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Agronomic strategies to increase asparagus yields

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Dear Mr Manson

Please find enclosed copies of the Crop & Food Research report prepared for Winegrowers of New Zealand by Rocky Renquist and Jeff Reid.

For any queries regarding the report please contact Rocky directly on (06) 870 0911 or (021) 183 6006.

Yours sincerely

Katherine Trought
Scientific editor

KT:HAP

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1 Executive summary

A goal of New Zealand's asparagus industry is to double the national average yield by 2010. In previous research we have contributed to this goal by (a) defining the key features of high performing crops, (b) establishing benchmarks for assessing the performance and potential of crops, and (c) determining the main agronomic causes of reductions below the benchmarks in lower yielding crops. In this report we describe recent progress in a project which aims to contribute to the industry's goal by developing agronomic strategies that growers can use to increase yields without compromising the long-term performance of their crops.

In spring 2000, various management treatments were established in growers' crops in the four main asparagus production areas (Waikato, Hawke's Bay, Manawatu and Canterbury). The aims were to investigate the short and longer-term effects of length of spear harvest, surface cultivation, and management during fern growth (fertiliser application and irrigation).

One way to obtain extra yield is to extend the harvest period by delaying the close-up date. We examined this by establishing varying close-up times to change the harvest duration at three sites in Waikato and one site each in Hawke's Bay and Canterbury. The extra saleable spear yields were measured, and then the subsequent fern growth, root carbohydrate (CHO) contents, and saleable spear yields from a standard harvest were measured in the following season. We found that the length of harvest often can be extended to obtain extra yield with little risk of causing any long term harm to crops. However, the decision to continue harvesting should be made only after ensuring that enough resources are still available in the root system. In some cases an early close-up may be advisable if root resources are depleted earlier than usual, but no instances of this occurred in our trials.

Asparagus crops are often cultivated to maintain spear diameter by keeping the crowns covered with soil to an adequate depth and to keep the soil loose between rows for better drainage and more efficient root penetration. However, cultivation equipment can damage roots, and may reduce CHO reserves and possibly initiate root diseases. We established cultivation treatments at two sites in Hawke's Bay and one site in the Manawatu. Cultivation had little effect on crop performance in the short term. However, yields may be reduced in the longer term through the effects of persistent damage to roots near the soil surface. On the other hand, cultivation may prove to be necessary to maintain spear size as crops age.

Applying fertiliser and irrigation usually promotes fern growth and is often necessary in establishing crops, especially in dry climates. We established contrasting fertiliser application treatments at three sites, two in Waikato and one in Hawke's Bay, and compared irrigated and unirrigated treatments at one site in Canterbury. Our results confirmed previous findings that, although

they increased fern growth, the treatments did not increase spear yield. Stimulating too much fern growth, especially flushes of new fern production, often reduces CHO replenishment in the root system and causes lower, rather than higher, spear yields at the following harvest.

2 Introduction

Management decisions affect the performance of asparagus crops in both the current year and future seasons. Effects in the current season are expressed mainly in spear yield and fern growth responses, and these are easy to observe. The longer-term effects are on the size and health of the root system, and these are more difficult to detect. But looking after the root system is the key to maintaining high production and safeguarding the longevity of crops. Therefore, management should aim to achieve the best balance between short-term gains and longer-term sustainability.

With these principles in mind, for several years we have conducted a project to help asparagus growers to achieve the industry's goal of doubling the average yield in New Zealand by 2010. Our objectives were to:

- define the key features of high performing crops
- establish benchmarks for assessing the performance and potential of crops
- determine the main agronomic causes of reductions below the benchmarks in lower yielding crops
- develop agronomic strategies to close the gap between actual and potential yields.

In previous years we have made good progress towards achieving the first three of these objectives. Results were presented at previous New Zealand Asparagus Council Research seminars. In summary, we found that high yielding crops have all or most of the following key characteristics:

- they are grown in deep, free-draining, unimpeded sandy-silt soils
- their populations are at least 13 000 plants/ha, with less than 30% of gaps in rows
- their root biomass and root carbohydrate (CHO) content at the start of harvest are greater than 10 t/ha and 40% respectively
- over 70% of their total spear yield is saleable.

In this report we describe research during the last two years in which we focused on the fourth objective - to develop strategies that growers can use to increase yields without compromising the long-term performance of their crops. In spring 2000, various management treatments were established in growers' crops in the four main asparagus production areas (Waikato, Hawke's Bay, Manawatu and Canterbury). The aims were to investigate the short and longer-term effects of length of spear harvest (five sites), surface cultivation (three sites), and management during fern growth (fertiliser application at three sites, and irrigation at one site).

