SOWING DATE AND SEED TREATMENT EFFECTS ON AUTUMN SOWN VINING PEAS (*PISUM SATIVUM*)

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by

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LINCOLN COLLEGE

1985

CERTIFICATE

I hereby certify that the work embodied in this dissertation was carried out by the candidate under my immediate supervision.

J.G.H. White
(Supervisor)

Abstract of a thesis submitted in partial fulfilment of the requirements for the Degree of B.Agr.Sc.(Hons.)

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BY R.L. DICKSON

Autumn-winter sowing of vining peas (Pisum sativum) is not practised in Canterbury, New Zealand, although some farmers have been sowing some cultivars of field peas for many years. A field experiment to measure emergence and winter survival of autumn sown vining peas was established on a Wakanui silt loam at Lincoln College. The cultivar Pania was sown on March 25th, April 15th, May 7th and May 30th, using seed which was treated with either captan or captan plus metalaxyl (Apron SD 70 WP).

The total emergence for the March 25th, April 15th, May 7th and May 30th sowing dates was 89, 84, 72 and 79% respectively. The emergence times were 8, 13, 13 and 15 days for the above sowing dates. Compared to the March sowing the total emergence of the April and May sowings decreased by 5.5%, 13% and 11% respectively. At August the plants in the May sowings had a shorter internodal distance which decreased 6.5 mm, 3.2 mm and 2.4 mm for the mean monthly temperature changes of 1.2, 4.6 and 1.7^{o}C. Consequently the plants in the May sowings developed a rosette stature which increased their winter tolerance as all leaves were green and normal. In early August the plants in the March and April sowings had only 24% and 45% of their nodes with actively photosynthesising leaves due to the infection of bacterial disease (Pseudomonas syringae), probably accentuated by frost damage. The bacterial disease killed the leaves on nodes 1 to 8 and 1 to 7 on the March and April sowings respectively. Aphids colonised all of the sowings except the fourth, but by the end of August overwintering aphid populations were reduced due to increasing plant height and diseased foliage providing an unsatisfactory environment. The March and April sowings flowered in early June and August at times when frost injury may have caused flowers to abort.

Some recommendations for autumn sowing of vining peas are discussed.

Additional keywords - Metalaxyl, Captan, *Pseudomonas syringae*, Emergence, Pania, Cold Tolerance.

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CHAPTER 1

Review of Literature

1.1 Introduction

In New Zealand vining peas are the most important processed vegetable crop with 8330 hectares used for canning and freezing, out of a total pea area of 26500 hectares (Agricultural Statistics 1983). Hawkes Bay and Canterbury are the main districts, growing 3200 and 3100 hectares respectively. These provinces grow most of the vining peas due to favourable soils, climate, and proximity to processing factories and export outlets.

In Canterbury all vining peas are sown in the spring (Aug-Nov) and are harvested from early December to late January. Sowing of vining peas in the autumn is not practised, although advocated seventeen years ago by (White (1968). Some local farmers have been sowing some cultivars of field peas in autumn for many years.

The sowing of vining peas in the autumn could confer the following advantages:

(a) The processing companies could commence harvesting one month earlier eg. (early-mid November), thus making more economical use of capital and labour (White 1968).

(b) The earlier harvest would allow greater flexibility in cropping programmes, thus with irrigation a second cash crop such as green beans or barley, could be grown after the peas, a forage crop sown, or the paddock fallowed for weed control before pasture is sown.

(c) The early sowing of vining peas would allow the extension of this crop to shallower droughty soils (eg. Chertsey silt loam) because most physiological processes would be completed before water stress occurred.

(d) Autumn sown crops are already established by early spring and therefore may take less time to reach optimum leaf area index and therefore intercept solar radiation over a longer time period than corresponding spring sown crops. Hence, autumn sown vining peas are potentially higher yielders than spring sown vining peas.

(e) High temperatures later in the spring cause rapid development and small plants with disproportioned growth to development. Autumn sown vining peas are established early in the spring and will have undergone sufficient growth before the high spring temperatures.

(f) On less moisture retentive soils which are irrigated, yields may rise, or the cost of irrigation may be avoided.

However there are possible disadvantages with autumn sowing of vining peas.

1.1.1 Waterlogging

Autumn sown vining peas grown on heavy soil types (eg. Temuka silt loam) may have an increased incidence of water logging from heavy autumn rains, causing growth to be reduced or plant death (Scott 1982, Greenwood and McNamara 1985).

1.1.2 Disease

Aphanomyces root rot (<u>Aphanomyces euteiches</u>) is one of the most destructive pea diseases. It persists in the soil from year to year. Soil moisture is a major factor controlling Aphanomyces infection and development. Water logging and cool temperatures accelerate the spread of the disease and aids its formation with disease complexes (eg. Pythium). For this reason, autumn sown vining peas on soils with an impeded drainage could be susceptible to attack, particularly if combined with a high Aphanomyces index (Pfender 1984). To date there is no simple method of controlling this disease other than using crop rotations, or growing brassica crops (Brassica napus, Raphano brassia and sinapis albo) in infested soils. Subsequent incorporation of roots alone causes a reduction in the Aphanomyces index (Chan, 1985).

The incidence of downy mildew (Peronspora vicia casp), bacterial blight (Pseudomonas sp) and fusarium root rot (Fusarium solani) may also increase because of moist conditions resulting from the autumn/winter rains.

1.1.3 Frosting

The frosting of vegetative growth is a high risk, particularly if sowing is too early. Also, a late spring frost could cause the abortion of the earlier flowers and damage to pods resulting from autumn sowing.

1.1.4 Bird and Insect Damage

Bird damage could occur during emergence in the late autumn/ winter period when other food sources are scarce.

Aphids may fly during the autumn and overwinter on the earlier sown pea crops causing the infection of virus diseases (eg. Pea Top Yellows) in susceptible varieties.

1.2 Sowing Date

The lack of sensitivity to daylength allows peas to be planted in autumn and harvested in late spring or early summer before any hot dry weather, particularly in the subtropical countries (Australia, India) where winter conditions are mild (Sutcliffe and Pate 1977). Vining pea crops must be sown at a time in the autumn to allow sufficient heat unit accumulation for harvesting at some scheduled time in spring suitable to the processing companies. In addition sowing time has to be carefully gauged to ensure that seedling size is optimal for maximum winter survival (Markarian and Anderson 1966).

Crop development of peas is mainly controlled by temperature. This was emphasised by Boswell (1926), who stated that "temperature is the most potent climatic factor affecting the yield and development of the pea plant" (refer Figure 1).

