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Improved pea production for sustainable arable farming: pea crop monitoring report 2006–07

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Contents

1 Executive summary

1.1 Project aim

- This report covers one of the projects carried out as part of the Pea Industry Development Group's programme to identify management practices to improve productivity, reliability and profitability of pea production.
- This particular project monitored 30 pea paddocks in the 2006-07 growing season to try to identify the principal management and environmental causes of plant establishment yield variability. 20 paddocks were sown with marrowfat peas (cv. Midichi) for pea seed, and 10 were process pea crops (cv Ashton) for vining. All the paddocks were located in Mid and Central Canterbury.
- The paddocks had a wide range of cropping histories, soil types and management practices. The last time the paddocks were in pasture ranged from 1 to 10 years. Cultivation ranged from intensive cultivation to direct drilling. Ten of the crops were irrigated, five Midichi and five Ashton paddocks.

1.2 Sampling details

- Each crop was visited and assessed three times (vining peas) or four times (field peas) during the season. The first visit was soon after drilling. At this visit the project was either introduced to new farmers or re-briefed to farmers already familiar with it. Details of cultivation, drilling management and methods were recorded from the farmer. A sample of the unsown peas was taken for germination, weight and physical damage assessment. Within each of the visited paddocks five fibreglass rods were placed on a transect across the crop to give five sampling locations. Adjacent to each rod, all sown peas in a 1 m length of two adjacent drill rows were excavated, counted separately and retained for physical assessment. Soil quality assessments were made down to 7.5 cm at three of the five locations. These assessments were aggregate size distribution, bulk density, soil moisture and aggregate stability analyses. Finally a soil sample was taken for an Aphanomyces test.
- The second visit was at about the three-node stage of crop development. Two samples were taken from each of the five sampling locations in a paddock. A different sampling method was used. Adjacent to each rod, the total numbers of all live and dead pea plants in a 1 m length of two adjacent drill rows at two locations were counted, and any obvious gaps in the rows were excavated to locate any dead or unemerged live seed. A visual soil surface crusting assessment was also made.

- The third visit was at the flat pod stage. Two visual assessments of ground cover were made at each rod, together with support photographs taken. Many soil quality assessments were made including penetration resistance at 0-15 and 15-25 cm depths at five positions around each of the five markers. A bulk density sample was collected from 0-15 and 15-25cm depths at each of the five markers. A soil profile assessment was also completed at one of the five markers.
- At around the same time, Plant Research Limited took plant samples for in-field assessments of Aphanomyces and disease severity and in-field measurements of top and root biomass.
- For the field peas, the fourth visit was made just before the crop was headed or windrowed. Samples were taken at three of the five markers. All pea material in a sample area of 2 m by 2m was removed and weighed, and a subsample of 20 plants (from each of the three samples) was weighed and taken to the laboratory, where it was reweighed and hung up to dry. When processed, each sample was weighed and put through a stationary thresher. The threshed peas were counted and weighed, and the vegetative material also weighed.
- For the vining peas, yields and tenderometer readings were provided by Heinz Wattie's.

1.3 Results and recommendations

- Despite the very favourable growing season, 17 of the 20 Midichi crops had plant populations below 80 plants/m^2.
- The variation in emergence within paddocks, and between adjacent rows within paddocks, was considerable.
- In half the Midichi crops and one third of the Ashton crops, over 10% of the seed sown did not produce a plant, and in a quarter of the Midichi crops, over a quarter of the seed did not produce a plant.
- However, there was very little relationship between the measured management and soil variables and plant establishment and subsequent yield.
- The Ashton crops all had full ground cover at flat pod, a consequence of their high plant populations at emergence. For Midichi, percentage cover tended to be higher in crops that had been in pasture less than 4 years previously.
- There was an average 23% decline in Midichi plant numbers from establishment to final harvest, especially in denser stands.
- This study was not able to isolate the factors that determine why establishment is so poor and variable.
- Future work should focus on factors not measured in this study, including drilling speed and how drills handle pea seed.

2 Introduction

In the previous report on this project, Wilson et al. (2006) found that, in the 30 Midichi crops they monitored:

- pea yields were poor to moderate;
- most paddocks had poor soil structure;
- plant establishment was generally poor;
- yields generally decreased with:
  - increasing bulk density;
  - increasing field Aphanomyces score;
  - decreasing crop ground cover at flat pod.

Wilson et al. (2006) recommended that future agronomic research on peas should focus on the crop establishment phase. The areas they highlighted were seed bed preparation, evenness of planting, factors impeding successful establishment of sown pea seed, and any influence of soilborne diseases.

This year, a similar survey approach to that of Wilson et al. (2006) was taken, but with a greater focus on the establishment phase. Also, to reflect the interests of the members of the Pea Industry Development Group, both field and vining pea crops were included.

In collaboration with Heinz-Wattie's and Canterbury Seed Co Limited an additional survey of a less comprehensive nature was carried out by representatives from both companies to help gather a wider range of information for a larger variety of pea crops around Canterbury. This was to be added to the database of information gathered for the 2006-07 season.

3 Methods

3.1 Site selection

The Group decided to include both the marrow fat pea cultivar Midichi and a smaller seed-sized process pea cultivar, Ashton, from Heinz-Wattie's.

It was decided to limit the geographical distribution of the paddocks this season to minimise travelling and logistics problems. The paddocks were located in an area bounded by Ashburton in the south, Methven and Kirwee in the north, and Lakeside and Lincoln in the east. In collaboration with PIDG members, Midlands Seed representatives and Heinz-Wattie's representatives, a list of over 30 growers in this area was identified, including some from last season and some new growers as well. The final selection of paddocks for this project was reduced to 20 Midichi crops and 10 Ashton crops.

3.2 Sampling and assessment programme

A meeting with each of the farmers was arranged plus a visit to the paddock once the peas had been drilled. The paddock was then revisited another three or four times, three for the process peas, and four for the field peas.

3.2.1 Visit 1 – Crop planting

The first visit was as close to the sowing date as possible, but varied from 1 to 10 days after drilling. The longer wait in some instances was to account for the final tillage pass with the roller so that accurate soil bulk density could be assessed.

The host grower was asked a range of questions about the crop and cultivation history of the paddock, and the drilling management relating to the sowing of the current pea crop. A sample of un-drilled peas was taken for germination testing, thousand seed weight calculations and physical damage assessment. A paddock diagram including the sample sites was recorded, and the soil type on each of the 30 paddocks was confirmed using the most recent soil mapping and classification information available from Environment Canterbury.

In each monitored paddock, five fibreglass rods were placed in a transect to represent five random monitoring sites that were to be resampled at each subsequent visit. Beside each marker a 1 m ruler was placed between two drill rows and the pea placement depth was measured. The peas were then excavated from both rows, counted separately, and placed in a paper bag for physical damage analysis. Later, a decision was made not to carry out any testing due to the deterioration of the seeds.

At markers one, three and five, a series of soil measurements were taken. A 0-7.5 cm sample was taken for aggregate size distribution (ASD) assessment. Three soil cores (0-7.5 cm) were combined for bulk density assessment, soil moisture, and aggregate stability analysis. GPS coordinates were recorded at the central marker in each paddock for identification of the most recent soil classification information available on a soil map.

A composite soil sample (0-15 cm) from across the paddock was taken for an Aphanomyces greenhouse test. 10 pea plants were grown in the soil sample in a glasshouse for 5-6 weeks under favourable conditions. The plants were then removed, and the roots washed and dried and scored for Aphanomyces using a 1-4 scale (1 = disease free, 4 = fully diseased).

3.2.2 Visit 2 – Full emergence

The second visit was scheduled to occur around the three-node stage; but this visit was usually later (up to the fifth node stage) as emergence was initially quite patchy in most crops.

At each of the five markers a 1 m ruler was placed between two drill strips and the live and dead plants counted on either side. Any obvious gaps in the rows were excavated in search for either germinated and un-emerged seed, or dead seed. This was repeated twice at each marker. A visual crusting

assessment of the soil surface was completed for any possible soil capping problems that could inhibit pea emergence.

3.2.3 Visit 3 – Flat pod

Canopy cover and soil quality were assessed at about the flat pod stage of crop development. Each of the five original sampling sites was revisited. Within each of the five sites, two sample locations were assessed.

- At each location, penetration resistance (PR) was measured at 0-15 cm and 15-25 cm depths using a penetrometer. Five measurements at each depth were made in order to provide an average for each sample site.
- Two bulk density samples (0-15 cm) were bulked at each of the five sample sites.
- From the bottom of one of the 0-15 cm bulk density holes at each site a 15-30 cm bulk density sample was taken. These five samples were bulked to provide a paddock average.
- Gravimetric soil moisture content (% w/w and % v/v) was determined on samples from both sample depths. These soil moisture data were used to normalise the PR results to a fixed soil moisture (30% v/v).

Soil profile density assessment (PDA) involved a visual inspection of the soil surface, the cultivated layer (0-15 cm), the sub-cultivated layer (15 cm to subsoil), and the subsoil at two of the original sampling locations (high canopy cover and low canopy cover) across the paddock. Within each layer crusting, soil density, pea roots, evidence of a pan, and degree of mottling were assessed visually, and the individual scores were amalgamated into a single soil PDA for each layer.

Soil samples were also taken for a field Aphanomyces score. Ten plants were dug out of the ground at random across the paddock, the roots washed and dried, and then scored for aphanomyces using the 1-4 scale (1 = disease free, 4 = fully diseased).

The roots were then cut away from the tops of the plants at node 1, and the total root biomass and top biomass was then weighed in the field.

Percentage canopy cover was estimated visually in two directions from the rod at each sampling site. Detailed photographs were taken at each site in order to provide further canopy assessment if required.

A disease severity index (DSI) was based on the 10 plant scores and calculated using the following formula (Sherwood & Hagedorn 1958):

$$\frac{100}{4}\left(\sum_{i=1}^{4} i \times \text{Number of plants with score i}\right) / \text{Number of plants assessed}$$

The fields were then assessed based on the DSI into three categories:

0-50: fields can be safely planted;

51-69: questionable safety i.e. risky;

70-100: don't plant with peas.

3.2.4 *Final harvest*

The Midichi crops were sampled just before heading or windrowing. Sampling was carried out by FAR and Plant Research Limited. Each paddock was sampled at three of the original locations: the first, third and fifth markers. An area of 2 x 2 m was removed and weighed, and a sub-sample of 20 plants weighed and kept from each sample (total 60 plants). The sub-sample was then re-weighed in the lab and hung up to dry. Each of the three samples from each paddock sampled was then weighed and put through a stationary thresher. The peas were counted and weighed and the vegetative material weighed to give an accurate yield and also a harvest index.

Heinz-Wattie's were able to provide accurate yield data on a paddock scale for the process crops; therefore a final harvest assessment on these paddocks was not done. Paddock harvest data were supplied with a specific tenderometer (TR) reading and then converted to a yield at TR 105 for ease of comparison.

3.2.5 *Analysis of data*

Summaries:

For the measurements made at multiple locations within the paddock, the mean or median paddock values, and the minimum and maximum values were calculated. Medians rather than means were used for many measurements, since medians are more representative where there are odd values. For those measurements where two samples were taken at each location (such as numbers of seeds at sowing), the difference between the two samples was calculated, then the minimum, median and maximum of these differences (ranges) obtained. This gives a summary of the local variation (within-location) in a paddock. All other measurements recorded were summarised graphically or with tabulation: no formal analysis was done on individual measurements.

Relationships between paddock values:

Relationships between measurements were explored graphically, with biplots (a graphical representation of principal components analysis (Gabriel 1981)), cluster analyses and regression screening.

Regression screening:

Plant counts at emergence and at harvest were explored using Poisson generalised linear modelling (a method appropriate for counts (McCullagh & Nelder 1989)), and percentage cover using binomial generalised linear modelling (a method appropriate for percentages). Yield relationships were explored with standard linear regression. In each case, a baseline model (described for each of these below) was fitted. Other variables were then added to this model (each time just baseline + variable) and assessed for importance with a chi-square or F- test of the change in deviance. A different set of variables that were appropriate were selected for testing for each of the three stages modelled. (For example, soil properties at flat pod were not tested for plant emergence counts). For variables that were assessed at several locations within the paddocks, the mean or median values were included, and also the range (maximum-minimum) of the values. Interactions

between the various measurements were not explored: there are many dozens of these possible. Similarly, associations that involve the baseline plus more than one other variable have not been explored. Consequently, there may be important associations that involved more than one of the measurements that have been overlooked.

4 Results

4.1 Cropping history

For all but four paddocks, cropping history was available for 10 years. Of the remaining four, information was available for 8, 7, 5 and only 1 year (the farmer had only just bought the paddock). From the histories, the following were calculated: number of years since last pasture, number of years since 2 consecutive years of pasture, number of years since last pea crop. Twelve paddocks (three Ashton) had not been in pasture for more than 10 years, and 14 had not had two consecutive pastures for more than 10 years (Table 1). Six paddocks (three Ashton, three Midichi) were in pasture last season (2005-06), and five had had pasture for the past two seasons. No paddocks had been in peas for either of the past two seasons, but one had been in peas three seasons ago.

Table 1: Number of paddocks with number of years since last pasture, two consecutive years of pasture and peas for Ashton and Midichi crops.

	Ashton			Midichi		
Years since last:	Pasture	2 pastures	Peas	Pasture	2 pastures	Peas
1	3	3	0	3	2	0
2	1	0	0	1	0	0
3	0	0	1	1	1	0
4	2	2	1	2	1	1
5	0	0	1	1	1	0
6	1	2	1	0	0	0
7	0	0	0	0	1	2
8	0	0	1	0	0	0
9	0	0	0	0	0	1
10	0	0	1	0	0	0
>10	3	3	3	9	11	13
Unknown	0	0	1	3	3	3

4.2 Tillage

The 20 Midichi paddocks varied in area from 5 to 24 ha (mean 12.2 ha) and the 10 Ashton paddocks from 2 to 18 ha (mean 9.2 ha). The majority of the paddocks were described by the farmers as having had a conventional tillage history, with only one paddock described as no tillage, and only four (one Ashton, three Midichi) as having had minimum tillage:

Prior to sowing, Midichi paddocks were tilled on one to eight occasions, with a total of one to nine tillage events. Ashton paddocks had slightly more tillage, carried out on four to eight occasions, with five to ten separate tillage passes. A large variety of tillage implements were used. The impact of each of these implements can be rated using a Soil Disturbance Rating (SDR), as in Table 2.

Table 2: Tillage implements and soil disturbance ratings.

Tillage	SDR	Tillage	SDR
Burn	0	Heavy Roll	4
Cambridge Roll	4	Incorporate	27
Direct Drilled	4	Maxitill	18
Disc	27	Packer Roller	4
Drill	3	Plough	29
Fine Grubber	22	Power Harrow	29
Grub	22	Press	5
Harrow	14	Rotocrumbler	18
Heavy Grubber	22	Subsoiled	16

A measure of the total impact of the pre-sowing tillage is the sum of the SDR for each tillage event. Total SDR scores ranged from 44 to 134 (median 98) for Ashton, and from 4 to 118 (median 77) for Midichi. Of the Midichi paddocks, four had scores of only 4. The remaining 16 paddocks had a SDR spread evenly over the range from 54 to 118. Only one of the ten Ashton paddocks had a score below 50, with the other nine having scores of 69 or more.

Only five paddocks were described by the farmers as having a history of minimum or no tillage. The ‘no tillage’ Midichi paddock was not tilled other than when the seed was direct drilled (SDR = 4). Two of the three ‘minimum’ tillage Midichi paddocks were also not tilled apart from direct drilling. However, the third (paddock 1) had an SDR of 118: prior to drilling, there were three grubbings, one maxitill and one burn followed by incorporation and a Cambridge roll. Similarly, the one Ashton paddock with a ‘minimum’ tillage history had an SDR of 143: prior to drilling, there were three maxitills, one harrow, a Cambridge roll, a pass with the grubber, and then a power harrow plus pack roller. Drilling was followed by another Cambridge roll! Of the paddocks described by farmers as having had a conventional tillage history, one Midichi paddock was not tilled apart from drilling (SDR = 4). Part

of the problem with the tillage data is that some farmers interpreted the question as “what tillage have you predominantly used in this paddock over the previous 10 years.”

4.3 Soil test results

These were available from the farmers for only 13 paddock sites, and not all measures were available for all of these. Farmer test results are summarised in Table 3.

Table 3: Farmer soil test results. Mean (range, number of paddocks tested).

Nutrient	Ashton	Midichi
pH	5.8 (5.6-6; 3)	5.9 (5.3-6.4; 10)
Olsen P	30.3 (26-36; 3)	24.5 (13-39; 10)
Sulphate S	4.3 (4-5; 3)	13.6 (4-32; 9)
K QT	6.3 (3-11; 3)	6.1 (4-9; 10)
Ca QT	9.0 (7-12; 3)	8.1 (5-11; 10)
Mg QT	15.0 (8-19; 3)	12.1 (4-20; 9)
Na	10.5 (10-11; 2)	7.2 (5-12; 5)

Only one site (paddock 5) had had an Aphanomyces test carried out: the score was 35.

4.4 Seed lines

Four seed lines were used for Ashton crops: 871280 (5 crops), 870274, 875140 (2 crops each) and 755377 and 667686 (1 crop each). All Ashton seed were treated.

Nine seed lines were sown for the Midichi crops, with line MFS the most commonly sown (five crops) followed by MFS 606 (three crops) and MFS 607 (two crops), with the remaining lines sown in one paddock each (MFS 601, 602, 604, 605, 609, 624). Three paddocks were sown with a mixture of two lines, and one paddock with a mixture of three lines. Only one Midichi crop used treated seed (paddock 10); however, there were three paddocks for which this information was missing (paddocks 14, 17 and 23), although it is likely that untreated Midichi seed was used in paddocks 14 and 17, and that treated Ashton seed was sown in paddock 23.

4.5 Drilling

Drills used for sowing varied enormously, and a number of the drills had been modified by the farmer. The main seed feed mechanisms used by the drills are summarised in Table 4, where roller feed types include bean feed types, Duncan Amazone, fluted rollers, metal fluted drive, and wheel feed.

Table 4: Number of paddocks where drill with each feed mechanism was used.

Drill feed type	Midichi	Ashton
Air	9	0
Roller	9	8
Foam and sponge	2	2

Farmers said their drilling speeds ranged from 7-12 km/h (mean 9.0) for Midichi crops, and 6-8 km/hr (mean 7.5) for Ashton crops.

Farmers said their seed was drilled at four spacings (12-18 cm), with the majority at 15 cm, and it was sown at depths ranging from 2 to 10 cm, with most at about 5 cm (Table 5).

Table 5: Summary of farmer information on row spacing and sowing depths.

Row space (cm)	Midichi	Ashton
12	3	0
14	1	1
15	15	9
18	1	0

Sowing depth (cm)	Midichi	Ashton
2	0	2
3	2	0
4	1	1
5	9	5
6	3	0
7	4	1
8	1	0
10	0	1

Farmer sowing rates ranged from 300-377 kg/ha for Midichi (mean 332) and 230-255 kg/ha for Ashton (mean 238). Thousand seed weights (TSW) ranged from 332-420 g (mean 376) for Midichi and 174-180 g for Ashton (mean 177, data for one crop missing). TSW also varied between crops that used the same seed line. Sowing rates as seeds/m^2 calculated from these varied between 76 and 105 for Midichi (median 89) and 128-145 for Ashton (median 131). Germination ranged from 72-95% for Midichi (median 89%), and 91-99% (median 98%) for Ashton. Very few seeds showed damage: for Ashton, only three crops had damaged seeds (1%), although this information was also missing for three crops. Damage levels were greater for the Midichi seed; with only one crop having no damaged seed and one crop having 9% damaged seed (paddock 18, with TSW of 420). Median damage for Midichi was 2%.

Sowing dates for Ashton varied from 5 Sept to 28 Nov, and those for Midichi from 4 Sep to 18 Oct. Twenty seven of the Midichi paddocks were sown in

September and three in October. Sowings of Ashton were spread more, with two in September, and four in both October and November.

4.6 *Aphanomyces scores*

Glasshouse Aphanomyces scores ranged from 25 to 100, whereas the field Aphanomyces index had a narrower range, from 35.5 to 87.5, with more than half having scores above 50%. Field and glasshouse scores were only weakly correlated (r=0.42, Figure 1). There were two paddocks with a field score of 87.5: one (paddock 14) had the highest glasshouse score (100), and, when the field samples were collected at flat pod, the crop was almost entirely dead.

Plant weights were negatively correlated with field Aphanomyces scores (Figure 1: Tops: r=-0.50; Roots: r=-0.40; Tops+Roots: r=-0.50), showing that the Aphanomyces had a noticeable effect on the plant's growth. However, plant weights were not correlated with the glasshouse scores (-0.2 < r < 0). For the one paddock where there had been an Aphanomyces test (paddock 5), the glasshouse score was 60 and the field score 57.5. Both of these values are well above the test result of 35.

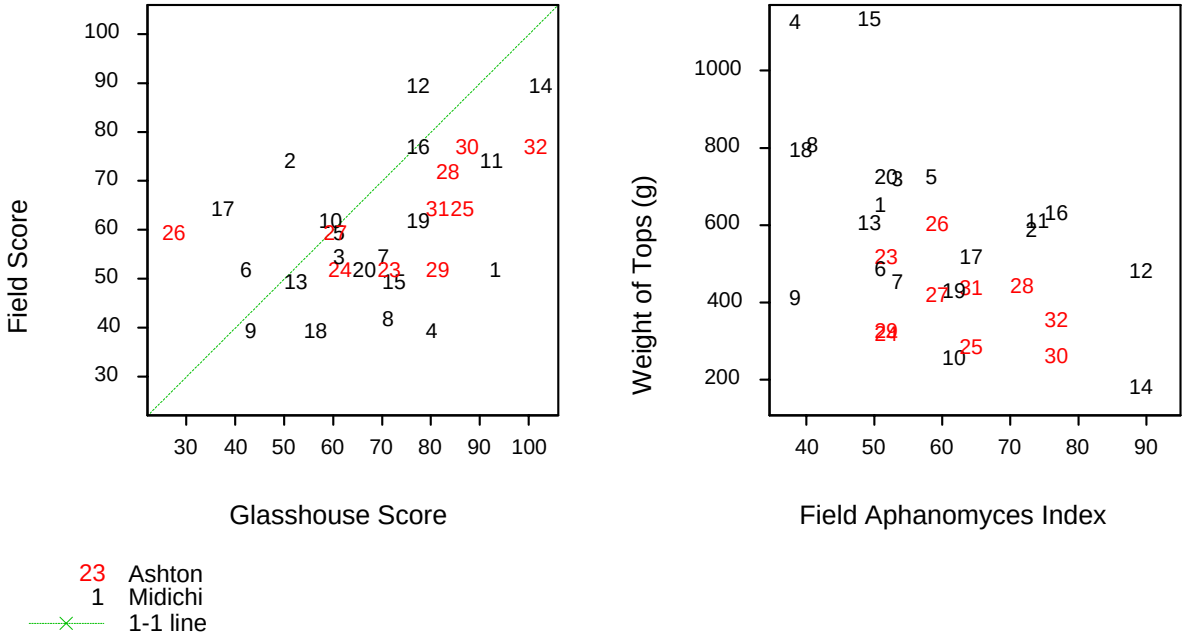


Figure 1: Comparison of (left) glasshouse and field Aphanomyces disease score indices, and (right) plant top weights with the field Aphanomyces indices. Black numbers are Midichi paddocks, red are Ashton paddocks. The dotted line is the 1:1 relationship between glasshouse and field Aphanomyces disease score indices.