3 Harvest duration

One management option is to vary the length of harvest by changing the close-up date:

In some cases harvest can be extended to obtain extra yield, and often get premium prices, without causing any long-term harm. The decision to continue beyond the usual close-up date depends on availability of enough resources in the root system, and must also consider the risk of leaving insufficient time for fern growth to replenish root reserves in autumn.

In other cases closing-up earlier than usual may be necessary if root resources become too depleted. This usually happens as a result of low CHO accumulation during the previous fern growth season. This can be caused by factors such as *Stemphylium* infection or excessive fern growth flushes stimulated by high rainfall.

We established varying close-up times to change the harvest duration in the 2000-01 season at three sites in Waikato and one site each in Hawke's Bay and Canterbury. Treatments at the North Island sites, which were all in established crops, varied from two to four close-up dates ranging from mid-December to mid-January. There were three treatments with close-up dates from mid-November to mid-December at the Canterbury site which was in a three year old establishing crop. In all cases there were three replicates of the treatments, and plot size was 10 m long and five rows (7.5 m) wide. The two outer rows of each plot were buffers, spear yields were measured in two rows, and samples were taken from the fifth row to measure fern growth and root CHO content. Extra saleable spear yields from the extended harvests were measured in 2000-01. Then measurements were made of the subsequent fern growth, root CHO contents, and saleable spear yields from a standard harvest in the 2001-02 season.

3.1 Site 1 in Waikato

Site 1 results are set out in Table 1.

In the 2000-01 season:

- Extending harvest by varying close-up from 18 December to 12 January produced extra saleable spear yield of up to 2350 kg/ha at a time when prices were high.
- Subsequent fern growth was variable, but generally it was less following the longer harvests.

In the 2001-02 season:

- CHO content at the start of harvest was a similar low value in all treatments.
- Spear yields from the standard harvest were lower following longer harvests in the previous season, with a large reduction following the 12 January close-up.
- Mean spear weight was lower following longer harvests in the previous season.

- Root CHO content was low and similar in all treatments at the end of harvest.
- Fern growth was similar in all treatments, and was notably less than in the previous summer. Despite the lower fern growth, root CHO content in May was higher for all treatments than at the end of the previous season.
- Root CHO content in May was significantly lower following the longest harvest treatment than in the ones that had been closed up in late December and early January in the previous season.
- We conclude that this crop has a very large root system because large spear yields were harvested with relatively small associated root CHO content changes.
- Yields from the plots were substantially higher than from the surrounding crop, probably because of higher recovery of saleable yield.

Table 1: Effects of harvest duration on mean saleable spear yield, fern growth and root CHO content at site 1 in Waikato.

	2000-01 season		2001-02 season					
Close-up date	Extra spear yield (kg/ha)	Fern growth (kg/ha)	Root CHO Sep. (mg/g)	Spear yield (kg/ha)	Mean spear weight (g)	Root CHO Dec. (mg/g)	Fern growth (kg/ha)	Root CHO May (mg/g)
18 Dec 00	-	7100	356	13350	22.4	284	3330	424
29 Dec 00	1100	2920	349	12540	22.2	266	3520	448
05 Jan 01	1790	4160	359	11950	20.0	275	3350	458
12 Jan 01	2350	5200	326	9640	20.1	269	3380	405
LSD (5%)			35	3040		28		40
CV (%)			15.8	12.8		15.1		14.7

3.2 *Site 2 in Waikato*

Site 2 results are set out in Table 2.

- Extending harvest by delaying close-up from 18 December to 5 January in 2000-01 produced an extra saleable yield of 1440 kg/ha at a time when prices were high.
- There was no penalty from taking this extra yield. Subsequent fern growth, root CHO contents and spear yields were not strongly affected by the treatments.
- We conclude that this crop has a large root system because large spear yields were harvested with relatively small associated root CHO content changes.

Table 2: Effects of harvest duration on mean saleable spear yield, fern growth and root CHO content at site 2 in Waikato.

	2000-01 season		2001-02 season					
Close-up date	Extra spear yield (kg/ha)	Fern growth (kg/ha)	Root CHO Sep. (mg/g)	Spear yield (kg/ha)	Mean spear weight (g)	Root CHO Dec. (mg/g)	Fern growth (kg/ha)	Root CHO May (mg/g)
18 Dec 00	-	5830	367	7500	21.6	318	4100	459
05 Jan 01	1440	5400	368	8270	21.3	315	4110	457
LSD (5%)				1080				
CV (%)				3.9				

3.3 Site 3 in Waikato

Site 3 results are set out in Table 3.

