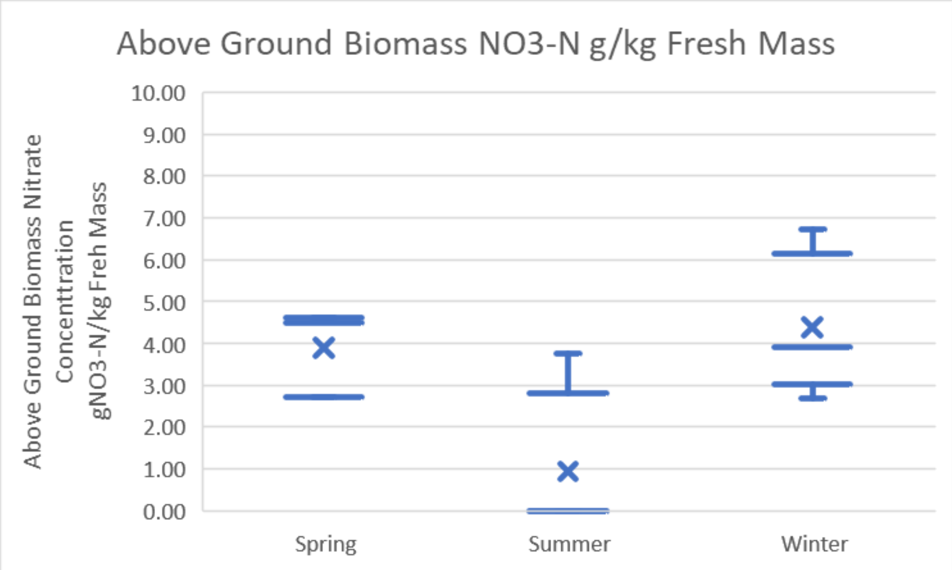

Figure 16 Nitrate concentration in above ground biomass in spring and summer (spears) and winter (fern residue and weeds)

Nitrate per hectare is shown in Figure 17, with summer showing as zero as sample biomass was negligible.

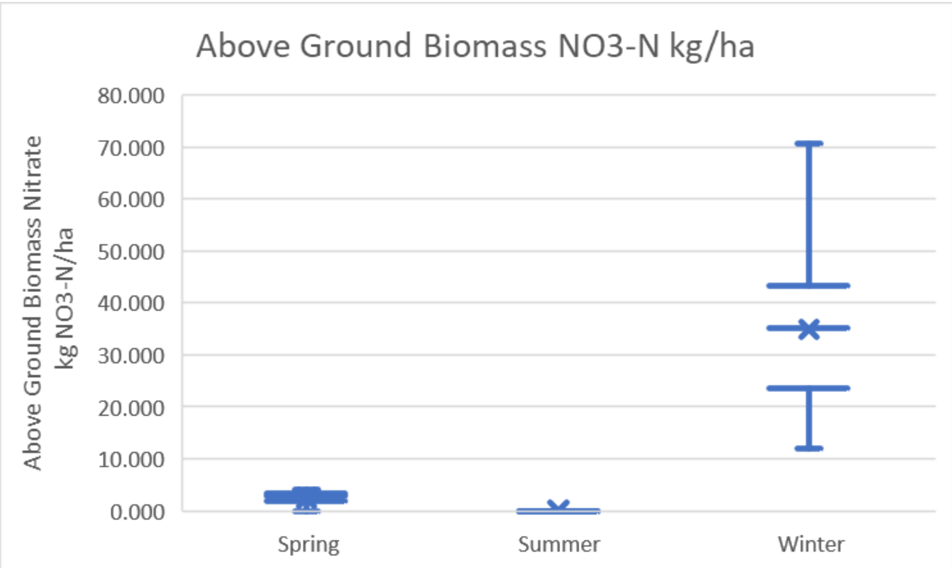

Figure 17 Nitrate nitrogen in above ground biomass kg N/ha in spring and summer (spears) and winter (fern residue and weeds)

Total system nitrate levels

Biomass assessments in spring when spears were being harvested have little useful meaning. Calculating the total biomass as seasonal yield would demonstrate the removal of nitrogen from the paddock, but insufficient data were collected except from one property. In addition, the intent was to assess the total nitrate nitrogen present in all pools as the season progresses, therefore only the spears present when soil and root measurements were taken are relevant.

Growers reported yields of between 3 and 4.4 t/ha. The corresponding NO3-N concentrations were 0.004 and 0.003 kg N/kg fresh weight, so the total nitrogen removed was about 12 – 13 kg NO3-N/ha.