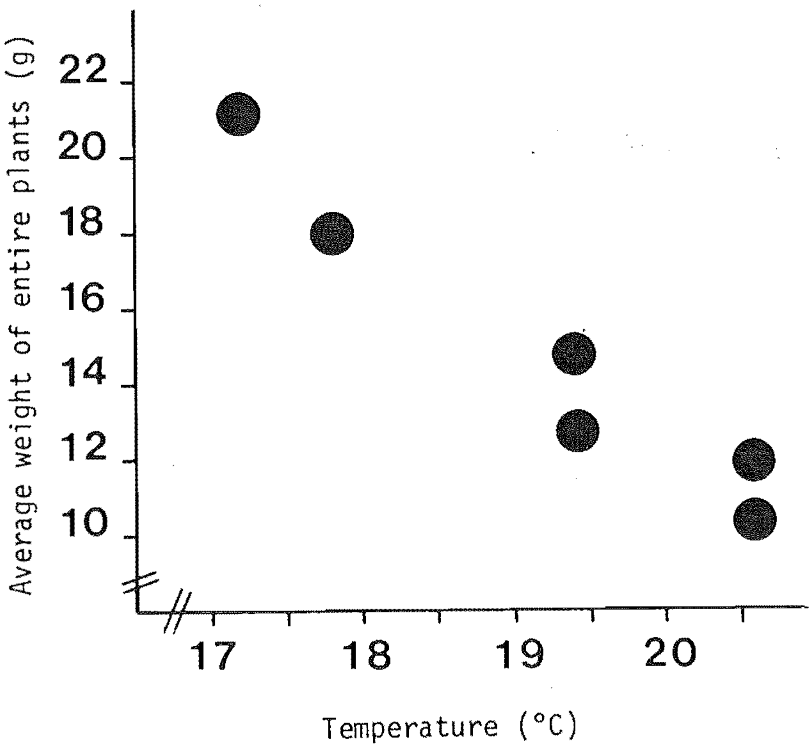

Figure 1: Influence of temperature upon growth and development of garden peas (1922).
Boswell (1926)

Figure 1 illustrates that if peas are sown late in the spring they experience high temperatures which leads to fast development and minimum growth, ie. reduced plant size and final yield due to an unbalanced growth to development ratio. This was supported by Milbourn and Hardwick (1968), and Silim, Hebblethwaite and Heath (1984), who noted that late spring sown pea crops had reduced yields. Silim <u>et al</u> (1984) concluded that this was because of water stress, high temperature and a shortened growing season. In Australia, early and late plantings of field peas (cv Provider) were carried out from April to October (Krudger 1973). By delaying plantings, the total number of days to maturity increased until June 12th, but then the number of days decreased due to increased temperature. It was concluded that temperature was most important for pea development and daylength and solar radiation less significant.

In eastern Australia research on 44 species of crops by Angus, Cunningham, Moncur, and Mackenzie (1980) showed that the base temperature for the field pea was 1.5^{o}C and it required 110.3 accumulated heat units (Degree days) to germinate. The base temperature refers to the minimum temperature at which pea plant growth will occur. Accumulated heat units describes the amount of time the pea plants have been subjected to a temperature above the base temperature. Using the above heat unit theory a plan to timing of sowing and harvesting of vining peas in the spring was stated by Katz (1951). However there is little published information on autumn sowing of vining peas. Most sowing date research has concentrated on spring sowings (Boswell 1926, Procter 1963, Milburn and Hardwick 1968, Krudger 1973).

In Britain, Silim _et al_ (1984) conducted experiments between 1978 and 1981 to investigate the effects of autumn and spring sowing on emergence, winter survival, growth and yield of field peas. Both spring (Filby, vedette) and winter hardy (Frimas) cultivars were used. They found from the time of sowing to fifty percent emergence, November and March sowings were slower than September, October and April sowings. The November sowings had a higher degree of winter survival than the earlier sowings. The dry matter production and photosynthetic area of the autumn compared to the spring sown crops varied considerably between seasons. Yield data showed that when winter survival was adequate autumn sown crops produced similar seed yields to spring sowings. The November sowings matured 2 to 4 weeks before the March sowings, but this depended on cultivar and season. The optimum sowing dates were found to be mid November and March. Large seed yield reductions occurred when sowing was delayed until April, a general finding by many workers (Boswell 1926, Proctor 1963, Salter and Williams 1967, Milbourn and Hardwick 1968, Krudger 1973).

In conclusion Silim _et al_ (1984) indicated that late sown autumn crops of spring varieties as well as winter hardy Frimas were able to survive the overwintering period and mature earlier producing comparable yields to spring sowings, especially if moisture became limiting. However the potential benefits arising from autumn compared to spring sowings were lost if water stress did not become limiting. This interaction required further investigation. These researchers also stated that there is a higher risk of crop failure through autumn sowing due to winter kill.

1.3 Emergence of Vining Peas

In New Zealand the importance of optimum plant populations is well established (White and Anderson 1974). One of the key factors in achieving these optimum populations is the use of high quality seed. The proportion of pea seed actually producing seedlings in the field is frequently less than the germination potential, because of unfavourable environmental conditions such as low soil temperature and moisture. Field emergence may be further reduced when seed is of low vigour (Hampton 1984). Seed vigour was defined (Hampton 1984) as those properties of seed which influence the speed and uniformity of germination and the ability of the seed to germinate and emerge under a wide range of field conditions.

It has been shown that seedling emergence is an expression of a complex interaction of the seed and soil factors acting at or after the time of sowing, namely soil type, method of seed bed preparation, soil aggregate size, fertiliser level, moisture and temperature levels (Sale and Harrison 1964). In India, Sandara Sarma and Nagarojaroa (1981) looked at the emergence of different crops in relation to soil physical conditions. A co-efficient of seedling emergence indice was derived for evaluating seedling emergence percent and rate:

(1) Co-efficient of velocity of emergence, (Cv) is given by:

$$Cv = f1 + f2 + f3 + f4 + \ldots\ldots fn/e1T1 + e2T2 + e3T3 + e4T4 + \ldots\ldots enTn \qquad (1)$$

where fn is the frequency of seedlings emerged at any particular time.

en is the number of new seedlings emerged on the nth day.

Tn is the time in days up to nth observation.

This index number was found to increase with increases in the number of emerged seedlings and with the decrease in emergence time. Chaudhary and Ghildyal (1970) looked at the emergence of rice seedlings and derived a formula also taking into account seedling emergence percent and rate. This was called an Emergence rate index (ERI).

Adverse soil physical conditions effect pea seedling emergence. In Britain, when soil was compacted by tractor wheels plant populations were reduced by 50% and yield by 65%. In a laboratory trial the number of fibrous lateral roots were reduced when the soil bulk density increased from 1.05 to 1.40 g/cm^3 (Dawkins et al 1981). The same trends were shown by Hebblethwaite and McGowan (1980) who found that plant populations on wheelings were reduced by 31% and yield by 46%.

1.4 Winter Survival

For autumn sown peas to survive and produce an acceptable yield in temperate climates it is necessary for the plants to survive the winter. In Hungary, a number of cold tolerant field pea cultivars have been developed in the past (Acikgoz 1981) (eg. winter hardy, "Austrian pea"). However, in areas where winters are severe, winter killing of autumn sown peas is still a problem. This was supported by Hebblethwaite (1978) who noted that there was a lack of winter hardiness by pea cultivars and winter kill was a problem at Sutton Bonington. In a trial carried out by Acikgoz (1981), a negative relationship was found between winter survival and leaflet growth, with leaflet length and width (leaflet size) significantly correlated with winter survival. The main cause of this significant correlation was that spring pea cultivars used in the trial produced large leaflets and had very low survival values.

In Britain processing peas were sown on August 16th, Sepember 1st, September 16th, September 30th, and October 21st (Dowker

1969). The mid August and early September sowings had a lower winter survival than those in mid or late September or October because of the larger leaflet area. This supports Markarian and Anderson (1966) who found field peas needed to emerge slowly and form a compact rosette of tillers if they were to survive the low temperatures of winter. Winter hardy peas exhibit weak apical dominance and branch freely at ground level. Silim et al (1984) also found that November sown peas in Britain had the greatest winter survival compared to the September and October sowings, because they had smaller leaflet areas. In the same trial a growth regulator PP333 (Paclobutrazol) was applied to a spring field pea cultivar, Filby, which was sown in September. There was a better winter survival due to reduced plant size.