- Extending harvest by delaying close-up from 18 December to 5 January in 2000-01 produced an extra saleable spear yield of 1800 kg/ha at a time when prices were high.
- There was no penalty from taking this extra yield. In fact, crop performance tended to be better after the 5 January close-up. Subsequent fern growth, root CHO content in spring, and spear yield in 2001 were all higher, although the differences were not statistically significant.
- Although root CHO content was significantly lower following the longer harvest in 2001, the level had recovered to be similar to the earlier close-up by March 2002.
- We conclude that this crop has a large root system because large spear yields were harvested with relatively small associated root CHO content changes.

Table 3: Effects of harvest duration on mean saleable spear yield, fern growth and root CHO content at site 3 in Waikato.

	2000-01 season		2001-02 season					
Close-up date	Extra spear yield (kg/ha)	Fern growth (kg/ha)	Root CHO Sep. (mg/g)	Spear yield (kg/ha)	Mean spear weight (g)	Root CHO Dec. (mg/g)	Fern growth (kg/ha)	Root CHO May (mg/g)
18 Dec	-	4590	358	7930	23.3	322	3720	371
05 Jan	1800	5740	385	10010	21.6	276	3050	362
LSD (5%)				4570		31		
CV (%)				14.5		15.3		

3.4 *Hawke's Bay*

Results for the Hawke's Bay site are set out in Table 4.

In the 2000-01 season:

- Extending harvest by delaying close-up from 29 December to 15 January produced extra saleable spear yield of 1220 kg/ha at a time when prices were high.
- Fern growth was lower following the longer harvest. Furthermore, the crop suffered severe needle drop caused by *Stemphylium* in mid-February. Plants in the extended harvest treatment already had less time to accumulate CHO reserves, and the needle drop stopped further accumulation.

In the 2001-02 season:

- Root CHO content at the start of harvest and saleable spear yield from the standard harvest were both lower following the longer harvest in the previous season.
- Mean spear weight and root CHO content at the end of harvest were both reduced by the longer harvest in the previous season.
- The extended harvest treatment went on to grow less fern than the earlier close-up treatment, but absence of foliar disease during autumn enabled good replenishment of root CHO.
- This crop is more uniform than the ones in the Waikato, and we conclude that it probably has a moderately large root system. Spear yields were lower and the associated root CHO content changes were greater.

Table 4: Effects of harvest duration on mean saleable spear yield, fern growth and root CHO content at the site in Hawke's Bay.

	2000-01 season		2001-02 season					
Close-up date	Extra spear yield (kg/ha)	Fern growth (kg/ha)	Root CHO Sep. (mg/g)	Spear yield (kg/ha)	Mean spear weight (g)	Root CHO Dec. (mg/g)	Fern growth (kg/ha)	Root CHO May (mg/g)
29 Dec 00	-	6530	399	9550	27.0	335	7780	467
15 Jan 01	1220	4580	357	7520	22.0	287	4680	494
LSD (5%)		1257	37	300	3.0	23	4030	48
CV (%)		6.6	14.9	1.0	9.4	11.3	18.4	15.1

3.5 Canterbury

Results for the Canterbury site are set out in Table 5.

- The trial was in a three year old establishing crop.
- Extending harvest by delaying close-up from 19 November to 16 December in 2000 produced an extra saleable spear yield of 820 kg/ha.
- Fern growth in autumn was lower following the longer harvests, but root CHO content at the start of the 2001 harvest was not strongly affected. All root CHO content values were very high.
- Saleable spear yields from the standard harvest in 2001 were lower following the longer harvests, but the reductions were not statistically significant ($P = 0.2$).
- Mean spear weight during the 2001 harvest was reduced by the longer harvests in the previous season.
- We conclude that this young crop has a small root system. Spear yields were low and the associated root CHO content changes were large.

Table 5: Effects of harvest duration on mean saleable spear yield, fern growth and root CHO content at the site in Canterbury.

Close-up date 2000-01	Extra yield spear 2000 (kg/ha)	Fern growth (kg/ha)	Root CHO Sep. 2001 (mg/g)	Spear yield 2001 (kg/ha)	Mean spear weight (g)	Root CHO Dec. 2001 (mg/g)
19 Nov	-	3380	585	4270	25.8	367
04 Dec	400	1930	595	3580	23.4	399
16 Dec	820	1990	566	3540	22.6	371
LSD (5%)				1220		
CV (%)				13.9		

4 Cultivation

Asparagus crops are cultivated in several ways and for a number of reasons. The most common is surface cultivation to maintain spear diameter by keeping the crowns covered with soil to an adequate depth as they grow upwards with age. Disadvantages are that shallow soil cover between the rows or incorrectly set cultivation equipment can damage roots, thus reducing CHO reserves and possibly initiating root diseases. In heavier soils or where a pan is present, deep ripping between rows is used sometimes to keep the soil loose for better drainage and more efficient root penetration.