4.7 Fertiliser, chemical and water applications

Fertiliser and chemical data were available for 29 crops; no information was available for paddock 17.

Fertiliser was applied to all but six paddocks (all Midichi). The majority of paddocks (20) received only one application, six received two or three applications, and two received four applications. A wide range of products were used, with the most common being Lime (five paddocks) and Cropmaster 15 (six paddocks).

Herbicide was applied to all paddocks, with up to five applications (median: 2). The most commonly used herbicides were Gardoprim and Roundup and Roundup Transorb (ten applications each). In contrast, Fungicide was only applied to eight paddocks: one received seven applications (paddock 3), paddock 1 received six applications and paddock 16 had five applications. The most commonly used products were Amistar/ Amistar WG (six), and Protek (five). Pesticides were quite sparely used; they were only applied once to paddocks 1, 3, 5 and 16.

Ten paddocks were irrigated, (five each of Midichi and Ashton), with between 15 and 70 mm applied in total. Eight of these paddocks were only irrigated once; however, two (paddocks 5 and 15) were irrigated three times. Midichi paddocks were irrigated with laterals (three paddocks), or Rotorainer irrigators (one paddock). Four Ashton paddocks were irrigated, two with rotating boom irrigators, one lateral and one with a gun.

4.8 Soil properties

(a) At sowing:

Soil properties at sowing are summarised in Table 6. Overall paddock means were similar for the two cultivars, and the range of paddock means was also fairly similar for most of the measurements. Soil water tended to be higher in the Ashton paddocks, and also the particle sizes tended to be larger (the % of particles <0.85 mm was lower on average and the % of particles >9.5 mm tended to be higher). Within paddocks, some measurements were quite variable in some cases. For example, the percentage of particles larger than 9.5 mm for the three samples from paddock 3 varied from 28% to 72% (range of over 44%), which is noticeably above the median range of only 6.7% between samples within a paddock. In contrast, the three samples from paddock 9 had very similar percentages of particles larger than 9.5 mm, ranging from 4.0 to 4.9%.

Table 6: Mean of paddock means (range of mean), and median of ranges within paddocks (range of within paddock ranges) for soil measurements taken at around sowing.

	Midichi		Ashton	
	Mean	Within-paddock range	Mean	Within-paddock range
Bulk density	1.22 (1.06-1.32)	0.11 (0.02-0.35)	1.18 (0.97-1.34)	0.13 (0.07-0.21)
AgStab. mean wt diam	1.73 (1.02-2.53)	0.37 (0.08-0.86)	1.69 (1.08-2.18)	0.60 (0.09-1.21)
Soil water (% w/w)	18.91 (11.99-30.44)	2.48 (0.95-7.13)	22.94 (13.85-37.93)	4.12 (1.36-14.09)
Soil water (% v/v)	22.98 (15.71-32.81)	3.92 (0.37-9.72)	26.38 (18.69-36.63)	4.91 (2.38-12.29)
% of particles <0.85 mm	24.09 (9.25-39.16)	6.74 (1.89-11.28)	21.26 (8.04-28.80)	4.35 (3.47-11.16)
% of particles >9.5 mm	23.57 (4.58-51.65)	7.58 (0.95-44.52)	27.73 (15.72-53.49)	10.72 (5.31-18.68)
Mean wt diam.	6.74 (2.93-15.66)	1.92 (0.05-16.50)	7.76 (4.88-14.85)	2.60 (1.18-6.98)
Mean wt diam. <19 mm	4.58 (2.84-7.05)	0.94 (0.05-2.83)	4.94 (3.98-6.87)	0.69 (0.52-1.93)
% particles 0.85-9.5 mm	52.34 (39.10-66.36)	4.44 (0.65-35.31)	51.01 (38.47-57.97)	7.16 (0.49-14.62)

(b) At flat pod

These measurements are summarized in Table 7. Measurements for four paddocks (Midichi 8, 16; Ashton 31, 32) could not be taken because of stones near the soil surface. In addition, no bulk density or soil water (% v/v) measurements could be done at 15-30 cm for paddocks 3, 15, 23 (all Midichi), again because of stones at that depth.

Table 7: Mean of paddock means (range of mean), and median of ranges within paddocks (range of within-paddock ranges) for soil measurements taken at flat pod.

	Midichi		Ashton	
	Mean	Within-paddock range	Mean	Within-paddock range
Bulk density 0-15 cm	1.23 (1.12-1.30)	0.12 (0.03-0.28)	1.23 (1.14-1.31)	0.09 (0.06-0.17)
Bulk density 15-30 cm	0.96 (0.83-1.08)	*	1.02 (0.93-1.11)	*
Soil water (%w/w) 0-15 cm	24.28 (18.44-30.55)	3.42 (1.14-7.70)	20.85 (12.25-28.35)	3.22 (2.19-12.65)
Soil water (%w/w) 15-30 cm	21.84 (15.52-28.46)	*	18.35 (11.28-23.54)	*
Soil water (%v/v) 0-15 cm	29.73 (22.52-37.53)	4.22 (1.28-9.86)	25.71 (14.69-32.07)	4.24 (1.36-12.05)
Soil water (%v/v) 15-30 cm	20.84 (14.92-24.82)	*	19.07 (10.56-25.09)	*
Penetration resistance (MPa) 0-15 cm	2.53 (1.12, 4.75)	0.78 (0.30, 1.67)	3.42 (2.28, 5.77)	1.25 (0.48, 3.77)
Penetration resistance (MPa) 15-30 cm	2.83 (1.90, 5.37)	0.59 (0.11, 4.47)	4.31 (2.68, 8.10)	1.15 (0.64, 4.96)

*Only one bulked measurement was taken for each paddock 15-30 cm.

The bulk density and water content differs between the two measurement times because the first was taken from the 0-7.5 cm depth in association with aggregate stability and aggregate size distribution, whereas the second was taken from the 0-15 cm depth is association with the profile assessments.

The soil profile density assessments (PDA) are summarised in Table 8.

PDA is the sum of the scores for the individual layers, which were scored as 1: none/loose, 2: moderate, 3: extensive/very dense. Scores were done for two pits in each paddock, and then averaged. Within paddocks, scores were mostly very consistent: Except for density in the cultivation layer, for all paddocks bar one (which varied with layer), the scores for the two pits varied by no more than 0.5 for any of the scores. Density in the cultivation layer varied by 0 or 0.5 for most paddocks, but varied by 1 for paddocks 2, 15 and 23.

PDA was on average slightly higher in the Ashton crops (median of 10.72 c.f. 9.92 for Midichi. This was principally due to the slightly higher density scores for the Ashton crops, in both the cultivation and sub-cultivation layers. All but one crust score for both crops was 1 (the exception being paddock 16, crust score=1.5). Similarly, all but one sub-cultivation layer mottle score was 1 (the exception was paddock 29, score=1.75), and only two sub-soil mottle scores were not 1 (paddocks 29 and 23, scores=2.0).

Table 8: Summary of profile density assessment scores: median (min, max).

	Midichi	Ashton
PDA	9.50 (8.25, 13.50)	10.00 (8.75, 14.50)
Surface:		
Crust	1.00 (1.00, 1.50)	1.00 (1.00, 1.00)
Cultivation Layer:		
Density	1.25 (1.00, 2.25)	1.38 (1.25, 2.55)
Roots	1.00 (1.00, 2.00)	1.00 (1.00, 2.00)
Sub-Cultivation Layer:		
Density	1.88 (1.00, 2.50)	1.88 (1.50, 2.75)
Pan	1.00 (1.00, 2.25)	1.13 (1.00, 2.00)
Roots	1.00 (1.00, 2.00)	1.00 (1.00, 2.00)
Mottles	1.00 (1.00, 1.00)	1.00 (1.00, 1.75)
Sub-soil:		
Mottles	1.00 (1.00, 1.00)	1.00 (1.00, 2.00)

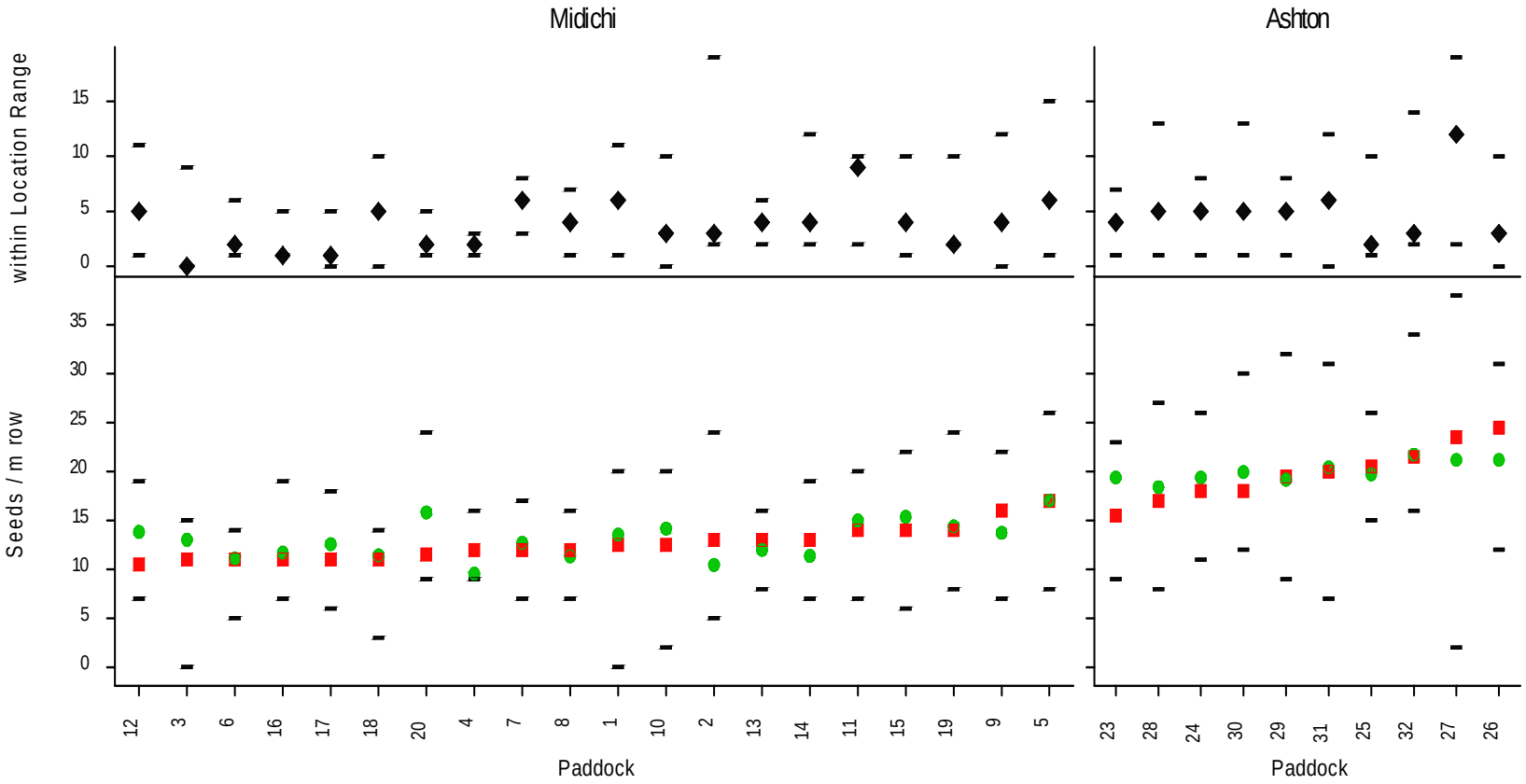


Figure 2: Variation in farmer estimate and measured number of seeds planted/m of row. Upper graph is the minimum, median and maximum range between adjacent rows within each sampling site. Lower graph is the minimum, median and maximum range of seeds sown across all sites in a paddock. ● Farmer estimate ■ Median of samples between sampling sites ━ Maximum and Minimum ◆ Median of samples between rows within sampling sites.

4.9 Seed counts after sowing

Figure 2 compares the number of seeds excavated from the soil with the number of seeds expected from the farmers' sowing rate adjusted for TSW. The expected number of seed per linear metre is (seeds/m^2)/(100/Row Space). For 22 paddocks, the median count of the sampled seed was within two seeds of the farmer's estimated sowing rate. However, there was a greater disparity for the remaining eight paddocks, with four varying by over 3 from the expected number. For three of these, the actual number was below the estimated number (paddocks 20, 23 and 12, differing by 4.3, 3.9 and 3.3 seeds), and one was above (paddock 26, 3.3 seeds more than expected). However, for some paddocks, there was a large variation in the numbers of seeds sown both between sampled locations within the paddock, and in some cases, between the two adjacent rows in the location (Figure 2). The greatest range in seeds found in samples was 36, for paddock 27, where two seeds were found in one row and 38 in another. The most consistent paddock was paddock 4, where the numbers found varied from nine to 16. The median range in seed numbers was 12 seeds for Midichi and 18.5 for Ashton. In three samples, no seeds were found (paddock 1, two samples for paddock 3).

In terms of sowing rates as kg/ha, some farmers' estimates were not reflected in the seed recovery in the field (Figure 4). This is particularly true for the Ashton crops, where the farmer's estimates (128-145 seeds/m^2) were much less diverse than the actual rates (103-163 seeds m^2). However, all these crops exceeded the recommended sowing rate of 80-100 seeds/m^2. Of the Midichi crops, most had actual sowing rates close to the recommended range, but four crops had rates below 75 seeds/m^2 (paddocks 3, 12, 17, 18), and two were over 105 seeds/m^2 (paddocks 2 and 9).

Figure 3 compares the target sowing depth with the depth of the excavated seeds. Median depths of seeds found varied for all but three paddocks by only 3 cm from the target depth. For those three paddocks, seeds were on average planted more shallowly than intended, with seeds at paddock 2 and 9 on average at only 2 cm compared with a target of 7 and 5 cm respectively, and seeds at paddock 27 at 7 cm compared with a target of 10 cm. As with seed numbers, the actual sowing depth varied within the paddocks between locations (Figure 3). There was much less variation between adjacent rows within a location, with the average difference being only 1 cm. Variation between the samples was much greater, up to 8 cm (paddock 23), with an average variation of 3 cm. Again, there was a poor relationship between some farmers' estimated sowing depth and measured sowing depth (Figure 4).

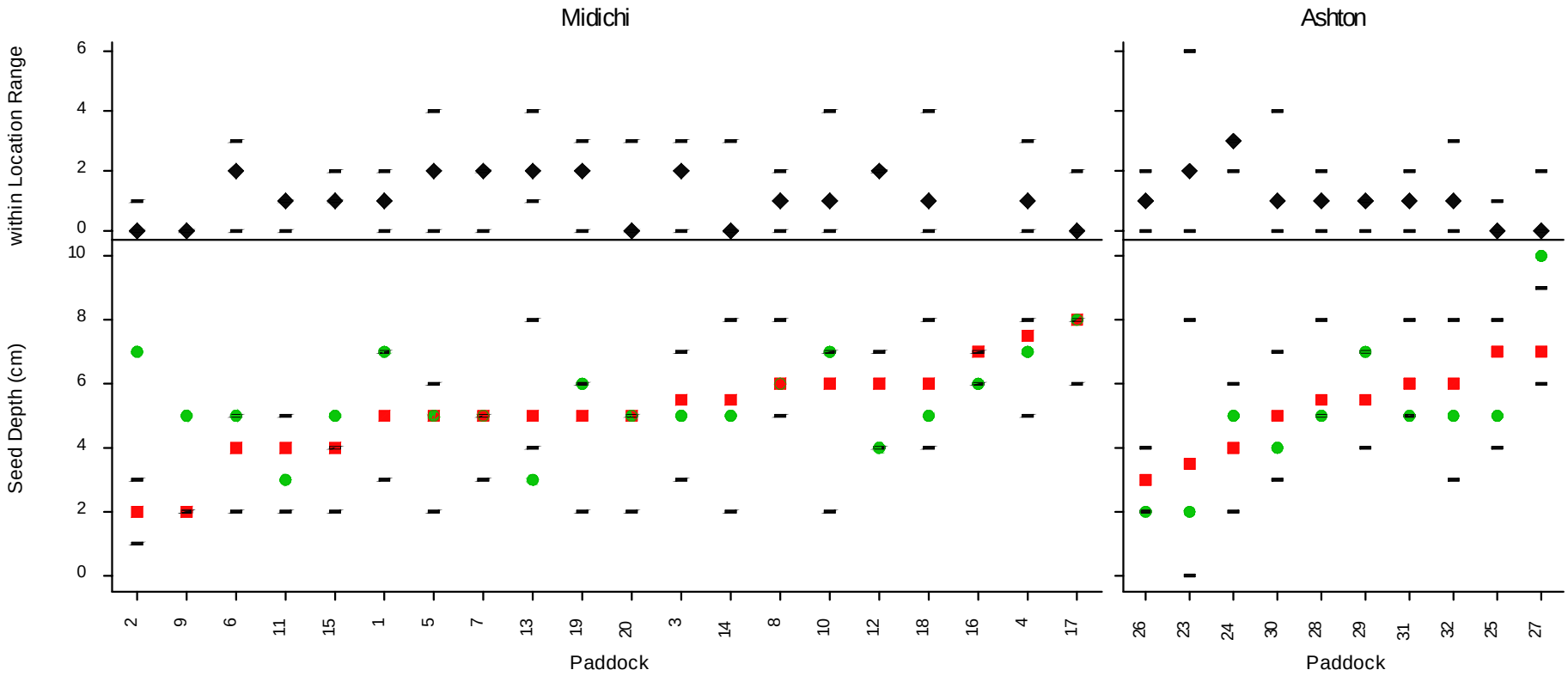


Figure 3: Variation in farmer estimated and measured depth of sowing. Upper graph is the minimum, median and maximum range between adjacent rows within each sampling site. Lower graph is the minimum, median and maximum range of sowing depths across all sites in a paddock. ● Farmer estimate ■ Median of samples between sampling sites ━ Maximum and Minimum ◆ Median of samples between rows within sampling sites.

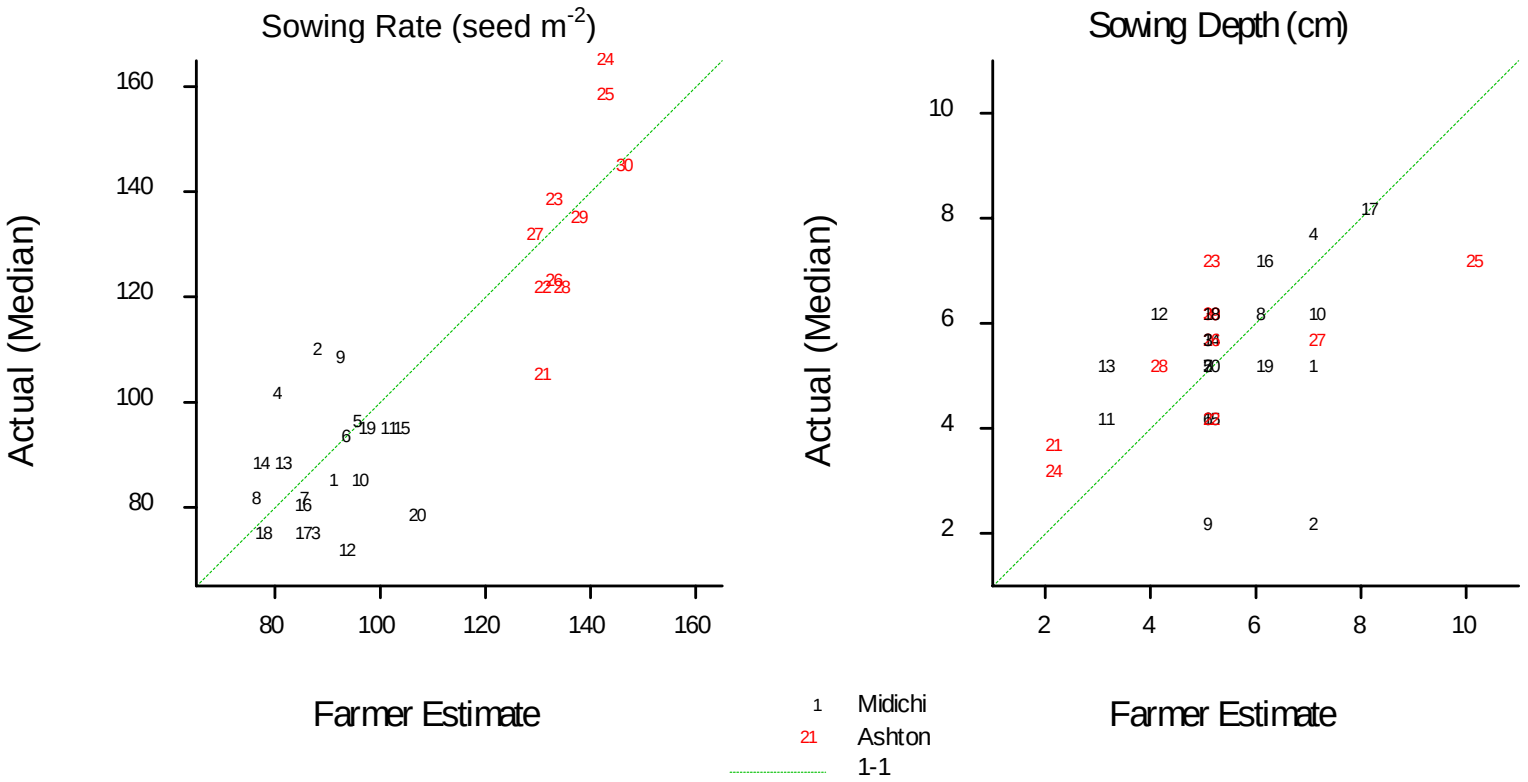


Figure 4: Comparison of (left) measured and farmer estimated sowing rate (plants/m2) and (right) measured and farmer estimated sowing depth (cm). Black numbers are Midichi paddocks, red Ashton paddocks. The dotted line is the 1:1 relationship actual and estimated values.

