GENOTYPE VARIATION IN SENSITIVITY TO DAYLENGTH AND AIR TEMPERATURE OF GLYCINE MAX. (L) MERRILL.

A thesis presented in partial fulfilment of
the requirements for the degree of
Master of Agricultural Science in Plant Science
at
Massey University

LOIS VALENTINE TURNBULL

1977

ABSTRACT

Thirteen cultivars of Glycine max. (L) Merrill, each representing one of the maturity groups from 00 to 11*, were grown under field conditions at Massey University, Palmerston North, New Zealand. The cultivars were sown at 14 day intervals from the 12th October 1974, to the 18th January 1975, inclusive. Daily plant observations were made to record the dates of seedling emergence, flowering onset, pod emergence, cessation of flowering and pod maturity. With the maturity groups 1 and 4 cultivars, a separate apical bud dissection study was made of the morphological changes occurring during floral initiation and subsequent bud development. Multiple regression analysis was used to study the effects of daylength and air temperature on the phasic growth patterns of each of the thirteen cultivars.

In all cultivars, germination increased at an exponential rate as air temperatures rose from 12°C to 21°C. Temperatures above 21°C inhibited germination in the maturity groups 2, 4, 6 and 8 cultivars and were inhibitory above 25°C for all other cultivars.

In all cultivars, transition from the vegetative to the reproductive state was accelerated by declining daylengths and rising temperatures. Sensitivity to daylength during the pre-flowering phase increased with genetic lateness of maturity among the cultivars. From the apical dissection studies, daylength and temperature were shown to affect both rates of floral initiation and subsequent bud development. In the absence of an adequate daylength stimulus, plant age became the main determinant of the rate of floral development.

Pod emergence showed a negative response to daylength in the maturity groups 00 to 5 cultivars and a positive response in the groups 8 to 10 cultivars. Temperature was the main determinant of podding duration, rates of pod development decreasing with decline in temperature as the season progressed.

Both flowering and podding duration increased with decline in daylength. The photoperiod response during these growth phases was not associated with genetic lateness of maturity among the cultivars tested.

* USA classification or its estimated equivalent

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INTRODUCTION

Soybean cultivars differ widely in their sensitivity to daylength (Johnson et al., 1960; Criswell and Hume, 1972; Hartwig, 1973). In the absence of a strong photoperiodic response, temperature may have a significant effect on the various phases of plant growth (Lawn and Byth, 1972; Polson, 1972; Major et al., 1975). However, photoperiod and temperature effects are rarely distinct; rather, it appears that the plant responds to the interaction of these two stimuli (Blaney and Hamner, 1957; Huxley and Summerfield, 1973).

Soybean cultivation in New Zealand is based almost entirely on American introductions, comprised mainly of cultivars in the early to medium maturity classes. i.e. USA grades 00 to 4. Although these cultivars have been tested in latitudes similar to those for which they were developed in the USA, cultivation in New Zealand has been successful in only a few areas, mainly in the North Island. Cultivar-sowing date trials have suggested that this adaptation limitation is due to the lower temperatures experienced in New Zealand, particularly at night, compared to those of the soybean belt in North America (Gerlach, 1967; Robb, 1968; Okereke, 1970; Gerlach et al., 1971; McCormick, 1974, 1975, 1976). However, little effort has been made to define more precisely the source of this problem of selecting cultivars which give both consistently high yields and mature within the practical limits of the New Zealand growing season (McCormick, 1974, 1975, 1976; Robb, 1968; Turnbull, 1976).

This study attempts to provide some basic phenological information for a diverse range of soybean genotypes, grown in the field, under the varying daylength and temperature conditions experienced during the growing season in New Zealand. Thirteen cultivars were used in the trial, each representing one of the maturity grades 00 to 11; (USA classification or its estimated equivalent).

Chapter One REVIEW

The influence of daylength and temperature on various phases of growth of Glycine max. (L) Merrill.

1.1 GERMINATION

The first process to occur in germination is the absorption or imbibition of water by the seed (Mederski et al., 1973). Soybean seeds require a minimum seed moisture content, (percentage dry weight), of 50% for germination (Hunter and Erikson, 1952). Soil water potential is the main determinant of water availability for imbibition under field conditions. Temperatures which result in reduced matric potential, (i.e. loss of soil water), may, by increasing the amount of energy and time required by the seed to obtain a unit volume of water, delay germination. According to Hunter and Erikson (1952), for rapid germination, (i.e. emergence within 5 to 8 days), of soybean seeds at 25°C, soil water potential must not fall below -6.6 bar.

Imbibition has been shown to occur in two phases, the first of which appears to be a purely physical, temperature-independent phase, while the second is affected by temperature and therefore probably a metabolic, energy-requiring process (Villiers, 1972). Interaction between seed moisture content and temperature during imbibition was reported by Hobbs and Obendorf, 1972. Where seed moisture content was less than 13%, exposure to chilling (5°C) temperatures during imbibition resulted in decreased survival and seedling vigour. Surviving plants were shorter and in some cultivars, for example Acme, gave reduced grain yields.

As the seed imbibes water, the respiration rate increases for a period of time, then levels off before it increases again (Mederski et al., 1973). Development of the soybean seedling is dependent on the utilisation of food reserves, largely lipid and protein, stored in the cotyledons (Ogren and Rinni, 1973). Mature soybean seeds lack starch, an essential precursor of the high-energy metabolites required during the germination process (Bils and Howell 1963). The rate of crystalline starch formation, which occurs in the cotyledons and hypocotyl of the germinating seed, is temperature-dependent (Hizukuri et al., 1961). Cold temperatures during germination increase exudation losses of both soluble sugars and amino acids from the seed (Hobbs and Obendorf, 1972).

Optimum temperatures reported for soybean germination vary from 20°C to 36°C, depending upon cultivar, with extremes ranging from 2°C to 44°C (Howell, 1960). For example, Enken and Koloskov (1959), reported optimums of 20-22°C for temperate (European) cultivars; Delouche (1953), 30°C for American cultivars and Inouye (1953), 34-36°C for Japanese cultivars.

According to Stucky (1976), of cultivar, temperature and depth of planting, temperature has the most pronounced influence on emergence. For the nine cultivars tested from maturity groups 3, 4 and 5, increasing temperature reduced variation in emergence time due to cultivar and planting depth. At 32°C no significant differences existed between 5 and 7.5cm depths in average time to emergence in all cultivars.

Hatfield and Egli (1974), described the response to temperature, of the complete process of germination from dry seed until cotyledon emergence from a depth of 5cm, as:

$$Y = 0.4136463 - 0.716088T + 0.003752T^2 - 0.0000599T^3$$

where Y = the rate of germination, in mm of hypocotyl elongation per hour, and

T = the temperature, in °C, at seed level.

For the two cultivars tested, Lee 68 (maturity group 6) and Cutler (3), the rate of hypocotyl elongation increased from 10°C to 32°C, with no germination at 40°C, due to seed death. The polynomial equation accounted for 96% of the variation in initial hypocotyl elongation, with both cultivars responding to temperature in a similar manner. Predicted times to 50% emergence were not consistently early in tests where the soil temperatures fell below 10°C, indicating that the rate of hypocotyl elongation is not influenced by the temperature history of the seed.

Inhibition of hypocotyl elongation occurs in some cultivars at 25°C (Grabe and Metzer, 1969). Variation in temperature response among the twenty-five cultivars tested, (maturity groups 0 to 4), was thought to be genetically controlled. Gilman et al. (1973), reported that in the cultivars Amsoy, Beeson, Ford and Clarke (maturity groups 2 to 4), the amount of hypocotyl inhibition was influenced by the length of exposure to inhibiting temperatures between 21°C and 28°C. This suggests possible thermoperiodic effects associated with daylength under field conditions, although soybean seeds have no specific light requirement for germination (Howell, 1960).

1.2 FLOWERING

1.2.1 Floral Initiation

In general, in its flowering response the soybean is a classic example of a short-day plant, although cultivars differ in the numerical length of their effective short days (Garner and Allard, 1920, 1923). This characteristic was used by plant breeders as the basis for classification of soybean lines into ten maturity groups, ranging from Group 00 for Canadian latitudes (50°N), to Group 8 for Gulf Coast areas (30°N). In recent years this classification system has been extended to include cultivars adapted to the low latitudes of the tropics (Byth, 1968), and cultivars, apparently day-neutral, have been isolated from maturity group 00 lines. (Holmberg, 1963; Polson, 1972).

Much of the early work investigating the photoperiodic response of Glycine max. (L) Merrill, was carried out using the Group 8 cultivar Biloxi. In the following discussion, unless otherwise stated, responses are those observed for this particular cultivar.

In 1938, Borthwick and Parker determined that the leaves were the sites of daylength perception, individual leaves differing in their capacity to cause floral initiation. This capacity was found to be correlated with relative states of leaf maturity and not with their distances from the growing points where flowers are formed. Leaf effectiveness in inducing the initiation of floral primordia peaked on attainment of full leaf size. The most active leaf alone was able to cause initiation of as many flowers per plant as formed when all leaves functioned simultaneously (Borthwick and Parker, 1940). The flower-forming stimulus produced in the leaves moved readily up and down the plant, with the region of quickest morphological response at the time of short-day treatment (8 hour days), being the undifferentiated meristem (Heinz et al., 1942). Anatomical changes in the stem, notably a marked reduction in cambial activity, preceded the appearance of floral primordia at apical meristems (Struckmeyer, 1941).

The period between induction and initiation was reduced, both by increasing the number of inductive cycles and with declining inductive daylengths. The increase in response to inductive treatments as plants aged, was attributed to the corresponding increase in number of leaves attaining full expansion (Borthwick and Parker, 1940).

Although temperature was not effective in causing floral initiation under non-inductive daylengths (16 hours), it did influence the rate of floral primordia appearance in induced plants. (Parker and Borthwick, 1940). Cooling of individual petioles, leaf blades and terminal meristems from 24°C to 2°C during induction, showed that temperature changes occurring at the leaf blades had the greatest effect on floral initiation (Parker and Borthwick, 1943). The maximum, positive response was caused by increasing the dark-period temperature during induction, from 13°C to 18°C. At 13°C, differentiation of new structures was virtually at a stand-still. Temperatures above 30°C also delayed the appearance of floral primordia following induction. From this work, Borthwick and Parker suggested that the inhibitory effect of low temperature on floral initiation appeared to be the result of its effect on the photoperiodic reactions occurring in the leaf blades during the dark period, rather than through its effect on translocation of a flower-inducing stimulus from the leaf to the terminal meristem, or its effect at the terminal meristem upon the differentiation and development of floral primordia.

Experimental evidence produced by Hamner (1940), indicated that the inductive reaction was not solely a function of the dark period, but dependent also on responses which occurred as a result of exposure to light. Borthwick and Parker (1938), had already reported a minimum light intensity requirement during the inductive photoperiod of 100fc, for floral initiation to occur. Conversely light intensities greater than 0.5fc were effective in extending the critical daylength. In 1957, Blaney and Hamner confirmed the earlier reports by Borthwick and Parker (1939), Hamner (1940), and Wareing (1940), which suggested that the lengths of both the dark and light periods influenced the degree of floral initiation. The length of the limiting photoperiod was found to vary with the length of the dark period, critical and optimum photoperiods becoming shorter when accompanied by longer dark periods and vice versa. Maximum flowering occurred on cycles of 24, 48 or 72 hours, with more or less complete inhibition at 32-36 and 56-60 hours. The degree of inhibition decreased with exposure to increasing number of photoinductive cycles (Nanda and Hamner, 1958-59). i.e. The photoperiod reactions were markedly affected by an endogenous rhythm of approximately 24 hours duration, whose effect decreased with time. Damping of the inhibitory oscillations with time would explain the eventual flowering of Biloxi, when grown under continuous long-day conditions (Borthwick and Parker, 1938; Wareing and Phillips, 1970).

Reports of the effects of temperature on the endogenous rhythm inhibiting flowering in Biloxi, are somewhat contradictory. Blaney and Hamner (1957), observed that cycles containing a warm (27°C), 16 hour photoperiod were non-inductive, maximum floral initiation occurring when the temperature during this photoperiod was low (12°C). Nanda and Hamner (1958-59), found that floral initiation was inhibited when inductive cycles included a cool temperature (12°C), 16 hour photoperiod, maximum and minimum initiation occurring with 36 and 60 hour - and 48 and 72 hour cycles, respectively. i.e. The low temperature appeared to alter the periodicity of rhythm oscillations, the 12 hour shift rendering inductive cycle lengths non-inductive and vice versa.

Insertion of a light-break into the dark period also rendered an inductive cycle non-inductive (Nanda and Hamner, 1958-59). At a given wavelength, the minimum energy required to prevent floral initiation, applied at the middle of the dark period, was independent of time and intensity of irradiation, so long as their product was constant (Parker et al., 1945). The overall response curve showed striking similarities to the curve for photosynthetic utilisation of carbon dioxide, suggesting possible involvement of the leaf chloroplast pigments with the dark period interruption reaction. Maximum and minimum inhibition occurred at wavelengths around 640nm and 480nm, respectively, with floral initiation being unaffected by wavelengths above 720nm. From these observations, Parker et al.(1945), hypothesized that energy absorbed by chlorophyll may be transferred to a reaction leading to the destruction of a material determining floral initiation. However, chlorophyll was later rejected as the active pigment (Parker and Borthwick, 1950), mainly because of the weak absorption in the blue region (450-500nm), where chlorophyll has a high absorption (Hendricks et al., 1952). The red inhibition of flowering was shown to be reversible on plant exposure to far-red radiation, about 735nm (Downs, 1956). With increasing number of red/far-red exposures, the degree of flowering repromotion declined. This led to the hypothesis of the existence of a special pigment, named phytochrome, with two interconvertible forms (Hendricks and Borthwick, 1959). In 1959, phytochrome was isolated from dark-grown seedlings of *Zea mays* (Briggs and Rice, 1972). Following studies showed that the effect of phytochrome was exerted through its effect on metabolism, respiration and oxidative phosphorylation, synthesis of anthocyanins and chlorophyll, enzyme activity and tissue content of growth promoting substances (Borthwick and Hendricks, 1961; Hendricks and Borthwick, 1967). According to Chailakhyan (1968), the many-sided effect of phytochrome proves that it is connected with some general metabolic link (or links), and is not a specific system which regulates photoperiodic reactions. The mode of action of phytochrome on floral induction is still not understood. Downs (1956), suggested that the far-red absorbing form of phytochrome (P_{fr}), initiated a series of temperature-dependent events which resulted in the slow build-up of a condition inhibitory to flowering. Waring and Phillips (1971), hypothesized that P_{fr} was in some way inhibitory to the synthesis of flowering hormones in short-day plants. Although the red-absorbing form (P_r), appeared to be a pre-requisite for this synthesis to proceed, the reversion of P_{fr} to P_r did not appear to be a direct control as the time required for this reaction is only a fraction of that of the dark period critical for flowering.