1.5 Seed Treatment

Autumn sown pea crops are in the ground for longer and during the winter months, hence they are more susceptible to disease attack. The various diseases that attack peas include fungal organisms such as Pythium spp, Ascochyta (Mycosphaerella pinodes), Fusarium root rot, Fusarium wilt (Fusarium oxysporum), downy mildew, Aphonomyces root rot (Aphanomyces euteiches) and Bacterial blight causing pre and post damping off (Brien, Chamberlain, Cottier, Cruickshank, Dye, Jacks, and Reed 1955 and Claridge 1972). However the main fungus disease is downy mildew (Peronospora vicia casp) which causes a loss in yield by reducing plant density (Gent G.P., pers. comm.). In Britain downy mildew is the most common foliar disease of pea plants, during most growth stages (Miller and de Walley, 1981). The incidence of this disease is higher in wet seasons and is particularly associated with early sowings. Attempts in the United Kingdom to control pea downy mildew with fungicides have in the past been disappointing (King and Gane 1965 cited in Miller and de Walley 1981), but control has recently been achieved using the systemic fungicide metalaxyl [± -methyl N-(2-methoxyacetyl)-N-(2,6-xyiyi) alaninate], (Smith 1979). In small plots and grower trials metalaxyl reduced the incidence of downy mildew and increased plant establishment and vigour, by reducing the primary infection phase of downy mildew to near zero and thus limiting the secondary infection phase (Miller and de Walley 1981). Superior control of Pythium damping off was also noted, as increases in plant populations were achieved when levels of primary mildew infections were low.

In New Zealand field trials were run to evaluate seed treatments with metalaxyl, metalaxyl plus captan [N-(trichloromethylthio) cyclohex-4-ene-1,2-dicarboximide] (Apron SD 70 WP) and other fungicides on peas (Trawally, Noonan, Close 1984). The results showed that metalaxyl seed treatments gave increasing seedling establishment and treatments inhibited the development of downy mildew on pea plants for about six weeks after sowing. Further results (Trawally 1984), showed that seedling establishment in late sown pea crops, under stress, was enhanced by metalaxyl seed treatment. It was also shown that captan and drazoxolon were good protectants against downy mildew (P. viciae) during early stages of growth but conferred no protection to the later stages. These fungicides increased the plant survival early in the crops life causing humidity to increase and downy mildew outbreak later when systemic protection was not present. A controlled glasshouse trial run by Trawally (1984) showed that when pea seeds, treated with metalaxyl, were sown into a soil at low temperature, higher germination percentages were observed compared to seeds treated with other systemic fungicides. It was also shown that at high soil temperature and moisture, metalaxyl treated seeds established better than seeds treated with other fungicides. For untreated pea seeds, seedling mortality increased with time because of post emergence damping off. This was not proved under field conditions.

1.6 Objectives and Hypotheses

The objectives of this project were to:

1. Establish the optimum sowing date for vining peas during the autumn period between March and May, measured by the rate of emergence, final plant population, disease incidence and winter survival data.

2. To assess the effectiveness of metalaxyl plus captan (Apron SD 70 WP) in preventing the incidence of downy mildew and pre and post emergence dampening off in autumn sown vining peas.

The study is based on the following hypotheses:

1. March and April sown vining peas are likely to have longer vines and therefore large leaflet areas which are more susceptible to frost kill.

2. Delaying the autumn sowing date may decrease emergence rate of seedlings and final plant population.

3. Seed treated with fungicides containing metalaxyl may have a lower incidence of pre and post damping off, due to the resulting plants having a lower incidence of downy mildew.

CHAPTER 2

This experiment was designed to provide information on the effects of four different autumn sowing dates and two seed treatments on the emergence and winter survival of vining peas. The cultivar "Pania" was chosen because it is commonly grown for processing in Canterbury, and is resistant to Pea Top Yellows Virus, Bean Yellow Mosaic Virus and Pea Wilt (Jermym 1983).

2.0 MATERIALS AND METHODS

2.1 Experimental Methods

The experiment was a randomised block design with four sowing times, two seed treatments and five replicates.

2.1.1 Calculation of sowing date

Pea plants were assumed to require 110 degree days above a base temperature of 1.5 degrees celsius to emerge (Angus et al 1980). The four sowing dates were then positioned from a calibration curve plotted from previous yearly averages (Gallagher, Hines and Baird 1982) which predicted that emergence of pea plants would occur in the early autumn (early April), mid-autumn (late April/early May), and late autumn (late May), (Table 1).

PLATE 1 General view of experimental site showing the trial layout. The front three plots show, from the left, an April 15th, May 7th and March 25th sowing. Four aphid traps are shown in the centre of the trial (photographed May).

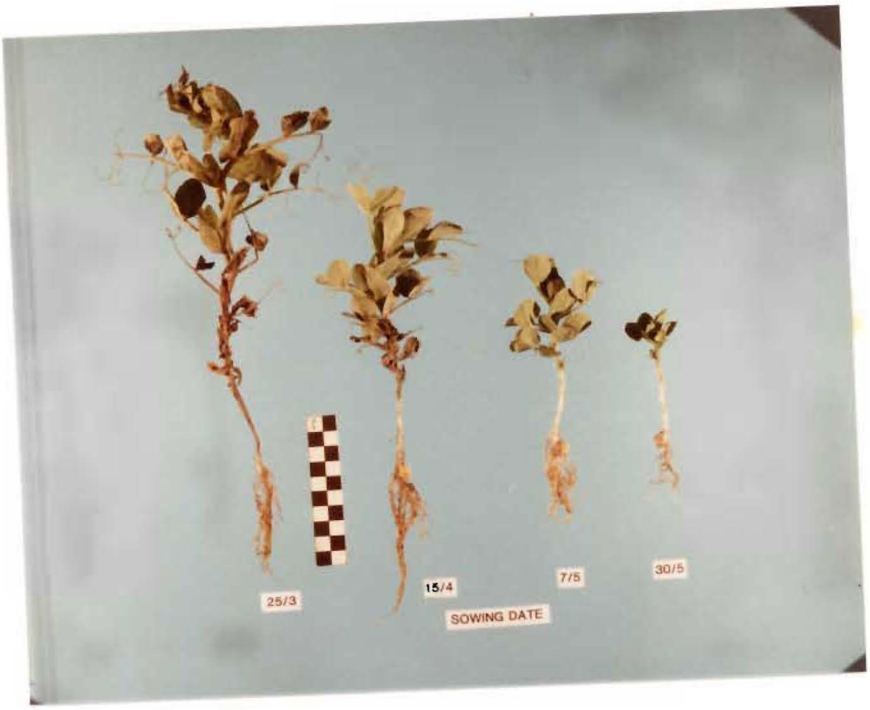

PLATE 2 Stage of development of Pania peas, sown at four dates, in July.

Table 1

Sowing and Expected Emergence Dates

Sowing time	Estimated Emergence
March 25th (T1)	April 5th
April 15th (T2)	May 2nd
May 7th (T3)	June 5th
May 30th (T4)	June 27th

2.1.2 Seed Vigour Determination

The bulk seed size was relatively uniform, with only a 20% by weight variation between the top and bottom 10% (seed size) of the sample. The thousand seed weight was 213.6 g.