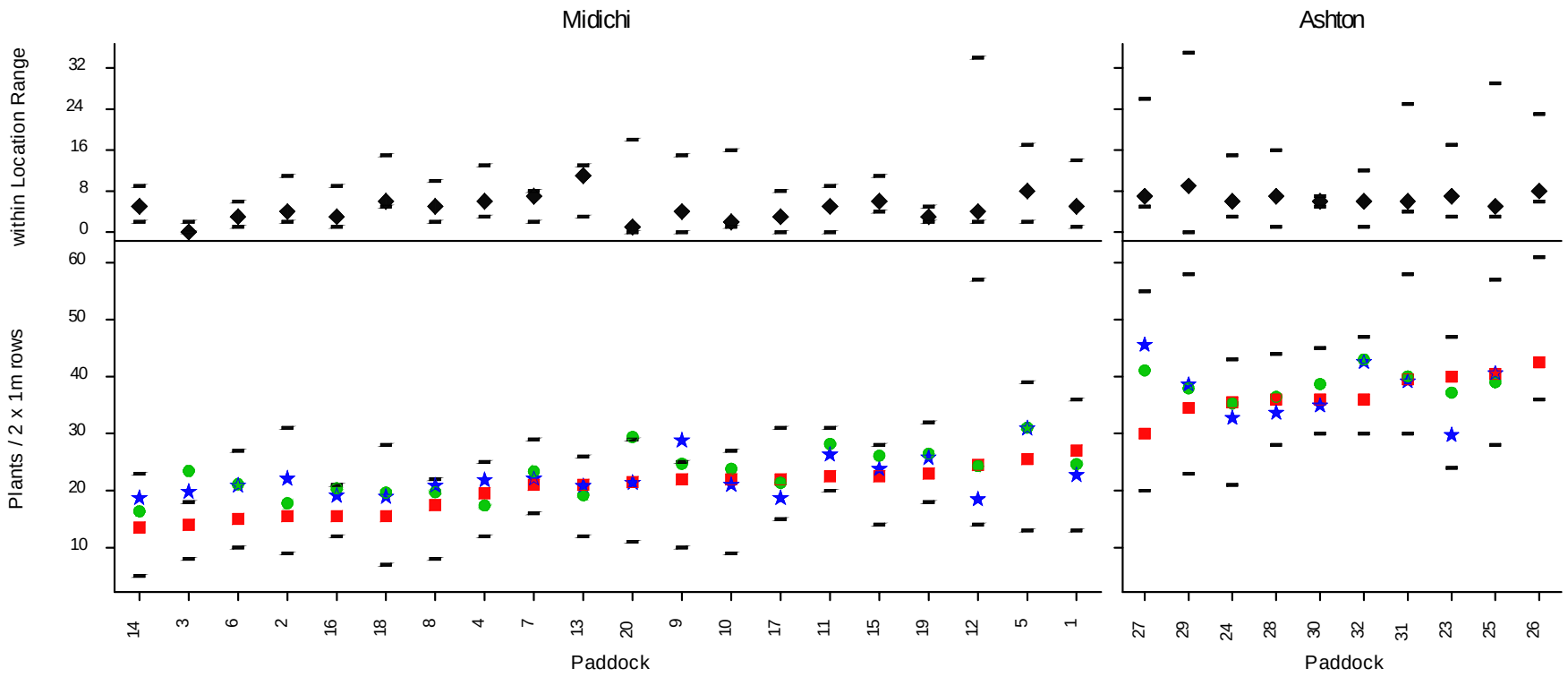


Figure 5: Variation in actual live plant counts at emergence, and calculated emergence from farmer-estimated seeding rate and from median of sown seed samples (both estimates corrected for seed viability). Upper graph is the minimum, median and maximum range between adjacent rows within each sampling site. Lower graph is the minimum, median and maximum range of plants/m^2 across all sites in a paddock.

Median of samples − Maximum and Minimum ◆ Median of within Location Range. ● Predicted emergence from farmer estimate of sown seed, ★ Predicted emergence from median of sown seed samples.

4.10 *Plant populations at emergence*

At the time of assessment, numbers of nodes per plant varied from 3 to 6, with a median of 5 (both cultivars).

There were few dead plants observed, with only 10 of the 300 samples having any dead plants. Of these, six samples came from paddock 5, two from paddock 19 and one each from paddocks 12 and 23. Other than in paddock 5, only one dead plant was found per sample. For paddock 5, the worst sample had four of 17 plants dead, followed by three of 29 plants dead.

Live plants varied from five to 61 per 2 x 1 m rows (Figure 5), with paddock medians varying from 13.5 plants/2 x 1 m row to 42.5 plants over all paddocks (Figure 5). This equates to median rates for Midichi ranging from 45 to 90 plants/m^2 (mean 68), and median rates for Ashton of 100-142 plants/m^2 (mean 124). These plant counts represent a noticeable reduction from the number of seeds sown for most paddocks, even if plant viability (% germination) is taken into account (Figure 6).

Plant counts varied quite considerably for some paddocks. For example, in paddock 12, the lowest count (for 2 x 1m rows) was 14 and the highest was 57. Paddocks 27 and 29 were also quite variable, with 22-55 and 23-58 plants. The least variable paddocks were paddock 16 (12-21) paddock 3 (8-18) and paddock 11 (10-31).

On average, the number of live plants found was less than the number of seeds counted after sowing.

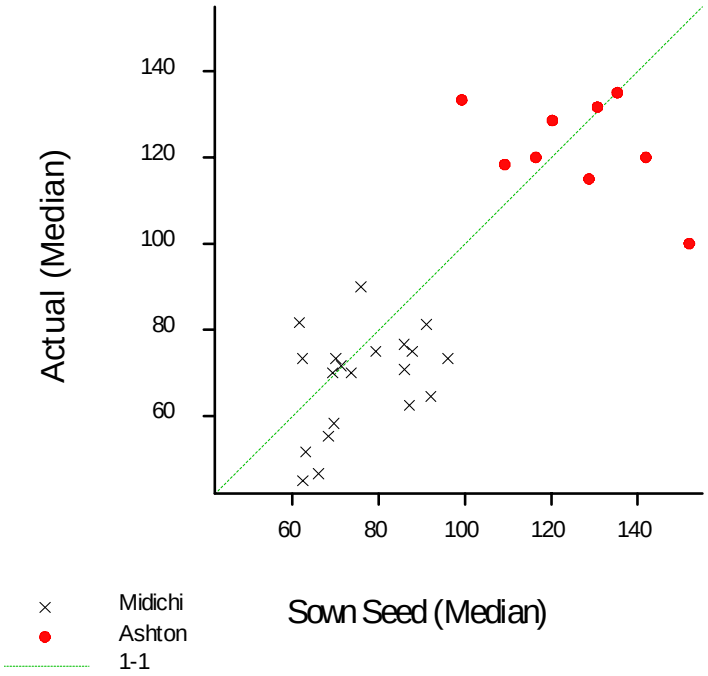


Figure 6: Plant counts at emergence (plants m^{-2}) compared to seed counts at sowing (adjusted for seed viability). Black numbers are Midichi paddocks, red Ashton paddocks. The dotted line is the 1:1 relationship.

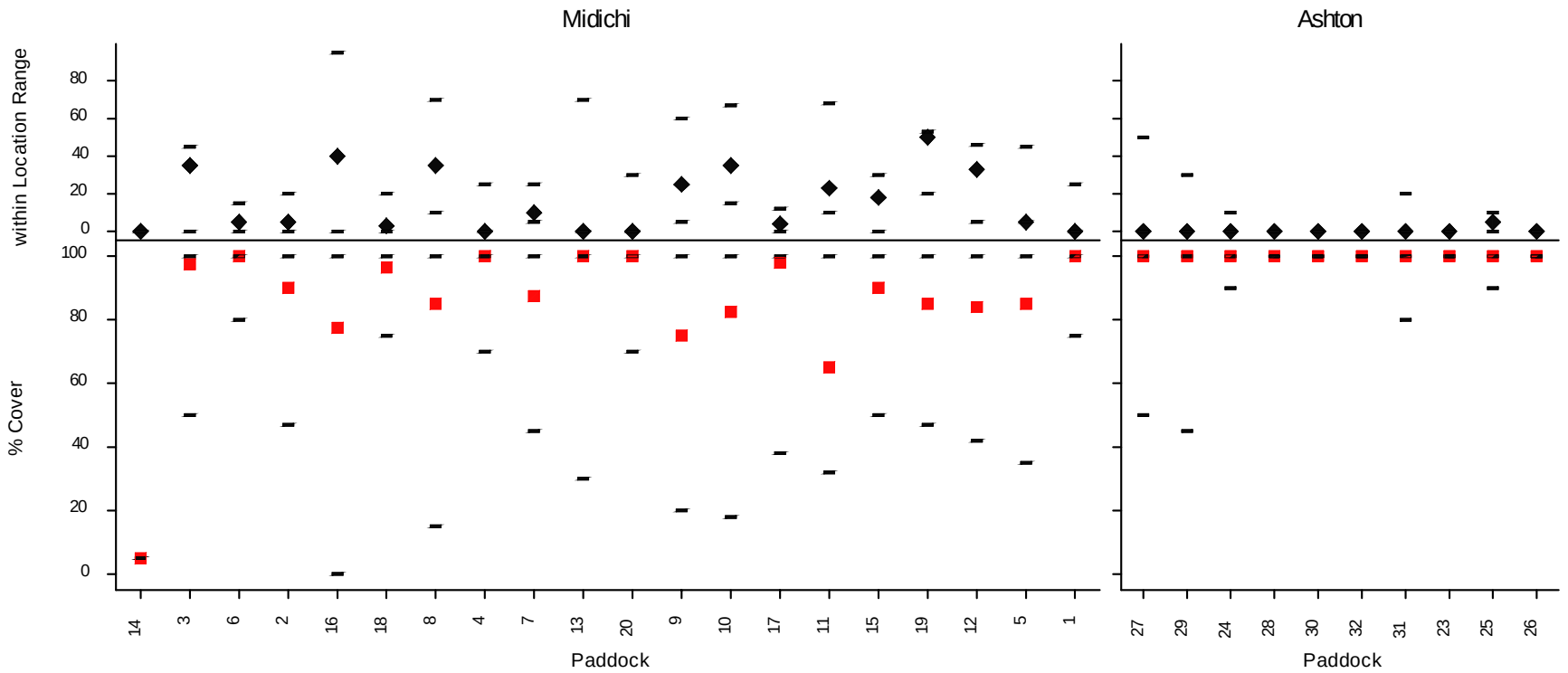


Figure 7: Variation in estimated % ground cover at flat pod stage. Upper graph is the minimum, median and maximum range between the two estimates at each sampling site. Lower graph is the minimum, median and maximum range of sowing depths across all sites in a paddock.

■ Median of samples between sampling sites ━ Maximum and Minimum ◆ Median of samples between rows within sampling sites.

4.11 Crop cover at flat pod

Median percentage cover at flat pod ranged from 5 to 100% for Midichi crops (mean 85%, Figure 7). Paddock 5 had the lowest cover (5%), followed by paddock 65. All other paddocks had median cover above 75%. All Ashton paddocks had median cover of 100%. Within paddocks, coverage could be quite patchy (Figure 7). For example, paddock 16 had no cover in one sample, but 100% cover in three others, and paddock 8 had 15% cover in one place, but 100% cover in another. Six paddocks had very uniform cover, with no variation in estimates between the ten samples. Of these, five were Ashton paddocks (23, 26, 28, 30, and 32), all with 100% cover, and one was paddock 14, which had very low plant cover of 5%.

4.12 Plant population at harvest

Harvest samples were only taken from the Midichi crops. There were no data from two paddocks: one crop (paddock 14) was abandoned, and another (paddock 19) was harvested before the samples could be taken. Median plant populations estimated from quadrat samples at harvest varied from 39 plants/m^2 to 71 plants/m^2 (Figure 8). Within paddocks, populations from the three quadrats varied from two to nearly 25 plants/m^2 with an average difference of around 14 plants/m^2. This is a substantial level of variation in populations across a paddock.

4.13 Changes in plant populations over sampling times:

Within paddocks, plant populations tended to decrease from sowing to harvest, as would be expected (Figure 9). However, estimates for four paddocks (1, 12, 23, and 28) *increased* from sowing to emergence. These increases were well within the range of variation of plant numbers at emergence for paddocks 1, 12 and 28 (below 12 plants/m^2), given that within paddocks, the median range of plant counts was over 50 plants/m^2. The increase for paddock 23 was still within this range, but was quite marked (30 plants/m^2). There were several other paddocks where the estimated plant count at emergence was above the number of seeds sown when adjusted for seed viability. However, these increases were very small (all below four plants), well below the level of variation within paddocks.

For the Midichi paddocks, estimates of plant counts increased only very slightly between emergence and harvest for two paddocks (3, 18).

The greatest decreases from sowing to emergence were in paddocks 9, 14, 2 and 27, with decreases in median counts of 33, 42, 44 and 57 plants/m^2. The decrease was below two plants in five paddocks (17, 30, 24, 31, and 25). The greatest decrease between emergence and harvest were for paddocks 11, 1, 13, and 10, with decreases in median counts of between 28 and 32 plants/m^2. There were four paddocks where plant counts changed little (change below five plants, paddocks 3, 18, 20 and 8). The reduction in plant numbers was well correlated with the numbers of plants at emergence ($r=0.76$), indicating that plant loss is proportionately greater for denser plant stands.

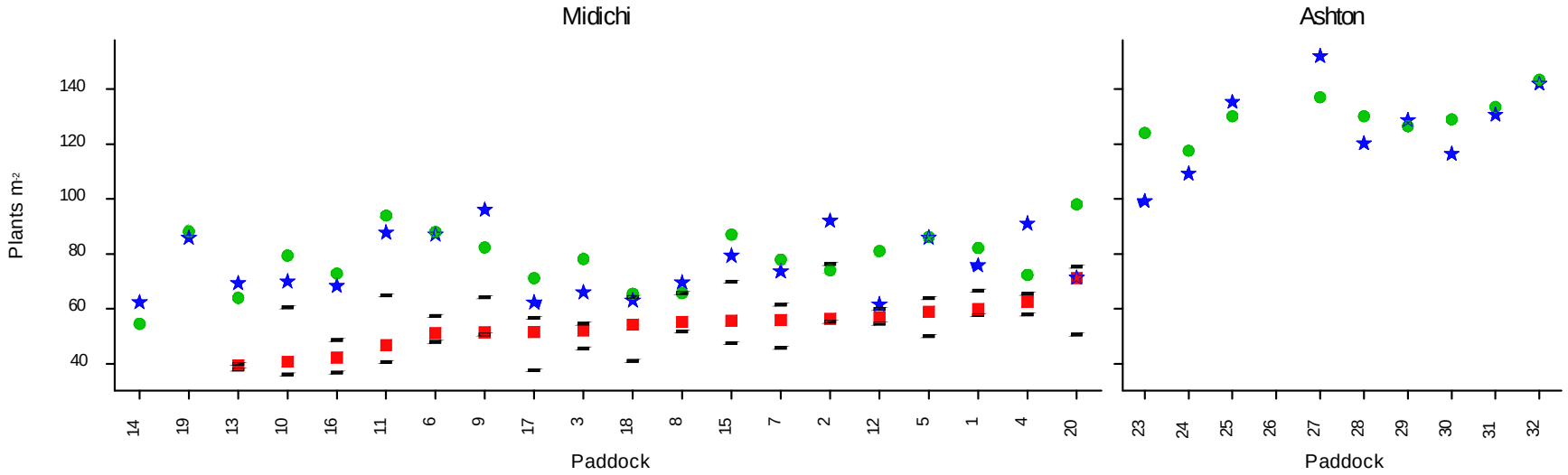


Figure 8: Variation in measured plant counts at harvest (Midichi only), and plant counts calculated from farmer estimates of sown seed or from the median of measured sown seed (both adjusted for seed viability).

Median of samples − Maximum and Minimum of samples. Population predicted from farmer estimate of sown seed. Population predicted from median of sown seed samples.

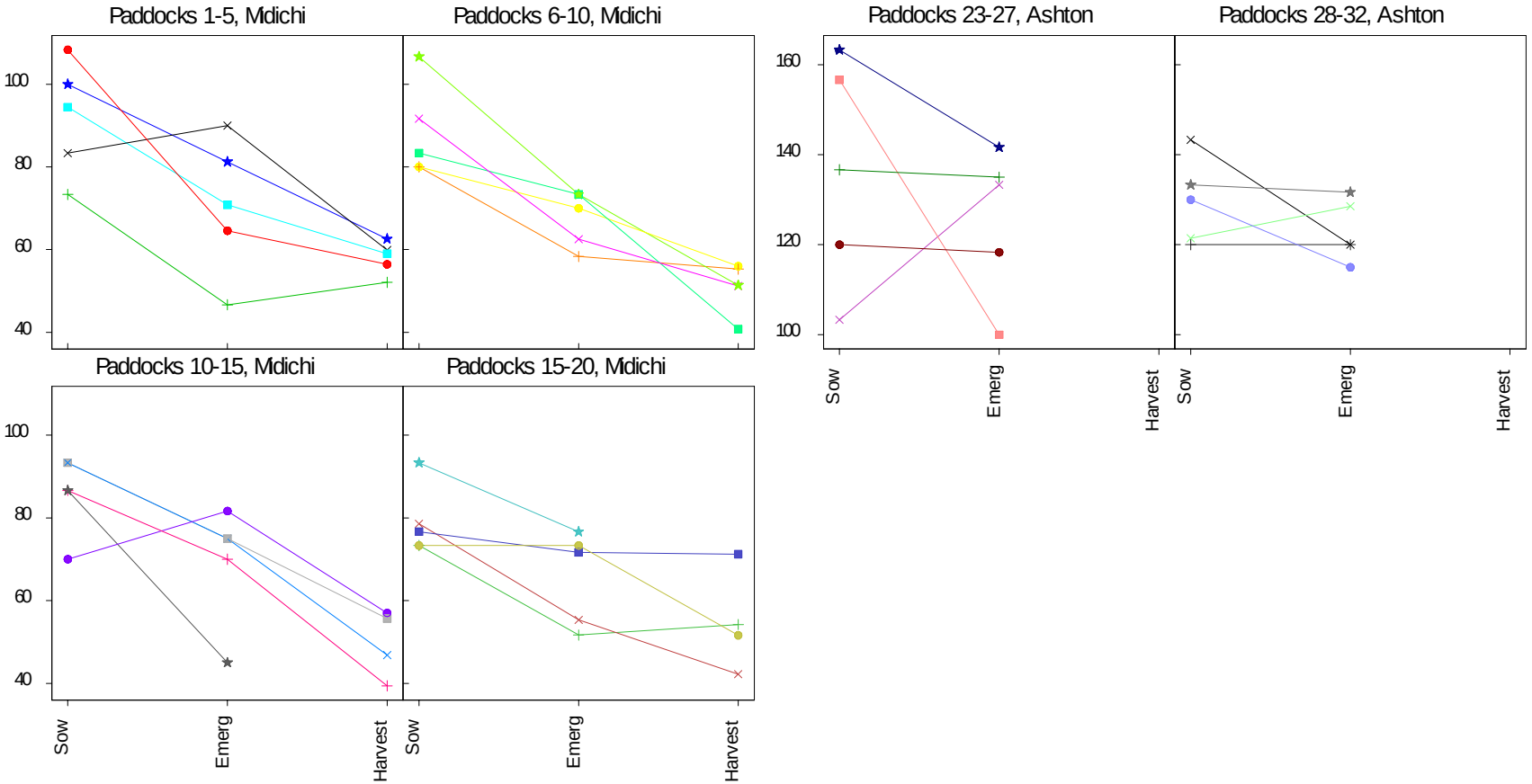


Figure 9: Changes in paddock median plant population over three (Midichi) or two (Ashton) crop stages. Colours indicate the different paddocks. Counts are medians from the samples taken at sowing, emergence and harvest, converted to plants/m^2.

4.14 Yields

4.14.1 Midichi

Farmer-estimated yields varied from 3.0 to 6.6 t/ha (mean 4.5, Figure 10). Yields as estimated from the paddock samples varied from 3.0 to 6.7 t/ha at 12% moisture (mean 4.6). These two sets of yield estimates were reasonably well correlated (r=0.85); however, there were noticeable differences between the two yields for some paddocks. In particular, for paddock 2, the farmer yield was almost 2 t/ha lower than the yield estimated from the samples (5 t/ha c.f. 6.7 t/ha), and the two yield estimates for paddocks 4, 12 and 13 differed by around 0.8 t/ha. Other harvest data are summarised in Table 9.

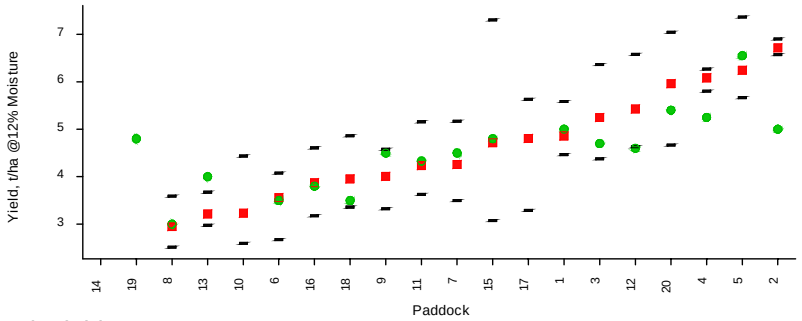
Table 9: Mean of paddock means (range of paddock means), and median of ranges within paddocks (range of within-paddock ranges) for Midichi crops, yield and yield components.