At least three kinds of timing mechanisms have been implicated in the control of the photoperiodic response in short-day plants (Hillman, 1969). For example - the 'hour-glass' model, in which

The time taken for a particular substance to be accumulated or depleted to a certain threshold level - i.e. models such as those proposed by:

Hamner (1940) $A,B \longrightarrow C \longrightarrow$ floral initiation

where A = the conditions or changes arising from exposure to light
B = the conditions or changes arising from exposure to darkness
C = the resultant changes related to A and B

Cumming and Wagner (1972)

$P_r \rightleftharpoons P_{fr} \rightleftharpoons P_{fr}.X$ --> regulation of --> photoresponse
transcription
translation
enzyme activity

The identification of three gene pairs affecting time of flowering in cultivars from the maturity groups 1 to 6 (Bernard and Weiss, 1973), supports Cumming and Wagners' hypothesis of gene action involvement in the flowering response to daylength.

The other two timing mechanisms are both rhythmic and relatively temperature insensitive, but one is set in motion by the 'light-on' signal provided at the start of the day period, while the other is affected by the 'light-off' signal at the start of the night (dark) period. According to Bunning (1957), it is this endogenous daily rhythm which determines the effect of daylength on flowering. He defined the rhthmic response as having two phases:

(i) the photophilous phase, which occurs in the light and is characterised by high synthetic ability, intensive photosynthesis and weak respiration:
(ii) the skotophilous phase, which occurs in the dark and is characterised by an increase in the hydrolytical ability, intensive respiration and the decomposition of sugars and starch.

Although metabolite availibility for synthesis and degradation during these phases has been shown to influence floral initiation, research has failed to prove the existence of a causal relationship. For example, Borthwick and Parker (1939), observed an increase in the starch content of Biloxi leaves exposed to inductive (8 hour) daylengths. The decline in stem starch content during the same period indicated that differences were due to changes in rates of translocation. Struckmeyer (1940), reported inhibition of phloem formation preceding floral initiation - cambial activity itself being under hormonal control (Hill, 1973) - supporting the theory of reduced translocation affecting tissue levels of starch. Plant soluble carbohydrate content was shown to be positively correlated with daylength, while total and non-protein levels of nitrogen in both stem and leaves were negatively correlated with daylength (Borthwick and Parker, 1939). Chailakhyan (1968), also reported the existence of a regular correlation between the nitrogen-floral reaction and the photoperiodic reaction. According to this author, the carbohydrate-nitrogen ratio does not condition the start of flowering, but contributes to the total metabolic state in relation to the preparation for flowering.

The possibility that flowering occurs due to changes in the levels of endogenous growth hormones, has also been extensively researched, but results are contradictory in many cases and far from satisfactory. For example, Chailakhyan hypothesized that the photo-induced stimulus is transmitted to the shoot apex via a specific hormonal complex, which he termed 'florigen'; whilst flowering required the presence of specific levels of essential metabolites, or 'anthesins'. In Pisum, the cotyledons were purported to be the site of floral inhibitor production, termed 'colysanthin' (Sprent and Barber 1957; Johnston and Crowden, 1967; Amos and Crowden, 1969; Murfett, 1971-73). However, more than thirty years after the inception of the flowering hormone concept, research workers have failed to identify such a compound or complex. Many of the known endogenous growth hormones have been shown to influence flowering, but again, consistent proof of a causal relationship has been elusive. For example, in Biloxi soybeans, Hanmer and Nanda (1956-57), showed that the degree of floral inhibition caused by indole-3-acetic acid (IAA), was proportional to the log of its concentration, inferring a simple relationship. As the concentration of IAA required to inhibit flowering was proportional to the length of the photoperiod of the photo-inductive cycle, the authors considered that IAA interacted with some product of the photoperiod. However, Lang (1952), reported that applications of IAA were most effective if made at the beginning of the dark period, inferring interaction with some function of the dark-period process of photoperiodism. Gibberellins have been reported as both promoting and inhibiting flowering in short-day plants (Molder and Owens, 1974). Lang (1965), suggested that gibberellins were the precursors of florigen, while Chailakhyan (1968), contended that although gibberellins induced stem formation and growth, they did not directly influence the development of floral organs. Evaluation of such studies is frequently confounded by the failure of the researchers to make the distinction between floral initiation and floral bud growth. i.e. The apparent inability of an applied hormone to cause flowering under non-inductive conditions may not be due to its failure to induce floral initiation, but to the absence of subsequent bud development.

1.2.2 Floral bud development

Daylengths adequate for initiation of floral primordia are often inadequate to ensure their subsequent development (Borthwick and Parker, 1939; Van Schaik and Probst, 1958; Johnson et al., 1960). Following initiation in Biloxi, similar rates of floral bud development were observed under daylengths ranging from 8 to 13 hours. Above 13 hours this rate declined, zero growth being recorded under 16 hour daylengths. For photoperiods of 8 hours or less, corollas failed to open at anthesis, simply elongating beyond the tips of the calyx, but remaining closed. Bud size also decreased with decline in daylength treatment (Borthwick and Parker, 1939). This may have merely been a function of carbohydrate availability for growth, soluble carbohydrate being positively correlated with daylength (Parker and Borthwick, 1939). Light intensity is also reported as having a quantitative effect on flowering in Glycine max. (L) Merrill; positive in relation to flower number and negative with respect to time of flowering (Yoshida, 1952; Major and Johnson, 1974).

Exposure to too few inductive cycles also resulted in failure of floral primordia to develop (Struckmeyer, 1940; Borthwick and Parker, 1939). Although floral initiation in Biloxi resulted from exposure to two inductive cycles, a minimum of nine cycles was required to ensure continued development (Borthwick and Parker, 1939). Struckmeyer (1940), also reported a requirement for warm temperatures (above 18°C), for normal bud growth. Insufficient exposure to short days at low temperatures (13°C), resulted in initiated plants gradually reverting to the vegitative state.

1.2.3 Cultivar variation in time of flowering

Information on specific photoperiod responses of cultivars, other than Biloxi, is limited. Garner and Allard (1920, 1930), Borthwick and Parker (1939), Scully et al. (1945), Van Schaik and Probst (1958), Byth (1968), Lawn and Byth (1973), Holmberg (1973), Major et al. (1975) and others, have studied the general flowering behaviour in cultivars ranging in maturity from Group 00 to Group 11. These studies have shown that, in general, the earlier a cultivar matures the longer the photoperiod on which floral bud initiation and development can occur. Cultivars of Group 00 to 3 may initiate floral primordia even under continuous light (24 hour daylength), but those of later maturity do not. Floral initiation is delayed on long photoperiods and flowering and fruiting do not generally occur on photoperiods longer than 16 hours in cultivars from Groups 1 to 11. Johnson et al. (1960) and Fisher (1963), reported variations in the time from initiation of floral primordia to the appearance of open flowers ranging from 14 to 40 days, depending upon cultivar, plant age and photoperiod.

Howell's (1960), assertion that 'there appears to be no case in which a soybean variety is indifferent to daylength', has been brought into question in recent years with the discovery of apparent 'day-neutral types, such as Fiskby V (Polson, 1972; Criswell and Hume, 1972; Holmberg, 1973).

Although daylength would appear to be the dominant floral stimulus, little is known of the response of different cultivars to temperature during the pre-flowering phase. Garner (1930), failed to find any evidence of a definite selective action of changing temperature in the response of cultivars from the maturity groups 1 and 8, low temperatures having similar delaying effects on flowering. In 1936, Steinburg and Garner reported that increasing temperatures hastened flowering up to an optimum of 28°C, above which flowering was delayed. Polson,(1972), found that soybean lines from the maturity groups 00 and 0 that were essentially day-neutral, were also insensitive to temperatures between 18-30°C. Lawn and Byth (1973), observed temperature effects in field grown cultivars from the maturity groups 3 to 11 - only in the absence of a strong photoperiodic response. However, the frequently close interrelationship of daylength and temperature under field conditions makes separation of their individual effects difficult. Using iterative regression techniques, Major et al. (1975) found that, under field conditions, the potential delaying effects caused by increasing daylengths were less than the hastening effects of warm temperatures on flowering of the maturity group 4 cultivar, Clarke 63.

Genes determining time of flowering and maturity (Bernard, 1971); sensitivity to light quality (Kilen and Hartwig, 1971) - thought related to the three pairs of genes controlling the flowering response (Bernard and Weiss, 1973); plant growth habit (Bernard, 1972), stem termination affecting the time of flowering, determinate flowering earlier than indeterminate cultivars of the same maturity group (Lawn and Byth, 1973) and lowest pod height (Martin and Wilcox, 1973), have been identified.

1.3 Fruit set

While flowering occurs most rapidly under short days, it will occur with prolonged exposure to long days (Borthwick and Parker, 1943). However, for fruitset to occur in Biloxi flowering under 14-15 hour days, daylength must fall below 13 hours. Nielson (1942), attributed this short-day requirement to failure to produce viable pollen under long-day conditions. This hypothesis was confirmed by Fisher (1962), working with the cultivars Lincoln, Hawkeye and Harosy, from the maturity groups 3, 2 and 2 respectively. Failure of large buds and expanded flowers to respond to short-day treatments, suggested that this photoperiod requirement for normal pollen production acted at an early stage in flower development.

1.4 Pod development

Little specific information is available on daylength influence on pod formation and subsequent development and senescence. Criswell and Hume (1972), reported that the rate of pod emergence (days from first flower to first pod of 1cm length), was negatively correlated to daylength. However, pod emergence did not appear to be associated with genetic lateness of maturity in the twelve cultivars tested, from the maturity groups 00 to 4. For example, in Hardacre (maturity group 0) and Lincoln (3), the rate of pod formation remained constant as daylength increased from 12 to 20 hours, declining from 20 hours, with no pods being formed under continuous light. In Hark, (maturity group 1), pod emergence rate was constant for daylengths between 12 and 16 hours, declining from 16 hours, with no pod formation at 20 hours. Fiskby V, from the maturity group 00, showed no response to the changes in daylength. For the thirty-five strains tested from Group 00, in which flowering was delayed by a 24 hour photoperiod, the interval from flowering to pod emergence was also delayed. However, there was no correlation between the lengths of the respective pre-flowering and pod emergence phases.

Van Schaik and Probst (1958), reported that pod emergence in Clarke and Midwest, from maturity group 4, showed no consistent temperature or photoperiodic effects. According to Hesketh et al. (1973), pods did not form in Wayne (maturity group 3), or Dare (5), when average hourly temperatures fell below 18°C, under daylength conditions purportedly promotive. Enken (1959), reported by Holmberg (1973), assigned biological minimum, sufficient and optimum temperatures for seed formation in Glycine max. (L) Merrill of 13-14°C, 18-19°C and 21-23°C, respectively.

Most observations on the effects of daylength and temperature on pod development have been made on the basis of the length of the period from flowering to maturity. As plant growth during this period is both positive (pod formation and seed growth) and negative, (pod senescence), such observations merely represent the dominant response for the period. It is probable that the roles of daylength and temperature in pod development alter as plant growth changes from positive to negative. Johnson et al.(1960), found that the period from the end of flowering to maturity in cultivars from maturity groups 3 to 6 was virtually constant for daylengths of 13 to 14½ hours. In Biloxi however, both pod number and weight, (per plant and per 100 pods), were affected by daylength, increasing as daylength increased from 8 to 12 hours (Parker and Borthwick, 1939). Shaw and Weber (1967) and Johnson et al. (1969), also reported the quantitative effect of light on seed yield, with cultivars from the maturity groups 2 and 3. According to Major and Johnson (1974), light intensity per se, has no detectable effect on either flowering or podding duration in cultivars from the maturity groups 1 to 5.

Lawn and Byth (1973), suggested that variation in the length of the podding phase depended largely on the range of photoperiod and temperature experienced by each cultivar during pod development. As this is primarily determined by the time of flowering, with delay in flowering the relative contributions of daylength and temperature, to pod development, could be expected to change. For daylengths ranging from 15.9 to 12.4 hours, the period from the end of flowering to maturity in cultivars from Groups 3 to 11, decreased as daylength declined. Temperatures during this period ranged from 30°C to 13°C (Lawn and Byth, 1973). For cultivars from the maturity groups 1 to 6, Major et al. (1975), also observed that the potential delaying effects of cool temperatures on pod development were less than the hastening influence of decreasing daylengths. According to Enken (1959), the biological temperature minimum for seed 'ripening' is 8 to 9°C.

Chapter Two

METHODS

2.1 INTRODUCTION

The phenological development of thirteen soybean cultivars, grown in the Agronomy plots at Massey University, was studied from October 1974 to July 1975. Cultivars were selected on the basis of diversity of photoperiod sensitivity, as indicated from their maturity group classification, and also to include both determinate and indeterminate growth types. The cultivars used in the trial are listed in Table 1.

Table 1 Cultivar Information

Cultivar	Relative maturity	*Grade	Growth type	Origin
Acme	very early	00	indeterminate	USA
Soysota x Mandarin (a)5	early	0	indeterminate	USA'
Amsoy x T19 (a) 69	early	1	indeterminate	USA'
Wayne x PI-54-608-II (a)	early-midseason	2	indeterminate	USA'
Wayne	midseason (early)	3	indeterminate	USA
Dare	midseason (late)	4	determinate	USA
Hill	late season (early)	5	determinate	USA
Ogden	late season (early)	6	determinate	USA
Bragg	late season (early)	7	determinate	USA
Wills	late season (mid)	8	determinate	USA
K162	late season (mid)	9	determinate	Africa"
Daintree	late	10	determinate	Africa"
Mamloxi	very late	11	determinate	Africa"

* USA maturity group classification - or estimated equivalent

' New Zealand selection

" Australian selection

2.2 EXPERIMENTAL METHODS

2.2.1 Site preparation

The trial was carried out on Tokomaru silt loam, a heavy soil with a pH of 5.95 and a field moisture capacity of 21.8% (Appendix 1).

Originally in established pasture, the area had been cropped in turnips during the autumn.

The site was dressed with 33kg P/ha, as granulated superphosphate and 178kg K/ha, as muriate of potash, during seedbed preparation. Following fertiliser application, soil pH was adjusted to 6.1 by the addition of 12 tonnes of lime per hectare (Appendix 2).