The seedling vigour tests were carried out according to Scott and Close (1976). The results were as follows (Table 2):

Table 2

Results from the Seeding Vigour Test

Germination	98%
Expected field emergence	88%
Conductivity	20 Micromohos Per Gram
Hollow Heart	9%

2.1.3 Seed Treatment

The seed was treated with two fungicides, Captan and Apron SD 70 WP. The application rates were as follows:

Apron SD 70 WP - 70g ai Captan + 70g ai metalaxyl/100 kg Seed
Orthocide 65 - 70g ai Captan/100 kg Seed

The chemical was applied to the seed with a knap sack sprayer and mixed in a concrete mixer. The mixing of chemicals and seed was done for a minimum period of five minutes.

2.1.4 Experimental Site

The experiment was conducted in paddock A 3/4, on the Lincoln College's Mixed Cropping Farm (Plate 1). The soil type was a Wakanui silt loam (Ward, Harris and Schapper 1964) which had previously been in wheat. After burning of the wheat stubble the site was cultivated. This procedure was carried out on the 8th-15th of March, by ploughing, grubbing, harrowing, and cambridge rolling. During cultivation a pre-emergence herbicide Trifluralin was applied at a rate of 1.0 kg ai/ha for weed control.

2.1.5 Drilling

One thousand pea seeds per plot were sown at a 5 cm depth with a 10 coulter Oyjord drill at a speed of 7 km per hour. To avoid soil compaction within the plots the tractor wheels were inverted to give an inside tyre width of 1.9 metres.

Each plot was 1.5 m by 5.0 m. No plots needed recultivating before any of the sowings, as no adverse weather conditions, or weed infestations occurred.

2.1.6 Soil and Seed Analysis

Chemical and disease analyses were carried out by Ministry of Agriculture and Fisheries (M.A.F.) on the north and south end soils. Also, the seed was tested for *Aphanomyces euteiches* and *Ascochyta pisi*. Refer to Tables 3 and 4.

Chemical Analysis

Table 3

Soil Quick Test Results

pH	Ca	P	K	Mg
6.2	16	24	7	8

Because of the satisfactory pH and high available phosphate levels, no lime or superphosphate was necessary for the trial area.

Disease Analysis - A test for Aphanomyces root rot.

Table 4

Soil and Seed Disease Tests

Aphanomyces Root Rot index = 0

Ascochyta = None detected

The above diseases were below critical levels.

2.1.7 Measurements

Ten plants per plot were randomly sampled in early August. The various stages of plant growth at sampling, are shown for each sowing in Plate 2.

The roots were washed and the stems cut at the first node to differentiate between the roots and shoots. Node number and vine length from the first node were measured and the nodes that had photosynthetically active leaves (ie. fully expanded) were recorded. This measurement indicated if the lower leaves of the earlier sowings were diseased or frosted. For one replicate the leaf area of the individual actively photo-synthesising leaves was measured using a Licor model 300 leaf area metre. The presence of flowers or of aphids was recorded by noting presence or absence. Finally root and shoot dry weights were determined after drying at 80 degrees celsius for 24 hours. Ten plants were randomly selected from the first two sowings and sent to the Plant Protection centre of M.A.F. (Lincoln), for foliage disease identification.

2.1.8 Calculations and Analyses

The coefficient of velocity of emergence for each sowing date was calculated according to Sundara Sarma and Nagarajarao (1981). The experiment was analysed using the Genstat statistical package to determine differences in seedling emergence, final plant populations, incidence of disease, presence of aphids and flowers between sowing dates and seed treatments.

2.2 Meteorological Data

The meteorological data was obtained from the Lincoln College Meteorological Station (Table 5).

Table 5

Meteorological Observations Made at Lincoln College, During the Months of March to July

Month	Mean Temp.	Mean Soil Temp (20 cm)	Total Precipitation (mm)	Days of Frost	Accumulated Temp. > 0 Degrees Celsius
March	14.6	14.2	40.5	3	495.0
	1 (15.5)	(15.8)	2 (44.6)	3 (1)	1 (483)
April	13.4	12.5	6.6	7	304.0
	1 (11.2)	(11.2)	2 (54.8)	3 (8.2)	1 (362)
May	8.8	8.2	31.8	13	285.0
	1 (8.6)	(7.7)	2 (51.1)	3 (14.3)	1 (279)

Table 5 (continued)

Month	Mean Temp.	Mean Soil Temp (20 cm)	Total Precipitation (mm)	Days of Frost	Accumulated Temp. > 0 Degrees Celsius
June	7.1	5.5	21.0	13	177.0
	1 (6.5)	(5.4)	2 (34.3)	3 (17.6)	1 (183)
July	6.9	5.1	44.7	16	215.0
	1 (5.7)	(5.4)	2 (68.0)	3 (15)	1 (189)

Long Term Means - 1 1976-1984 : 2 1930-1981 : 3 1982-1984

The growing season was the driest on record with 142 deficit days (i.e. where evapotranspiration exceeded rainfall). April had the lowest rainfall during the trial with 28 deficit days, which was the driest this month has been for 105 years. The mean air and soil temperatures were approximately 1 degree celsius higher than normal. The warmer temperatures were very conducive to aphid flights which were very prolific and were occurring up until early June. The aphid flights were recorded weekly by counting the number of aphids captured in four aphid traps (Plate 1).

CHAPTER 3

Results

3.1 Seedling Emergence

The initial emergence was subjectively measured. It was assessed as the day when the first plumules appeared in any of the plots. The initial emergence of the March and late May sowings occurred on the predicted date, but the April and early May sowings began emerging approximately one week early.

3.2 Final Plant Population

The total emergence values of the March 25th, April 15th, May 7th and May 30th sowings were 89%, 84%, 72% and 79% percent respectively (Figure 2). Compared to the March 25th sowing the April 15th, May 7th and May 30th sowings final emergence decreased by 5.5%, 13%, and 11% respectively. The late May sowing had a total emergence which was 8% higher than the early May sowing. These differences were highly significant ($p < 0.001$). As the sowing date was delayed the final plant populations decreased for both seed treatments. However the plots sown with metalaxyl plus captan treated seed had a mean total emergence which was 2% (23 plants) less than the plots sown with captan treated seed.

3.3 Rate of Seedling Emergence

The rate of seedling emergence was significantly ($p < 0.001$) different between sowing dates, but not between seed treatments. The differences in the rate of seedling emergence are illustrated by the slopes of the lines in Figure 2. Also the coefficient of velocity of emergence (Cv), which is an index describing the relationship between the number of emerged seedlings and the time taken for total emergence, is shown in Table 6. The emergence times (i.e. from initial to final emergence) of the March, April and two May sowings were 8, 13, 13 and 15 days respectively.