	Mean	Within-paddock range
Yield, t/ha @12% moisture	4.63 (2.95-6.71)	1.52 (0.33-4.22)
Plants/m^2	54.2 (39.1-65.8)	14.0 (1.9-24.7)
Seeds/m^2	1408 (984-1870)	379 (85-1019)
TSW (g)	326.3 (260.9-367.1)	40.9 (14.9-126.6)
Harvest index (%)	52.2 (42.0-61.0)	4.7 (1.9-24.1)

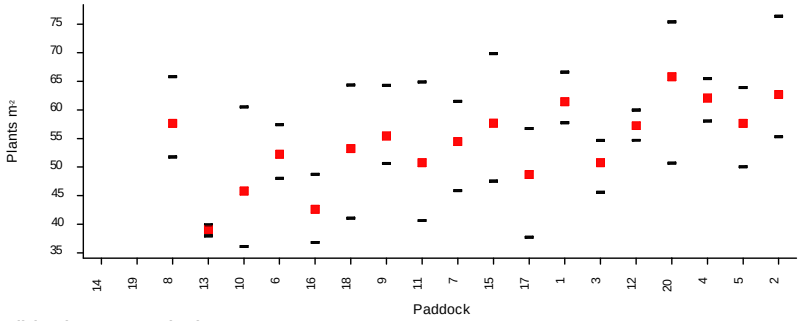
All of the yield components varied quite substantially within some paddocks (Figure 10). This has been noted above for plant populations and yields. Estimated numbers of seeds/m^2 varied by as much as 1018 seeds across the paddock for paddock 15: the variation was about 30% of the mean number of seeds. The most consistent paddock was paddock 4 (range of 85 seeds). TSW was similarly variable in some paddocks, with the greatest range again from paddock 15 (range of 127 g), and the smallest variation from paddock 18 (15 g). Harvest index was most variable in paddock 15 (range of 24%) and least variable in paddock 12.

4.14.2 Ashton

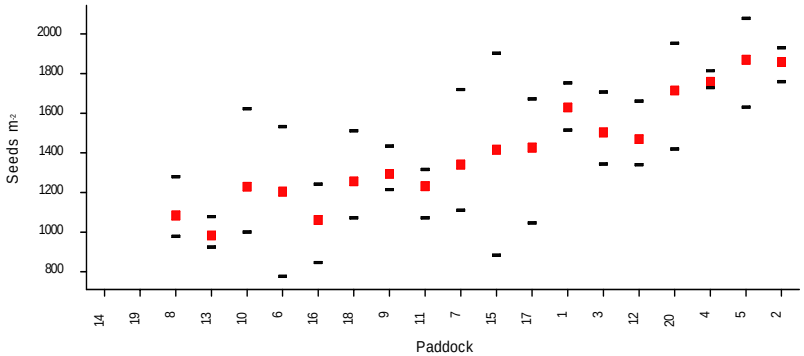
Yields for one Ashton paddock (32) were not taken, as the paddock was bypassed by the viners. Of the others, yield (adjusted to a tenderometer reading (TR) of 105) ranged from 5.8 to 9.0 t/ha, with a mean of 7.2. TR ranged from 95-140, with a mean of 122.8.



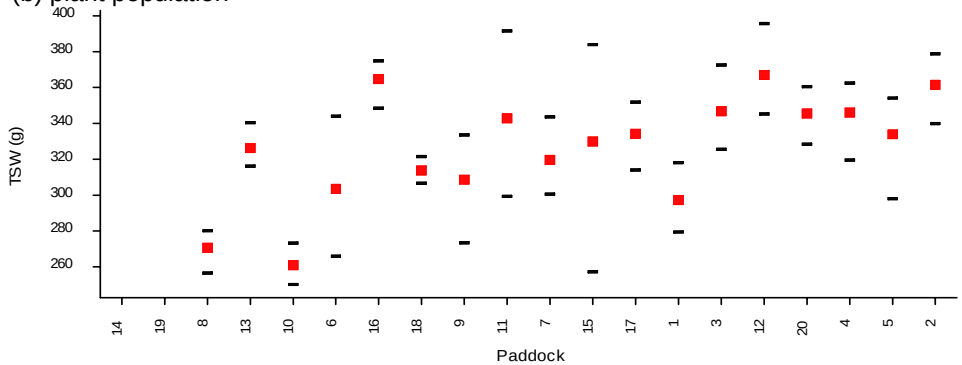
(a) Yield



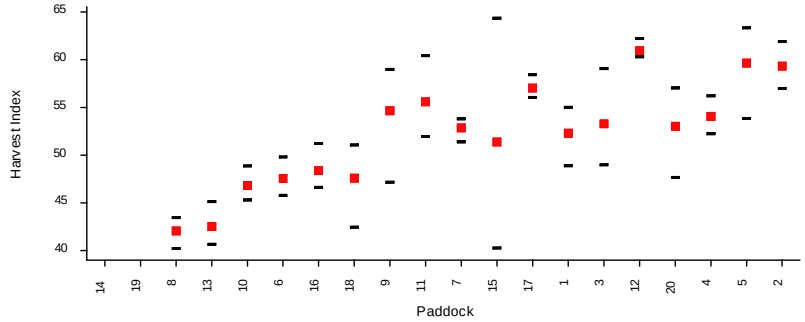
(b) plant population



(c)seeds/m2



(d) Thousand Seed Weight



(e) Harvest Index

● Farmer estimate ■ Mean of samples ━ Maximum and Minimum of samples

Figure 10: Yield and Yield components: Ordered by paddock means of yield samples.

4.15 Analyses of relationships

4.15.1 Plant counts at emergence

The median plant count per paddock at emergence (as plants/m^2) was analysed. Three factors were included in the baseline model: % germination, median sowing rate and cultivar. As would be expected, all of these were strongly related to differences in establishment (P<0.001). Variables added to this baseline model should be related to changes in plant counts between sowing and emergence after adjusting for seed viability. Including data (where available) for all 30 paddocks, there were 13 variables that showed reasonable association with plant numbers. The five with the strongest association were TSW, pesticide, tillage history, the range in aggregated ASD values, and sowing date (all P<0.01) (Figure 11). Weaker, but still significant (P<0.05) relationships were found with the number of fungicides applied, the mean bulk density at sowing, and the within-paddock range of bulk densities at sowing. The weakest but still notable associations (0.05<P<0.1) were with number of years since 2 consecutive years of pasture, percentage of seeds damaged, mean soil water at sowing, years since last pasture, and the within-paddock range of seed counts at sowing.

Plant counts at emergence tended to *decrease* with increasing TSW. A likely explanation for this is that larger seeds tend to be more damaged on sowing than smaller seeds. It would be expected that such damage would vary with the drill type, and if drill type was also included in the model, there was some minor evidence (0.05<P<0.1) that the relationship between plants at emergence and TSW did vary slightly with drill type, with a slightly greater decrease with increasing seed weight for the air type than for the roller types. Pesticides had not of course been applied before emergence. However, emergence counts were slightly lower on average for the three Midichi crops where pesticide was applied once. It is possible that this is evidence of a pest problem much earlier than when the decision to apply the chemical was made. The one crop that had two pesticide applications, one at emergence, had a similar emergence rate to the mean rate for Midichi.

The association with tillage history was entirely because the single No Tillage crop (paddock 3) had low plant numbers (but see discussion of this paddock later on). The association with the within-paddock range of aggregated ASD values was also entirely because of paddock 3, which had a large range of ASD values, but a low plant count at emergence. Similarly the weaker association with the number of fungicides applied was due to the seven applied to paddock 3. Many of the relationships found with bulk density at sowing and the within-paddock ranges of these were primarily because of this one paddock, but there does appear to be some effect of bulk density on establishment, particularly in the Ashton paddocks, with a tendency for mean establishment to increase with increasing bulk density, but to decrease with increasing within-paddock variability of bulk density.

Crop establishment tended to decrease with later sowing dates with a similar pattern of decrease for both cultivars. It also decreased slightly with increasing number of years since the paddock was last in 2 successive years

of pasture. The relationship with the percentage of damaged seeds was primarily because of paddock 18, which had low establishment and high damage (9%): this was the paddock with the largest Midichi TSW. Minor associations were also found with soil water (slight decrease in establishment with increased moisture), years since last peas (slight increase with increasing years) and within-paddock variation in the sowing rate (tendency for establishment to decrease with patchier sowing).

4.15.2 Percentage cover at flat pod

Only the Midichi paddocks were included in this analysis, since median percentage cover for all Ashton paddocks was the same (100%). Also, paddock 14, which had a very low percentage cover (5%) was excluded, since that paddock would be highly influential and dominate the analysis. Plant counts at emergence were included as the baseline model; however, there was essentially no association between cover and plant counts at emergence (P=0.55). Consequently, in the graphs showing the relationship of % cover to other factors (Figure 12), the data were not first adjusted for the baseline model (as was necessary for emergence counts).

Only three variables had any association (P<0.1) with % cover: number of years since 2 consecutive years of pasture, number of years since last pasture, and weight of roots at flat pod. The first two are almost the same, since there were only three paddocks with a single year of pasture in the past 10 years. For all paddocks that had been in pasture less than 4 years previously, median percentage cover was 90% or above, whereas cover was below this for all but two paddocks with 4 or more years since the last pasture. Percentage cover tended to increase with root weight at flat pod.

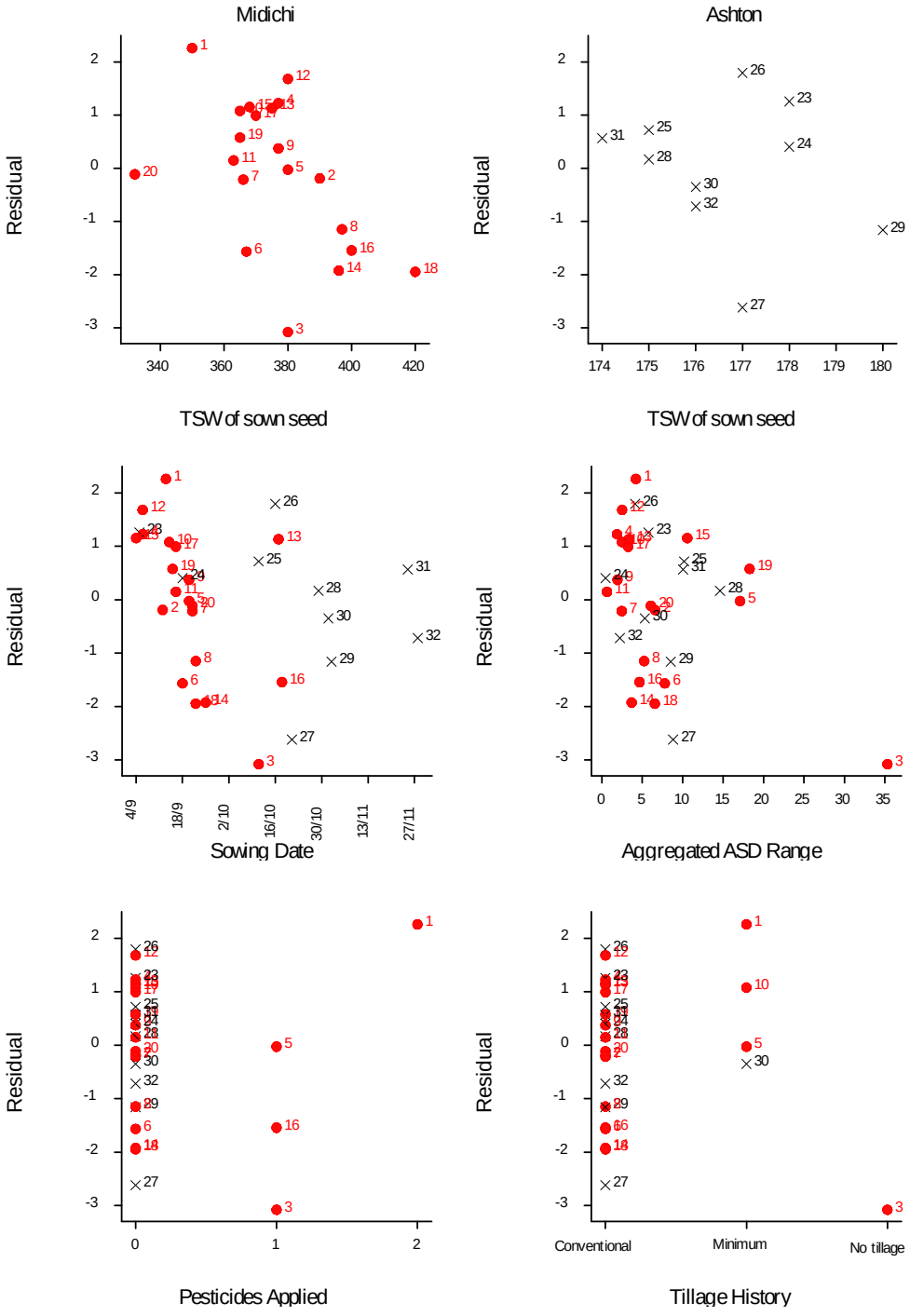


Figure 11: Variables that show strong association with plant establishment. Residual is deviance residual after fitting sowing rate, % germination and cultivar to establishment with a Poisson generalised linear model (roughly, data-fitted model, scaled, i.e. scaled counts after adjusting for baseline model).

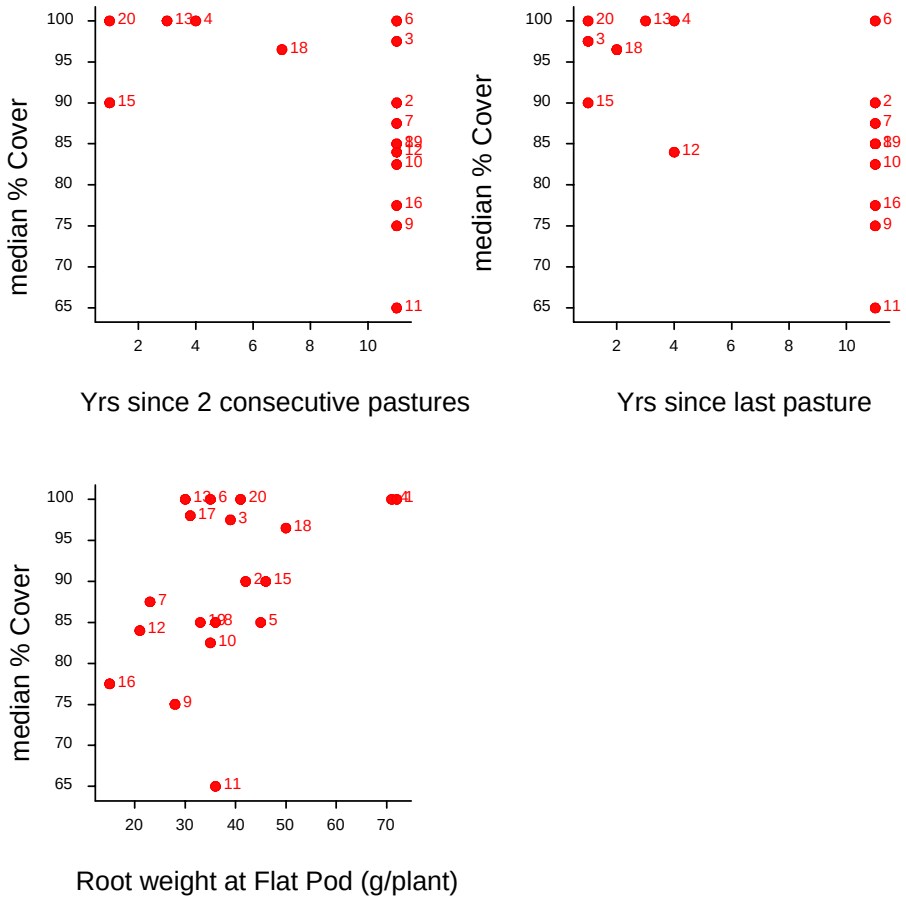


Figure 12: Variables that showed a strong association with % ground cover at flat pod.

4.15.3 *Plant populations at harvest (mean plants/m^2 per paddock)*

Only the Midichi paddocks were included in this analysis, since no harvest samples were taken from Ashton crops. Plant counts at emergence were included as the baseline model; however, there was essentially no association between plant counts at emergence and plant counts at harvest (P=0.24). Consequently, in the graphs showing the relationship of % cover to other factors (Figure 13), the data were not first adjusted for the baseline model (as was necessary for emergence counts). Fourteen variables showed some association (P<0.1) with counts at harvest. Of these, the five strongest (all had 0.01<P<0.06) were the within-paddock range of percentage cover, seed treatment, weights of plant tops and of roots at flat pod, and sowing date. Only one crop (paddock 10) had a seed treatment. It had the second lowest plant population at harvest. There was a tendency for the later-sown crops to have lower plant populations, and for population to increase with larger plants. Populations tended to decrease with increasing patchiness of cover at flat pod (i.e. with a wider range of % cover assessments within a paddock). The next most associated variables (0.06<P<0.1) were number of fungicides, median percentage cover, soil moisture, and years since last

pasture. Plant populations tended to be slightly lower with increasing years since last pasture, and lower with increasing soil moisture. They tended to be slightly greater with greater cover at flat pod. The fungicide relationship was principally associated with paddock 20, which had two fungicide sprays, and the highest median plant count at harvest.

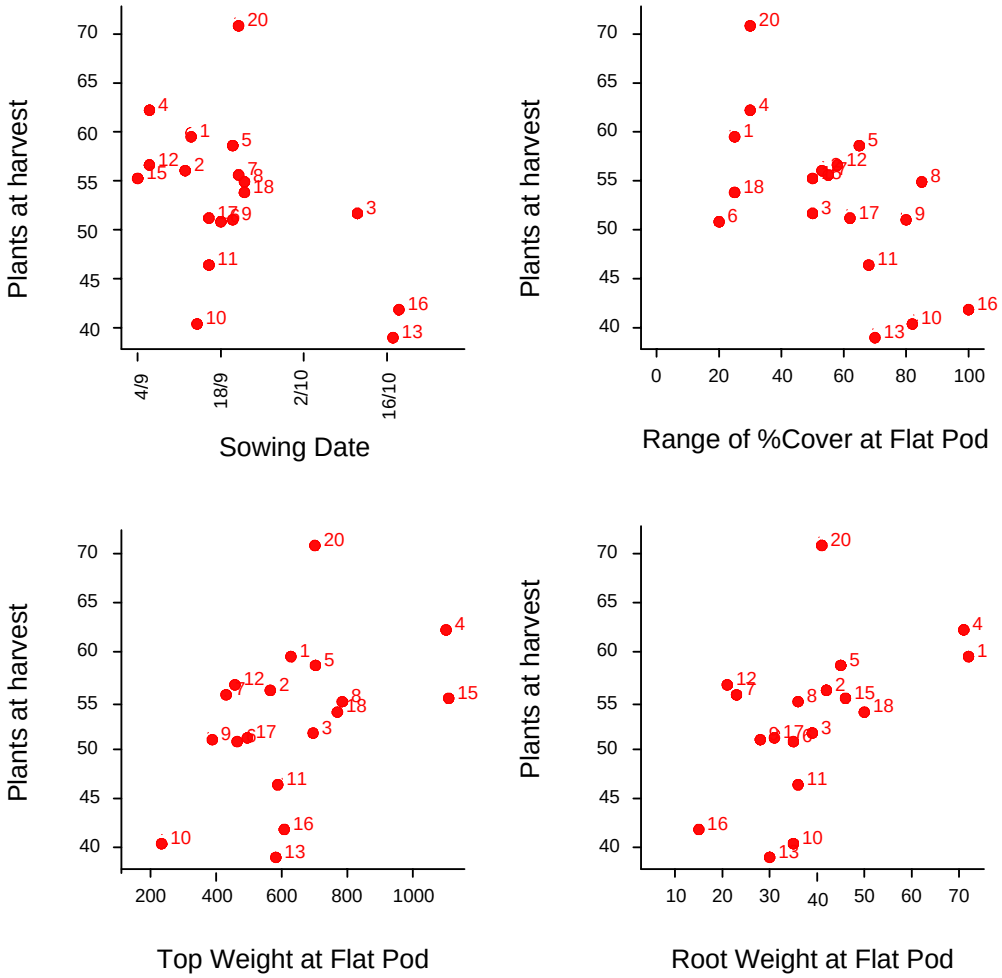


Figure 13: Relationship between plant populations at harvest and the most strongly associated variables.

4.15.4 *Yields (t/ha per paddock)*

Only the Midichi paddocks were included in this analysis, since no harvest samples were taken from Ashton crops. No measurements were included in the baseline model. Only soil water content at flat pod (both depths, $P<0.005$) and soil bulk density at flat pod (15-30 cm, $P=0.063$) showed any relationship with yields. Yield tended to decrease with increased soil moisture at flat pod, and increase with increasing bulk density at 15-25 cm at flat pod (Figure 14). There was essentially no relationship with sown seed ($P=0.34$, r=0.24),

population at emergence (P=0.33, r=0.24) or percentage cover at flat pod (P=0.39, r=0.21) (Figure 15). Similarly, there was little relationship with the within-field variability of these counts (P>0.05 for all).

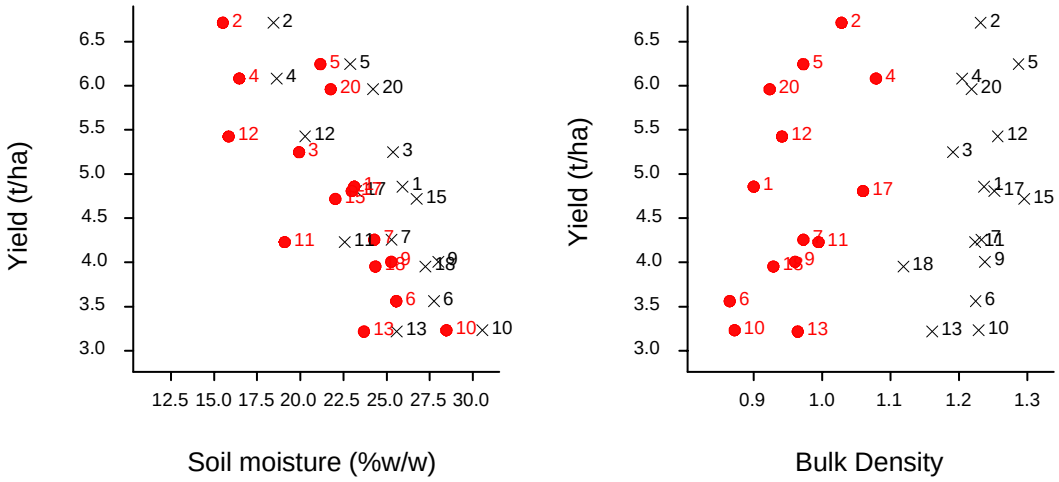


Figure 14: Relationship between yield of Midichi crops, and the most strongly associated variables: × 0-15 cm • 15-25 cm.