2.2.2 Seed preparation

(a) Germination tests

A preliminary check was made to ensure the viability of all seed lines to be used in the trial (Appendix 3).

(b) Seed size

To minimize possible emergence, leaf area, height and yield effects arising from variation in seed size (Burris et al. 1971, 1973), seed used in the trial was selected for uniformity of size.

(c) Seed inoculation

Inoculation was carried out immediately prior to sowing. Graphite powder was used to maximise adhesion, each seed being coated with approximately 13×10^4 rhizobial cells.
Four strains of Rhizobium japonicum were used in the inoculum to ensure infection of all cultivars. The strains used were:

USDA 138
USDA 5A-43
YEMS 61A-72

known to inoculate successfully cultivars in the 00 to 4 maturity groups under New Zealand conditions (M. Greenwood pers. comm.), and

CB 1809

as used by D. Byth in Queensland, on cultivars with maturity ratings of 5 to 11 (Lawn and Byth, 1973).
The parent cultures were maintained at Massey University and the inoculum prepared from these as required (Appendix 4).

Root examination, made during seedling 'thinning', showed that inoculation had been successful in all cultivars.

2.2.3 Trial design

The thirteen cultivars were sown in two randomised complete blocks on each of eight sowing dates (Appendix 5). The single-row plots were 1.8m x 0.5m in size. Sowing began on the 12th October 1974 and continued in consecutive areas at 14 day intervals until the 18th January 1975. Inoculated seed was sown to a depth of 3cm, in 1.8m long rows. At the third trifoliate leaf stage, seedlings were thinned to ten plants per plot, giving an approximate intra-row spacing of 20cm.

2.2.4 Irrigation

Soil moisture was held approximately at field capacity by the use of sprinkler irrigation, based on gravimetric analysis (Appendix 6).

2.2.5 Weed and pest control

The site was kept free of weeds by hand cultivation.

Spergon was applied to the December sowings only, to control seed corn maggot (*Hylemya platura* (Meigen)).

To prevent the build up of lepidopterous larvae, all green plants were sprayed regularly with Gramathion.

Poison baits were laid during January and February of 1975, to control rabbit damage.

2.2.6 Disease incidence

Soybean mosaic virus symptoms were expressed in the occasional plant of the cultivars Dare and Hill.

Minor bacterial blight (*Pseudamonas glycinea*) damage was recorded in the cultivars Acme, Soysota x Mandarin, Amsoy x T19 and Wayne x PI-54-608-II.

There is no known means of plant control of these two diseases.

2.2.7 Data collection

(a) Daylength

Meterological daylengths for the site latitude of 40°.23'S. were obtained from the 1974 and 1975 editions of the British Nautical Almanac. As extremely low light intensities (0.6fc., Borthwick and Parker, 1938), may extend the critical daylength inhibitory to floral induction, the period of civil twilight, (minimum intensity of 0.4fc., Salisbury, 1963), was included in all daylength calculations (Appendix 7).

(b) Air temperature

Air temperature was monitored continuously at the trial site, using a screened thermohygrograph. The average hourly temperature for each day and night period was derived from these recordings (Appendices 8 and 9).

For the purposes of the trial, a 24 hour day was deemed to comprise the meterological daylength, (i.e. sunrise to sunset, including civil twilight), plus the preceding night period.

(c) Phenological data

Data collection followed the plot order set up at planting. This ensured that the interval between measurements was maintained fairly constant for all plants. Daily observations were made on each plant to record the dates of the growth stages as defined below:

1. EMERGENCE: the appearance of the hypocotyl above the soil surface. Counts were taken from initial emergence until no further hypocotyls emerged (Appendix 3).
2. FLOWERING: this started on the day the first flower opened and ended on the last day recorded for the appearance of a new flower.
3. PODDING: this commenced with the emergence of the first pod beyond the calyx and terminated at maturity, when 95% of the plants tissue had senesced.

This data were used to calculate, for each plot, the duration of the following growth phases:

i. Germination: days from sowing to emergence, with the plot mean emergence time being calculated by determining the number of days taken to reach 50% of the final count.

ii. Pre-flowering: days from 50% emergence to first flower.

iii. Flowering: days from start to end of flowering.

iv. Pod emergence: days from first flower to first pod appearance.

v. Podding: days from first pod appearance to maturity.

The average daylength, hourly day and hourly night temperatures during each plot growth phase were then calculated. For the pre-flowering, flowering and podding phases, the daylength at the start and end of the phase were also recorded.

2.3 Apical bud dissection study

With delineating parameters based on gross morphological changes, the various phases of growth, as described above, are somewhat subjective. For example, initiation of floral primordia, rather than flower bud opening, would be a more objective starting point for the flowering phase, but this was not used in the trial as its measurement requires destruction of the plant, precluding further growth observations. In order to examine more closely, morphological changes occurring during the pre-flowering phase, plant material was obtained from a further trial of similar experimental design. (For details of this second trial, see Appendix 15). Of the cultivars available, Amsoy x T19 and Dare were selected as representative of the two distinct flowering types, predominant in the original trial. i.e.

1. Indeterminate growth habit, flowering under relatively long days.
2. Determinate growth habit, with a definite 'short-day' requirement for flowering.

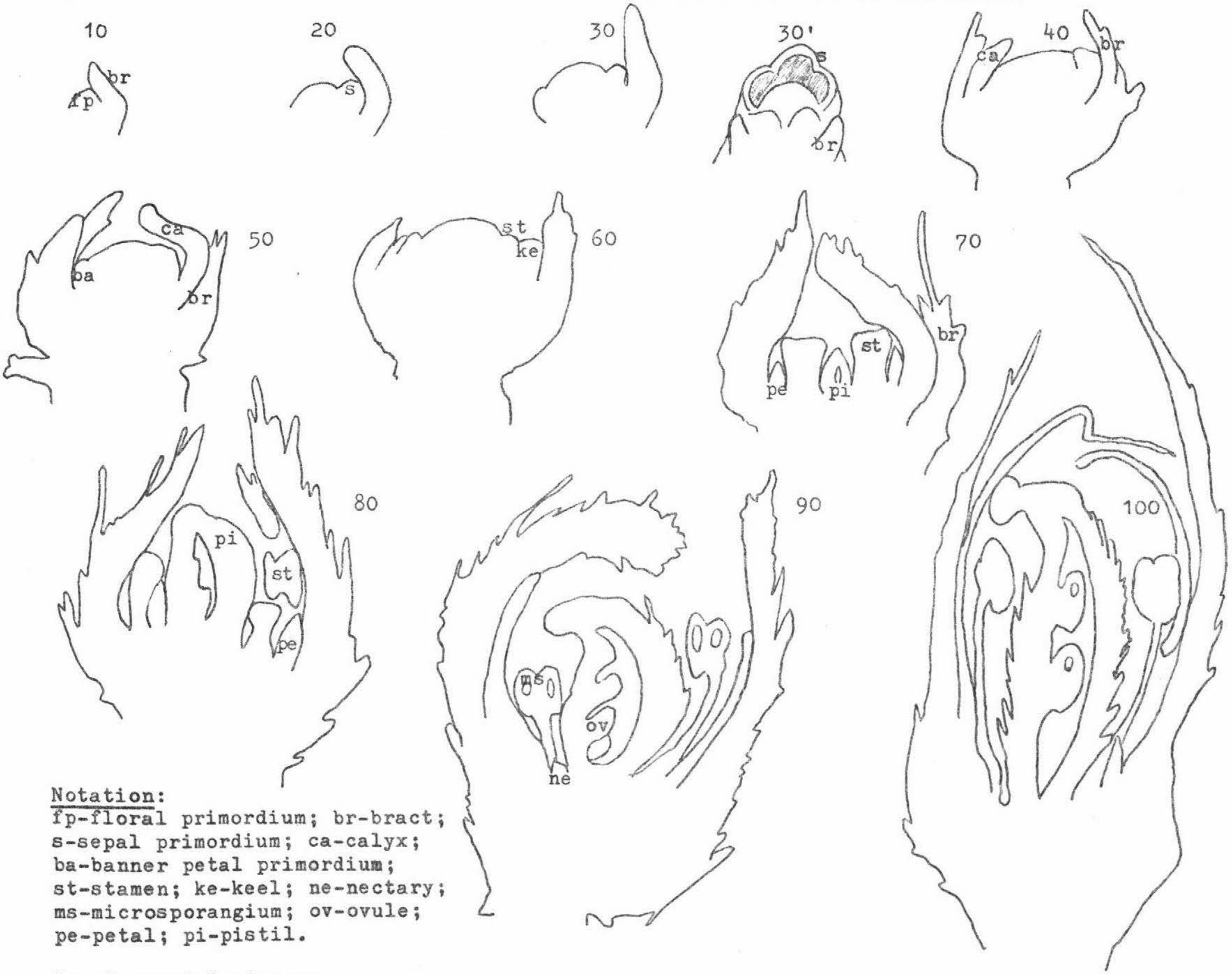
2.3.1 Data collection

Plot sampling began when plants reached the second trifoliate leaf stage. Plants were selected at random, two from each of the four replicate plots, per cultivar, per sampling date. Sampling intervals varied, increasing from five to ten days on detection of floral primordia. Sampling was discontinued when dissection results indicated that the cultivars were about to flower.

The apical bud complement of each plant was examined, using a dissection microscope with a maximum magnification of 80x. Primordia were graded using a scale of 0 (primordia vegetative) to 100 (fully developed floral bud), with 10 levels of floral development, as shown in Figure 1.

Figure 1 Gross floral development in the soybean

Ten stages of development - adapted from Carlson, J.B. Morphology. p.70-71. Caldwell, B.E. Soybeans: Improvement, Production and Uses. Diagrams - longitudinal sections.



Notation:
fp-floral primordium; br-bract;
s-sepal primordium; ca-calyx;
ba-banner petal primordium;
st-stamen; ke-keel; ne-nectary;
ms-microsporangium; ov-ovule;
pe-petal; pi-pistil.

Developmental stages:
10 - floral primordium in axil of bract
20 - first sepal primordium; abaxial side of floral primordium
30 - floral primordium showing two sepal primordia: 30' - perspective view, showing 5 sepals
40 - floral primordium showing bract and elongating calyx tube
50 - floral primordium showing banner petal primordium on adaxial side - all petal primordia present at this stage
60 - first stamen primordium on abaxial side between keel primordia
70 - lateral longitudinal section showing outer floral organs - i.e. stamens, petals
80 - young flower with first indication of ovule primordia in pistil
90 - flower with ovules at time of integument initiation; megasporocytes present in ovule; anthers have microsporangia with microsporocytes; nectary visible, around pistil base
100- mature flower prior to anthesis

The following data were recorded for each plant:

1. the maximum state of floral development at each node;
2. the total number of nodes on the plant;
3. the date the plant was sampled;
4. the age of the plant at sampling, (days from emergence to sampling, using the plot mean emergence date for each plant).

The average daylength, hourly day and hourly night temperatures during each sampling interval, were also calculated. (Appendices 17.1, 18.1).

2.4 STATISTICAL METHODS

(With reference to Draper and Smith, 1966; Steele and Torrie, 1960; Little and Hill, 1972).

2.4.1 Growth Phase Analysis

Plot means were processed using 'Minitab' computor program format (Ryan et al., 1972).

Multiple regression analysis was used to compare cultivar response to daylength and temperature at each phase of growth. Regression equations used were of the form:

$$Y = a + b_1X_1 + b_2X_2 + \ldots\ldots + b_kX_k$$

and

$$Y = a.b_1^{X_1}.b_2^{X_2} \ldots\ldots b_k^{X_k}$$

where k = the number of independent variables in the equation,

a, the Y intercept

= the value of Y when X = 0, and

$$\hat{a} = \bar{Y} - \hat{b}_1\bar{X}_1 - \hat{b}_2\bar{X}_2 - \ldots\ldots - \hat{b}_k\bar{X}_k$$

b, the partial regression coefficient

= the amount of change in Y per unit change in X,

$$\hat{b} = \frac{\Sigma(X_i - \bar{X})(Y_i - \bar{Y})}{\Sigma(X_i - \bar{X})^2}$$

where all summations (Σ), are from i = 1 to n, the number of observations.

$\hat{Y}$, the regressed value of Y, given values of X,

$$= \hat{a} + \hat{b}_1X_1 + \hat{b}_2X_2 + \ldots\ldots + \hat{b}_kX_k$$

$S_{Y.X_{1\ldots k}}$, the estimated standard deviation of $\hat{Y}$ about the regression line,

$$= \sqrt{\frac{\Sigma\,(Y_i - \hat{Y})^2}{n - k - 1}}$$

$R^2_{Y.X_{1\ldots k}}$, the proportion of the variation in Y explained by the regression equation,

$$= \frac{\Sigma\,(\hat{Y} - \overline{Y})^2}{\Sigma\,(Y_i - \overline{Y})^2}$$

$R_{Y.X_{1\ldots k}}$, = the multiple correlation coefficient, measuring the combined effect of the independent variables $X_{1\ldots k}$ on the dependent variable Y.

The significance of each regression coefficient was obtained by testing the null hypothesis ($H_0 : \hat{b} = 0$), with:

$$\hat{t} = \frac{\hat{b}}{\hat{S}_b} \quad \text{with } n - k - 1 \text{ degrees of freedom,}$$

where $\hat{S}_b$, the standard error of the regression coefficient $\hat{b}$,

$$= \frac{\hat{S}_{YX}}{\sqrt{\Sigma\,(X_i - \overline{X})^2}}$$

$$= \frac{\hat{S}_{YX}}{\hat{S}_X}$$

Comparison of the standard partial regression coefficients*, $\hat{b}'_{1\ldots k}$, was used to give a measure of the relative importance of the X variables in predicting Y:

$$\text{where} \quad \hat{b}'_{1\ldots k} = \hat{b}_{1\ldots k} \cdot \frac{\hat{S}_{X_{1\ldots k}}}{S_Y}$$

---

* also referred to as the 'standardised partial regression coefficient'

Homogeneity of the regression coefficients was determined from the t-test:

$$t = \frac{\hat{b}_p - \hat{b}_q}{\sqrt{\hat{S}^2_{b_p} + \hat{S}^2_{b_q}}} \quad \text{with } n_p + n_q - 4 \text{ degrees of freedom,}$$

where, for the partial regression coefficient $\hat{b}_{1...k}$, p and q ($p \neq q$), represent any pair of cultivars under test.