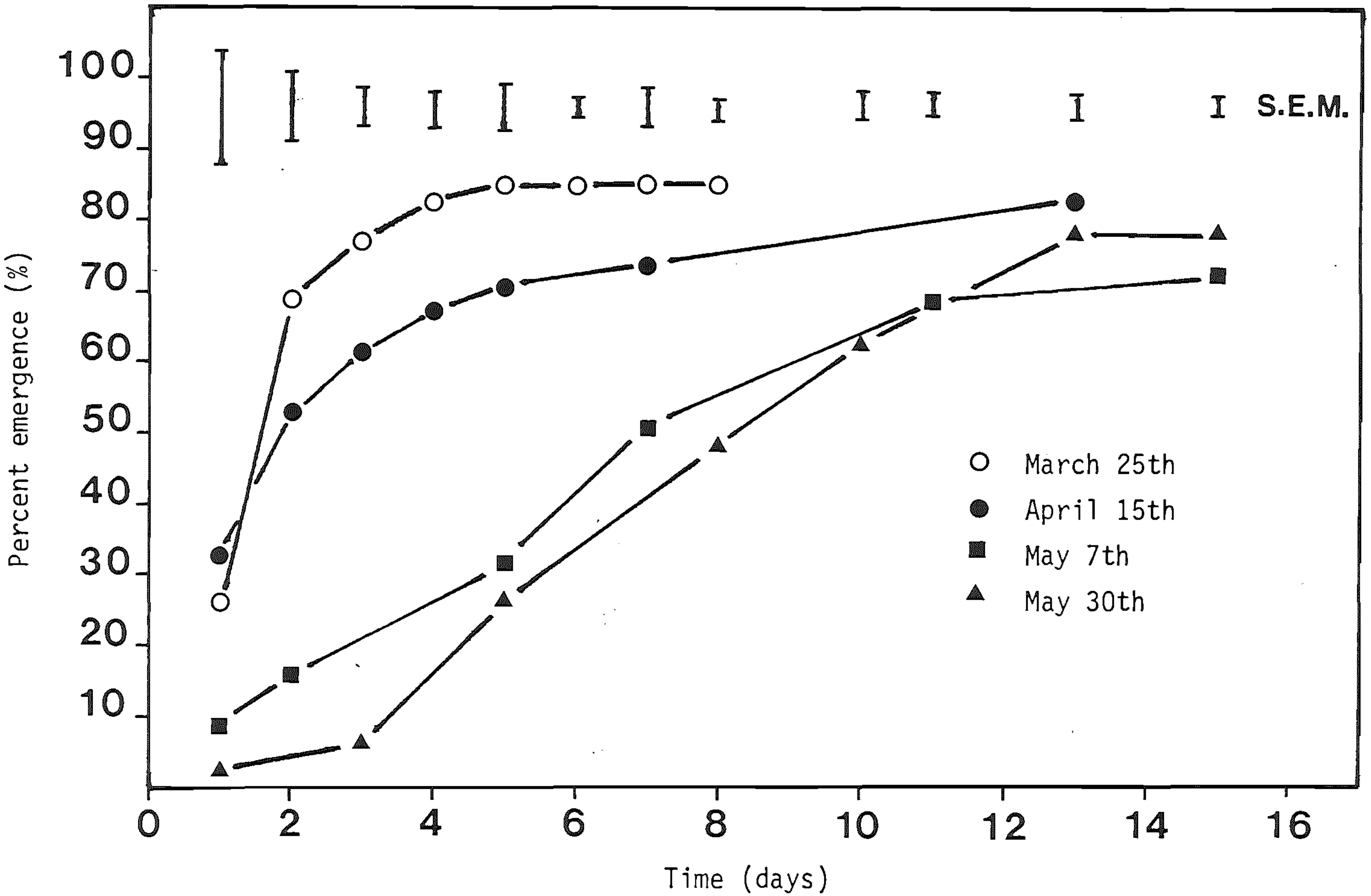

Figure 2: A relationship between percentage emergence and time (days) from initial emergence.

Consequently the March and April sowings had a higher rate of seedling emergence, and Cv, compared to the two May sowings. As the rate of seedling emergence slowed the time from drilling to initial emergence increased 16 days, from the first to the fourth sowing (Table 6).

Table 6

Days to initial emergence and the coefficient of velocity of emergence (Cv) for the each sowing date

Sowing Date	Days to initial Emergence	Coefficient of velocity of emergence (Cv)
March 25th	11	1.83
April 15th	13	0.20
May 7th	19	0.07
May 30th	27	0.09
SEM		0.15
Level of Significance		**

** $p < 0.001$

The dates of initial emergence were subjectively measured and they were the same for all of the ten plots at each sowing date, consequently there was no variation to be shown for column 1 in Table 6.

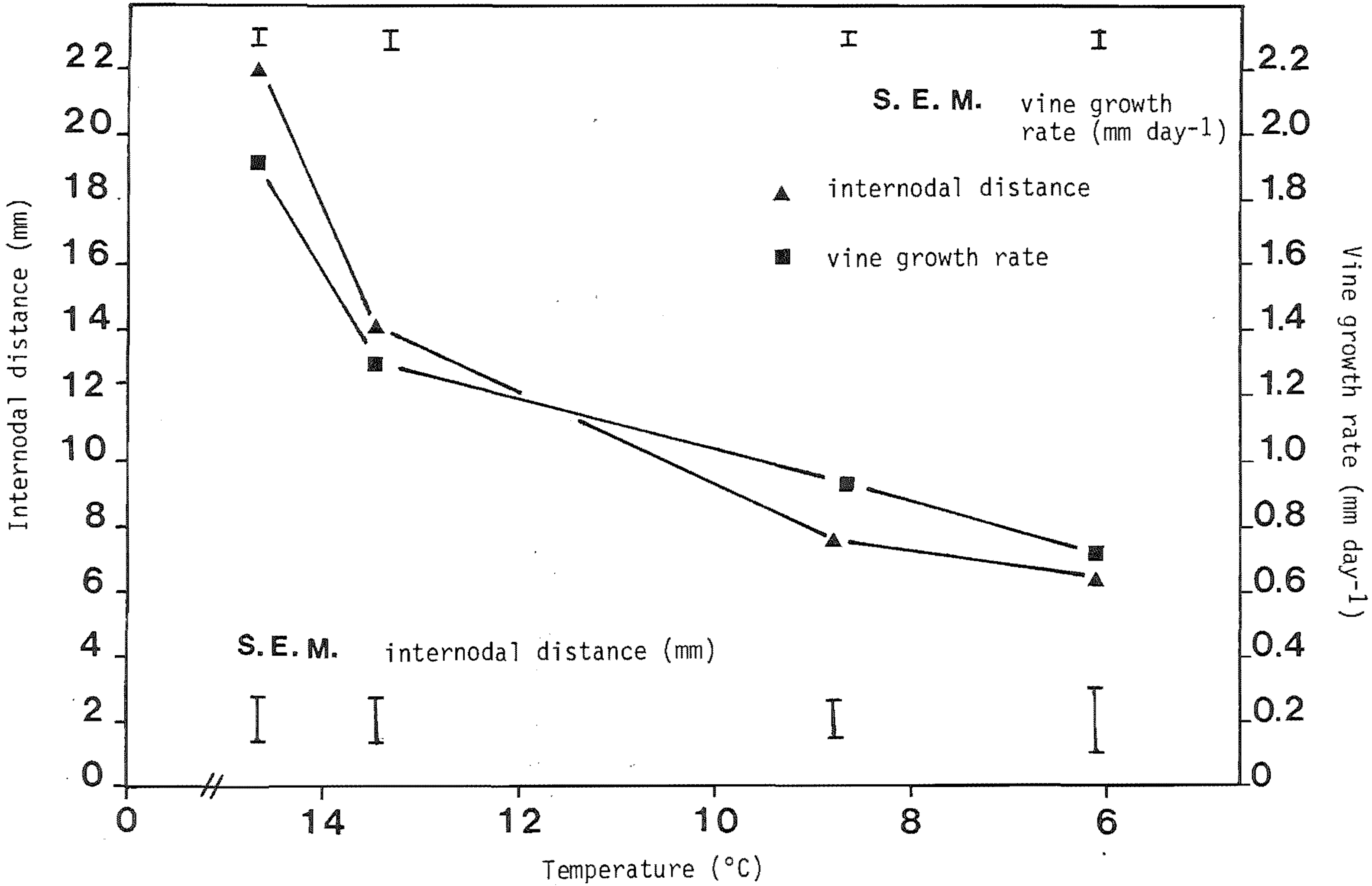

Figure 3: Relationship between internodal distance (mm), vine growth rate (mm day^{-1}) and temperature (°C).