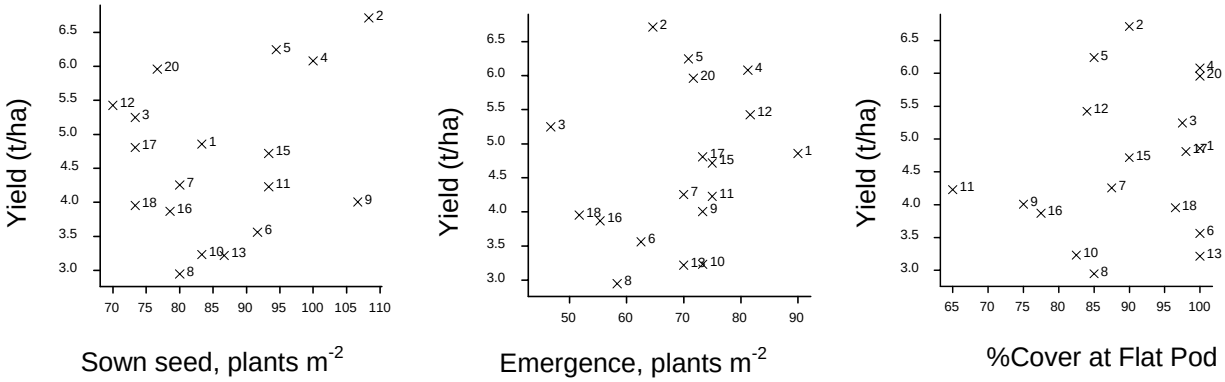


Figure 15: Relationship between yield of Midichi crops and plant counts at sowing, plant counts at emergence and % crop cover at flat pod.

4.15.5 *Penetration resistance and PDA scores*

These were only included in the analyses for % cover at flat pod, plant population at harvest, and yield, since they were measured at flat pod and may have varied prior to then. None of them showed any relationship of note with % cover, plant population at harvest or yields.

4.15.6 Unusual paddocks

Unusual paddocks were identified with a series of cluster analyses and principal component biplot analyses (details not shown). With only 10 paddocks, and one for which there were no harvest data, it is difficult to identify unusual paddocks for the Ashton crops.

Of the Midichi crops, paddocks 2, 3 and 15 were most distinctive.

Paddock 3 was direct-drilled. At sowing, it had the lowest mean bulk density, the lowest mean ASD (% particles by weight 0.85-9.5 mm), the highest mean soil moisture (by weight), and highest mean MWD aggregate stability. It also had the largest within-paddock range of bulk density and ASD measurements, indicating a high level of variation in soil characteristics within the field. At flat pod, mean bulk density was the third lowest of those measured (1.2), and soil moisture was still amongst the highest (0-15 cm). However, the paddock was still highly variable, with the one of the largest ranges in bulk density and soil moisture measurements (differences of 0.20 and 7.0 between the lowest and highest, respectively). Paddock 3 had the second lowest estimated mean sowing rate, and the lowest mean plant count at emergence. The range of sowing rates within the field was around the average for the 20 paddocks, but by emergence, counts were more consistent than average, with the second lowest range in counts. By flat pod, mean percentage cover was high, at 97.5%, although cover was a little patchy, with four of the ten samples having 50-70% cover. At harvest, there was a mean of 52 plants/m^2, which was around the average for all the Midichi crops harvested. Yield was above the average for the 20 paddocks at 5.2 t/ha, but was also slightly more variable across the paddock than average (range of 1.8 t/ha between the three samples).

Paddock 2 had the highest yield (6.7 t/ha), and also the most consistent yield (only 0.3 difference between the three quadrats). The seed was sown very shallow (at 2 cm). It had the highest bulk density at sowing, and the second lowest soil moisture. It had the second highest number of seeds sown, the greatest within-paddock range in sown seed, and the highest number of emerged plants. Percentage cover at flat pod and numbers of plants at harvest were comparatively good (90% and 56 plants/m^2), but not the highest.

Paddock 15 had the highest mean sowing rate, at 108 plants/m^2, but these seeds were also sown very shallow (at 2 cm), and the range of sowing rates was the largest, with a difference of 158 plants/m^2 between the lowest and highest rates for the ten samples. Paddock 15 was more variable on average than most paddocks for soil and harvest measurements. It had higher than average sowing and emergence rates, but only moderate cover (mean of 90%). At sowing, it had the largest range in MWD aggregate stability values, and had the second highest soil moistures at the flat pod stage. Yields however, were only moderate at 4.7 t/ha, but were by far the most variable (range of 4.2 between the samples).

5 Discussion

5.1 Pre crop establishment

The main objective of this research was to determine the factors affecting pea crop establishment, an area identified in the previous report (Wilson et al 2006) as the major contributor to gappy crops and poor yields. Has this survey achieved this objective?

The 2006-07 season was very favourable to pea crop growth. Cool wet conditions through much of the growing season led to a long growing season and little water stress, which should have removed environmental limitations to plant establishment and high yields.

Plant establishments did, in fact, reflect this with mean establishment averaging 71 plants/m^2 for Midichi (compared with 57 last year) and 124 plants/m^2 for Ashton. The benchmark suggested by Wilson et al. (2006) was 80 plants per m^2, and there were still 17 of the 20 Midichi crops with populations below this.

The variation in emergence within paddocks for both cultivars was considerable, even between adjacent samples: in one paddock (29), the two samples from one location varied by 39 plants per 2 x 1 m rows (equivalent to 116 plants/m^2). Across a paddock, the smallest variation was nine plants per 2 x 1 m row, but the greatest was 43 plants, equivalent to a variation of 143 plants/m^2!

The factors we investigated to identify the causes of this variability included cropping history, soil properties, Aphanomyces score, tillage practices, seed line, seed size, seed germination, seed damage, sowing date, sowing rate, drill type, seed depth, seed number, seed number variability and seed mortality.

There were 13 variables which showed some association with plant establishment. Of these, seed size, pesticide, tillage history, ASD values and sowing date were the major factors. There was some minor evidence that the larger seeds were more susceptible to damage than small seeds when they pass through certain types of drill, confirming anecdotal reports from the industry that some drills are more damaging to seed.

The relationship with pesticides is problematic as the pesticides were applied after emergence, and it is more likely that those farmers were responding to the poor crop emergence.

One paddock behaved differently to the others, and this resulted in associations between establishment and tillage history and ASD values.

Later sowings had slightly poorer establishment, which may be a reflection of the season, as usually warmer conditions improve pea crop establishment.

So, on the face of it, there was no really close association between any of these factors and the poor and variable establishment of pea crops. However, in half the Midichi crops and a third of the Ashton crops, at least 10% of the seed did not produce a plant, and in a quarter of the Midichi crops, over 20% of the seed did not produce a plant. So is poor

establishment due to something else that was not measured in these trials, such as speed of drilling or predation?

In an associated report, Riddle et al. (2007) found that drilling speed had a large influence on plant populations at emergence. Drilling speed was not measured in this trial, and should be the focus of any future work on pea establishment. Also, the drill that Riddle et al. (2007) used was not able to drill the large Midichi seed at the required sowing rate, and it would be useful to determine whether other drill types have the same problem.

5.2 Post crop establishment

All Ashton crops, with their high plant populations at emergence, had full ground cover by the flat pod stage.

For Midichi, crops grown in paddocks which had been in pasture less than 4 years previously had higher percentage ground covers than other crops. However, yield was not related to percentage cover at flat pod. There was no strong relationship between yields and soil properties other than moisture content and bulk density or disease scores.

Plant numbers in Midichi crops declined overall by 23% from establishment to final harvest, with plant loss proportionately greater for denser plant stands.

Dry pea yields of Midichi crops averaged 4.5 t/ha, compared with 4.1 t/ha for the crops sampled in the previous season (Wilson et al. 2006). The range between the highest and lowest crops was similar.

Fresh pea yields of Ashton crops ranged from 5.8 to 9.0 t/ha. These were similar to other Ashton crops in this season (Bruce Snowden, pers. comm.).

Wilson et al (2006) suggested some key performance indicators for Midichi pea crops. These were: at least 80 plants/m^2 at establishment, 90% ground cover at flat pod, 45% harvest index, 1600 seeds/m^2 at harvest, and 360 mg seed weight. For the 20 crops sampled here, three had over 80 plants/m^2 at establishment, and ten (half) had over 90% ground cover at flat pod. Of the 18 sampled at harvest, 16 had over 45% harvest index, five over 1600 seeds/m^2 at harvest, and three over 360 mg seed weight. Thus, many crops are not meeting these KPIs.

The results from this survey also support the findings of last year's survey (Wilson et al. 2006) that some farmers are not following good practice by growing peas too frequently in a rotation or growing them in paddocks with high Aphanomyces scores.

6 Conclusions and recommendations

- Despite the very favourable growing season, 17 of the 20 Midichi crops had plant populations below 80 plants/m^2.
- The variation in emergence within paddocks, and between adjacent rows within paddocks, was considerable.
- In half the Midichi crops and one third of the Ashton crops, over 10% of the seed sown did not produce a plant, and in a quarter of the Midichi crops, over a quarter of the seed did not produce a plant.
- However, there was very little relationship between the measured management and soil variables and plant establishment and subsequent yield.
- The Ashton crops all had full ground cover at flat pod, a consequence of their high plant populations at emergence. For Midichi, percentage cover was higher in crops that had been in pasture less than 4 years previously.
- There was a 23% decline in Midichi plant numbers from establishment to final harvest, especially in denser stands.
- This study was not able to isolate the factors that determine why establishment is so poor and variable.
- Future work should focus on factors not measured in this study, including drilling speed and how drills handle pea seed.

7 References

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8 Appendix

Site: 1

1. Paddock Details

Irrigated: Yes **Tillage Class:** Minimum **Soil Disturbance Rating:** 118
Years since Last: **Peas** - **Pasture** -

2. Crop

Cultivar: Midichi **Sown:** 13/09/06 **%Germination:** 91 **%Damage:** 2 **TSW:** 350

Drill: **Type** Great Plains Solid Stand 1500 **Feed Mechanism** Fluted Rollers **Speed** 10

Sowing Rate (plants m^{-2})
Farmer Estimate: 90.3
Excavated: **Median** 83.3 **Minimum** 0.0 **Maximum** 133.3
Median within-Location Range 40.0

Sowing Depth (cm)
Farmer Estimate: 7
Excavated: **Median** 5.0 **Minimum** 3.0 **Maximum** 7.0
Median within-Location Range 1.0

Plants at Establishment (plants m^{-2})
Median 90.0 **Minimum** 43.3 **Maximum** 120.0
Median within-Location Range 16.7

3. Soil at Planting

Soil Type: Eyre shallow silt loam

Soil Properties:

	Mean	Min.	Max
Aggregate stability (MWD)	1.44	1.35	1.54
Aggregate size distribution (MWD):	46.69	44.83	49.04
Bulk density (g/cm3, 0-7.5 cm)	1.13	1.05	1.18
Soil moisture (% by weight to 7.5 cm)	17.72	16.00	19.90

Glass House Aphanomyces Index (DSI): 92

4. Plant and Soil at Flat Pod

%Cover: **Median** 100 **Min.** 75 **Max.** 100 **within-Location Range** 0

Soil Properties:

	Mean	Min.	Max.
Bulk density (g/cm3, 0-15 cm)	1.24	1.16	1.29
(15-30 cm)	0.90	-	-
Soil moisture (% by weight to 15 cm)	25.92	23.44	28.06
(15-30 cm)	23.13	23.13	23.13
Penetration Resistance (MPa to 15 cm)	3.35	2.64	4.31
(15-30 cm)	2.79	2.50	3.19

Crusting: 1.0

Soil Profile Assessment Scores:
Total: 9.50
For each component:

	Cultivation	Sub Cultivation	Subsoil
Soil Density	1.2	2.2	-
Pea Root Density	1.0	1.0	-
Pan	-	1.0	-
Mottles	-	1.0	1.0

Field Aphanomyces Index (DSI): 50

Plant Weight (g): **Tops:** 628 **Roots** 72

5. Harvest

	Mean	Min.	Max.
Yield (t/ha)	4.9	4.5	5.6
Population (plants m^{-2})	61.4	57.8	66.6
Seeds (number m^{-2})	1630.1	1515.8	1754.7
Thousand Seed Weight (g)	297.3	279.4	318.0
Harvest Index (%)	52.3	48.9	55.0

Site: 2

1. Paddock Details

Irrigated: No **Tillage Class:** Conventional **Soil Disturbance Rating:** 84
Years since Last: **Peas** 11 **Pasture** 11

2. Crop

Cultivar: Midichi **Sown:** 12/09/06 **%Germination:** 85 **%Damage:** 5 **TSW:** 390

Drill: **Type** Vaderstad **Feed Mechanism** Air **Speed** 10

Sowing Rate (plants m^{-2})
Farmer Estimate: 87.2
Excavated: **Median** 108.3 **Minimum** 41.7 **Maximum** 200.0
Median within-Location Range 25.0

Sowing Depth (cm)
Farmer Estimate: 7
Excavated: **Median** 2.0 **Minimum** 1.0 **Maximum** 3.0
Median within-Location Range 0.0

Plants at Establishment (plants m^{-2})
Median 64.6 **Minimum** 37.5 **Maximum** 129.2
Median within-Location Range 16.7

3. Soil at Planting

Soil Type: Chertsey moderately deep silt loam

Soil Properties:

	Mean	Min.	Max.
Aggregate stability (MWD)	1.32	1.21	1.42
Aggregate size distribution (MWD):	45.37	42.72	49.30
Bulk density (g/cm3, 0-7.5 cm)	1.32	1.23	1.37
Soil moisture (% by weight to 7.5 cm)	15.78	12.86	18.42

Glass House Aphanomyces Index (DSI): 50

4. Plant and Soil at Flat Pod

%Cover: **Median** 90 **Min.** 47 **Max.** 100 **within-Location Range** 5

Soil Properties:

	Mean	Min.	Max.
Bulk density (g/cm3, 0-15 cm)	1.23	1.17	1.30
(15-30 cm)	1.03	-	-
Soil moisture (% by weight to 15 cm)	18.44	17.66	18.96
(15-30 cm)	15.52	15.52	15.52
Penetration Resistance (MPa to 15 cm)	2.40	1.94	2.81
(15-30 cm)	3.17	2.46	3.54

Crusting: 1.5

Soil Profile Assessment Scores:
Total: 9.50
For each component:

	Cultivation	Sub Cultivation	Subsoil
Soil Density	1.5	2.0	-
Pea Root Density	1.0	1.0	-
Pan	-	1.0	-
Mottles	-	1.0	1.0

Field Aphanomyces Index (DSI): 72

Plant Weight (g): **Tops:** 565 **Roots** 42

5. Harvest

	Mean	Min.	Max.
Yield (t/ha)	6.7	6.6	6.9
Population (plants m^{-2})	62.7	55.3	76.4
Seeds (number m^{-2})	1859.9	1760.8	1932.1
Thousand Seed Weight (g)	361.5	339.9	378.8
Harvest Index (%)	59.3	57.0	61.9

Site: 3

1. Paddock Details

Irrigated: No **Tillage Class:** No tillage **Soil Disturbance Rating:** 4
Years since Last: **Peas** 7 **Pasture** 1

2. Crop

Cultivar: Midichi **Sown:** 11/10/06 **%Germination:** 90 **%Damage:** 2 **TSW:** 380

Drill: **Type** Cross Slot D.P. **Feed Mechanism** air **Speed** 8

Sowing Rate (plants m^{-2})
Farmer Estimate: 86.8
Excavated: **Median** 73.3 **Minimum** 0.0 **Maximum** 100.0
Median within-Location Range 0.0

Sowing Depth (cm)
Farmer Estimate: 5
Excavated: **Median** 5.5 **Minimum** 3.0 **Maximum** 7.0
Median within-Location Range 2.0

Plants at Establishment (plants m^{-2})
Median 46.7 **Minimum** 26.7 **Maximum** 60.0
Median within-Location Range 0.0

3. Soil at Planting

Soil Type: Lismore shallow silt loam

Soil Properties:

	Mean	Min.	Max.
Aggregate stability (MWD)	2.53	2.25	2.68
Aggregate size distribution (MWD):	39.10	23.23	58.54
Bulk density (g/cm3, 0-7.5 cm)	1.06	0.90	1.25
Soil moisture (% by weight to 7.5 cm)	30.44	29.26	32.26

Glass House Aphanomyces Index (DSI): 60

4. Plant and Soil at Flat Pod

%Cover: **Median** 98 **Min.** 50 **Max.** 100 **within-Location Range** 35

Soil Properties:

	Mean	Min.	Max.
Bulk density (g/cm3, 0-15 cm)	1.19	1.10	1.30
(15-30 cm)	-	-	-
Soil moisture (% by weight to 15 cm)	25.38	22.04	29.07
(15-30 cm)	19.92	19.92	19.92
Penetration Resistance (MPa to 15 cm)	4.75	3.97	5.48
(15-30 cm)	-	-	-

Crusting: 1.0

Soil Profile Assessment Scores:

Total: 8.75

For each component:

	Cultivation	Sub Cultivation	Subsoil
Soil Density	1.2	1.5	-
Pea Root Density	1.0	1.0	-
Pan	-	1.0	-
Mottles	-	1.0	1.0

Field Aphanomyces Index (DSI): 52

Plant Weight (g): **Tops:** 696 **Roots** 39

5. Harvest

	Mean	Min.	Max.
Yield (t/ha)	5.2	4.4	6.4
Population (plants m^{-2})	50.8	45.6	54.7
Seeds (number m^{-2})	1504.6	1343.9	1707.5
Thousand Seed Weight (g)	346.7	325.6	372.6
Harvest Index (%)	53.3	49.0	59.1

Site: 4

1. Paddock Details

Irrigated: No **Tillage Class:** Conventional **Soil Disturbance Rating:** 54
Years since Last: **Peas** 11 **Pasture** 4

2. Crop

Cultivar: Midichi **Sown:** 06/09/06 **%Germination:** 91 **%Damage:** 0 **TSW:** 377

Drill: **Type** Atchison **Feed Mechanism** Sponge Feed **Speed** 9

Sowing Rate (plants m^{-2})
Farmer Estimate: 79.6
Excavated: **Median** 100.0 **Minimum** 75.0 **Maximum** 133.3
Median within-Location Range 16.7

Sowing Depth (cm)
Farmer Estimate: 7
Excavated: **Median** 7.5 **Minimum** 5.0 **Maximum** 8.0
Median within-Location Range 1.0

Plants at Establishment (plants m^{-2})
Median 81.2 **Minimum** 50.0 **Maximum** 104.2
Median within-Location Range 25.0

3. Soil at Planting

Soil Type: Lismore stony silt loam

Soil Properties:

	Mean	Min.	Max.
Aggregate stability (MWD)	1.84	1.74	1.91
Aggregate size distribution (MWD):	55.69	54.91	56.80
Bulk density (g/cm3, 0-7.5 cm)	1.22	1.17	1.26
Soil moisture (% by weight to 7.5 cm)	19.72	18.29	21.53

Glass House Aphanomyces Index (DSI): 79

4. Plant and Soil at Flat Pod

%Cover: **Median** 100 **Min.** 70 **Max.** 100 **within-Location Range** 0

Soil Properties:

	Mean	Min.	Max.
Bulk density (g/cm3, 0-15 cm)	1.20	1.11	1.27
(15-30 cm)	1.08	-	-
Soil moisture (% by weight to 15 cm)	18.63	16.29	22.09
(15-30 cm)	16.46	16.46	16.46
Penetration Resistance (MPa to 15 cm)	1.63	1.32	2.28
(15-30 cm)	1.90	1.76	2.16

Crusting: 1.0

Soil Profile Assessment Scores:
Total: 11.00
For each component:

	Cultivation	Sub Cultivation	Subsoil
Soil Density	2.2	2.2	-
Pea Root Density	1.2	1.0	-
Pan	-	1.2	-
Mottles	-	1.0	1.0

Field Aphanomyces Index (DSI): 38

Plant Weight (g): **Tops:** 1102 **Roots** 71

5. Harvest

	Mean	Min.	Max.
Yield (t/ha)	6.1	5.8	6.3
Population (plants m^{-2})	62.1	58.1	65.5
Seeds (number m^{-2})	1759.3	1729.9	1815.1
Thousand Seed Weight (g)	346.1	319.5	362.4
Harvest Index (%)	54.1	52.2	56.2

Site: 5

1. Paddock Details

Irrigated: Yes **Tillage Class:** Minimum **Soil Disturbance Rating:** 4
Years since Last: **Peas** - **Pasture** -

2. Crop

Cultivar: Midichi **Sown:** 20/09/06 **%Germination:** 91 **%Damage:** 2 **TSW:** 380

Drill: **Type** John Deere, Air seeder - converted himself
Feed Mechanism Air **Speed** 8

Sowing Rate (plants m^{-2})
Farmer Estimate: 94.7
Excavated: **Median** 94.4 **Minimum** 44.4 **Maximum** 144.4
Median within-Location Range 33.3

Sowing Depth (cm)
Farmer Estimate: 5
Excavated: **Median** 5.0 **Minimum** 2.0 **Maximum** 6.0
Median within-Location Range 2.0

Plants at Establishment (plants m^{-2})
Median 70.8 **Minimum** 36.1 **Maximum** 108.3
Median within-Location Range 22.2

3. Soil at Planting

Soil Type: Chertsey moderately deep silt loam

Soil Properties:

	Mean	Min.	Max.
Aggregate stability (MWD)	2.04	1.63	2.49
Aggregate size distribution (MWD):	56.90	47.15	64.25
Bulk density (g/cm3, 0-7.5 cm)	1.31	1.30	1.34
Soil moisture (% by weight to 7.5 cm)	18.13	16.20	19.33