Similarly, for $\hat{a}$,

$$t = \frac{\hat{a}_p - \hat{a}_q}{\sqrt{\hat{S}^2_{a_p} + \hat{S}^2_{a_q}}} \quad \text{etc.}$$

2.4.2 Growth phase regression models

The regression models were determined as follows:

1. At each growth phase, simple correlation matrices were constructed for each cultivar, between the pertinent variables:

Y = the duration, in days, of the growth phase

$Y_1 = \log_{10} Y$

X_1 = the average daylength, in hours, for the growth phase

X_2 = the average hourly day temperature, in °C, for the growth phase

X_3 = the average hourly night temperature, in °C, for the growth phase

X_4 = the daylength, in hours, on the day the phase commences

X_5 = the daylength, in hours, on the day the phase ends

where the correlation coefficient,

$$\hat{r}_{YX} = \frac{\Sigma(X_i - \overline{X})(Y_i - \overline{Y})}{\sqrt{\Sigma(X_i - \overline{X})^2 \Sigma(Y_i - \overline{Y})^2}}$$

2. The correlation coefficients for Y and Y_1 were examined to determine if the dominant response was linear or curvilinear.

3. The X variable most highly correlated with this response was then selected as the first variable to enter the regression.

4. Inclusion and ordering of further X variables in the model were dependent upon:

(a) the degree of correlation with Y; i.e. rank in the correlation matrix;

(b) the level of intercorrelation with X variables already in the equation;

(c) the increase in $R^2_{YX_{1\ldots k}}$, to be gained from the addition of a variable;

(d) the partial F-test value of the variable most recently entered, (rejected if less than that required for significance at the 5% level);

(e) the growth phase being examined, i.e. a priori considerations.

5. Plots of the standardised residuals versus $\hat{Y}$ were examined to check that the final model was correct: i.e. that in performing the regression analysis, the assumptions made about the residuals, defined as the n differences $e_i = Y_i - \hat{Y}_i$, had not been violated. Where these assumptions (namely that the e_i's are independent, have zero mean, a constant variance and follow a normal distribution), appear inviolate, the above plot results in a horizontal band.

Consequently, the models selected as best suited to describe the predominant cultivar response pattern at each phase of growth, were:

1. GERMINATION PHASE

$$\log_{10}Y = \log_{10}a + (\log_{10}b_{2,3})X_{2,3} + 2(\log_{10}b_{2,3})X_{2,3}$$

i.e. $$Y = a \cdot b_{2,3}^{\;X_{2,3}} \cdot b_{2,3}^{\;X^2_{2,3}}$$

As the dominant independent variable X_2 was highly intercorrelated with X_3, the average hourly temperature during the 24 hour day plus night period was used. i.e:

$$X_{2,3} = \frac{X_1 \cdot X_2 + (24 - X_1)\,X_3}{24}$$

Both temperature variables were highly intercorrelated with daylength. Thermoperiod effects on emergence have been suggested from hypocotyl elongation studies (Gilman et al., 1973). The quantitative effect of daylength is inherent in the use of the temperature variable $X_{2,3}$.

The daylength variable, X_1, was also significantly correlated to Y_1 (Appendix 10.1), however, germination in Glycine max. (L) Merrill is reportedly non-photoblastic (Howell, 1960).

Of the temperature and temperature plus photoperiod models considered, a quadratic polynomial equation, with temperature as the sole variable, gave the best fit (Appendix 10.2)

2. PRE-FLOWERING PHASE

The model selected was:

$$\log_{10}Y = \log_{10}a + (\log_{10}b_1)X_1 + (\log_{10}b_{2,3})X_{2,3} + (\log_{10}b\ )X_5 + (\log_{10}b_4)X_4$$

i.e. $$Y = a \cdot b_1^{X_1} \cdot b_{2,3}^{X_{2,3}} \cdot b_5^{X_5} \cdot b_4^{X_4}$$

The dominant independent variable in the correlation matrix (Appendix 11.1), was X_5 and the response variable Y_1.

Significant correlations existed between:

X_2	X_3	(all cultivars)
X_5	X_1	(all cultivars)
X_5	X_4	(seven cultivars)
X_5	$X_{2,3}$	(nine cultivars)
X_4	$X_{2,3}$	(ten cultivars)

As the level of correlation between X_1 and $X_{2,3}$ was non-significant for ten of the thirteen cultivars, X_1 preceded $X_{2,3}$, as the first variable to enter the model.

In order to determine if further variation, due to X_5, existed (i.e. other than that attributable to the relation of X_5 with X_1 and $X_{2,3}$), it was entered as the third variable in the equation.

As partial F-tests showed that X_4 made a significant contribution for five of the thirteen cultivars, it was retained as the last variable in the model (Appendix 11.2).

The validity of the ordering of $X_{2,3}$ was tested by comparing models in which $X_{2,3}$ was entered as the third variable, behind X_5, X_1 and as the final variable in the regression. This showed that the additional variation due to temperature was significant for eight of the thirteen cultivars, when entered as the last variable and significant for all cultivars, when following X_5 and X_1 into the model (Appendix 11.2).

Where the independent variables in a regression are highly intercorrelated - as in the pre-flowering phase model - partitioning of the response variation becomes dependent on the order in which these variables enter the equation. For example, if

$$\text{(i)} \quad Y = a + b_1X_1 + b_2X_2$$

then the total variation in $Y = \Sigma(Y_i - \overline{Y})^2$

and the regression due to $X_1 = (r^2_{Y.X_1}).\Sigma(Y_i - \overline{Y})^2$, whilst the

additional regression due to $X_2 = (r^2_{YX_2.X_1}(1 - r^2_{Y.X_1}).\Sigma(Y_i - \overline{Y})^2$;

whereas, if $\quad \text{(ii)} \quad Y = a + b_2X_2 + b_1X_1$

then the regression due to $X_2 = (r^2_{Y.X_2}).\Sigma(Y_i - \overline{Y})^2$, and the

additional regression due to $X_1 = r^2_{YX_2.X_1}(1 - r^2_{Y.X_2}).\Sigma(Y_i - \overline{Y})^2$

From $r^2_{YX_2.X_1}$, the square of the partial correlation between Y and

X_1, with a fixed X_2, $$= \frac{(r_{Y.X_1} - r_{Y.X_2}(r_{X_1.X_2}))^2}{(1 - r^2_{Y.X_2})(1 - r^2_{X_1.X_2})}$$

it can be seen that as the correlation between X_1 and X_2 increases, the value of $r^2_{YX_2.X_1}$ will decrease. i.e. As $r_{X_1.X_2}$ approaches unity, the regression attributable to the X variable entering the equation last, will approach zero. Conversely, an increase in $r_{X_1.X_2}$ will amplify the value of both partial regression coefficients b_1 and b_2, as:

$$b_1 = \frac{r_{Y.X_1} - r_{Y.X_2}\,(r_{X_1.X_2}) \cdot S_Y}{(1 - r^2_{X_1.X_2}) \cdot S_{X_1}}$$

and

$$b_2 = \frac{r_{Y.X_2} - r_{Y.X_1}\,(r_{X_1.X_2}) \cdot S_Y}{(1 - r^2_{X_1.X_2}) \cdot S_{X_2}}$$

Obviously, if $r_{X_1.X_2}$ equals unity, then $(1 - r^2_{X_1.X_2})$ will equal zero and no solution can be derived for either partial regression coefficient, b_1 or b_2.

Comparison of cultivars based on partial regression coefficients will therefore be affected if the values of $r_{X_1.X_2}$, for a growth phase, are heterogeneous. However, inherent in the determination of $r_{X_1.X_2}$ is the influence exerted by Y in delineating the boundaries of the parameters selected to represent X_1 and X_2. So although heterogeneity amongst the $r_{X_1.X_2}$ values may result in mathematical bias, this bias is an integral function of the variation between the cultivars in their response to X_1 and X_2.

3. FLOWERING PHASE

The model selected as that explaining the greatest proportion of the variation in Y for the bulk of the cultivars, was:

$$Y = a + b_5X_5 + b_4X_4$$

The dominant independent variable was X_5 and the response variable Y (Appendix 12.1).

As highly significant correlations existed between all the X variables, comparison was made of models based on daylength and temperature, with those predicting Y from daylength alone (Appendix 12.2). This resulted in the selection of the daylength model, as shown above.

4. POD EMERGENCE PHASE

The model selected was:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3$$

Daylength, X_1, was the dominant variable during this phase of growth, with the response variable, Y (Appendix 13.1).

The degree of intercorrelation of the independent variables differed from cultivar to cultivar. The correlations between $X_1{:}X_2$ and $X_2{:}X_3$, were significant for twelve of the thirteen cultivars, but between $X_1{:}X_3$, significant for only six cultivars. For this reason, rather than use the single temperature variable $X_{2,3}$, day and night temperatures were retained as separate parameters in the model.

5. PODDING PHASE

The model used to describe the variation in the duration of the pod filling phase was:

$$Y = a + b_{2,3}X_{2,3} + b_4X_4$$

Examination of the correlation matrix (Appendix 14.1), showed that all the X variables were highly intercorrelated. Temperature, represented by $X_{2,3}$, was the dominant independent variable, with the response Y.

In order to test if any effect (additional to that explained by $X_{2,3}$), could be ascribed to daylength, X_4 was included in the regression model. Selection of X_4, rather than X_1 or X_5, as the daylength variable, was an *a priori* consideration, based on evidence from the correlation matrix for the pod emergence phase. Here the dominant variable was daylength, represented by X_1 and equatable to X_4 of podding, due to the differences in phase lengths.

2.4.3 Apical bud dissection study

(a) Preliminary data organisation

The parameters measured were defined using the following symbols:

r_n = the maximum floral state recorded at a node, n; r having values from 0 to 100.

R = the maximum floral state recorded for the plant.

A = the average floral state of the plant, i.e.

$$A = \frac{\Sigma r_n}{\Sigma n}$$

t = the sampling date

N = the number of plants sampled at t

Where i = 1 to k, the number of plants sampled at time, t
and j = 1 to l, the number of sowing date treatments
and m = 1 to q, the number of contiguous sampling dates, then the mean floral state of the population sampled at time, t_{mj}, can be estimated from:

(i) at the bud level, $\bar{R}_j = \frac{\Sigma_i R_{ijm}}{N_{mj}}$ and

(ii) for the whole plant, $\bar{A}_j = \frac{\Sigma_i A_{ijm}}{N_{mj}}$

The daily rate of change in the floral state of a plant between sampling dates, say t_1 and t_2, is given by:

(i) at the bud level, $\frac{R_{ijt_2} - \bar{R}_{ijt_1}}{t_2 - t_1}$.

(ii) for the whole plant, $\frac{A_{ijt_2} - \bar{A}_{ijt_1}}{t_2 - t_1}$

From the meterological data collected during the trial, the following parameters were obtained for each sampling interval:

X_1, the average daylength, including civil twilight, in hours
X_2, the average hourly day temperature, in °C
X_3, the average hourly night temperature, in °C

For each cultivar, sampling periods were designated as 'pre' or 'post initiation' phases, depending upon the level of floral development (R), indicated by the dissection data. i.e.

1. 'Pre-initiation' phase, being the period from emergence to a maximumum development level of approximately R_{30}

2. 'Post-initiation' phase, being the period of floral bud development from R_{30} to R_{100}

The selection of R_{30} as the boundary level between the two phases, was somewhat subjective. As by this stage the five sepal primordia had developed, it was thought that differentiation was probably sufficiently advanced to preclude the possibility of regression to the vegetative state. According to Struckmeyer (1941), this may occur where conditions become unfavorable, (to maintain floral bud growth), for example, under increasing daylengths.

(b) Multiple regression analysis

Simple correlation matrices were constructed for each growth phase, incorporating the following variables:

X_1 = the average daylength, in hours
X_2 = the average hourly day temperature, in °C
X_3 = the average hourly night temperature, in °C
X_4 = plant age, in days
X_5 = A, the plant average floral state (Y_1)
X_5' = $\log_{10}X_5$
X_6 = R, the plant maximum floral state (Y_2)
X_6' = $\log_{10}X_6$
X_7 = the daily change in R (Y_3)
X_7' = $\log_{10}X_7$
X_8 = the daily change in A (Y_4)
X_8' = $\log_{10}X_8$

Using the methods as previously described, multiple regression modeling was used as a means of examining the effect of daylength and temperature on floral initiation and subsequent bud development. Data, correlation matrices and regression models are listed in Appendices 17 and 18.

Chapter Three RESULTS AND DISCUSSION

3.1 GERMINATION PHASE

The length of the germination phase ranged from 4 to 23 days, under average hourly temperature regimes of 21.8°C and 13.4°C, respectively (Appendix 10).

Due to seed germination failure, no counts were recorded for the cultivar Wayne, from the first three sowing dates (Appendix 3).

Prediction of the variation in days to emergence varied from 78% for the cultivar Wayne, to 95.2% for K162 and was significant for all cultivars (Table 2).

Table 2 Germination phase regression data.

Polynomial coefficients a, b_1 and b_2 are for the equation:

$$Y = a \cdot b_1^{X} \cdot b_2^{X^2}$$

where Y = the length, in days, of the germination phase
and X = $X_{2,3}$, the average hourly temperature, in °C, during the germination phase.

Cultivar	a	b_1	b_2	$100R^2$	F	
Acme	474	0.7656	1.0021	89.3	50.29	***
Soysota x Mandarin	18,493	0.4679	1.0174	84.5	35.50	***
Amsoy x T19	2,748	0.5974	1.0099	94.7	116.94	***
Wayne x PI-54-608-II	98,855	0.3914	1.0221	93.8	98.28	***
Wayne	13	1.0058	0.9975	78.0	12.43	**
Dare	108,393	0.3809	1.0240	97.1	215.61	***
Hill	546	0.7163	1.0053	92.1	75.47	***
Ogden	124,451	0.3867	1.0226	92.0	74.30	***
Bragg	1,045	0.6674	1.0069	95.0	123.08	***
Wills	68,549	0.4040	1.0216	94.7	115.86	***
K162	18,923	0.4881	1.0153	95.2	119.76	***
Daintree	21,184	0.4583	1.0186	86.3	40.87	***
Mamloxi	13,740	0.4824	1.0167	88.3	45.41	***

*** = $P < 0.001$; ** = $P < 0.01$

The regression equations were homogeneous for nine of the thirteen cultivars tested. These cultivars were Acme, Soysota x Mandarin, Amsoy x T19, Wayne, Hill, Bragg, K162, Daintree and Mamloxi, (Group A). Of the remaining four cultivars, Wayne x PI-54-608-II, Dare, Ogden and Will, significant differences were recorded for the partial regression coefficients a and b_1 only (Table 3). In Wayne x PI-54-608-II, Ogden and Wills (Group B), the rate of germination was less responsive to changes in temperature than that of the cultivars Acme, Wayne, Hill and Bragg from Group A, (Group C). This was also the case for Dare (Group D), when compared to Acme, Amsoy x T19 and Wayne. These differences are shown in Figure 2, with Amsoy x T19, Ogden, Hill and Dare representing the response patterns of the cultivars in Groups A, B, C and D, respectively.