We established cultivation treatments in established crops at three sites. At two sites in Hawke's Bay, surface cultivation before harvest in 2001 was compared with no cultivation. At one site in Manawatu two treatments (surface cultivation before harvest and deep ripping between rows in the previous season) were compared with no cultivation. In all cases there were

three replicates of the treatments, and plot size was 10 m long and five rows (7.5 m) wide. The two outer rows of each plot were buffers, spear yields were measured in two rows, and samples were taken from the fifth row to measure fern growth and root CHO content. Measurements were made of saleable spear yields, root CHO contents and fern growth in the 2001-02 season.

4.1 Hawke's Bay

Hawke's Bay results are set out in Table 6.

- Surface cultivation before harvest had no effect on spear yield, mean spear weight or root CHO content at both sites.
- Subsequent fern growth in the cultivated treatment at Site 1 was significantly less than in the uncultivated treatment (P = 0.02). The soil was ridged higher at this site (15-20 cm above ground level) than at Site 2.
- At both sites cultivation had no effect on final root CHO content in June 2002.

4.2 Manawatu

Manawatu results are set out in Table 6.

- Surface cultivation before harvest had no effect, but deep ripping between rows in the previous season significantly increased spear yield (P = 0.04).
- Subsequently, root CHO content and fern growth were similar in all treatments.

Table 6: Effects of surface cultivation (SC) and deep ripping (DR) treatments on mean saleable spear yield, fern growth and root CHO content at three sites in 2001-02.

Site	Treatment	Root CHO Sep. (mg/g)	Spear yield (kg/ha)	Mean spear weight (g)	Root CHO Dec. (mg/g)	Fern growth (kg/ha)	Root CHO June (mg/g)
Hawke's Bay 1	No Cult.	399	9550	27.0	335	7780	467
	SC	388	9630	27.0	313	3710	444
Hawke's Bay 2	No Cult.	385	6160	18.5	315	6510	445
	SC	417	6500	19.3	317	6340	450
Manawatu	SC & DR	452	9420	15.0	316	6320	414
	No SC, +DR	401	9790	16.5	321	7680	399
	No SC or DR	450	7700	18.1	327	6750	444

5 Management during fern growth

5.1 Fertiliser application

Applying fertiliser at close-up is one way that growers can influence crop performance. A wide variety of fertiliser management regimes are applied to asparagus, including organic fertilisers such as chicken manure and compost. Fertiliser usually stimulates fern growth but the effects on CHO replenishment in the root system and subsequent spear yields have seldom been measured.

We established contrasting treatments at two sites in Waikato and one site in Hawke's Bay. Plots were left unfertilised when the crops were fertilised by the growers at close-up in late 2000. In all cases there were three replicates of the treatments, and plot size was 10 m long and five rows (7.5 m) wide. The two outer rows of each plot were buffers, spear yields were measured in two rows, and samples were taken from the fifth row to measure fern growth and root CHO content. Measurements were made of fern growth in autumn 2001, and saleable spear yields and root CHO contents were measured in spring 2001. The results are in Table 7.

The fertiliser treatments did not significantly affect any aspect of crop performance. There was a tendency for increased fern growth but the effect was inconsistent.

The results from Site 1 at Waikato were judged to be unreliable because the area chosen for the plots without fertiliser was near the edge of the paddock, and this may have affected yields more than the fertiliser treatments.

Table 7: Effects of fertiliser application on mean fern growth in autumn, and saleable spear yield, spear weight and root CHO content in spring at three sites in 2001.

Site	Treatment	Fern growth (kg/ha)	Root CHO Sep. 2001 (mg/g)	Spear yield (kg/ha)	Mean spear weight (g)	Root CHO Dec. 2001 (mg/g)
Waikato 1	No fertiliser	3850	411	6250	21.5	335
	Fertiliser	5400	368	8270	21.3	315
Waikato 2	No fertiliser	3680	364	11160	22.0	290
	Fertiliser	5740	385	10010	21.6	276
Hawke's Bay	No fertiliser	7900	401	9950	25.3	317
	Fertiliser	6530	399	9550	27.0	335

5.2 Irrigation

Irrigation during fern growth is recommended for establishing crops in dry climates. However, applying too much water or irrigating established crops can stimulate unnecessarily vigorous fern growth and/or flushes of new fern production. These can cause reduced, rather than increased, spear yields at the following harvest.