Glass House Aphanomyces Index (DSI): 60

4. Plant and Soil at Flat Pod

%Cover: **Median** 85 **Min.** 35 **Max.** 100 **within-Location Range** 5

Soil Properties:

	Mean	Min.	Max.
Bulk density (g/cm3, 0-15 cm)	1.29	1.26	1.31
(15-30 cm)	0.97	-	-
Soil moisture (% by weight to 15 cm)	22.90	19.89	24.95
(15-30 cm)	21.17	21.17	21.17
Penetration Resistance (MPa to 15 cm)	3.60	3.11	4.01
(15-30 cm)	3.26	2.29	3.81

Crusting: 1.0

Soil Profile Assessment Scores:
Total: 8.75
For each component:

	Cultivation	Sub Cultivation	Subsoil
Soil Density	1.2	1.5	-
Pea Root Density	1.0	1.0	-
Pan	-	1.0	-
Mottles	-	1.0	1.0

Field Aphanomyces Index (DSI): 58

Plant Weight (g): **Tops:** 703 **Roots** 45

5. Harvest

	Mean	Min.	Max.
Yield (t/ha)	6.2	5.7	7.4
Population (plants m^{-2})	57.6	50.0	63.9
Seeds (number m^{-2})	1870.4	1631.0	2079.8
Thousand Seed Weight (g)	333.9	298.1	354.1
Harvest Index (%)	59.7	53.8	63.3

Site: 6

1. Paddock Details

Irrigated: No **Tillage Class:** Conventional **Soil Disturbance Rating:** 72
Years since Last: **Peas** 11 **Pasture** 11

2. Crop

Cultivar: Midichi **Sown:** 18/09/06 **%Germination:** 95 **%Damage:** 1 **TSW:** 367

Drill: **Type** Kongskilde Demeter Classic 4000 **Feed Mechanism** wheel **Speed** 9

Sowing Rate (plants m^{-2})
Farmer Estimate: 92.6
Excavated: **Median** 91.7 **Minimum** 41.7 **Maximum** 116.7
Median within-Location Range 16.7

Sowing Depth (cm)
Farmer Estimate: 5
Excavated: **Median** 4.0 **Minimum** 2.0 **Maximum** 5.0
Median within-Location Range 2.0

Plants at Establishment (plants m^{-2})
Median 62.5 **Minimum** 41.7 **Maximum** 112.5
Median within-Location Range 12.5

3. Soil at Planting

Soil Type: Lyndhurst moderately deep silt loam

Soil Properties:

	Mean	Min.	Max.
Aggregate stability (MWD)	1.32	1.07	1.62
Aggregate size distribution (MWD):	55.62	52.18	59.97
Bulk density (g/cm3, 0-7.5 cm)	1.15	1.11	1.17
Soil moisture (% by weight to 7.5 cm)	15.51	14.72	16.65

Glass House Aphanomyces Index (DSI): 41

4. Plant and Soil at Flat Pod

%Cover: **Median** 100 **Min.** 80 **Max.** 100 **within-Location Range** 5

Soil Properties:

	Mean	Min.	Max.
Bulk density (g/cm3, 0-15 cm)	1.22	1.16	1.30
(15-30 cm)	0.86	-	-
Soil moisture (% by weight to 15 cm)	27.73	27.17	28.97
(15-30 cm)	25.56	25.56	25.56
Penetration Resistance (MPa to 15 cm)	2.33	2.09	2.76
(15-30 cm)	1.90	1.79	1.97

Crusting: 1.5

Soil Profile Assessment Scores:
Total: 9.50
For each component:

	Cultivation	Sub Cultivation	Subsoil
Soil Density	1.0	2.2	-
Pea Root Density	1.2	1.0	-
Pan	-	1.0	-
Mottles	-	1.0	1.0

Field Aphanomyces Index (DSI): 50

Plant Weight (g): **Tops:** 464 **Roots** 35

5. Harvest

	Mean	Min.	Max.
Yield (t/ha)	3.6	2.7	4.1
Population (plants m^{-2})	52.2	48.0	57.4
Seeds (number m^{-2})	1206.1	777.3	1533.4
Thousand Seed Weight (g)	303.5	266.0	344.0
Harvest Index (%)	47.6	45.8	49.8

Site: 7

1. Paddock Details

Irrigated: Yes **Tillage Class:** Conventional **Soil Disturbance Rating:** 63
Years since Last: **Peas** 11 **Pasture** 11

2. Crop

Cultivar: Midichi **Sown:** 21/09/06 **%Germination:** 92 **%Damage:** 1 **TSW:** 366

Drill: **Type** Allen Air Seeder **Feed Mechanism** Air **Speed** 10

Sowing Rate (plants m^{-2})
Farmer Estimate: 84.7
Excavated: **Median** 80.0 **Minimum** 46.7 **Maximum** 113.3
Median within-Location Range 40.0

Sowing Depth (cm)
Farmer Estimate: 5
Excavated: **Median** 5.0 **Minimum** 3.0 **Maximum** 5.0
Median within-Location Range 2.0

Plants at Establishment (plants m^{-2})
Median 70.0 **Minimum** 53.3 **Maximum** 96.7
Median within-Location Range 23.3

3. Soil at Planting

Soil Type: Lyndhurst moderately deep silt loam

Soil Properties:

	Mean	Min.	Max.
Aggregate stability (MWD)	1.53	1.12	1.85
Aggregate size distribution (MWD):	53.71	52.55	55.02
Bulk density (g/cm3, 0-7.5 cm)	1.23	1.22	1.25
Soil moisture (% by weight to 7.5 cm)	18.87	17.66	19.78

Glass House Aphanomyces Index (DSI): 69

4. Plant and Soil at Flat Pod

%Cover: **Median** 88 **Min.** 45 **Max.** 100 **within-Location Range** 10

Soil Properties:

	Mean	Min.	Max.
Bulk density (g/cm3, 0-15 cm)	1.23	1.19	1.26
(15-30 cm)	0.97	-	-
Soil moisture (% by weight to 15 cm)	25.29	24.13	26.05
(15-30 cm)	24.28	24.28	24.28
Penetration Resistance (MPa to 15 cm)	1.72	1.52	1.93
(15-30 cm)	2.16	2.12	2.22

Crusting: 1.5

Soil Profile Assessment Scores:

Total: 9.00

For each component:

	Cultivation	Sub Cultivation	Subsoil
Soil Density	1.2	1.5	-
Pea Root Density	1.0	1.2	-
Pan	-	1.0	-
Mottles	-	1.0	1.0

Field Aphanomyces Index (DSI): 52

Plant Weight (g): **Tops:** 430 **Roots** 23

5. Harvest

	Mean	Min.	Max.
Yield (t/ha)	4.3	3.5	5.2
Population (plants m^{-2})	54.5	45.9	61.5
Seeds (number m^{-2})	1341.6	1110.4	1719.9
Thousand Seed Weight (g)	319.6	300.6	343.6
Harvest Index (%)	52.8	51.4	53.8

Site: 8

1. Paddock Details

Irrigated: No **Tillage Class:** Conventional **Soil Disturbance Rating:** 80
Years since Last: **Peas** 9 **Pasture** 11

2. Crop

Cultivar: Midichi **Sown:** 22/09/06 **%Germination:** 87 **%Damage:** 1 **TSW:** 397

Drill: **Type** Great Plains disc drill **Feed Mechanism** Roller **Speed** 12

Sowing Rate (plants m^{-2})
Farmer Estimate: 75.6
Excavated: **Median** 80.0 **Minimum** 46.7 **Maximum** 106.7
Median within-Location Range 26.7

Sowing Depth (cm)
Farmer Estimate: 6
Excavated: **Median** 6.0 **Minimum** 5.0 **Maximum** 8.0
Median within-Location Range 1.0

Plants at Establishment (plants m^{-2})
Median 58.3 **Minimum** 26.7 **Maximum** 73.3
Median within-Location Range 16.7

3. Soil at Planting

Soil Type: Mayfield moderately deep and stony silt loam

Soil Properties:

	Mean	Min.	Max.
Aggregate stability (MWD)	1.73	1.62	1.84
Aggregate size distribution (MWD):	52.56	50.17	55.41
Bulk density (g/cm3, 0-7.5 cm)	1.14	1.06	1.19
Soil moisture (% by weight to 7.5 cm)	18.42	17.92	19.21

Glass House Aphanomyces Index (DSI): 70

4. Plant and Soil at Flat Pod

%Cover: **Median** 85 **Min.** 15 **Max.** 100 **within-Location Range** 35

Soil Properties:

	Mean	Min.	Max.
Bulk density (g/cm3, 0-15 cm)	-	-	-
(15-30 cm)	-	-	-
Soil moisture (% by weight to 15 cm)	-	-	-
(15-30 cm)	-	-	-
Penetration Resistance (MPa to 15 cm)	2.54	2.14	2.84
(15-30 cm)	5.37	3.57	8.04

Crusting: 1.0

Soil Profile Assessment Scores:

Total: 8.75

For each component:

	Cultivation	Sub Cultivation	Subsoil
Soil Density	1.2	1.5	-
Pea Root Density	1.0	1.0	-
Pan	-	1.0	-
Mottles	-	1.0	1.0

Field Aphanomyces Index (DSI): 40

Plant Weight (g): **Tops:** 785 **Roots** 36

5. Harvest

	Mean	Min.	Max.
Yield (t/ha)	2.9	2.5	3.6
Population (plants m^{-2})	57.6	51.8	65.8
Seeds (number m^{-2})	1085.2	979.7	1281.5
Thousand Seed Weight (g)	270.6	256.5	280.2
Harvest Index (%)	42.0	40.2	43.4

Site: 9

1. Paddock Details

Irrigated: No **Tillage Class:** Conventional **Soil Disturbance Rating:** 4
Years since Last: **Peas** 11 **Pasture** 11

2. Crop

Cultivar: Midichi **Sown:** 20/09/06 **%Germination:** 90 **%Damage:** 1 **TSW:** 377

Drill: **Type** Great Plains NTA 1300 **Feed Mechanism** Air **Speed** 8

Sowing Rate (plants m^{-2})
Farmer Estimate: 91.5
Excavated: **Median** 106.7 **Minimum** 46.7 **Maximum** 146.7
Median within-Location Range 26.7

Sowing Depth (cm)
Farmer Estimate: 5
Excavated: **Median** 2.0 **Minimum** 2.0 **Maximum** 2.0
Median within-Location Range 0.0

Plants at Establishment (plants m^{-2})
Median 73.3 **Minimum** 33.3 **Maximum** 83.3
Median within-Location Range 13.3

3. Soil at Planting

Soil Type: Lyndhurst moderately deep silt loam

Soil Properties:

	Mean	Min.	Max.
Aggregate stability (MWD)	2.07	1.81	2.38
Aggregate size distribution (MWD):	66.36	65.23	67.17
Bulk density (g/cm3, 0-7.5 cm)	1.16	1.12	1.22
Soil moisture (% by weight to 7.5 cm)	19.75	19.41	20.37

Glass House Aphanomyces Index (DSI): 42

4. Plant and Soil at Flat Pod

%Cover: **Median** 75 **Min.** 20 **Max.** 100 **within-Location Range** 25

Soil Properties:

	Mean	Min.	Max.
Bulk density (g/cm3, 0-15 cm)	1.24	1.19	1.30
(15-30 cm)	0.96	-	-
Soil moisture (% by weight to 15 cm)	27.99	26.89	28.62
(15-30 cm)	25.27	25.27	25.27
Penetration Resistance (MPa to 15 cm)	2.11	1.61	2.55
(15-30 cm)	2.04	1.80	2.29

Crusting: 1.0

Soil Profile Assessment Scores:

Total: 8.25

For each component:

	Cultivation	Sub Cultivation	Subsoil
Soil Density	1.2	1.0	-
Pea Root Density	1.0	1.0	-
Pan	-	1.0	-
Mottles	-	1.0	1.0

Field Aphanomyces Index (DSI): 38

Plant Weight (g): **Tops:** 388 **Roots** 28

5. Harvest

	Mean	Min.	Max.
Yield (t/ha)	4.0	3.3	4.6
Population (plants m^{-2})	55.4	50.6	64.3
Seeds (number m^{-2})	1295.2	1216.1	1434.6
Thousand Seed Weight (g)	308.6	273.3	333.6
Harvest Index (%)	54.7	47.2	59.0

Site: 10

1. Paddock Details

Irrigated: No **Tillage Class:** Minimum **Soil Disturbance Rating:** 4
Years since Last: **Peas** 11 **Pasture** 11

2. Crop

Cultivar: Midichi **Sown:** 14/09/06 **%Germination:** 84 **%Damage:** 3 **TSW:** 365

Drill: **Type** Cross Slot Air Seeder **Feed Mechanism** Air **Speed** 8

Sowing Rate (plants m^{-2})
Farmer Estimate: 94.5
Excavated: **Median** 83.3 **Minimum** 13.3 **Maximum** 133.3
Median within-Location Range 20.0

Sowing Depth (cm)
Farmer Estimate: 7
Excavated: **Median** 6.0 **Minimum** 2.0 **Maximum** 7.0
Median within-Location Range 1.0

Plants at Establishment (plants m^{-2})
Median 73.3 **Minimum** 30.0 **Maximum** 90.0
Median within-Location Range 6.7

3. Soil at Planting

Soil Type: Lyndhurst moderately deep silt loam

Soil Properties:

	Mean	Min.	Max.
Aggregate stability (MWD)	1.76	1.49	1.91
Aggregate size distribution (MWD):	55.51	54.65	57.15
Bulk density (g/cm3, 0-7.5 cm)	1.30	1.26	1.38
Soil moisture (% by weight to 7.5 cm)	22.78	22.02	23.19

Glass House Aphanomyces Index (DSI): 57

4. Plant and Soil at Flat Pod

%Cover: **Median** 82 **Min.** 18 **Max.** 100 **within-Location Range** 35

Soil Properties:

	Mean	Min.	Max.
Bulk density (g/cm3, 0-15 cm)	1.23	1.20	1.26
(15-30 cm)	0.87	-	-
Soil moisture (% by weight to 15 cm)	30.55	30.19	31.34
(15-30 cm)	28.46	28.46	28.46
Penetration Resistance (MPa to 15 cm)	2.72	2.57	2.87
(15-30 cm)	2.40	2.27	2.60

Crusting: 1.0

Soil Profile Assessment Scores:
Total: 10.25
For each component:

	Cultivation	Sub Cultivation	Subsoil
Soil Density	2.0	2.2	-
Pea Root Density	1.0	1.0	-
Pan	-	1.0	-
Mottles	-	1.0	1.0

Field Aphanomyces Index (DSI): 60

Plant Weight (g): **Tops:** 233 **Roots** 35

5. Harvest

	Mean	Min.	Max.
Yield (t/ha)	3.2	2.6	4.4
Population (plants m^{-2})	45.8	36.1	60.5
Seeds (number m^{-2})	1230.1	1001.3	1623.5
Thousand Seed Weight (g)	260.9	250.1	273.3
Harvest Index (%)	46.8	45.3	48.9

Site: 11

1. Paddock Details

Irrigated: Yes **Tillage Class:** Conventional **Soil Disturbance Rating:** 115
Years since Last: **Peas** 11 **Pasture** 11

2. Crop

Cultivar: Midichi **Sown:** 16/09/06 **%Germination:** 94 **%Damage:** 1 **TSW:** 363

Drill: **Type** Duncan Quantum 720 **Feed Mechanism** Bean feed, rubber fingers
Speed 10

Sowing Rate (plants m^{-2})
Farmer Estimate: 100
Excavated: **Median** 93.3 **Minimum** 46.7 **Maximum** 133.3
Median within-Location Range 60.0

Sowing Depth (cm)
Farmer Estimate: 3
Excavated: **Median** 4.0 **Minimum** 2.0 **Maximum** 5.0
Median within-Location Range 1.0

Plants at Establishment (plants m^{-2})
Median 75.0 **Minimum** 66.7 **Maximum** 103.3
Median within-Location Range 16.7

3. Soil at Planting

Soil Type: Lismore shallow silt loam

Soil Properties:

	Mean	Min.	Max.
Aggregate stability (MWD)	1.46	1.25	1.57
Aggregate size distribution (MWD):	50.29	49.87	50.52
Bulk density (g/cm3, 0-7.5 cm)	1.26	1.22	1.30
Soil moisture (% by weight to 7.5 cm)	20.14	16.94	22.99

Glass House Aphanomyces Index (DSI): 90

4. Plant and Soil at Flat Pod

%Cover: **Median** 65 **Min.** 32 **Max.** 100 **within-Location Range** 23

Soil Properties:

	Mean	Min.	Max.
Bulk density (g/cm3, 0-15 cm)	1.22	1.07	1.33
(15-30 cm)	0.99	-	-
Soil moisture (% by weight to 15 cm)	22.58	19.73	26.13
(15-30 cm)	19.10	19.10	19.10
Penetration Resistance (MPa to 15 cm)	3.16	2.46	3.79
(15-30 cm)	3.61	2.94	4.30

Crusting: 2.2

Soil Profile Assessment Scores:
Total: 13.50
For each component:

	Cultivation	Sub Cultivation	Subsoil
Soil Density	2.2	2.5	-
Pea Root Density	2.0	2.0	-
Pan	-	1.8	-
Mottles	-	1.0	1.0

Field Aphanomyces Index (DSI): 72

Plant Weight (g): **Tops:** 588 **Roots** 36

5. Harvest

	Mean	Min.	Max.
Yield (t/ha)	4.2	3.6	5.2
Population (plants m^{-2})	50.8	40.6	64.9
Seeds (number m^{-2})	1232.1	1073.7	1317.1
Thousand Seed Weight (g)	342.8	299.2	391.6
Harvest Index (%)	55.6	52.0	60.4

Site: 12

1. Paddock Details

Irrigated: No **Tillage Class:** Conventional **Soil Disturbance Rating:** 94
Years since Last: **Peas** 7 **Pasture** 4

2. Crop

Cultivar: Midichi **Sown:** 06/09/06 **%Germination:** 88 **%Damage:** 3 **TSW:** 380

Drill: **Type** Duncan Agvance **Feed Mechanism** roller **Speed** 7

Sowing Rate (plants m^{-2})
Farmer Estimate: 92.1
Excavated: **Median** 70.0 **Minimum** 46.7 **Maximum** 126.7
Median within-Location Range 33.3

Sowing Depth (cm)
Farmer Estimate: 4
Excavated: **Median** 6.0 **Minimum** 4.0 **Maximum** 7.0
Median within-Location Range 2.0

Plants at Establishment (plants m^{-2})
Median 81.7 **Minimum** 46.7 **Maximum** 190.0
Median within-Location Range 13.3

3. Soil at Planting

Soil Type: Chertsey moderately deep silt loam

Soil Properties:

	Mean	Min.	Max.
Aggregate stability (MWD)	1.16	0.94	1.40
Aggregate size distribution (MWD):	48.37	47.24	49.75
Bulk density (g/cm3, 0-7.5 cm)	1.21	1.12	1.29
Soil moisture (% by weight to 7.5 cm)	16.85	15.70	18.84

Glass House Aphanomyces Index (DSI): 75

4. Plant and Soil at Flat Pod

%Cover: **Median** 84 **Min.** 42 **Max.** 100 **within-Location Range** 33

Soil Properties:

	Mean	Min.	Max.
Bulk density (g/cm3, 0-15 cm)	1.26	1.15	1.36
(15-30 cm)	0.94	-	-
Soil moisture (% by weight to 15 cm)	20.28	17.54	22.77
(15-30 cm)	15.85	15.85	15.85
Penetration Resistance (MPa to 15 cm)	2.79	2.27	3.74
(15-30 cm)	3.26	2.89	3.61

Crusting: 1.0

Soil Profile Assessment Scores:
Total: 12.00
For each component:

	Cultivation	Sub Cultivation	Subsoil
Soil Density	2.0	2.2	-
Pea Root Density	1.8	1.8	-
Pan	-	1.2	-
Mottles	-	1.0	1.0

Field Aphanomyces Index (DSI): 88

Plant Weight (g): **Tops:** 457 **Roots** 21

5. Harvest

	Mean	Min.	Max.
Yield (t/ha)	5.4	4.6	6.6
Population (plants m^{-2})	57.2	54.7	60.0
Seeds (number m^{-2})	1469.8	1341.9	1661.7
Thousand Seed Weight (g)	367.1	345.2	395.7
Harvest Index (%)	61.0	60.3	62.2

Site: 13

1. Paddock Details

Irrigated: No **Tillage Class:** Conventional **Soil Disturbance Rating:** 72
Years since Last: **Peas** 11 **Pasture** 3

2. Crop

Cultivar: Midichi **Sown:** 17/10/06 **%Germination:** 80 **%Damage:** 3 **TSW:** 375

Drill: **Type** Duncan Agvance **Feed Mechanism** fluted roller **Speed** 10

Sowing Rate (plants m^{-2})
Farmer Estimate: 80
Excavated: **Median** 86.7 **Minimum** 53.3 **Maximum** 106.7
Median within-Location Range 26.7

Sowing Depth (cm)
Farmer Estimate: 3
Excavated: **Median** 5.0 **Minimum** 4.0 **Maximum** 8.0
Median within-Location Range 2.0

Plants at Establishment (plants m^{-2})
Median 70.0 **Minimum** 40.0 **Maximum** 86.7
Median within-Location Range 36.7

3. Soil at Planting

Soil Type: Lismore shallow silt loam

Soil Properties:

	Mean	Min.	Max.
Aggregate stability (MWD)	2.23	2.08	2.43
Aggregate size distribution (MWD):	59.58	57.69	61.04
Bulk density (g/cm3, 0-7.5 cm)	1.18	1.17	1.19
Soil moisture (% by weight to 7.5 cm)	17.22	16.13	18.33

Glass House Aphanomyces Index (DSI): 50

4. Plant and Soil at Flat Pod

%Cover: **Median** 100 **Min.** 30 **Max.** 100 **within-Location Range** 0

Soil Properties:

	Mean	Min.	Max.
Bulk density (g/cm3, 0-15 cm)	1.16	1.11	1.21
(15-30 cm)	0.96	-	-
Soil moisture (% by weight to 15 cm)	25.58	23.42	26.74
(15-30 cm)	23.69	23.69	23.69
Penetration Resistance (MPa to 15 cm)	1.76	1.48	2.03
(15-30 cm)	2.45	2.38	2.51