Temperatures between 13.4°C and 21.8°C effected a positive and exponential increase in the rate of seed germination in all cultivars. For the nine cultivars in Group A, the optimum temperature occurred at 17°C, germination continuing, but at a reduced rate, at 22°C. For the cultivars in Group C, a similar response was noted, but with a higher optimum temperature of 18.5°C. In Groups B and D, the optimum temperature for germination was approximately 15°C, with maxima occurring at 20.8°C and 20.5°C, respectively. Germination was inhibited at temperatures above 25°C, 22°C and 21°C, in cultivars from Groups A, B and D, respectively.

Inherent differences, (not directly related to the temperature response), were suggested from the significant differences between the values for the partial regression coefficient a; (the value of Y when X = 0). The significantly larger values of 'a' for Wayne x PI-54-608-II, Dare, Ogden and Wills, than those for Acme, Wayne, Hill and Bragg, (and also from Amsoy x T19, in the case of Dare), infers an inherently slower rate of embryo development in these cultivars.

Table 3 Germination Phase (Cultivars no. 00 to 11 as per Table 1)

Between cultivar comparisons of the partial regression coefficients for the model

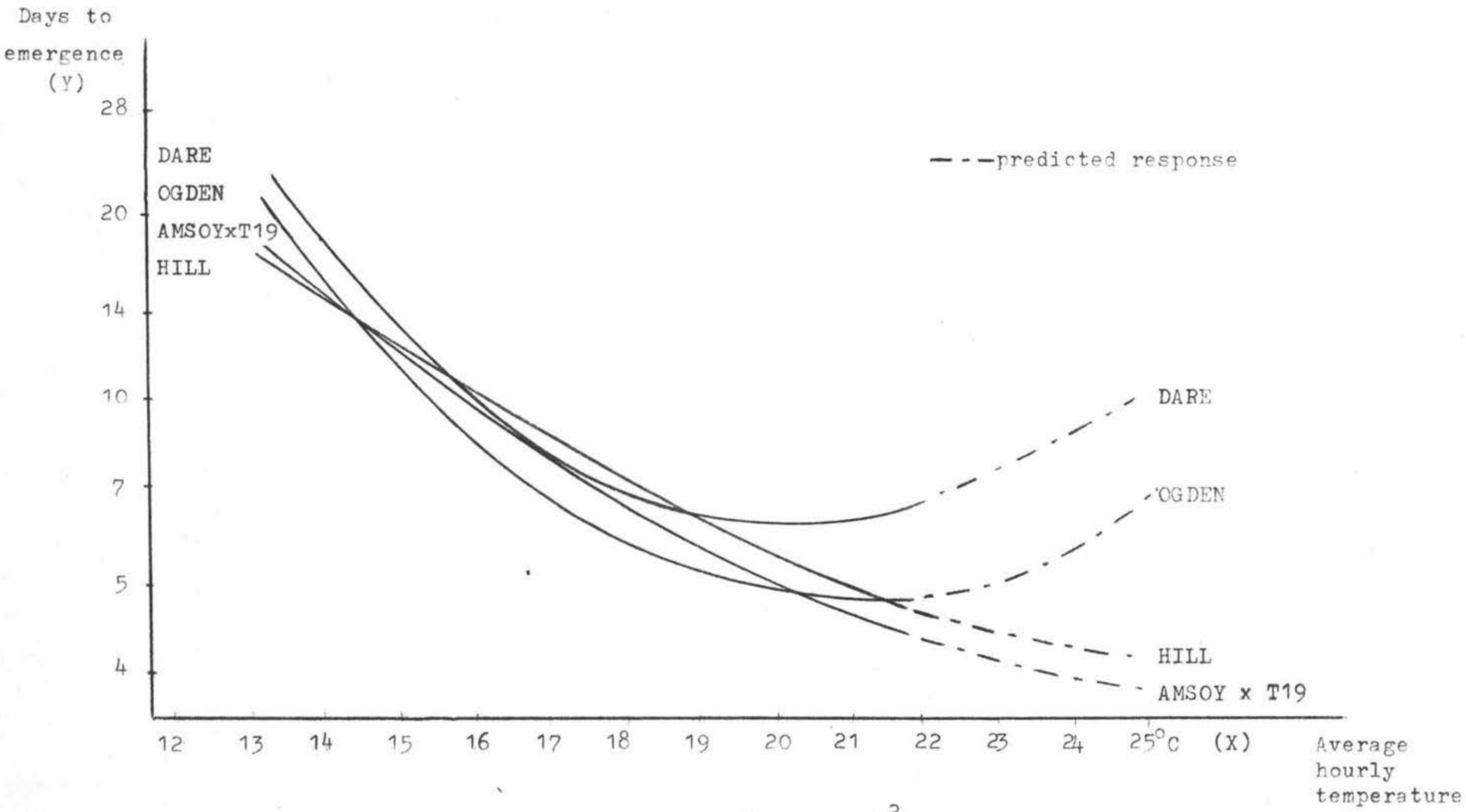
$$Y = a.b_1^{X}.b_2^{X^2}$$

where Y = the length, in days, of the germination phase
and X = $X_{2,3}$ the average hourly temperature, in °C, during germination

T-test significance levels: ** = $P < 0.01$; * = $P < 0.05$; ns = not significant at the 5% level
(for actual t-ratios, see appendix 10.5)

	00			0			1			2			3			4			5			6			7			8			9			10		
	a	b_1	b_2	a	b_1	b_2	a	b_1	b_2	a	b_1	b_2	a	b_1	b_2	a	b_1	b_2	a	b_1	b_2	a	b_1	b_2	a	b_1	b_2	a	b_1	b_2	a	b_1	b_2	a	b_1	b_2
00																																				
0	ns	ns	ns																																	
1	ns	ns	ns	ns	ns	ns																														
2	*	*	ns	ns	ns	ns	ns	ns	ns																											
3	ns	ns	ns	ns	ns	ns	ns	ns	ns	*	*	ns																								
4	*	*	ns	ns	ns	ns	*	*	ns	ns	ns	ns	*	*	ns																					
5	ns	ns	ns	ns	ns	ns	ns	ns	ns	*	*	ns	ns	ns	ns	**	ns	ns																		
6	*	*	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	*	*	ns	ns	ns	ns	*	*	ns															
7	ns	ns	ns	ns	ns	ns	ns	ns	ns	*	*	ns	ns	ns	ns	**	ns	ns	ns	ns	ns	*	*	ns												
8	*	*	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	*	*	ns	ns	ns	ns	*	*	ns	ns	ns	ns	*	*	ns									
9	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns						
10	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns			
11	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

Figure 2 Variation in cultivar response to temperature during germination



where for Amsoy x T19 $Y = 2{,}748 \cdot 0.5974^{X} \cdot 1.0099^{X^{2}}$

Dare $Y = 108{,}393 \cdot 0.3809^{X} \cdot 1.0240^{X^{2}}$

Hill $Y = 546 \cdot 0.7163^{X} \cdot 1.0053^{X^{2}}$

Ogden $Y = 124{,}451 \cdot 0.3867^{X} \cdot 1.0226^{X^{2}}$

3.2 PRE-FLOWERING PHASE

The number of days from emergence to flowering varied from 31 days in the cultivar Acme, to 169 days for Mamloxi. The average daylength and hourly temperature during these periods ranged from 16.0 hours and 20.5°C for Acme, to 14.7 hours and 17.8°C for Mamloxi. Minimum daylengths recorded for each cultivar were 15.7 hours and 12.0 hours, for Acme and Mamloxi respectively (Appendix 11).

Absence of visual flowering in Daintree sown on the 18th January and Mamloxi, sown on the 4th and 18th January, precluded further growth phase measurements being made on these plots.

Prediction of the variation in phase length ranged from 86.4% for the cultivar Acme, to 99.5% for Daintree and was significant for all cultivars (Table 4).

Validity of the use of the parameters, selected as predictor variables, was confirmed by the predominantly significant t-test values for the partial regression coefficients (Appendix 11.4). The values of these coefficients, (given in Table 4), indicate that days to flowering were reduced with decline in average daylength and increase in average hourly temperature. With values less than unity for their partial regression coefficients, the effects of daylength at the start and end of the phase were also negative. Exceptions to this general pattern of response were found in the positive effects, of temperature in Hill, Daintree and Mamloxi and of daylength at the start of the phase in Wayne and Wills. However, of these deviant responses, only that of Daintree to temperature, was statistically significant (Appendix 11.4). Sensitivity to daylength and temperature declined as plants aged, as shown by the curvilinear response of Y to the predictor variables.

The relative contributions made by the X variates to Y, in each cultivar, can be seen by comparing the values of the standardised partial regression coefficients, given in Table 5.

From Table 5 then, daylength appears to have been the main determinant of the length of the pre-flowering phase. The reversal

Table 4 Pre-flowering phase regression data

Partial regression coefficients a, b_1, $b_{2,3}$, b_5 and b_4 are for the equation:

$$Y = a \cdot b_1^{X_1} \cdot b_{2,3}^{X_{2,3}} \cdot b_5^{X_5} \cdot b_4^{X_4}$$

where Y = the length, in days, of the pre-flowering phase
X_1 = the average daylength, in hours, during the pre-flowering phase
$X_{2,3}$ = the average hourly temperature, in °C, during the pre-flowering phase
X_5 = the daylength, in hours, at the end of the pre-flowering phase
X_4 = the daylength, in hours, at the start of the pre-flowering phase

Significance levels: ** = $P < 0.01$; *** = $P < 0.001$.

Cultivar	a	b_1	$b_{2,3}$	b_5	b_4	$100R^2$	F
Acme	132.71	2.5183	0.8945	0.6003	0.6939	86.4	15.83 ***
Soysota x Mandarin	48.70	4.5583	0.8867	0.4361	0.5658	98.6	196.47 ***
Amsoy x T19	11.39	1.6558	0.8177	0.7229	0.8712	94.0	42.95 ***
Wayne x PI-54-608-II	379.93	1.7811	0.9294	0.7470	0.7135	96.6	78.73 ***
Wayne	1.20	1.0524	0.6786	0.9638	1.8009	92.4	15.22 **
Dare	58.95	1.4713	0.9616	0.8507	0.8470	87.9	19.93 ***
Hill	72.26	1.5667	1.0032	0.7889	0.8050	97.8	120.23 ***
Ogden	20.11	1.8273	0.9732	0.7308	0.8335	97.5	107.27 ***
Bragg	108.12	1.9006	0.7905	0.6893	0.9763	97.5	108.69 ***
Wills	26.57	2.2182	0.8022	0.6023	1.0165	98.3	156.40 ***
K162	135.46	1.5718	0.9471	0.7261	0.8931	97.7	106.19 ***
Daintree	3711.08	1.2735	1.1074	0.6832	0.7668	99.5	423.42 ***
Mamloxi	6241.66	1.0844	1.1089	0.7688	0.7872	95.7	33.01 ***

Table 5 Standardised partial regression coefficients for daylength (b'_1, b'_4, b'_5) and temperature ($b'_{2,3}$)

Cultivar	b'_1 (a)	$b'_{2,3}$ (b)	b'_5 (c)	b'_4 (d)	Rank
Acme	*7.086	-0.876	-1.275	-1.526	a d c b
Soysota x Mandarin	15.571	-1.209	-2.259	-2.875	a d c b
Amsoy x T19	1.719	-0.736	-1.106	-0.876	a c d b
Wayne x PI-54-608-II	4.281	-0.237	-0.939	-1.988	a d c b
Wayne	0.190	-1.226	-0.234	5.554	d b c a
Dare	1.344	-0.117	-0.620	-0.918	a d c b
Hill	1.474	0.011	-0.945	-1.041	a d c b
Ogden	1.818	-0.083	-1.100	-0.821	a c d b
Bragg	1.779	-0.618	-1.106	-0.085	a c b d
Wills	2.195	-0.586	-1.573	0.049	a c b d
K162	2.370	-0.241	-1.989	-0.681	a c d b
Daintree	1.339	0.591	-2.510	-1.592	c d a b
Mamloxi	0.395	0.845	-1.590	-1.624	d c b a

*$\log_{10}$ transformed data

in importance of daylength at the start and end of the phase, with delay in flowering, merely reflects the changing pattern of daylength with time. (A graph of the annual pattern of daylength for the trial latitude, is given on page 45, Figure 6). In the early-maturing cultivars, flowering commenced under a fairly static photoperiod; i.e. when the daylength was either inclining to, or declining from, its maximum for the latitude. For these cultivars then, an increasing daylength predominated during the pre-flowering phase, with the minimum photoperiod experienced occurring at the start of the phase. In the later maturing cultivars, flowering commenced under a rapidly declining daylength, the minimum photoperiod experienced occurring at the end of the pre-flowering phase.

If the rate of change in decline in daylength also influences development during the pre-flowering phase, this may explain the apparent deviation of Amsoy x T19 and Mamloxi from the general pattern of response. For these two cultivars, flowering commenced when daylength changes were at a minimum. For Amsoy x T19, the first cultivar to flower, this occurred under the maximum daylength of 16.1 hours. Little variation occurred in phase length until the daylength began to decline (Appendix 11). Conversely, in Mamloxi, the greatest variation in daylength occurred at the start of the phase, flowering commencing under decreasing rates of decline in daylength.

Separation of daylength and temperature effects was confounded by the close relationship between these parameters. When following average daylength in the model, the effect of temperature was significant in all cultivars except Wayne - absent from the first four sowings, therefore exposed to a relatively narrow range of temperature during the pre-flowering phase of growth. However, if all significant daylength variables were considered prior to temperature, significant temperature effects were discernible in only five of the thirteen cultivars (Appendix 11.2). These cultivars were Soysota x Mandarin, Amsoy x T19, Wayne, Wills and Daintree.

The regression equations were homogeneous for cultivars in the following groups:

(a) Acme, Soysota x Mandarin.
(b) Acme, Amsoy x T19, Dare, Ogden, Bragg.
(c) Acme, Amsoy x T19, Ogden, Bragg, Wills.
(d) Acme, Wayne x PI-54-608-II, Dare, Bragg, K162.
(e) Acme, Dare, Hill, Ogden, Bragg, K162.