The total system nitrogen is shown in Figure 18. The winter average was 242 kg NO3-N/ha (n=21). In spring the average was 162 kg NO3-N/ha (n=6). The summer average of 66 kg NO3-N/ha (n=16) but does not include any nitrogen in above ground biomass (spears or weeds). Note that the spring data has few sample points. Between the summer and winter measurements, 50kg N/ha fertiliser was added to three blocks, but this is insufficient to explain the low summer values.

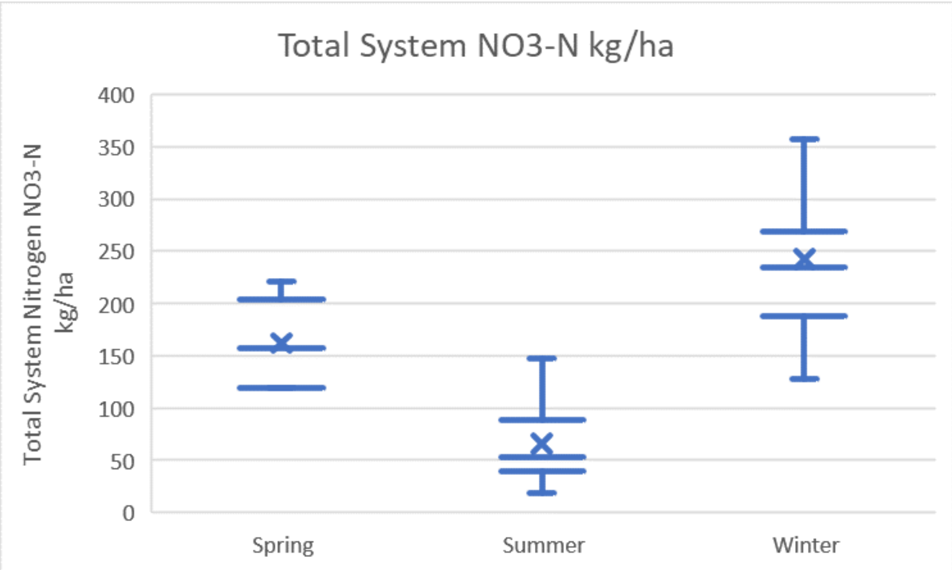

Figure 18 Total system nitrate nitrogen in soil, roots and above ground biomass by season

The dominant factor behind these data is the very high amount of nitrogen in the storage roots of the asparagus, with other pools being relatively minor contributors.

In spring the roots accounted for 62.8% of the total NO3-N, and 64.2% of NO3-N found in summer. The spring data presented here are from measurements made during, in some cases well through, the spear harvest period by which time root storage can be assumed depleted. However, the winter data show the roots held 80.5% of all the NO3-N identified in the system (Figure 19). At the beginning of harvest, the root contribution can be expected to mirror the end of winter levels.

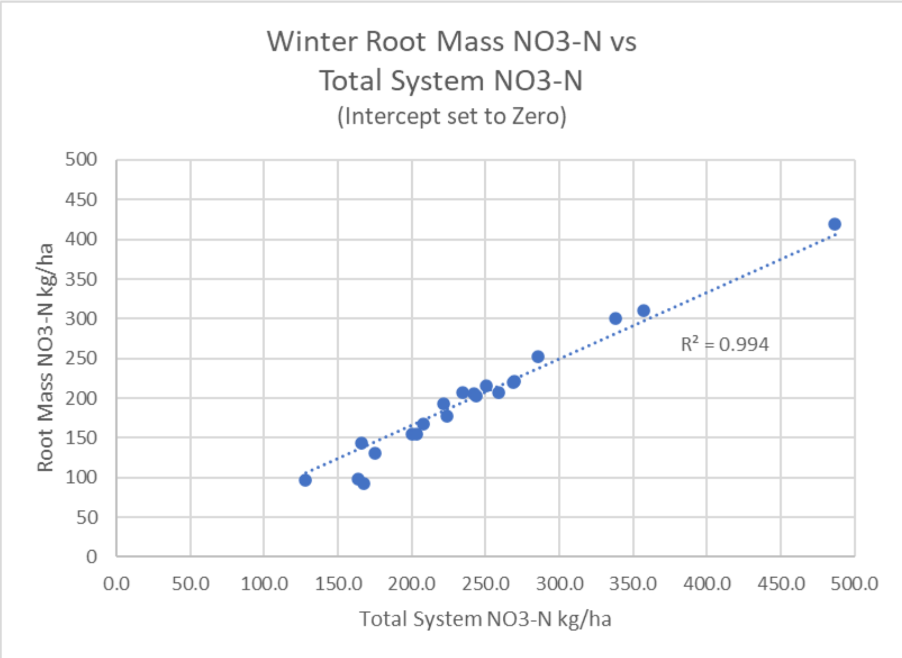

Figure 19 Chart of the NO3-N in the storage root mass relative to the NO3-N in the total system in winter (Intercept set to zero)

Grower as a Researcher Training Workshops

We involved growers one on one in our on-site activities at each visit. They were intimately involved in selecting the sites for rate trials, in setting out the trial plots and taking the first set of soil samples.