Crusting: 1.0

Soil Profile Assessment Scores:

Total: 9.25

For each component:

	Cultivation	Sub Cultivation	Subsoil
Soil Density	1.2	1.0	-
Pea Root Density	1.2	1.2	-
Pan	-	1.5	-
Mottles	-	1.0	1.0

Field Aphanomyces Index (DSI): 48

Plant Weight (g): **Tops:** 582 **Roots** 30

5. Harvest

	Mean	Min.	Max.
Yield (t/ha)	3.2	3.0	3.7
Population (plants m^{-2})	39.1	38.0	39.9
Seeds (number m^{-2})	984.1	925.1	1078.7
Thousand Seed Weight (g)	326.1	316.2	340.5
Harvest Index (%)	42.5	40.6	45.1

Site: 14

1. Paddock Details

Irrigated: No **Tillage Class:** Conventional **Soil Disturbance Rating:** 102
Years since Last: **Peas** 4 **Pasture** 5

2. Crop

Cultivar: Midichi **Sown:** 25/09/06 **%Germination:** 72 **%Damage:** 4 **TSW:** 396

Drill: **Type** John Deere disc **Feed Mechanism** **Speed** 8

Sowing Rate (plants m^{-2})
Farmer Estimate: 75.8
Excavated: **Median** 86.7 **Minimum** 46.7 **Maximum** 126.7
Median within-Location Range 26.7

Sowing Depth (cm)
Farmer Estimate: 5
Excavated: **Median** 5.5 **Minimum** 2.0 **Maximum** 8.0
Median within-Location Range 0.0

Plants at Establishment (plants m^{-2})
Median 45.0 **Minimum** 16.7 **Maximum** 76.7
Median within-Location Range 16.7

3. Soil at Planting

Soil Type: Lismore shallow silt loam

Soil Properties:

	Mean	Min.	Max.
Aggregate stability (MWD)	1.89	1.66	2.18
Aggregate size distribution (MWD):	52.88	50.68	54.38
Bulk density (g/cm3, 0-7.5 cm)	1.31	1.27	1.38
Soil moisture (% by weight to 7.5 cm)	11.99	11.01	12.82

Glass House Aphanomyces Index (DSI): 100

4. Plant and Soil at Flat Pod

%Cover: **Median** 5 **Min.** 5 **Max.** 5 **within-Location Range** 0

Soil Properties:

	Mean	Min.	Max.
Bulk density (g/cm3, 0-15 cm)	1.26	1.25	1.28
(15-30 cm)	1.00	-	-
Soil moisture (% by weight to 15 cm)	19.38	18.24	21.16
(15-30 cm)	20.78	20.78	20.78
Penetration Resistance (MPa to 15 cm)	2.17	2.02	2.36
(15-30 cm)	3.01	2.69	3.39

Crusting: 2.0

Soil Profile Assessment Scores:
Total: 10.25
For each component:

	Cultivation	Sub Cultivation	Subsoil
Soil Density	1.8	1.8	-
Pea Root Density	1.2	1.2	-
Pan	-	1.2	-
Mottles	-	1.0	1.0

Field Aphanomyces Index (DSI): 88

Plant Weight (g): **Tops:** 158 **Roots** 34

5. Harvest

	Mean	Min.	Max.
Yield (t/ha)	*	*	*
Population (plants m^{-2})	*	*	*
Seeds (number m^{-2})	*	*	*
Thousand Seed Weight (g)	*	*	*
Harvest Index (%)	*	*	*

Site: 15

1. Paddock Details

Irrigated: Yes **Tillage Class:** Conventional **Soil Disturbance Rating:** 106
Years since Last: **Peas** 11 **Pasture** 1

2. Crop

Cultivar: Midichi **Sown:** 04/09/06 **%Germination:** 85 **%Damage:** 4 **TSW:** 368

Drill: **Type** Duncan 720 Quantum **Feed Mechanism** Bean Feed Roller **Speed** 7

Sowing Rate (plants m^{-2})
Farmer Estimate: 102.4
Excavated: **Median** 93.3 **Minimum** 40.0 **Maximum** 146.7
Median within-Location Range 26.7

Sowing Depth (cm)
Farmer Estimate: 5
Excavated: **Median** 4.0 **Minimum** 2.0 **Maximum** 4.0
Median within-Location Range 1.0

Plants at Establishment (plants m^{-2})
Median 75.0 **Minimum** 46.7 **Maximum** 93.3
Median within-Location Range 20.0

3. Soil at Planting

Soil Type: Eyre shallow silt loam

Soil Properties:

	Mean	Min.	Max.
Aggregate stability (MWD)	1.80	1.67	1.98
Aggregate size distribution (MWD):	45.21	41.27	51.85
Bulk density (g/cm3, 0-7.5 cm)	1.30	1.19	1.37
Soil moisture (% by weight to 7.5 cm)	25.35	22.28	29.41

Glass House Aphanomyces Index (DSI): 70

4. Plant and Soil at Flat Pod

%Cover: **Median** 90 **Min.** 50 **Max.** 100 **within-Location Range** 18

Soil Properties:

	Mean	Min.	Max.
Bulk density (g/cm3, 0-15 cm)	1.30	1.26	1.37
(15-30 cm)	-	-	-
Soil moisture (% by weight to 15 cm)	26.74	24.28	31.98
(15-30 cm)	22.03	22.03	22.03
Penetration Resistance (MPa to 15 cm)	3.83	3.32	4.86
(15-30 cm)	-	-	-

Crusting: 1.0

Soil Profile Assessment Scores:

Total: 10.50

For each component:

	Cultivation	Sub Cultivation	Subsoil
Soil Density	1.5	2.0	-
Pea Root Density	1.5	1.5	-
Pan	-	1.0	-
Mottles	-	1.0	1.0

Field Aphanomyces Index (DSI): 48

Plant Weight (g): **Tops:** 1110 **Roots** 46

5. Harvest

	Mean	Min.	Max.
Yield (t/ha)	4.7	3.1	7.3
Population (plants m^{-2})	57.7	47.5	69.8
Seeds (number m^{-2})	1417.2	883.8	1902.4
Thousand Seed Weight (g)	329.8	257.3	383.9
Harvest Index (%)	51.4	40.3	64.3

Site: 16

1. Paddock Details

Irrigated: No **Tillage Class:** Conventional **Soil Disturbance Rating:** 74
Years since Last: **Peas** 11 **Pasture** 11

2. Crop

Cultivar: Midichi **Sown:** 18/10/06 **%Germination:** 87 **%Damage:** 3 **TSW:** 400

Drill: **Type** Airseeder horsh **Feed Mechanism** Air **Speed** 10

Sowing Rate (plants m^{-2})
Farmer Estimate: 83.8
Excavated: **Median** 78.6 **Minimum** 50.0 **Maximum** 135.7
Median within-Location Range 7.1

Sowing Depth (cm)
Farmer Estimate: 6
Excavated: **Median** 7.0 **Minimum** 6.0 **Maximum** 7.0
Median within-Location Range *

Plants at Establishment (plants m^{-2})
Median 55.4 **Minimum** 42.9 **Maximum** 75.0
Median within-Location Range 10.7

3. Soil at Planting

Soil Type: Templeton deep silt loam

Soil Properties:

	Mean	Min.	Max.
Aggregate stability (MWD)	1.59	1.35	1.74
Aggregate size distribution (MWD):	44.96	41.98	46.65
Bulk density (g/cm3, 0-7.5 cm)	1.27	1.20	1.34
Soil moisture (% by weight to 7.5 cm)	16.39	15.13	17.66

Glass House Aphanomyces Index (DSI): 75

4. Plant and Soil at Flat Pod

%Cover: **Median** 78 **Min.** 0 **Max.** 100 **within-Location Range** 40

Soil Properties:

	Mean	Min.	Max.
Bulk density (g/cm3, 0-15 cm)	-	-	-
(15-30 cm)	-	-	-
Soil moisture (% by weight to 15 cm)	-	-	-
(15-30 cm)	-	-	-
Penetration Resistance (MPa to 15 cm)	2.12	1.87	2.29
(15-30 cm)	3.58	3.14	3.72

Crusting: 1.0

Soil Profile Assessment Scores:
Total: 9.25
For each component:

	Cultivation	Sub Cultivation	Subsoil
Soil Density	1.2	1.5	-
Pea Root Density	1.0	1.0	-
Pan	-	1.0	-
Mottles	-	1.0	1.0

Field Aphanomyces Index (DSI): 75

Plant Weight (g): **Tops:** 608 **Roots** 15

5. Harvest

	Mean	Min.	Max.
Yield (t/ha)	3.9	3.2	4.6
Population (plants m^{-2})	42.6	36.8	48.7
Seeds (number m^{-2})	1062.4	848.0	1242.4
Thousand Seed Weight (g)	364.7	348.4	374.9
Harvest Index (%)	48.4	46.6	51.2

Site: 17

1. Paddock Details

Irrigated: No **Tillage Class:** Conventional **Soil Disturbance Rating:** 74
Years since Last: **Peas** - **Pasture** -

2. Crop

Cultivar: Midichi **Sown:** 16/09/06 **%Germination:** 85 **%Damage:** 2 **TSW:** 370

Drill: **Type** Vaderstad **Feed Mechanism** Air **Speed** 9

Sowing Rate (plants m^{-2})
Farmer Estimate: 83.8
Excavated: **Median** 73.3 **Minimum** 40.0 **Maximum** 120.0
Median within-Location Range 6.7

Sowing Depth (cm)
Farmer Estimate: 8
Excavated: **Median** 8.0 **Minimum** 6.0 **Maximum** 8.0
Median within-Location Range 0.0

Plants at Establishment (plants m^{-2})
Median 73.3 **Minimum** 50.0 **Maximum** 103.3
Median within-Location Range 10.0

3. Soil at Planting

Soil Type: Wakanui deep silt loam on clay loam

Soil Properties:

	Mean	Min.	Max.
Aggregate stability (MWD)	1.02	0.69	1.20
Aggregate size distribution (MWD):	52.16	50.17	53.42
Bulk density (g/cm3, 0-7.5 cm)	1.24	1.17	1.32
Soil moisture (% by weight to 7.5 cm)	16.96	14.56	20.56

Glass House Aphanomyces Index (DSI): 35

4. Plant and Soil at Flat Pod

%Cover: **Median** 98 **Min.** 38 **Max.** 100 **within-Location Range** 4

Soil Properties:

	Mean	Min.	Max.
Bulk density (g/cm3, 0-15 cm)	1.25	1.11	1.39
(15-30 cm)	1.06	-	-
Soil moisture (% by weight to 15 cm)	23.24	20.97	25.02
(15-30 cm)	22.98	22.98	22.98
Penetration Resistance (MPa to 15 cm)	2.83	2.42	3.46
(15-30 cm)	3.68	2.75	4.77

Crusting: 1.8

Soil Profile Assessment Scores:

Total: 10.75

For each component:

	Cultivation	Sub Cultivation	Subsoil
Soil Density	1.8	2.0	-
Pea Root Density	1.2	1.8	-
Pan	-	1.0	-
Mottles	-	1.0	1.0

Field Aphanomyces Index (DSI): 62

Plant Weight (g): **Tops:** 495 **Roots** 31

5. Harvest

	Mean	Min.	Max.
Yield (t/ha)	4.8	3.3	5.6
Population (plants m^{-2})	48.7	37.7	56.7
Seeds (number m^{-2})	1428.3	1047.2	1673.3
Thousand Seed Weight (g)	334.1	314.0	351.9
Harvest Index (%)	57.0	56.0	58.4

Site: 18

1. Paddock Details

Irrigated: No **Tillage Class:** Conventional **Soil Disturbance Rating:** 108
Years since Last: **Peas** 11 **Pasture** 2

2. Crop

Cultivar: Midichi **Sown:** 22/09/06 **%Germination:** 86 **%Damage:** 9 **TSW:** 420

Drill: **Type** Aitchen 1420 **Feed Mechanism** Sponge feed **Speed** 9

Sowing Rate (plants m^{-2})
Farmer Estimate: 76.2
Excavated: **Median** 73.3 **Minimum** 20.0 **Maximum** 93.3
Median within-Location Range 33.3

Sowing Depth (cm)
Farmer Estimate: 5
Excavated: **Median** 6.0 **Minimum** 4.0 **Maximum** 8.0
Median within-Location Range 1.0

Plants at Establishment (plants m^{-2})
Median 51.7 **Minimum** 23.3 **Maximum** 93.3
Median within-Location Range 20.0

3. Soil at Planting

Soil Type: Highbank moderately deep silt loam

Soil Properties:

	Mean	Min.	Max.
Aggregate stability (MWD)	2.10	2.02	2.25
Aggregate size distribution (MWD):	53.32	50.49	57.05
Bulk density (g/cm3, 0-7.5 cm)	1.16	1.12	1.19
Soil moisture (% by weight to 7.5 cm)	20.42	19.24	21.67

Glass House Aphanomyces Index (DSI): 54

4. Plant and Soil at Flat Pod

%Cover: **Median** 96 **Min.** 75 **Max.** 100 **within-Location Range** 3

Soil Properties:

	Mean	Min.	Max.
Bulk density (g/cm3, 0-15 cm)	1.12	1.07	1.22
(15-30 cm)	0.93	-	-
Soil moisture (% by weight to 15 cm)	27.25	25.47	28.99
(15-30 cm)	24.35	24.35	24.35
Penetration Resistance (MPa to 15 cm)	1.12	0.91	1.46
(15-30 cm)	2.14	1.87	2.47

Crusting: 1.5

Soil Profile Assessment Scores:

Total: 10.00

For each component:

	Cultivation	Sub Cultivation	Subsoil
Soil Density	1.2	1.8	-
Pea Root Density	1.0	1.0	-
Pan	-	2.0	-
Mottles	-	1.0	1.0

Field Aphanomyces Index (DSI): 38

Plant Weight (g): **Tops:** 770 **Roots** 50

5. Harvest

	Mean	Min.	Max.
Yield (t/ha)	4.0	3.4	4.9
Population (plants m^{-2})	53.2	41.1	64.4
Seeds (number m^{-2})	1257.1	1072.6	1513.0
Thousand Seed Weight (g)	313.8	306.6	321.4
Harvest Index (%)	47.6	42.4	51.1

Site: 19

1. Paddock Details

Irrigated: No **Tillage Class:** Conventional **Soil Disturbance Rating:** 114
Years since Last: **Peas** 11 **Pasture** 11

2. Crop

Cultivar: Midichi **Sown:** 15/09/06 **%Germination:** 92 **%Damage:** 1 **TSW:** 365

Drill: **Type** John Deere 450 **Feed Mechanism** Metal fluted drive **Speed** 8

Sowing Rate (plants m^{-2})
Farmer Estimate: 95.9
Excavated: **Median** 93.3 **Minimum** 53.3 **Maximum** 160.0
Median within-Location Range 13.3

Sowing Depth (cm)
Farmer Estimate: 6
Excavated: **Median** 5.0 **Minimum** 2.0 **Maximum** 6.0
Median within-Location Range 2.0

Plants at Establishment (plants m^{-2})
Median 76.7 **Minimum** 60.0 **Maximum** 106.7
Median within-Location Range 10.0

3. Soil at Planting

Soil Type: Lismore shallow silt loam

Soil Properties:

	Mean	Min.	Max.
Aggregate stability (MWD)	1.35	1.25	1.54
Aggregate size distribution (MWD):	52.09	40.87	59.15
Bulk density (g/cm3, 0-7.5 cm)	1.20	1.15	1.26
Soil moisture (% by weight to 7.5 cm)	17.04	15.86	17.81

Glass House Aphanomyces Index (DSI): 75

4. Plant and Soil at Flat Pod

%Cover: **Median** 85 **Min.** 47 **Max.** 100 **within-Location Range** 50

Soil Properties:

	Mean	Min.	Max.
Bulk density (g/cm3, 0-15 cm)	1.21	1.18	1.22
(15-30 cm)	0.83	-	-
Soil moisture (% by weight to 15 cm)	25.01	23.74	26.54
(15-30 cm)	22.74	22.74	22.74
Penetration Resistance (MPa to 15 cm)	2.07	1.82	2.40
(15-30 cm)	2.19	1.93	2.35

Crusting: 1.0

Soil Profile Assessment Scores:
Total: 10.75
For each component:

	Cultivation	Sub Cultivation	Subsoil
Soil Density	1.5	2.0	-
Pea Root Density	1.0	1.0	-
Pan	-	2.2	-
Mottles	-	1.0	1.0

Field Aphanomyces Index (DSI): 60

Plant Weight (g): **Tops:** 406 **Roots** 33

5. Harvest

	Mean	Min.	Max.
Yield (t/ha)	*	*	*
Population (plants m^{-2})	*	*	*
Seeds (number m^{-2})	*	*	*
Thousand Seed Weight (g)	*	*	*
Harvest Index (%)	*	*	*

Site: 20

1. Paddock Details

Irrigated: No **Tillage Class:** Conventional **Soil Disturbance Rating:** 98
Years since Last: **Peas** 11 **Pasture** 1

2. Crop

Cultivar: Midichi **Sown:** 21/09/06 **%Germination:** 93 **%Damage:** 1 **TSW:** 332

Drill: **Type** Allan Air Seeder **Feed Mechanism** Air **Speed** 10

Sowing Rate (plants m^{-2})
Farmer Estimate: 105.4
Excavated: **Median** 76.7 **Minimum** 60.0 **Maximum** 160.0
Median within-Location Range 13.3

Sowing Depth (cm)
Farmer Estimate: 5
Excavated: **Median** 5.0 **Minimum** 2.0 **Maximum** 5.0
Median within-Location Range 0.0

Plants at Establishment (plants m^{-2})
Median 71.7 **Minimum** 36.7 **Maximum** 96.7
Median within-Location Range 3.3

3. Soil at Planting

Soil Type: Lyndhurst moderately deep silt loam

Soil Properties:

	Mean	Min.	Max.
Aggregate stability (MWD)	2.36	2.32	2.40
Aggregate size distribution (MWD):	60.42	58.00	64.07
Bulk density (g/cm3, 0-7.5 cm)	1.29	1.25	1.34
Soil moisture (% by weight to 7.5 cm)	18.61	18.02	19.21

Glass House Aphanomyces Index (DSI): 64

4. Plant and Soil at Flat Pod

%Cover: **Median** 100 **Min.** 70 **Max.** 100 **within-Location Range** 0

Soil Properties:

	Mean	Min.	Max.
Bulk density (g/cm3, 0-15 cm)	1.22	1.19	1.27
(15-30 cm)	0.92	-	-
Soil moisture (% by weight to 15 cm)	24.21	22.66	25.49
(15-30 cm)	21.76	21.76	21.76
Penetration Resistance (MPa to 15 cm)	1.53	1.32	1.64
(15-30 cm)	2.04	1.96	2.12

Crusting: 1.0

Soil Profile Assessment Scores:

Total: 9.00

For each component:

	Cultivation	Sub Cultivation	Subsoil
Soil Density	1.2	1.5	-
Pea Root Density	1.0	1.0	-
Pan	-	1.2	-
Mottles	-	1.0	1.0

Field Aphanomyces Index (DSI): 50

Plant Weight (g): **Tops:** 701 **Roots** 41

5. Harvest

	Mean	Min.	Max.
Yield (t/ha)	6.0	4.7	7.0
Population (plants m^{-2})	65.8	50.7	75.4
Seeds (number m^{-2})	1715.9	1421.0	1953.8
Thousand Seed Weight (g)	345.6	328.3	360.5
Harvest Index (%)	53.0	47.6	57.0

Site: 23

1. Paddock Details

Irrigated: No **Tillage Class:** Conventional **Soil Disturbance Rating:** 98
Years since Last: **Peas** 8 **Pasture** 1

2. Crop

Cultivar: Ashton **Sown:** 05/09/06 **%Germination:** 96 **%Damage:** 0 **TSW:** 178

Drill: **Type** Great Plains **Feed Mechanism** Fluted Roller **Speed** 8

Sowing Rate (plants m^{-2})
Farmer Estimate: 129.2
Excavated: **Median** 103.3 **Minimum** 60.0 **Maximum** 153.3
Median within-Location Range 26.7

Sowing Depth (cm)
Farmer Estimate: 2
Excavated: **Median** 3.5 **Minimum** 0.0 **Maximum** 8.0
Median within-Location Range 2.0

Plants at Establishment (plants m^{-2})
Median 133.3 **Minimum** 80.0 **Maximum** 156.7
Median within-Location Range 23.3

3. Soil at Planting

Soil Type: Lismore stony silt loam

Soil Properties:

	Mean	Min.	Max.
Aggregate stability (MWD)	1.84	1.58	1.99
Aggregate size distribution (MWD):	53.70	50.52	56.29
Bulk density (g/cm3, 0-7.5 cm)	1.29	1.26	1.33
Soil moisture (% by weight to 7.5 cm)	22.65	22.05	23.40

Glass House Aphanomyces Index (DSI): 69

4. Plant and Soil at Flat Pod

%Cover: **Median** 100 **Min.** 100 **Max.** 100 **within-Location Range** 0

Soil Properties:

	Mean	Min.	Max.
Bulk density (g/cm3, 0-15 cm)	1.17	1.07	1.24
(15-30 cm)	-	-	-
Soil moisture (% by weight to 15 cm)	16.43	15.69	17.87
(15-30 cm)	16.20	16.20	16.20
Penetration Resistance (MPa to 15 cm)	2.97	2.45	3.47
(15-30 cm)	-	-	-

Crusting: 1.0

Soil Profile Assessment Scores:
Total: 10.50
For each component:

	Cultivation	Sub Cultivation	Subsoil
Soil Density	1.5	2.0	-
Pea Root Density	1.0	1.0	-
Pan	-	1.0	-
Mottles	-	1.0	2.0

Field Aphanomyces Index (DSI): 50

Plant Weight (g): **Tops:** 495 **Roots** 12

5. Harvest

Yield (t/ha, 105 TR): 8 **Tenderometer Reading (TR)** 95

Site: 24

1. Paddock Details

Irrigated: No **Tillage Class:** Conventional **Soil Disturbance Rating:** 90
Years since Last: **Peas** 11 **Pasture** 4

2. Crop

Cultivar: Ashton **Sown:** 18/09/06 **%Germination:** 91 **%Damage:** 0 **TSW:** 178

Drill: **Type** Great Plains 1200 solid stand disc **Feed Mechanism** Fluted roller
Speed 8