For all other possible cultivar comparisons, the regression equations were heterogeneous (Table 6).

As expressed by the regression model, variation between cultivars in duration of the pre-flowering phase, can be attributed to:

1. intrinsic (genetic) differences - represented in the model by variation in the values of the partial regression coefficient, 'a', (the value of Y when X = 0); and
2. phenotypic differences, being the responses to the X variates, as represented by the values of the 'b' partial regression coefficients.

From Table 6 then, cultivar differences can be summarised as shown in Figures 3, 4 and 5, where, for cultivars within a box, differences are not significant at the 5% level - and between boxes, significantly different ($P < 0.05$).

Figure 3 Genotypic variation in length of the pre-flowering phase - as measured by the partial regression coefficient 'a'.

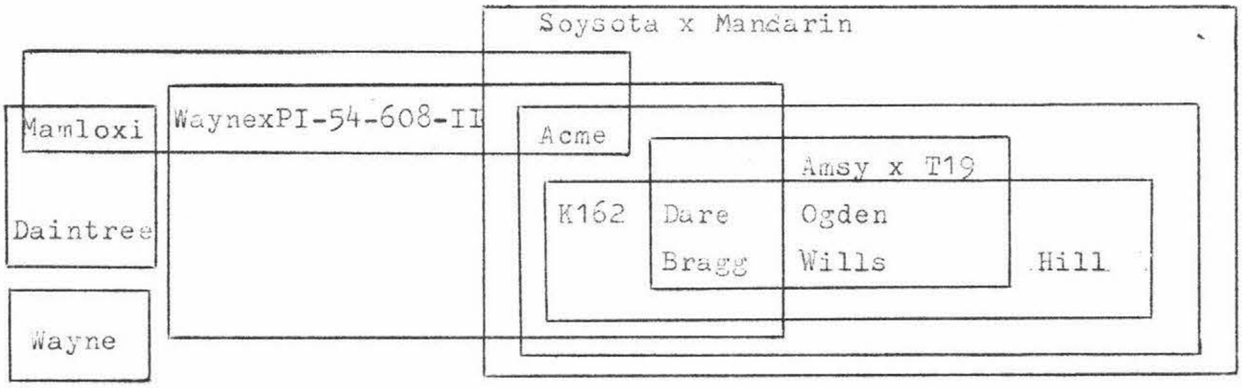


Figure 4 Phenotypic variation in response to daylength during the pre-flowering phase - as measured by the partial regression coefficient 'b_1'.

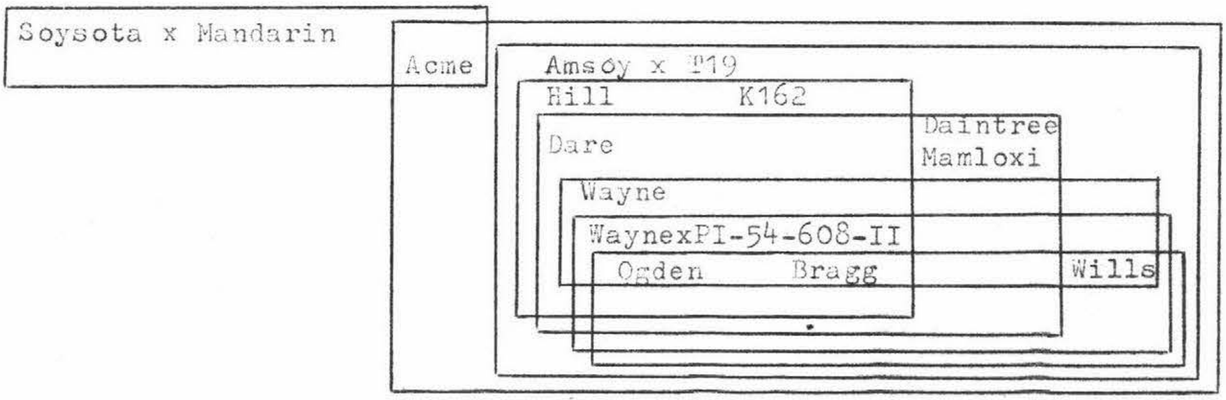


Figure 5 Phenotypic variation in response to temperature during the pre-flowering phase - as measured by the partial regression coefficient '$b_{2,3}$'.

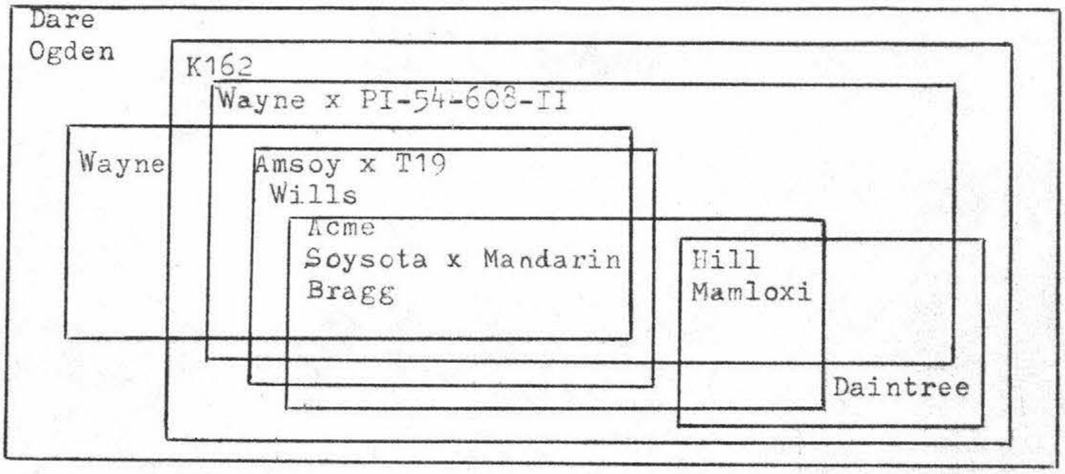


Table 6 Pre-Flowering Phase (Cultivars no. 00 to 11 as per Table 1)

Between cultivar comparisons of the partial regression coefficients for the model

$$Y = a \cdot b_1^{X_1} \cdot b_{2,3}^{X_{2,3}} \cdot b_5^{X_5} \cdot b_4^{X_4}$$

where Y = the length, in days, of the pre-flowering phase
X_1 = the average daylength, in hours, during the phase
$X_{2,3}$ = the average hourly temperature, in °C, during the phase
X_5 = the daylength, in hours, at the end of the phase
X_4 = the daylength, in hours, at the start of the phase

T-test significance levels: ** = $P < 0.01$; * = $P < 0.05$; ns = not significant at the 5% level. (For actual t-ratios, see Appendix 11.5).

	00					0					1					2					3				
	a	b_1	$b_{2,3}$	b_5	b_4	a	b_1	$b_{2,3}$	b_5	b_4	a	b_1	$b_{2,3}$	b_5	b_4	a	b_1	$b_{2,3}$	b_5	b_4	a	b_1	$b_{2,3}$	b_5	b_4
00																									
0	ns	ns	ns	ns	ns																				
1	ns	ns	ns	ns	ns	ns	**	ns	**	*															
2	ns	ns	ns	ns	ns	**	**	ns	**	ns	**	ns	ns	ns	ns										
3	*	ns	ns	ns	ns	**	**	ns	**	**	*	ns	ns	ns	*	**	ns	*	ns	**					
4	ns	ns	ns	ns	ns	ns	**	ns	**	*	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	*	ns	ns	ns	ns
5	ns	ns	ns	ns	ns	ns	**	ns	**	**	*	ns	*	ns	ns	*	ns	ns	ns	ns	**	ns	*	ns	ns
6	ns	ns	ns	ns	ns	ns	**	ns	**	*	ns	ns	ns	ns	ns	**	ns	ns	ns	ns	*	*	ns	ns	ns
7	ns	ns	ns	ns	ns	ns	**	ns	*	**	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	**	*	ns	ns	ns
8	ns	ns	ns	ns	ns	ns	**	ns	*	**	ns	ns	ns	ns	ns	**	ns	ns	ns	*	**	**	ns	**	ns
9	ns	ns	ns	ns	ns	ns	**	ns	**	**	*	ns	ns	ns	ns	ns	ns	ns	ns	ns	**	ns	*	ns	ns
10	*	ns	**	ns	ns	**	**	**	**	**	**	ns	**	ns	ns	**	**	**	ns	ns	**	ns	**	*	ns
11	ns	ns	ns	ns	ns	**	**	ns	**	*	**	ns	*	ns	ns	ns	*	ns	ns	ns	**	ns	*	ns	ns

4					5					6					7					8					9					10				
a	b_1	b_3	b_5	b_4	a	b_1	b_3	b_5	b_4	a	b_1	b_3	b_5	b_4	a	b_1	b_3	b_5	b_4	a	b_1	b_3	b_5	b_4	a	b_1	b_3	b_5	b_4	a	b_1	b_3	b_5	b_4
ns	ns	ns	ns	ns																														
ns	ns	ns	ns	ns	ns	ns	ns	ns	ns																									
ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns																				
ns	**	ns	*	ns	ns	*	*	ns	*	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns															
ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	*	ns	ns	ns										
**	ns	ns	*	ns	**	*	ns	ns	ns	**	**	ns	ns	ns	**	*	*	ns	ns	**	**	**	ns	**	**	*	ns	ns	ns					
*	ns	ns	ns	ns	*	*	ns	ns	ns	**	**	ns	ns	ns	*	*	ns	ns	ns	**	**	*	ns	*	ns	*	ns	ns	ns	ns	ns	ns	ns	ns

3.3 FLOWERING PHASE

The length of the flowering phase varied from 33 days for the cultivar Acme, to 78 days for Wayne x PI-54-608-II, under declining daylength regimes of 16.0 to 15.1 hours and 14.3 to 11.0 hours, respectively (Appendix 12).

Prediction of the variation in flowering duration ranged from 74.5% for the cultivar Bragg, to 99.3% for Daintree and Mamloxi and was significant for all cultivars (Table 7).

Table 7 Flowering phase regression data

Partial regression coefficients a, b_5 and b_4 are for the equation

$$Y = a + b_5X_5 + b_4X_4$$

where Y = the length, in days, of the flowering phase
X_5 = the daylength, in hours, at the end of flowering
X_4 = the daylength, in hours, at the start of flowering

Cultivar	a	b_5	b_4	$100R^2$	F
Acme	160.12	- 8.421	0.222	97.1	202.05 ***
Soysota x Mandarin	141.15	- 6.566	- 0.177	90.0	58.44 ***
Amsoy x T19	272.57	8.290	-21.220	77.4	20.53 ***
Wayne x PI-54-608-II	33.55	-15.302	14.603	75.9	20.43 ***
Wayne	115.25	-17.499	10.694	93.6	51.44 ***
Dare	137.81	-18.743	10.009	94.9	111.94 ***
Hill	145.59	-21.444	11.392	88.9	51.95 ***
Ogden	181.34	-18.769	6.962	88.7	50.96 ***
Bragg	221.64	-37.260	18.765	74.5	18.97 ***
Wills	287.37	-40.573	16.358	77.4	22.26 ***
K162	538.63	-72.544	23.033	88.8	47.48 ***
Daintree	278.42	-46.069	21.449	99.3	820.21 ***
Mamloxi	-27.18	-19.733	24.025	99.3	608.29 ***

*** = $P < 0.001$

As flowering occurred under declining daylengths, X_4 and X_5 also represent the phase maximum and minimum daylengths, respectively. The use of X_5 and X_4 as predictor variables, was confirmed by the significant t-test values for the partial regression coefficients b_5 and b_4 (Appendix 12.4). The predominantly negative values for b_5 and positive values of b_4, indicate that flowering duration increased with declining minimum and increasing maximum daylength. Exceptions to this response pattern were observed in:

(i) the nonsignificant t-test values for Acme and Soysota x Mandarin, (b_4) and for Amsoy x T19 and K162, (b_5);

(ii) the differences in signs of the partial regression coefficients for Amsoy x T19, (negative b_4, positive b_5) and Soysota x Mandarin, (negative b_4). (Appendix 12.4)

Examination of the contribution of X_5 and X_4 to the regression sums of squares, gave the following results:

Table 8 F-test comparisons - Flowering phase Analysis of Variance

Cultivar	Maturity Group	$F_{Y_1X_5 \cdot X_4}$	$F_{Y_1X_4 \cdot X_5}$
1. Additional regression due to X_4 - non significant:			
Acme	00	403.93 ***	0.003 ns
Soysota x Mandarin	0	116.91 ***	0.012 ns
2. Additional regression due to X_4 - significant:			
Amsoy x T19	1	34.60 ***	6.46 *
Wayne x PI-54-608-II	2	31.11 ***	9.77 **
Wayne	3	95.87 ***	7.01 *
Dare	4	203.38 ***	20.52 ***
Hill	5	66.53 ***	37.38 ***
Ogden	6	89.88 ***	12.02 **
Bragg	7	4.43 ns	33.52 ***
Wills	8	25.70 ***	18.82 ***
K162	9	62.71 ***	32.25 ***
Daintree	10	842.78 ***	797.48 ***
Mamloxi	11	225.08 ***	991.60 ***

*** = P 0.001; ** = P 0.01; * = P 0.05; ns = not significant at the 5% level.

From Table 8 it can be seen that, with delay in flowering, dominance of the effect of the daylength at the end of the phase gave way to that of daylength at the start of the phase. This reflects the change in rate of decline in daylength with time, (Figure 6), variation in daylength increasing with flowering in the early maturing cultivars (00, 0) and decreasing as flowering continues in the late maturing cultivars (10, 11). It also explains the apparently deviant response in Amsoy x T19, the first cultivar to flower. Here the phase commenced under a static daylength, flowering duration responding when the daylength, in this case still at the X_4 level, began to decline (Appendix 12).