Compared to the first sowing the Cv of the second, third and fourth sowings decreased by 89%, 94% and 93% respectively. This increased the emergence time and possibly caused the reduction in total emergence.

3.4 Vine Growth Rate

The mean vine growth rate decreased 1.07, 0.64 and 0.15 mm day^{-1} for the mean monthly temperature changes of 1.2, 4.6 and 1.7 degrees celcius respectively.

Figure 3 shows that the March sowings had higher growth rates and longer vines compared to the April, early and late May sowings respectively.

3.5 Internodal Distance

As the mean monthly temperature decreased by 1.2^{o}C, 4.6^{o}C and 1.7^{o}C, the mean internodal distances decreased 6.5 mm, 3.2 mm and 2.4 mm respectively (Figure 3). This showed that as autumn temperatures decreased, growth per unit of development decreased (i.e. less vine growth per node formed). Some secondary branching occurred in the early and late May sowings, which had plants with a postrate growth habit (Plate 3b).

3.6 Percentage of Nodes with Fully Expanded Leaves

PLATE 3a

(A)

PLATE 3b

(B)

Percentage of nodes with fully expanded, actively photosynthesising leaves at each sowing date.

(A) Sowing dates T1 and T2 with nodes 1-10 severely infected with disease and damaged by frost.

(b) Sowings T3 and T4 disease free and not damaged by frost. (Photographed early August).

Table 7

The percentage of nodes with fully expanded leaves

Sowing Date	Percentage of Nodes with fully expanded Leaves
March 25th	24
April 15th	45
May 7th	61
May 30th	40
SEM	8.2
Level of significance	**

** $p < 0.001$

The first two sowings were less photosynthetically efficient as 86% and 50% respectively of their leaves were diseased. All of the leaves on the bottom nodes were dead for the first sowing. The third sowing had the most photosynthetically efficient plants, because they had a higher proportion of disease free leaves. The fourth sowing did not have diseased plants, but they did have a reduced photosynthetic area, compared to the earlier sowings. However, compared to the March sowing the May 30th sowing had a higher (16%) proportion of leaf area per plant.

Plate 3a shows that in early August the first sowing had leaflets on nodes 1 to 8 severely diseased with <u>Pseudomonas syringae</u>

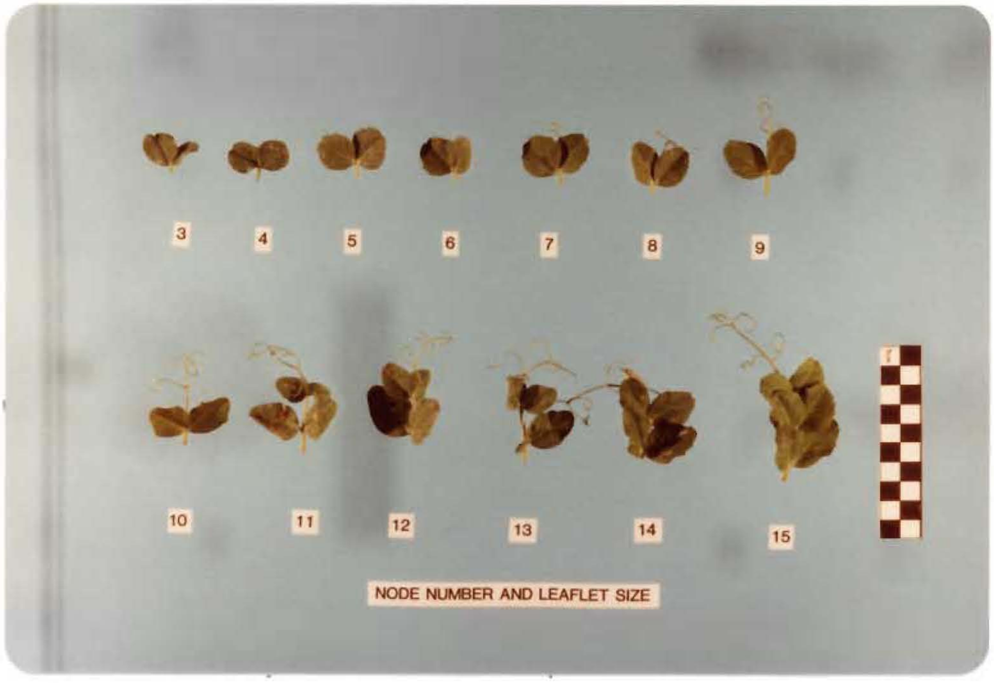

PLATE 4 Leaflet size from nodes 3-15 in late July
(Nodes 3-9 May sowings, Nodes 10-15 March/April sowings).

'LATE 5 A plot showing the typical foci pattern of Bacterial disease (Pseudomonas syringae) attack in association with frost damage in a March sowing. (Photographed mid August).

(M.A.F. Identification) and possibly frost damaged, while leaflets on nodes 1 to 7 were diseased in the second sowing. Plate 3b shows the third and fourth sowings did not have any leaflets diseased or frosted.

3.7 Leaflet Area Index

Leaflet area index was only recorded for one replicate and consequently was not analysed statistically. However the figures do give an indication of the possible cold tolerance of the four sowings (Table 8).

Plate 4 shows that the first and second sowings had larger leaflets on nodes 10 to 15 than the third and fourth sowings which had smaller leaflets on nodes 1 to 7.

Table 8

Leaflet area index of the four sowing dates

Sowing Date	L.A.I.
March 25th	0.94
April 15th	0.65
May 7th	0.34
May 30th	0.10

3.8 Winter Survival

Bacterial disease moved through the March and April sowings by forming central foci patterns (Plate 5). These sowings had the lowest winter survival and by the end of October all of the plants from the March sowing were dead. The May sowings emerged more slowly to form rosette type plants with small leaflets which conferred a superior overwintering ability (Plate 3b).

3.9 Aphids

Table 9

Percentage of pea plants colonised by aphids in August

	March 25	April 15	May 7	May 30
Percentage of plants colonised by Aphids	3	15	17	0
S.E.M.	1.4	3.6	5.0	0.0
Significance of single d.f. orthogonal comparisons	March vs April **		May 7th vs May 30th *	

** $p < 0.001$

* $p < 0.05$

The March sowings had significantly less overwintering aphids compared to the early May sowing. The last sowing had no overwintering aphids.

3.10 Flowering

Flowering commenced in early June and August for the March and April sowings respectively (Plate 3a). The early May sowings flowered late September. Flowering was found to be highly significantly different ($p < 0.001$) for sowing date.

CHAPTER 4

Discussion

4.1 Emergence

4.1.1 Initial Emergence

Although the emergence date was predicted correctly for the March 25th and May 30th sowings, the April 15th and May 7th sowings emerged one week early, probably because the temperature of the autumn was above average, particularly during April and May (Table 5). This would have accelerated seed germination.