Growers generally assisted when we visited to take soil and root samples, and representative sampling was discussed and demonstrated on-site. Although provided with soil corers, they did not take measurements without us present.

They were provided with a bag containing necessary tools for the Nitrate Quick Test and the process discussed or demonstrated. But with no soil sampling, there was no Quick Nitrate testing.

Spear harvest measurement was poorly completed in general. In part this was due to harvest being underway by the time the project started. One grower did reliably collect weekly samples, counting and weighing spears per plot and providing the data. These could be combined with daily total yields to assess annual yields per plot and treatment.

With Covid-19 and staff shortages impacting growers and increasing resistance to travel to meetings, we offered an on-line seminar addressing how to undertake on-farm trials, soil sampling strategies, and interpreting soil tests. The presentations were recorded and are available on YouTube:

On-Farm Nitrate Trials (Dan Bloomer) https://youtu.be/o3fkFZmcG7A

Interpreting Soil Tests (Alex Dickson) https://youtu.be/LaKMMII-lms

Discussion

We set out to collaborate with growers across the growing regions to collect data upon which we could build understanding of nitrogen pools and dynamics, and together determine what Best Practice should be. We have collected data and have increased understanding of nitrogen pools, finding they are generally in line with other reports in literature. Data are yet to be collected from the coming harvest to relate last season's nitrogen fertiliser rates to subsequent yields, a task in the hands of collaborating growers.

We have identified a wide range of nitrogen management practices, which indicate no agreed industry best practice. In general, if any nitrogen is needed, fertiliser should be added just before fern growth at the end of harvest. While there is support for additional nitrogen in the establishment phase, the need for additions to mature crops is not clear. Data to be collected post-project will help clarify understanding.

The project faced several challenges due to the late start and because it was a very difficult season for growers who experienced collapsed markets, poor weather and a severe shortage of labour. We established and monitoring trials in five crops, but data has gaps where growers did not collect yield information and in two cases did not apply alternative fertiliser treatments. This is understandable when severe pressure such as experienced in the 2021-22 season impacts growers and they are forced to prioritise and make compromises.

The growers through the New Zealand Asparagus Council have committed to continuing this trial post-project, and data will be collected from at least three crops where alternative fertiliser treatments were applied.

Surveys showed growers do not prepare formal documented nutrient budgets, but they do take relevant variables into account when determining how much (if any) fertiliser to apply. At the start of harvest in spring there is very little NO3-N in the soil matrix. Because in winter and spring a very large proportion of the system nitrogen is held in the storage roots, preparing a pre-season nutrient budget for nitrogen would require careful sampling of the storage root mass. To get robust estimates, a reasonably large number of samples is required, and extracting and cleaning roots is a time consuming process. Given the very low nitrate requirements, typically low additions, and low soil nitrate levels, it may not be considered worthwhile. Preparation of a summary budget post-season is similarly difficult as virtually all the nitrate is held in the roots.

Limited yield data have collected so far for this project, with the yields to be collected during the 2022-23 season being relevant to alternative fertiliser treatments applied in 2021-22. The limited data we collected in 2021-22 and reported typical yields from our grower surveys are generally similar to those reported by Hunt et al. (2019).

While Drost and Wilson (2003) found roots to at least 80 cm depth, most of the soils in our trials had limitations from wetness or stones at about 45 cm. The average 91,700 kg/ha fresh root mass measured at the end of fern growth is generally at the higher end of root masses in literature reports (Drost, 2013). The average concentration of NO3-N in root tissue was 1.38% of dry mass which is similar to German research that found about 1.78% N in dry matter (Hartmann et al., 1990).

When we review the data collected and the amounts of nitrogen determined in the key pools as the crop proceeds from spring through summer to winter, the overpowering influence of the nitrate levels in the massive storage root system is apparent, especially in winter when more than 80% of identified NO3-N was in the storage roots.

Growers have a wide range of fertiliser policies, some applying no nutrients at all, and others applying at rates much higher than can be expected to be exported in the harvested crop.

From the total season yield information supplied and the laboratory test data obtained, the amount of NO3-N exported in the harvested crop is about 12 – 13 kg NO3-N/ha. Of the trial growers that report applying nitrogen fertilisers, the rates were 24, 55 and 69 kg NO3-N/ha. This fits with the rates reported by the wider group that responded to the NZAC survey.

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