Sowing Rate (plants m^{-2})
Farmer Estimate: 129.2
Excavated: **Median** 120.0 **Minimum** 73.3 **Maximum** 173.3
Median within-Location Range 33.3

Sowing Depth (cm)
Farmer Estimate: 5
Excavated: **Median** 4.0 **Minimum** 2.0 **Maximum** 6.0
Median within-Location Range 3.0

Plants at Establishment (plants m^{-2})
Median 118.3 **Minimum** 70.0 **Maximum** 143.3
Median within-Location Range 20.0

3. Soil at Planting

Soil Type: Lismore stony silt loam

Soil Properties:

	Mean	Min.	Max.
Aggregate stability (MWD)	1.86	1.69	1.97
Aggregate size distribution (MWD):	55.48	55.29	55.77
Bulk density (g/cm3, 0-7.5 cm)	1.29	1.25	1.33
Soil moisture (% by weight to 7.5 cm)	16.20	14.26	19.79

Glass House Aphanomyces Index (DSI): 59

4. Plant and Soil at Flat Pod

%Cover: **Median** 100 **Min.** 90 **Max.** 100 **within-Location Range** 0

Soil Properties:

	Mean	Min.	Max.
Bulk density (g/cm3, 0-15 cm)	1.20	1.12	1.29
(15-30 cm)	0.94	-	-
Soil moisture (% by weight to 15 cm)	12.25	11.15	13.63
(15-30 cm)	11.28	11.28	11.28
Penetration Resistance (MPa to 15 cm)	2.28	1.48	3.11
(15-30 cm)	3.09	2.69	3.54

Crusting: 1.0

Soil Profile Assessment Scores:
Total: 11.20
For each component:

	Cultivation	Sub Cultivation	Subsoil
Soil Density	2.5	2.6	-
Pea Root Density	1.0	1.0	-
Pan	-	1.0	-
Mottles	-	1.0	1.0

Field Aphanomyces Index (DSI): 50

Plant Weight (g): **Tops:** 296 **Roots** 6

5. Harvest

Yield (t/ha, 105 TR): 9 **Tenderometer Reading (TR)** 115

Site: 25

1. Paddock Details

Irrigated: No **Tillage Class:** Conventional **Soil Disturbance Rating:** 98
Years since Last: **Peas** 3 **Pasture** 6

2. Crop

Cultivar: Ashton **Sown:** 11/10/06 **%Germination:** 99 **%Damage:** 0 **TSW:** 175

Drill: **Type** Great Plains **Feed Mechanism** roller **Speed** 8

Sowing Rate (plants m^{-2})
Farmer Estimate: 131.4
Excavated: **Median** 136.7 **Minimum** 100.0 **Maximum** 173.3
Median within-Location Range 13.3

Sowing Depth (cm)
Farmer Estimate: 5
Excavated: **Median** 7.0 **Minimum** 4.0 **Maximum** 8.0
Median within-Location Range 0.0

Plants at Establishment (plants m^{-2})
Median 135.0 **Minimum** 93.3 **Maximum** 190.0
Median within-Location Range 16.7

3. Soil at Planting

Soil Type: Hatfield deep sandy loam

Soil Properties:

	Mean	Min.	Max.
Aggregate stability (MWD)	1.08	0.81	1.51
Aggregate size distribution (MWD):	43.29	38.46	48.64
Bulk density (g/cm3, 0-7.5 cm)	1.25	1.19	1.30
Soil moisture (% by weight to 7.5 cm)	20.83	19.50	21.96

Glass House Aphanomyces Index (DSI): 84

4. Plant and Soil at Flat Pod

%Cover: **Median** 100 **Min.** 90 **Max.** 100 **within-Location Range** 5

Soil Properties:

	Mean	Min.	Max.
Bulk density (g/cm3, 0-15 cm)	1.29	1.24	1.37
(15-30 cm)	0.99	-	-
Soil moisture (% by weight to 15 cm)	23.09	21.80	25.36
(15-30 cm)	21.76	21.76	21.76
Penetration Resistance (MPa to 15 cm)	2.52	2.00	3.42
(15-30 cm)	3.02	2.72	3.35

Crusting: 1.0

Soil Profile Assessment Scores:
Total: 8.75
For each component:

	Cultivation	Sub Cultivation	Subsoil
Soil Density	1.2	1.5	-
Pea Root Density	1.0	1.0	-
Pan	-	1.0	-
Mottles	-	1.0	1.0

Field Aphanomyces Index (DSI): 62

Plant Weight (g): **Tops:** 262 **Roots** 12

5. Harvest

Yield (t/ha, 105 TR): 6 **Tenderometer Reading (TR)** 130

Site: 26

1. Paddock Details

Irrigated: Yes **Tillage Class:** Conventional **Soil Disturbance Rating:** 44
Years since Last: **Peas** - **Pasture** 1

2. Crop

Cultivar: Ashton **Sown:** 16/10/06 **%Germination:** * **%Damage:** * **TSW:** *

Drill: **Type** Duncan Quantum **Feed Mechanism** Duncan amazone feed **Speed** 8

Sowing Rate (plants m^{-2})
Farmer Estimate: *
Excavated: **Median** 163.3 **Minimum** 80.0 **Maximum** 206.7
Median within-Location Range 20.0

Sowing Depth (cm)
Farmer Estimate: 2
Excavated: **Median** 3.0 **Minimum** 2.0 **Maximum** 4.0
Median within-Location Range 1.0

Plants at Establishment (plants m^{-2})
Median 141.7 **Minimum** 120.0 **Maximum** 203.3
Median within-Location Range 26.7

3. Soil at Planting

Soil Type: Wakanui deep silt loam

Soil Properties:

	Mean	Min.	Max.
Aggregate stability (MWD)	2.00	1.57	2.27
Aggregate size distribution (MWD):	51.07	49.50	53.62
Bulk density (g/cm3, 0-7.5 cm)	1.34	1.29	1.42
Soil moisture (% by weight to 7.5 cm)	13.85	9.00	17.15

Glass House Aphanomyces Index (DSI): 25

4. Plant and Soil at Flat Pod

%Cover: **Median** 100 **Min.** 100 **Max.** 100 **within-Location Range** 0

Soil Properties:

	Mean	Min.	Max.
Bulk density (g/cm3, 0-15 cm)	1.30	1.28	1.34
(15-30 cm)	1.04	-	-
Soil moisture (% by weight to 15 cm)	22.00	20.42	23.28
(15-30 cm)	19.08	19.08	19.08
Penetration Resistance (MPa to 15 cm)	2.58	2.18	3.11
(15-30 cm)	2.78	2.22	3.18

Crusting: 1.0

Soil Profile Assessment Scores:
Total: 9.00
For each component:

	Cultivation	Sub Cultivation	Subsoil
Soil Density	1.2	1.5	-
Pea Root Density	1.0	1.0	-
Pan	-	1.2	-
Mottles	-	1.0	1.0

Field Aphanomyces Index (DSI): 58

Plant Weight (g): **Tops:** 579 **Roots** 27

5. Harvest

Yield (t/ha, 105 TR): 9 **Tenderometer Reading (TR)** 105

Site: 27

1. Paddock Details

Irrigated: Yes **Tillage Class:** Conventional **Soil Disturbance Rating:** 80
Years since Last: **Peas** 4 **Pasture** 2

2. Crop

Cultivar: Ashton **Sown:** 21/10/06 **%Germination:** 97 **%Damage:** 1 **TSW:** 177

Drill: **Type** Duncan 701 **Feed Mechanism** Fluted Roller **Speed** 6

Sowing Rate (plants m^{-2})
Farmer Estimate: 141.2
Excavated: **Median** 156.7 **Minimum** 13.3 **Maximum** 253.3
Median within-Location Range 80.0

Sowing Depth (cm)
Farmer Estimate: 10
Excavated: **Median** 7.0 **Minimum** 6.0 **Maximum** 9.0
Median within-Location Range 0.0

Plants at Establishment (plants m^{-2})
Median 100.0 **Minimum** 66.7 **Maximum** 183.3
Median within-Location Range 23.3

3. Soil at Planting

Soil Type: Wakanui deep silt loam

Soil Properties:

	Mean	Min.	Max.
Aggregate stability (MWD)	1.73	1.53	2.04
Aggregate size distribution (MWD):	49.07	43.67	52.51
Bulk density (g/cm3, 0-7.5 cm)	1.25	1.17	1.31
Soil moisture (% by weight to 7.5 cm)	23.54	21.80	25.34

Glass House Aphanomyces Index (DSI): 58

4. Plant and Soil at Flat Pod

%Cover: **Median** 100 **Min.** 50 **Max.** 100 **within-Location Range** 0

Soil Properties:

	Mean	Min.	Max.
Bulk density (g/cm3, 0-15 cm)	1.26	1.24	1.29
(15-30 cm)	0.93	-	-
Soil moisture (% by weight to 15 cm)	24.38	22.10	28.21
(15-30 cm)	21.99	21.99	21.99
Penetration Resistance (MPa to 15 cm)	2.80	2.13	3.21
(15-30 cm)	2.68	2.11	3.26

Crusting: 1.0

Soil Profile Assessment Scores:
Total: 8.75
For each component:

	Cultivation	Sub Cultivation	Subsoil
Soil Density	1.2	1.5	-
Pea Root Density	1.0	1.0	-
Pan	-	1.0	-
Mottles	-	1.0	1.0

Field Aphanomyces Index (DSI): 58

Plant Weight (g): **Tops:** 396 **Roots** 25

5. Harvest

Yield (t/ha, 105 TR): 7 **Tenderometer Reading (TR)** 140

Site: 28

1. Paddock Details

Irrigated: Yes **Tillage Class:** Conventional **Soil Disturbance Rating:** 69
Years since Last: **Peas** 10 **Pasture** 1

2. Crop

Cultivar: Ashton **Sown:** 29/10/06 **%Germination:** 99 **%Damage:** 1 **TSW:** 175

Drill: **Type** Aitcheson **Feed Mechanism** Foam Feed **Speed** *

Sowing Rate (plants m^{-2})
Farmer Estimate: 131.4
Excavated: **Median** 121.4 **Minimum** 57.1 **Maximum** 192.9
Median within-Location Range 35.7

Sowing Depth (cm)
Farmer Estimate: 5
Excavated: **Median** 5.5 **Minimum** 5.0 **Maximum** 8.0
Median within-Location Range 1.0

Plants at Establishment (plants m^{-2})
Median 128.6 **Minimum** 100.0 **Maximum** 157.1
Median within-Location Range 25.0

3. Soil at Planting

Soil Type: Temuka deep clay loam & Taumutu gravelly sandy loam

Soil Properties:

	Mean	Min.	Max.
Aggregate stability (MWD)	1.59	1.56	1.64
Aggregate size distribution (MWD):	57.97	49.39	64.01
Bulk density (g/cm3, 0-7.5 cm)	1.16	1.10	1.23
Soil moisture (% by weight to 7.5 cm)	17.64	16.60	19.02

Glass House Aphanomyces Index (DSI): 81

4. Plant and Soil at Flat Pod

%Cover: **Median** 100 **Min.** 100 **Max.** 100 **within-Location Range** 0

Soil Properties:

	Mean	Min.	Max.
Bulk density (g/cm3, 0-15 cm)	1.20	1.16	1.22
(15-30 cm)	1.08	-	-
Soil moisture (% by weight to 15 cm)	20.22	19.09	21.97
(15-30 cm)	16.88	16.88	16.88
Penetration Resistance (MPa to 15 cm)	4.28	3.75	5.29
(15-30 cm)	5.27	4.01	6.04

Crusting: 1.0

Soil Profile Assessment Scores:
Total: 12.00
For each component:

	Cultivation	Sub Cultivation	Subsoil
Soil Density	2.2	2.5	-
Pea Root Density	1.2	1.5	-
Pan	-	1.5	-
Mottles	-	1.0	1.0

Field Aphanomyces Index (DSI): 70

Plant Weight (g): **Tops:** 418 **Roots** 17

5. Harvest

Yield (t/ha, 105 TR): 6 **Tenderometer Reading (TR)** 135

Site: 29

1. Paddock Details

Irrigated: No **Tillage Class:** Conventional **Soil Disturbance Rating:** 107
Years since Last: **Peas** 6 **Pasture** 11

2. Crop

Cultivar: Ashton **Sown:** 02/11/06 **%Germination:** 99 **%Damage:** * **TSW:** 180

Drill: **Type** Duncan 734 Multiseeder **Feed Mechanism** Fluted Roller **Speed** *

Sowing Rate (plants m^{-2})
Farmer Estimate: 127.8
Excavated: **Median** 130.0 **Minimum** 60.0 **Maximum** 213.3
Median within-Location Range 33.3

Sowing Depth (cm)
Farmer Estimate: 7
Excavated: **Median** 5.5 **Minimum** 4.0 **Maximum** 7.0
Median within-Location Range 1.0

Plants at Establishment (plants m^{-2})
Median 115.0 **Minimum** 76.7 **Maximum** 193.3
Median within-Location Range 30.0

3. Soil at Planting

Soil Type: Templeton deep fine sandy loam & Eyre shallow sandy loam

Soil Properties:

	Mean	Min.	Max.
Aggregate stability (MWD)	1.85	1.20	2.36
Aggregate size distribution (MWD):	38.47	33.66	42.20
Bulk density (g/cm3, 0-7.5 cm)	0.99	0.91	1.12
Soil moisture (% by weight to 7.5 cm)	30.06	24.06	38.16

Glass House Aphanomyces Index (DSI): 79

4. Plant and Soil at Flat Pod

%Cover: **Median** 100 **Min.** 45 **Max.** 100 **within-Location Range** 0

Soil Properties:

	Mean	Min.	Max.
Bulk density (g/cm3, 0-15 cm)	1.14	1.07	1.18
(15-30 cm)	1.07	-	-
Soil moisture (% by weight to 15 cm)	28.35	25.07	37.72
(15-30 cm)	23.54	23.54	23.54
Penetration Resistance (MPa to 15 cm)	5.77	3.96	7.74
(15-30 cm)	5.02	2.04	7.01

Crusting: 1.0

Soil Profile Assessment Scores:
Total: 14.50
For each component:

	Cultivation	Sub Cultivation	Subsoil
Soil Density	2.2	2.5	-
Pea Root Density	2.0	2.0	-
Pan	-	1.0	-
Mottles	-	1.8	2.0

Field Aphanomyces Index (DSI): 50

Plant Weight (g): **Tops:** 302 **Roots** 15

5. Harvest

Yield (t/ha, 105 TR): 6 **Tenderometer Reading (TR)** 140

Site: 30

1. Paddock Details

Irrigated: Yes **Tillage Class:** Minimum **Soil Disturbance Rating:** 134
Years since Last: **Peas** 5 **Pasture** 11

2. Crop

Cultivar: Ashton **Sown:** 01/11/06 **%Germination:** 97 **%Damage:** 1 **TSW:** 176

Drill: **Type** Duncan 701 **Feed Mechanism** **Speed** 8

Sowing Rate (plants m^{-2})
Farmer Estimate: 133
Excavated: **Median** 120.0 **Minimum** 80.0 **Maximum** 200.0
Median within-Location Range 33.3

Sowing Depth (cm)
Farmer Estimate: 4
Excavated: **Median** 5.0 **Minimum** 3.0 **Maximum** 7.0
Median within-Location Range 1.0

Plants at Establishment (plants m^{-2})
Median 120.0 **Minimum** 100.0 **Maximum** 150.0
Median within-Location Range 20.0

3. Soil at Planting

Soil Type: Wakanui deep silt loam

Soil Properties:

	Mean	Min.	Max.
Aggregate stability (MWD)	1.42	1.29	1.58
Aggregate size distribution (MWD):	50.86	48.18	53.52
Bulk density (g/cm3, 0-7.5 cm)	1.18	1.08	1.29
Soil moisture (% by weight to 7.5 cm)	18.81	16.63	20.21

Glass House Aphanomyces Index (DSI): 85

4. Plant and Soil at Flat Pod

%Cover: **Median** 100 **Min.** 100 **Max.** 100 **within-Location Range** 0

Soil Properties:

	Mean	Min.	Max.
Bulk density (g/cm3, 0-15 cm)	1.31	1.28	1.34
(15-30 cm)	1.11	-	-
Soil moisture (% by weight to 15 cm)	20.09	17.42	22.84
(15-30 cm)	16.04	16.04	16.04
Penetration Resistance (MPa to 15 cm)	3.79	2.73	4.37
(15-30 cm)	4.11	2.40	5.85

Crusting: 1.0

Soil Profile Assessment Scores:
Total: 13.75
For each component:

	Cultivation	Sub Cultivation	Subsoil
Soil Density	2.2	2.8	-
Pea Root Density	1.8	2.0	-
Pan	-	2.0	-
Mottles	-	1.0	1.0

Field Aphanomyces Index (DSI): 75

Plant Weight (g): **Tops:** 239 **Roots** 10

5. Harvest

Yield (t/ha, 105 TR): 6 **Tenderometer Reading (TR)** 125

Site: 31

1. Paddock Details

Irrigated: Yes **Tillage Class:** Conventional **Soil Disturbance Rating:** 108
Years since Last: **Peas** 11 **Pasture** 11

2. Crop

Cultivar: Ashton **Sown:** 25/11/06 **%Germination:** 98 **%Damage:** 0 **TSW:** 174

Drill: **Type** Duncan 701 **Feed Mechanism** duncan 701 roller **Speed** 7

Sowing Rate (plants m^{-2})
Farmer Estimate: 136.2
Excavated: **Median** 133.3 **Minimum** 46.7 **Maximum** 206.7
Median within-Location Range 40.0

Sowing Depth (cm)
Farmer Estimate: 5
Excavated: **Median** 6.0 **Minimum** 5.0 **Maximum** 8.0
Median within-Location Range 1.0

Plants at Establishment (plants m^{-2})
Median 131.7 **Minimum** 100.0 **Maximum** 193.3
Median within-Location Range 20.0

3. Soil at Planting

Soil Type: Templeton deep and moderately deep silt loam on clay loam

Soil Properties:

	Mean	Min.	Max.
Aggregate stability (MWD)	2.18	1.66	2.87
Aggregate size distribution (MWD):	56.91	51.29	61.36
Bulk density (g/cm3, 0-7.5 cm)	1.11	1.07	1.14
Soil moisture (% by weight to 7.5 cm)	27.89	25.77	30.42

Glass House Aphanomyces Index (DSI): 79

4. Plant and Soil at Flat Pod

%Cover: **Median** 100 **Min.** 80 **Max.** 100 **within-Location Range** 0

Soil Properties:

	Mean	Min.	Max.
Bulk density (g/cm3, 0-15 cm)	1.15	1.05	1.23
(15-30 cm)	1.30	-	-
Soil moisture (% by weight to 15 cm)	27.64	23.74	31.96
(15-30 cm)	21.88	21.88	21.88
Penetration Resistance (MPa to 15 cm)	3.21	3.04	3.52
(15-30 cm)	4.75	4.07	5.14

Crusting: 1.0

Soil Profile Assessment Scores:
Total: 9.25
For each component:

	Cultivation	Sub Cultivation	Subsoil
Soil Density	1.2	1.5	-
Pea Root Density	1.0	1.0	-
Pan	-	1.5	-
Mottles	-	1.0	1.0

Field Aphanomyces Index (DSI): 62

Plant Weight (g): **Tops:** 414 **Roots** 11

5. Harvest

Yield (t/ha, 105 TR): 7 **Tenderometer Reading (TR)** 120

Site: 32

1. Paddock Details

Irrigated: No **Tillage Class:** Conventional **Soil Disturbance Rating:** 126
Years since Last: **Peas** 11 **Pasture** 4

2. Crop

Cultivar: Ashton **Sown:** 28/11/06 **%Germination:** 99 **%Damage:** 0 **TSW:** 176

Drill: **Type** Aitchison **Feed Mechanism** Sponge Feed **Speed** 7

Sowing Rate (plants m^{-2})
Farmer Estimate: 145
Excavated: **Median** 143.3 **Minimum** 106.7 **Maximum** 226.7
Median within-Location Range 20.0

Sowing Depth (cm)
Farmer Estimate: 5
Excavated: **Median** 6.0 **Minimum** 3.0 **Maximum** 8.0
Median within-Location Range 1.0

Plants at Establishment (plants m^{-2})
Median 120.0 **Minimum** 100.0 **Maximum** 156.7
Median within-Location Range 20.0

3. Soil at Planting

Soil Type: Templeton deep and moderately deep silt loam

Soil Properties:

	Mean	Min.	Max.
Aggregate stability (MWD)	1.37	0.91	1.79
Aggregate size distribution (MWD):	53.27	51.79	54.04
Bulk density (g/cm3, 0-7.5 cm)	0.97	0.90	1.06
Soil moisture (% by weight to 7.5 cm)	37.93	33.24	46.25

Glass House Aphanomyces Index (DSI): 99

4. Plant and Soil at Flat Pod

%Cover: **Median** 100 **Min.** 100 **Max.** 100 **within-Location Range** 0

Soil Properties:

	Mean	Min.	Max.
Bulk density (g/cm3, 0-15 cm)	0.92	0.84	0.99
(15-30 cm)	1.15	-	-
Soil moisture (% by weight to 15 cm)	35.60	29.77	46.79
(15-30 cm)	32.65	32.65	32.65
Penetration Resistance (MPa to 15 cm)	4.00	3.60	4.42
(15-30 cm)	8.10	6.88	9.36

Crusting: 1.5

Soil Profile Assessment Scores:
Total: 9.50
For each component:

	Cultivation	Sub Cultivation	Subsoil
Soil Density	1.2	1.8	-
Pea Root Density	1.0	1.0	-
Pan	-	1.5	-
Mottles	-	1.0	1.0

Field Aphanomyces Index (DSI): 75

Plant Weight (g): **Tops:** 333 **Roots** 8

5. Harvest

Yield (t/ha, 105 TR): * **Tenderometer Reading (TR)** *

9 Photographs

Photo 1: Typical conventionally cultivated Midichi crop at emergence.

Photo 2: Typical direct-drilled Midichi crop at emergence.

Photo 3: Typical conventionally cultivated Ashton crop at emergence.

Photo 4: Ashton crop with high % ground cover at flat pod.

Photo 5: Midichi crop with high % ground cover at flat pod.

Photo 6: Midichi crop with low % ground cover at flat pod.