4.1.2 Emergence Rate and Total Emergence

Delaying the sowing date decreased the emergence rate and increased the time from germination to initial and final emergence (i.e. the Cv decreased because less seedlings emerged and the emergence time increased). This supports overseas work where wheat seedling emergence rates decreased as sowing date was delayed, probably due to cooler soil temperatures resulting in decreased seedling vigour (Chaudhary and Ghildyal 1970, Anon. 1982). The slower emergence of the pea seedlings may have reduced total emergence because of the extended period of risk to pre-emergence attack by soil pests and disease (eg. Pythium). Also, the lack of winter hardiness of the spring pea cultivar Pania may have delayed and reduced total emergence. This supports Silim et al (1984) who concluded that the lack of winter hardiness of the French Field pea cultivar 'Frimas' delayed and reduced total emergence. Finally, The 8.0% increase in total emergence in the late May compared to the early May sowing may have been due to increased seedling mortality in the May 7th sowing, because of limited soil moisture reducing seedling emergence (Doreen and MacGillary, 1943). The autumn was dry, especially April (Table 5). Consequently the available soil water levels may have been low when the May 7th sowing was emerging reducing seedling emergence. By the end of May and mid June the soil water pores would have been recharged from increased rainfall (Table 5). Hence, 8% more seedlings emerged for the May 30th sowing, which also increased the Cv index by 0.02.

4.2 Optimum Plant Population

The results show that the March and April sowings emerged rapidly and had a total emergence equivalent to the calculated expected field emergence of 88%. The early and late May sowings emerged more slowly and had a total emergence that was approximately 10% below the expected field emergence (Figure 2). The possible reasons for the higher total emergence of the early sowings are that the months of March and April were mild and had soil temperature and moisture levels equivalent to the spring (Gallagher et al, 1982). Hence the total emergence, and rate of emergence were similar to a spring sown crop of vining peas. For 1985, the calculated seeding rate, using 88% as the expected field emergence value, was correct for establishing optimum plant populations of 120 plants m^{-2}, as found by White et al (1982) for spring sowings. However as the sowing date was delayed to May, field conditions were less favourable reducing total emergence. Hence to establish plant populations equivalent to the early sowings the seeding rate would needed to have been increased by approximately 20 kg ha^{-1} and 60 kg ha^{-1} for the early and late May sowings, to allow for failed seedlings.

4.3 Seed Treatment

The results indicate that captan was a significantly superior protectant against pre emergence dampening off organisms. The mean final plant population was 2.8% higher than the captan plus metalaxyl seed treatment. The reasons for this difference are unknown, because the autumn/winter season was milder and drier than normal and downy mildew or other fungal infections did not occur to thoroughly test the differences between the seed treatments. Also, the trial had five replications, which caused the small differences in total emergence values between seed treatments to be significantly different. Hence the significant test needs to be interpreted with caution. Significant differences depend on the number of samples taken as well as on the magnitude of the differences between populations and their variances (Beckett and Webster 1971). Agronomically, the 2.8% difference in total emergence between seed treatments would not be expected to affect the final yield. Because the remaining plants, in the metalaxyl plus captan seed treatment, would exhibit plasticity and increase other yield components (eg. pods/plant, peas/pod) to compensate for the 23 plants not present. Before any conclusions can be made about the effectiveness of the metalaxyl plus captan seed treatment, the trial would need to be run for a series of seasons to test this seed treatment with different cultivars under severe downy mildew and pre- and post- dampening off infections.

4.4 Disease

The March and April sowings showed severe symptoms of disease (Pseudomonas syringae, mycosphaerella pinodes). The March sowings lodged and were less photosynthetically efficient because the leaves on the bottom nodes were dead (Plate 3a). The April 15th and May 7th sowings, had plants with more leaflets actively photosynthesising, as disease of the lower stems and leaflets did not occur to the same extent. The May 30th sowing had less fully expanded and productive leaves than the April 15th and May 7th sowings because plant growth and leaf expansion was still occurring. However, this sowing still had a higher (16%) proportion of actively photo-synthesising leaves than the plants in the March sowing. This indicates the extent to which the leaflets on these plants were diseased.

The presence of severe bacterial disease (P. syringae) is accentuated by frost damage which increases susceptibility of plant tissue to the pathogen, allowing rapid infection through the plant, (Boelema 1967). Frost damage may have accounted for the rapid spread of P. syringae in this trial, as autumn-sown field pea crops in Canterbury are more severely damaged by blight than are spring sown crops (Young and Dye 1970). Also, lodging could have accentuated the spread of P. syringae in the first two sowings. In Britain, Milbourn and Hardwick (1968) found that near harvest, pods abcissed from the lower nodes due to bacterial attack, which was caused by high humidity and low light levels near the base of the plant. These conditions prevailed for the March and April sowings, particularly after the March sowing began to lodge with increasing vine length. Mycosphaerella pinodes was the second disease identified on the plants. The two sources of inoculum of this disease could have been spores blowing into the plots from diseased pea stubble and straw, or spores already present within the soil. Secondary infection would have occurred by rain splashing spores from infected plants to others nearby (Brien et al 1955).

4.5 Winter Survival

(When northern hemisphere months are quoted, equivalent antipodeal calendar months are given in parenthesis).

The autumn and winter seasons were very favourable for the overwintering of pea plants, and the cold tolerance of Pania vining peas was not fully tested. However, by late September the March sowings had no plants alive due to a possible combination of bacterial attack (P. syringae) and frosting. Although disease was only identified on the leaves of the bottom nodes (1-8) of the March sowing, frost injury could have contributed to the lodging and browning of these plants. They had long vines and a large leaflet area which according to Acikgoz (1981) reduces their cold tolerance. The above research is further supported by Dowker (1969), who found that winter survival of early autumn sowings, in Britain, was low due to the combined effect of pathogen attack and frost injury. Frosting caused rupturing of the epidermis, death and shrinkage of the cortex, and in extreme cases severed the tops from the root system. The early and late May sowings did not show symptoms of frost injury, disease or lodging, as these sowings emerged slowly and formed small compact rosette plants with short vine lengths and a smaller leaflet area index. These results support those of Markarian and Anderson (1966), Hebblethwaite (1978) and Silim et al (1984) who found November (May) sowings had the superior overwintering ability, compared to September (March) and October (April) sowings. In Canterbury, if vining peas were to be sown during the month of May so that seedlings emerged and experienced temperatures in a range of $9.0^{o}C$ to $7.0^{o}C$, winter survival would be optimal. Because vine growth rates would be slow (0.62 mm/day), the plants would lose some apical dominance (Markarian and Anderson 1966), and branching may occur depending on the cultivar. Lodging would not occur, hence humidity would not increase within the crop. This would minimise disease and frost injury (Dowker 1969). Also the small rosette plants would support a reduced leaflet area, increasing their winter tolerance (Ackegoz 1981). March and April sowings would not be advisable if winter conditions are likely to be wet and cold, (Hebblethwaite 1978) and if an early maturing cultivar is sown which is likely to flower in the winter (refer Section 4.8).

4.6 Aphids

Peas are not attractive hosts for aphids, except for the pea aphid (Acyrthosiphon pisum). However, it was observed that aphids overwintered on all but the last sowing. Aphid traps indicated that there were eight species of aphid flying above the crop (Appendix E). However, it could not be assumed that the same species of aphid were landing on the pea plants (Ferro pers. comm.). Because of limited experimental time the aphids on the pea plants were not identified.