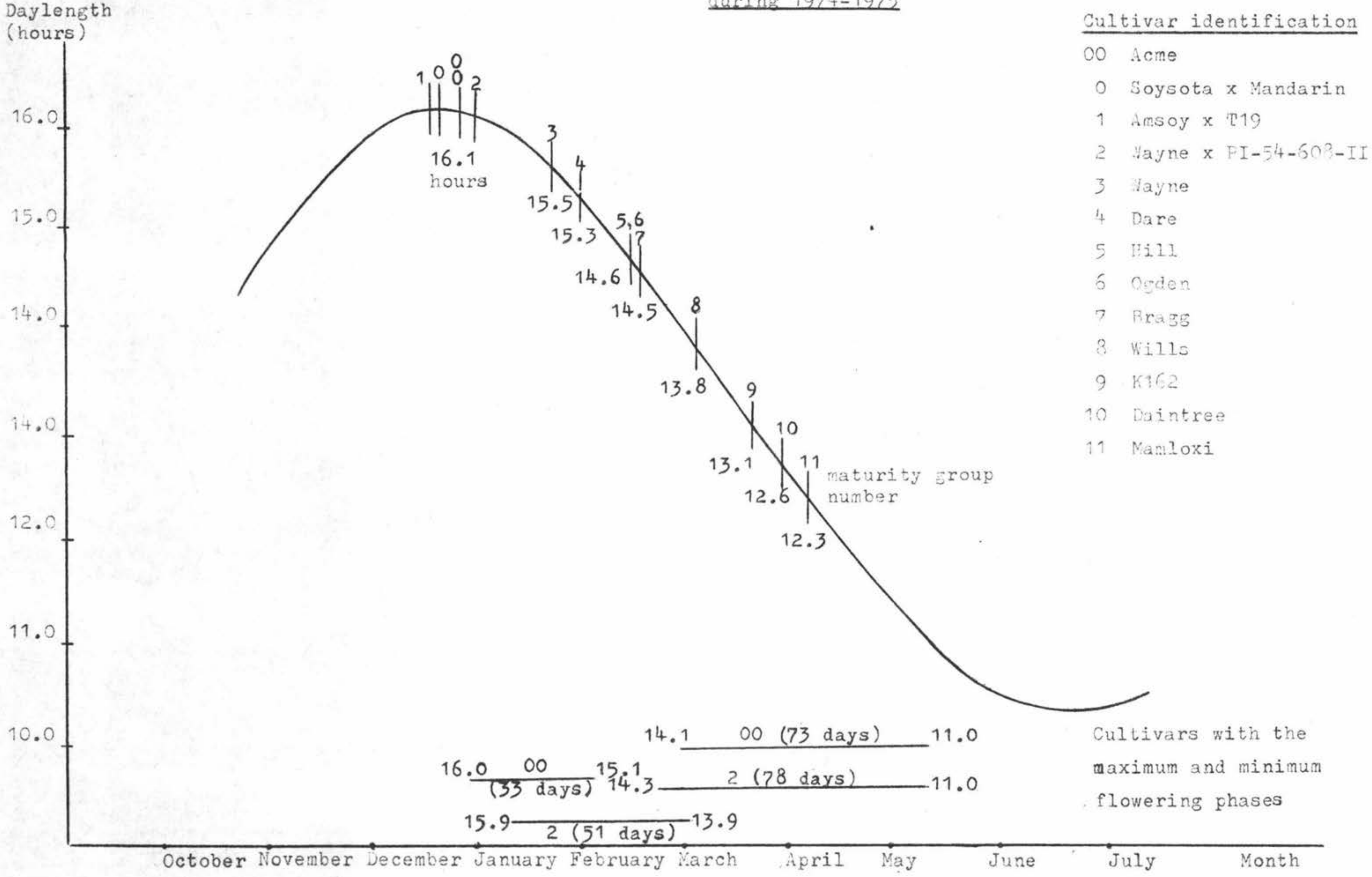
For each cultivar, the relative contributions of X_5 and X_4 to the variation in Y, can be seen from comparison of their standardised partial regression coefficients.(Table 9).

Table 9 Ratio's of the standardised partial regression coefficients for daylength (b'_5, b'_4).

Cultivar	b'_5	b'_4	$b'_5:b'_4$	
Acme	-0.9976	0.0124	80.45	increasing
Soysota x Mandarin	-0.9313	-0.0131	71.09	importance
Daintree	-3.2076	1.2468	2.57	of X_4
Wayne	-1.8490	0.9154	2.02	
Ogden	-1.6582	0.8385	1.98	↑
Dare	-1.9232	1.0374	1.85	
Hill	-2.1725	1.5266	1.42	
Wayne x PI-54-608-II	-2.4386	1.7317	1.41	
Wills	-2.0486	1.4942	1.37	↓
Bragg	-3.4489	3.2565	1.06	
Amsoy x T19	1.4305	-2.2652	0.63	increasing
K162	-0.4794	1.4068	0.34	importance
Mamloxi	-0.1017	1.0446	0.10	of X_5

Apparent discrepancies existing between Tables 8 and 9, in the relative importance attributed to each daylength parameter, arise due to the close correlation between X_5 and X_4. Although this correlation affects the value of the partial regression coefficients, their

Figure 6 Annual distribution of daylength at 40°32'S, showing the maximum daylengths for onset of flowering in cultivars from the maturity groups 00 to 11 during 1974-1975



estimation is simultaineous and not dependent upon the order of entry of the X variables into the model, as are the relative values of F.

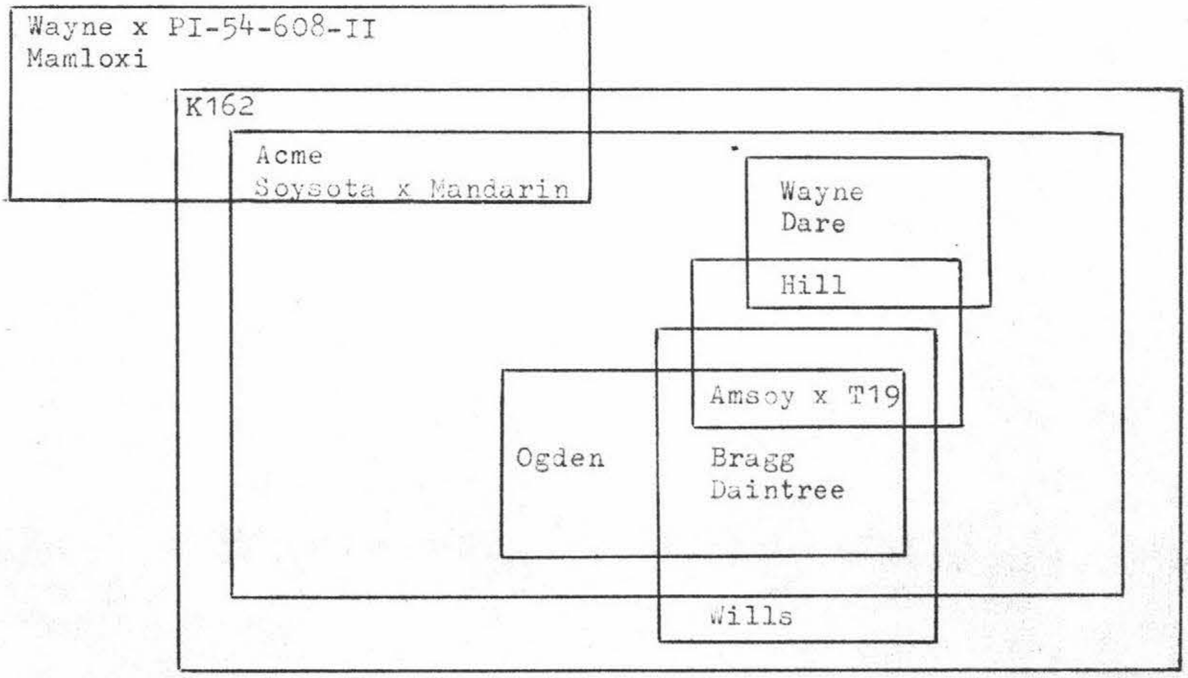
The variation existing between cultivars, in flowering duration response to the two daylength parameters, is shown in Table 10.

For cultivars within the following groups, the regression equations predicting flowering duration, were homogeneous:

(a) Acme, Soysota x Mandarin
(b) Wayne x PI-54-608-II, K162, Mamloxi
(c) Wayne, Dare, Hill
(d) Bragg, Wills, K162, Daintree

For all other possible cultivar comparisons, the regression equations were heterogeneous. From Table 10, these differences can be summarised as follows:

Figure 7 Genotypic variation in flowering duration - as measured by the partial regression coefficient 'a'



where, for cultivars within a box, differences are not significant at the 5% level - and between boxes, significantly different ($P < 0.05$). Similarly, in Figures 8 and 9:

Figure 8 Phenotypic variation in flowering duration response to daylength at the end of the phase - as measured by the partial regression coefficient 'b_5'.

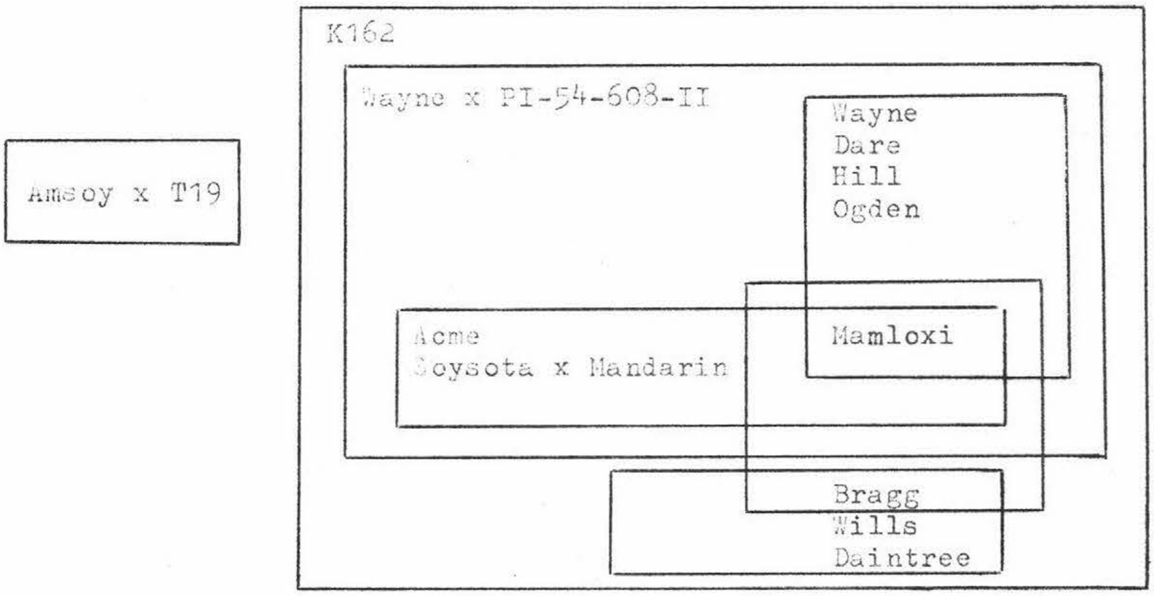


Figure 9 Phenotypic variation in flowering duration response to daylength at the start of the phase - as measured by the partial regression coefficient 'b_4'.

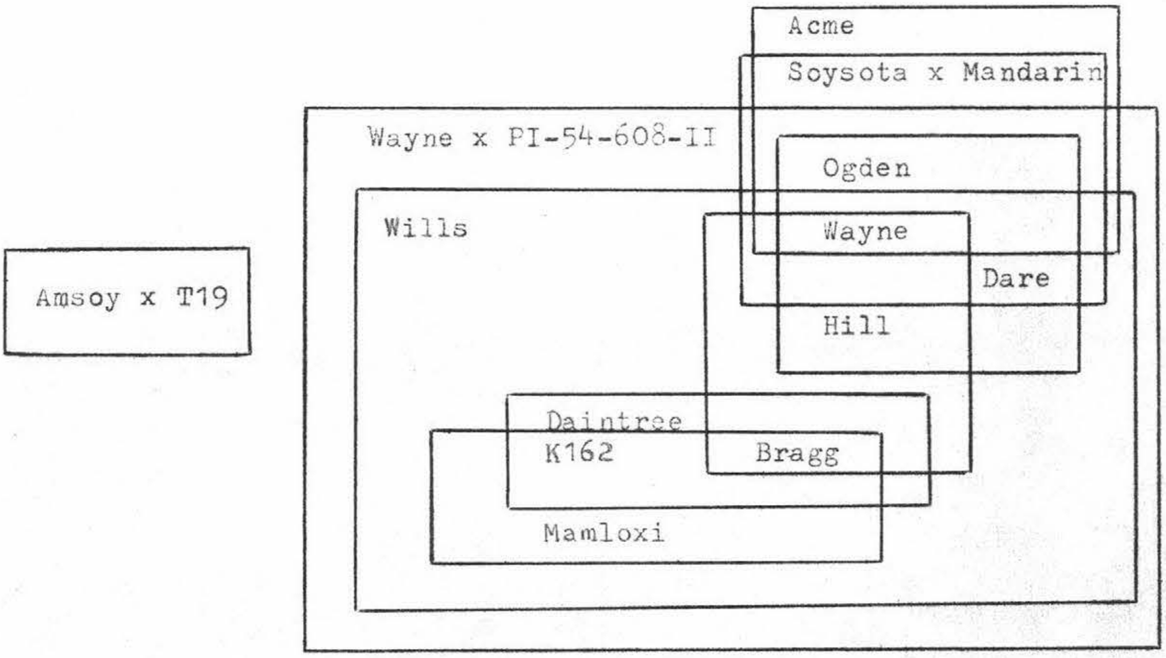


Table 10 **Flowering Phase** (Cultivars no. 00 to 11 as per Table 1)

Between cultivar comparisons of the partial regression coefficients for the model

$$Y = a + b_5X_5 + b_4X_4$$

where Y = the length, in days, of the flowering phase
X_5 = the daylength, in hours, at the end of the phase
X_4 = the daylength, in hours, at the start of the phase

T-test significance levels: ** = $P < 0.01$; * = $P < 0.05$; ns = not significant at the 5% level
(for actual t-ratios, see appendix 12.5)

	00			0			1			2			3			4			5			6			7			8			9			10		
	a	b_5	b_4	a	b_5	b_4	a	b_5	b_4	a	b_5	b_4	a	b_5	b_4	a	b_5	b_4	a	b_5	b_4	a	b_5	b_4	a	b_5	b_4	a	b_5	b_4	a	b_5	b_4	a	b_5	b_4
00																																				
0	ns	ns	ns																																	
1	ns	**	*	ns	*	*																														
2	*	ns	*	ns	ns	*	**	**	**																											
3	ns	*	ns	ns	*	ns	*	**	**	*	ns	ns																								
4	ns	**	*	ns	**	ns	*	**	**	**	ns	ns	ns	ns	ns																					
5	ns	**	*	ns	**	*	ns	**	**	**	ns	ns	ns	ns	ns	ns	ns	ns																		
6	ns	**	ns	ns	**	ns	ns	**	**	**	ns	ns	*	ns	ns	**	ns	ns	*	ns	ns															
7	ns	**	**	ns	**	**	ns	**	**	**	**	ns	**	**	ns	**	**	*	*	*	ns	ns	**	**												
8	*	**	**	*	**	*	ns	**	**	**	**	ns	**	**	ns	**	**	ns	**	*	ns	**	**	*	ns	ns	ns									
9	ns	ns	**	ns	ns	**	ns	*	**	ns	ns	ns	ns	ns	*	ns	ns	**	ns	ns	*	ns	ns	**	ns	ns	ns	ns	ns	ns						
10	ns	**	**	ns	**	**	ns	**	**	**	**	ns	*	**	*	*	**	**	*	**	**	ns	**	**	ns	ns	ns	ns	ns	ns	ns	ns	ns			
11	*	ns	**	*	ns	**	**	**	**	ns	ns	ns	*	ns	**	*	ns	**	*	ns	**	**	ns	**	**	ns	ns	**	*	ns	ns	ns	ns	**	**	*

3.4 POD EMERGENCE PHASE

Following flowering, the number of days taken for the first pod to appear, ranged from 3.5 days for the cultivar Acme, to 14.9 days for Wills (Appendix 13). The respective average daylength, hourly day and hourly night temperatures during these periods were, 14.4 hours, 20.6°C and 18.6°C for Acme and 11.6 hours, 15.7°C and 12.2°C for Wills.