We established plots in unreplicated irrigated and unirrigated areas in a three year old establishing crop in Canterbury in 2001. Rainfall was lower than usual in autumn and the irrigated area was watered twice during fern growth. There were three plots in each area, and plot size was 10 m long and five rows (7.5 m) wide. The two outer rows of each plot were buffers, spear yields were measured in two rows, and samples were taken from the fifth row to measure fern growth and root CHO content. Measurements were made of fern growth in autumn 2001, and saleable spear yields and root CHO contents were measured in spring 2001. The results are in Table 8.

- Irrigation increased fern growth, but the difference was small and probably not significant.
- There was no effect on root CHO content before harvest or at close-up in the following spring.
- There was no significant effect on spear yield.

Table 8: Effects of irrigation on mean fern growth in autumn, and saleable spear yield, spear weight and root CHO content in spring at three sites in 2001.

Treatment	Fern growth (kg/ha)	Root CHO Sep. 2001 (mg/g)	Spear yield 2001 (kg/ha)	Mean spear weight (g)	Root CHO Dec. 2001 (mg/g)
Irrigation	3380	585	4270	25.8	367
No irrigation	2730	614	3570	22.9	359

6 Discussion and conclusions

All the trials were conducted in commercial crops with considerable assistance from the collaborating growers, especially with measuring and recording spear harvest data. Practical considerations, particularly the large amount of work involved in daily harvesting, restricted the number of plots (i.e. treatments and replicates) that could be included in each trial. Ideally, with only two or three treatments as we had in many of the trials, a lot of replicates (at least six) are usually needed to have a fair chance of detecting statistically significant differences and of getting good estimates of the treatment effects. Larger trials with more plots would have allowed us to obtain more conclusive results. Nevertheless, we are able to reach some conclusions that are of practical importance to growers.

We conclude that the length of harvest often can be extended to obtain extra yield with little risk of causing any long term harm to crops. However, the decision to continue harvesting should be made only after ensuring that enough resources are still available in the root system. In some cases an early close-up may be advisable if root resources are depleted earlier than usual, but no instances of this occurred in our trials.

We were unable to reach any firm conclusions about the effects of cultivation. It had little detectable effect on crop performance in the short term. However,

yields may be reduced in the longer term through the effects of persistent damage to roots near the soil surface. On the other hand, cultivation may prove to be necessary to maintain spear size as crops age.

In the past we have found that, in general, treatments such as fertiliser and water application that stimulate unnecessary fern growth seldom produce any spear yield advantage. Results from our trials support this conclusion. Young crops need adequate water and nutrients, and applications of fertiliser and irrigation during fern growth are often necessary during the establishment years, especially in dry climates. However, applying too much water or fertiliser to established crops can stimulate unnecessarily vigorous fern growth and/or flushes of new fern production which can lead to reduced, rather than increased, spear yields at the following harvest.

We noticed that root CHO content at the start of harvest differed widely among our test crops. Most values in Canterbury, where the cultivar was UC157, were in the 500-600 mg/g range. The highest value was just over 700 mg/g. In Waikato, where the cultivar was Jersey Giant Syn 4, values were generally in the 350-400 mg/g range. Hawke's Bay crops were intermediate. The differences were probably due to several factors:

- The crops in Waikato had much larger root systems, so a small CHO content range meant a large change in amount of CHO. A larger change of root CHO content occurred in crops further south because they had smaller root systems.
- Besides a climatic effect, differences in root system size are also cultivar-dependent. UC157 produces a much smaller root system than Jersey Giant Syn 4.
- It was very wet in Waikato during fern growth in the 2000-01 season. New flushes of fern production and/or *Stemphylium* infection may have reduced CHO accumulation.
- In contrast, fern growth at some Waikato sites was notably less in the 2001-02 season, with a correspondingly higher final root CHO content.

Yields were higher at the northern sites, probably because spear growth depends strongly on temperature irrespective of resource availability. Cool temperatures can limit the yields of crops with high levels of accumulated CHO and, sometimes, all available CHO is not used in cool conditions. Extended harvests are more feasible in cooler seasons or locations because stored CHO is used more slowly than in warm conditions.

The combined effects of temperature and resource availability determine daily spear production. The highest values were at a Manawatu site where the average daily saleable yield was 173 kg/ha/day (10.5 t/ha for the season). The highest yielding treatment, at a Waikato site, averaged 132 kg/ha/day and produced a total of 13.3 t/ha of saleable spears. At the Manawatu site, an average plant produced a saleable spear once every 2.2 days. In contrast, at the Canterbury site the corresponding value was every 9.6 days. The mean for all sites was about 5 days.

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