The March and April sowings were heavily colonised with aphids on May 28th. At this time the May 7th sowing was only emerging and was not colonised to the same extent, as the aphid flights were slowing. However, the overwintering counts on August 10th, showed that the March and April sowings had less overwintering aphids present than the May 7th sowing. This was probably because the March and April sowings were increasing in height, had diseased leaves and were expressing antibiosis, hence, providing an unsatisfactory overwintering environment (Table 9). The fact that Cartier (1963) found that pea aphid (Acyrthosiphon pisum) populations decreased as plant internode distances increased, making the foliage less dense, lends support to this possibility. The sparse foliage, caused by stem elongation and leaf disease, exposed the aphids to more parasites, predators, heat, direct sunlight and rain. Also, as the plant age increased antibiosis may have been expressed, making the plant sap more toxic. Thus reducing body weight attained by the female aphids, limiting future generation numbers. The late May sowing was not colonised by aphids as the peas emerged after the aphid flights had stopped. In 1985 aphid flights occurred more prolifically and for a longer period in the autumn, compared to other years (Ferro pers. comm.). May sowings would not be expected to be colonised by significant aphid populations in a cooler autumn.

4.7 Flowering

Flowering occurred during the winter for the March and April sowings because Pania is a mid season cultivar (Jermyn 1983) and for this reason is non-sensitive to photoperiod, particularly at cool temperatures. Photoperiod sensitivity and time of flowering was researched by Berry and Atkin (1979) who found that early maturing pea cultivars are insensitive to photoperiod at low temperatures.

Table 8

Days to first flower

Mean Daily Temperature (^{o}C)
6

	Photoperiod (hr) 8	24	(diff)
Alaska	93	90	3
Greenfeast	133	130	3
Mackay	287	166	121

Adapted from Berry and Aitken (1979)

The above table shows that a mid season cultivar (eg. Greenfeast) was insensitive to photoperiod and would flower during the winter or spring. The late maturing cultivar Mackay was sensitive to photoperiod, particularly at a low temperature (6°C). If this cultivar was sown in the autumn it would not flower until the photoperiod had increased in the spring, thus reducing the risk of flower injury by frosts.

Pania was insensitive to photoperiod, it did not delay flowering with the shortening photoperiod and progressively cooler temperatures of the autumn. Hence, the March and April sowings flowered during mid and late winter. The March sowing flowers aborted because of frost and this was expected to have happened to the flowers of the April 15th sowing. For autumn sowing of a mid season cultivar like Pania, the sowing date would need to be positioned so that approximately 80 to 90 days from sowing to flowering did not pass before winter and spring frosts had ended.

For satisfactory yield, early and mid season cultivars (eg. Pania, Novella) may need to be sown in mid June, as flowering and pod development could be terminated if 5-6^{o}C frosts occurred in

September and October, as was the case for 1985 (White pers. comm.). Alternatively, later maturing cultivars (eg. Dark skin perfection) could be sown in May and would possibly not flower or develop pods until the probability of late spring frosts was low.

CHAPTER 5

Conclusion

The autumn and winter seasons were milder and drier than normal. Therefore the cold tolerance of Pania vining peas and effectiveness of the two seed treatments were not thoroughly tested.

The early autumn sowings (March 25th, April 15th) emerged rapidly and established higher plant populations than the late autumn sowings (May 7th, May 30th), which emerged more slowly. The slower rate of emergence of the later sowings could have reduced the final established plant populations because of pre-emergence dampening off and reduced seedling vigour due to adverse soil conditions (eg. low soil temperature). Because of the less favourable field conditions during the late autumn, plant populations were reduced, hence higher seeding rates may be required for optimum yields.

Seed treated with captan had a 2% higher total emergence than seed treated with captan plus metalaxyl. However, no conclusions can be made about the effectiveness of the seed treatment as the autumn and winter were mild and dry and severe infections of downy mildew and pre and post dampening off did not occur. However, in August the first two sowings were severely diseased with P. syringae which was probably accentuated by frost injury. Consequently by the end of September none of the plants in the March sowing, and only a few in the April sowing, were alive.

All the sowings except the last one were colonised with overwintering aphids. By early August aphid populations had decreased on the March and April sowings, because the plants became taller and the bottom leaves died. Hence their foliage became less dense exposing the aphids to predators, sunlight, wind, heat and rain. Also, antibiosis could have been expressed. Although aphids were overwintering on the first three sowings no significant viral diseases were present.

Flowering occurred during the winter and early spring on the March and April sowings because Pania was insensitive to the decreasing photoperiod of autumn and winter. The flowers on the March sowing were frosted and aborted and it is expected the same will have happened to the April sowing. Therefore a combination of disease and flower frosting means that these two sowings will not yield.

The early and late May sowings overwintered better than the March and April sowings in 1985. The plants in the early and late May sowings emerged slowly to form small plants, with a rosette stature and reduced leaflet area. These plants did not lodge or become severely diseased. Their emergence occurred when the aphid flights were less intense and significant aphid populations did not colonise, reducing the risk of viral disease. Flowering would have occurred in the spring after the risk of frost damage was minimised.

Future experimental research could investigate the possibilities of later autumn sowing from late April to mid June in an aim to reduce the risk of flower and pod frosting from late spring frosts. Different cultivars could be tested, especially ones that are late maturing (eg. Dark skin perfection). If dark skin perfection was sown in late May its development would be slow and flowering would not occur until favourable conditions in the spring. Plant growth regulators (eg. Paclobutrazol, ICI PIC) could be used to reduce vegetative growth. This would prevent lodging and disease infection, also the leaflet size may be reduced increasing cold tolerance. If the correct plant growth regulator was used flowering of early maturing cultivars could be delayed reducing the probability of frost damage by early spring frosts. Finally, empirical methods could be developed which model the pea plant development and winter survival. Using long term meteorological data, this would allow the winter survival and final yield to be assessed quickly for a wide range of sowing dates.

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APPENDIX A

Mean Emergence Data

Sowing Date 1 (March 25)

Day	Captan	Captan plus Metalaxyl
1	287	277
2	702	695
3	811	776
4	871	832
5	900	854
6	906	864
7	906	872
8	906	872

Sowing Date 2 (April 15)

Day	Captan	Captan plus Metalaxyl
1	423	329
2	650	539
3	689	615
4	748	672
5	774	705
7	783	739
13	850	830

Sowing Date 3 (May 7)

Day	Captan	Captan plus Metalaxyl
1	88	86
2	153	143
5	345	312
7	557	517
11	690	683
1~~5~~3	731	721

Sowing Date 4 (May 30)

Day	Captan	Captan plus Metalaxyl
1	46	37
3	63	66
5	306	276
8	525	487
10	665	624
13	807	784
15	807	784

APPENDIX B

Mean Vine Growth Rates and Internodal Distances

	25th March	15th April	7th May	30th May
Mean Vine Growth Rates (mm/day)	2.48	1.41	0.77	0.62
Mean Internodal Distance (mm)	19.04	12.59	9.28	7.12

APPENDIX C

Percentage of Nodes with Fully Expanded and Actively Photosynthesising Leaves

	25th March	15th April	7th May	30th May
Percentage	24	45	61	40

APPENDIX D

Leaflet Area at Each Node for One Replicate

Node Number	Leaflet Area (m^2)
3	0.004
4	0.005
5	0.005
6	0.006
7	0.007
8	0.007
9	0.007
10	0.008
11	0.009
12	0.010
13	0.015
14	0.015
15	0.020

APPENDIX E

Aphid Species

Acyrthosiphon pelargonii
Acyrthosiphon pisum (pea aphid)
Acyrthosiphon kondoi (blue green aphid)
Aulocarthum soloni
Brevicoryne brassicae
Capitophorus aucuparii
Lipaphis erysimi mustardaphis
Myzus persicae