Where significant, prediction of the days to pod emergence ranged from 60.9% for the cultivar Bragg, to 87.2% for Hill. The regression model was non significant for the cultivars Ogden, Daintree, Wayne and Mamloxi, predicting 26.5%, 56.8%, 63.5% and 64.2% of the phase variation, respectively (Table 12).

As suggested from the results of the correlation matrix for this phase, the relationship of the individual X variates with Y differed widely, depending on the cultivar. The significance of the contributions of daylength and temperature to the variation in rate of pod emergence in each cultivar, from the model, are given in Table 11.

Table 11 F values for the Pod Emergence regression equation

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3$$

where Y = the length, in days, of the pod emergence phase
X_1 = the average daylength, in hours, during pod emergence
X_2 = the average hourly day temperature, in °C, during the phase
X_3 = the average hourly night temperature, in °C, during the phase

Cultivar	$F_{YX_1 \cdot X_2X_3}$	$F_{YX_2 \cdot X_1X_3}$	$F_{YX_3 \cdot X_1X_2}$	'F_{YX_1}
Acme	16.87 **	1.79 ns	1.51 ns	15.33 **
Soysota x Mandarin	53.59 ***	1.40 ns	2.19 ns	47.75 ***
Amsoy x T19	64.06 ***	0.27 ns	14.86 **	37.94 ***
Wayne x PI-54-608-II	23.80 ***	1.26 ns	0.00 ns	25.13 ***
Wayne	8.42 *	0.61 ns	1.42 ns	8.38 *
Dare	22.62 ***	6.45 *	5.16 *	13.00 **
Hill	41.11 ***	19.58 **	7.52 *	13.30 **
Ogden	0.28 ns	3.24 ns	0.38 ns	0.25 ns
Bragg	0.60 ns	15.72 **	2.83 ns	0.28 ns
Wills	28.70 ***	3.30 ns	0.07 ns	26.13 ***
K162	16.24 **	1.53 ns	0.40 ns	16.38 **
Daintree	7.58 *	0.49 ns	0.60 ns	7.60 *
Mamloxi	5.15 ns	1.97 ns	0.04 ns	3.79 ns

Table 12 Pod emergence phase regression data

Partial regression coefficients a, b_1, b_2 and b_3 are for the equation

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3$$

where Y = the length, in days, of the pod emergence phase
X_1 = the average daylength, in hours, during pod emergence
X_2 = the average hourly day temperature, in °C, during pod emergence
X_3 = the average hourly night temperature, in °C, during pod emergence

Significance levels: *** = $P < 0.001$; ** = $P < 0.01$; * = $P < 0.05$; ns = not significant at the 5% level.

Cultivar	a	b_1	b_2	b_3	$100R^2$	F	
Acme	-6.755	1.2824	-0.0325	-0.3656	64.7	6.73	**
Soysota x Mandarin	-29.622	1.7059	1.2192	-0.7861	83.9	19.05	***
Amsoy x T19	-21.815	2.5196	0.2227	-0.7826	86.8	26.40	***
Wayne x PI-54-608-II	-11.202	1.6333	-0.2837	0.0168	67.6	8.35	**
Wayne	7.131	1.1161	0.4012	-1.4522	63.5	3.48	ns
Dare	-7.715	1.8117	0.5186	-1.0309	75.7	11.41	**
Hill	6.878	0.3236	1.2514	-1.7158	87.2	22.73	***
Ogden	25.479	0.1449	-1.6766	1.0128	24.5	1.30	ns
Bragg	2.739	1.9667	0.1058	-1.2868	60.9	6.24	**
Wills	37.339	-1.1962	-0.7535	0.1711	72.8	7.97	**
K162	30.057	-0.8494	-0.0883	-0.6762	75.2	6.06	*
Daintree	108.850	-11.3750	4.0465	-2.3724	56.8	2.60	ns
Mamloxi	70.527	-7.3872	1.4004	0.5326	64.2	2.39	ns

Table 11 continued:

Re the column headed 'F_{YX_1} - this is for the equation

$$Y = a + b_1X_1$$

Significance levels: *** = P 0.001; ** = P 0.01; * = P 0.05; ns = not significant at the 5% level.

To summarise Tables 11 and 12:

(i) The effect of daylength was significant in all cultivars except Ogden, Bragg and Mamloxi. The rate of pod emergence increased as daylength declined, for all cultivars except Wills, K162, Daintree and Mamloxi.

(ii) The additional variation attributable to temperature was significant in only four of the thirteen cultivars tested. Dare, Hill and Bragg showed a response to day temperature and Amsoy x T19, Dare and Hill responded to night temperature. For these cultivars, the rate of pod emergence increased with rising night temperatures and declining day temperatures.

The regression equations were homogeneous for all cultivars except Soysota x Mandarin, Amsoy x T19, Hill and Wills. Differences in these cultivars were due mainly to variation in sensitivity to daylength (Table 13). i.e. In Amsoy x T19, the rate of pod emergence was more responsive to the variation in daylength than that in the cultivars Acme, Hill, Ogden and Wills; Soysota x Mandarin and Hill being more responsive than Wills - both Hill and Wills being less responsive than Wayne x PI-54-608-II, Dare and Bragg. Pod emergence in the cultivars Soysota x Mandarin and Hill were also more responsive to fluctuations in temperature, than in Wills, and Wayne x PI-54-608-II and Wills, respectively. However, due to the inadequacy of the model to explain consistently the variation in length of the pod emergence phase, little weight can be given to these differences, being based on comparisons of the model's parameters. For this reason, summaries are given for the partial regression coefficients 'a' and 'b_1' only (Figures 10 and 11).

Model inadequacy was probably due, in part, to the sensitivity of the phase to measurement error. Initial flowering in the soybean usually occurs in node axils, with more than one floral bud being

Table 13 Pod Emergence Phase (Cultivars no. 00 to 11 as per Table 1).

Between cultivar comparisons of the partial regression coefficients for the model

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3$$

where Y = the length, in days, of the pod emergence phase
X_1 = the average daylength, in hours, during the phase
X_2 = the average hourly day temperature, in °C, during the phase
X_3 = the average hourly night temperature, in °C, during the phase

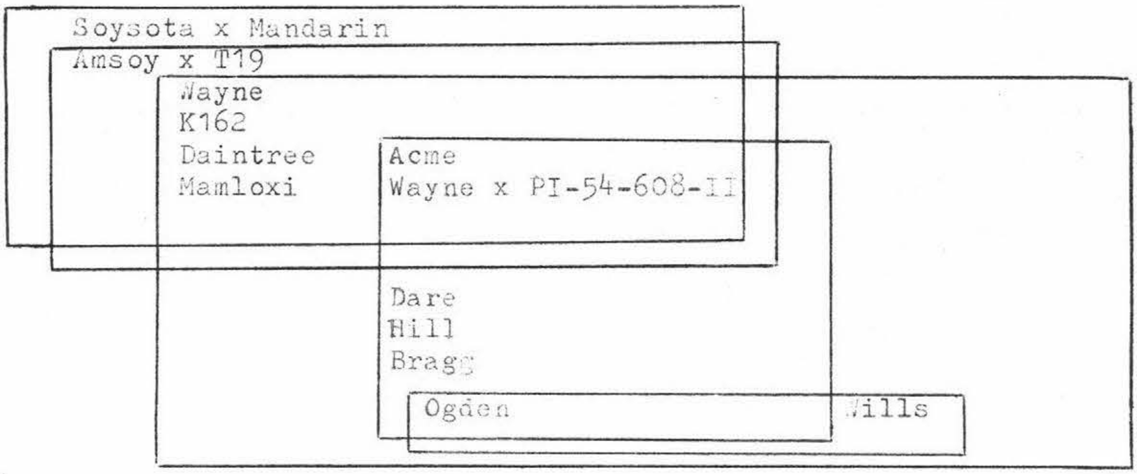
T-test significance levels: ** = $P < 0.01$; * = $P < 0.05$; ns = not significant at the 5% level. (For actual t-ratios, see Appendix 13.5).

	00				0				1				2				3				4			
	a	b_1	b_2	b_3	a	b_1	b_2	b_3	a	b_1	b_2	b_3	a	b_1	b_2	b_3	a	b_1	b_2	b_3	a	b_1	b_2	b_3
00																								
0	**	ns	ns	ns																				
1	ns	*	ns	ns	ns	ns	ns	ns																
2	ns	ns	ns	ns	*	ns	ns	ns	ns	ns	ns	ns												
3	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns								
4	ns	ns	ns	ns	**	ns	ns	ns	*	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns				
5	ns	ns	ns	ns	**	ns	ns	ns	**	**	ns	ns	ns	*	ns	*	ns	ns	ns	ns	ns	*	ns	ns
6	ns	ns	ns	ns	**	ns	ns	ns	*	*	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
7	ns	ns	ns	ns	**	ns	ns	ns	*	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
8	**	ns	ns	ns	**	*	*	ns	**	**	ns	ns	**	*	ns	ns	ns	ns	ns	ns	**	*	ns	ns
9	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
10	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
11	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

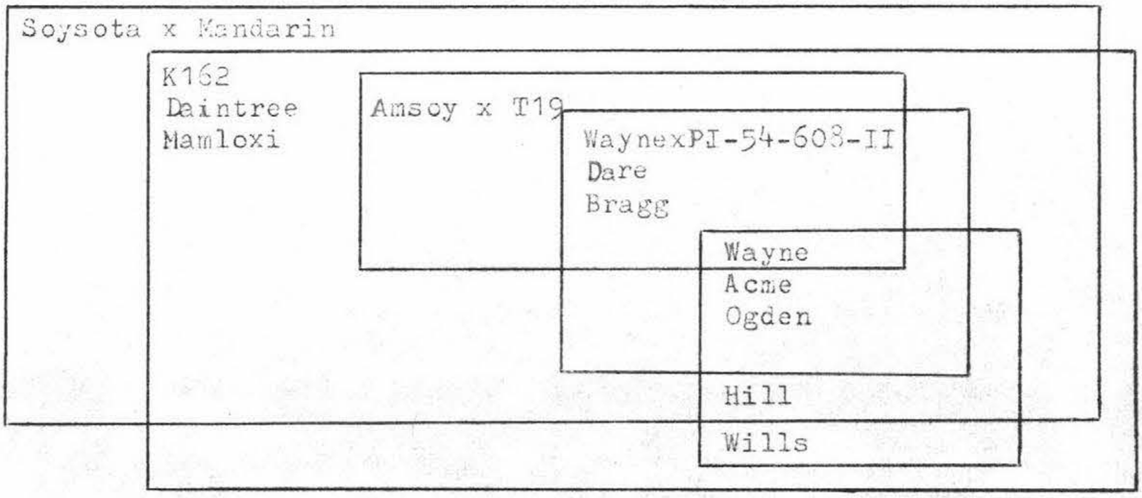
	5				6				7				8				9				10			
	a	b_1	b_2	b_3	a	b_1	b_2	b_3	a	b_1	b_2	b_3	a	b_1	b_2	b_3	a	b_1	b_2	b_3	a	b_1	b_2	b_3
	ns	ns	ns	ns																				
	ns	*	ns	ns	ns	ns	ns	ns																
	*	ns	*	*	ns	ns	ns	ns	*	*	ns	ns												
	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns								
	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns				
	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

produced at a single node. If florets abort, or if flowering is cleistogamous, the first pod to emerge at the node of first flower may not have arisen necessarily from that same flower. Due to the short phase length, small discrepancies, of even one day, could have induced disproportionately large time and temperature errors, values for the latter often changing dramatically from day to day (Appendix 13).

<u>Figure 10</u> Genotypic variation in pod emergence rate - as measured by the partial regression coefficient 'a'.



<u>Figure 11</u> Phenotypic variation in pod emergence response to daylength - as measured by the partial regression coefficient 'b_1'



where, for cultivars within a box, differences are not significant at the 5% level - and between boxes, significantly different ($P < 0.05$).

3.5 PODDING PHASE

Duration of the podding phase ranged from 103 days in the cultivar Ogden, to 57 days for Mamloxi. The corresponding values for the test variables, average hourly temperature and daylength at the start of the phase, were 11.5°C and 12.7 hours for Ogden - and 9.8°C and 11.0 hours for Mamloxi (Appendix 14).

Pod emergence failure precluded data collection from the January sowings of the cultivar K162; from the late December and both January sowings of Daintree - and for all sowings of Mamloxi, made during these two months.

Model prediction of the variation in podding duration ranged from 52.8% for the cultivar Dare, to 97.5% for K162 and was significant for all cultivars (Table 14).

Table 14 Podding phase regression data

Partial regression coefficients a, $b_{2,3}$ and b_4 are for the equation

$$Y = a + b_{2,3}X_{2,3} + b_4X_4$$

where Y = the length, in days, of the podding phase

$X_{2,3}$ = the average hourly temperature, in °C, during podding

X_4 = the daylength, in hours, at the start of podding

Cultivar	a	$b_{2,3}$	b_4	$100R^2$	F
Acme	56.96	-11.938	14.919	88.2	44.82 ***
Soysota x Mandarin	- 14.80	-16.363	25.170	86.5	41.68 ***
Amsoy x T19	6.49	-16.933	24.385	96.8	183.52 ***
Wayne x PI-54-608-II	-101.94	-23.320	39.220	85.6	48.74 ***
Wayne	201.40	- 1.692	- 6.956	96.2	88.65 ***
Dare	- 55.06	- 9.468	20.649	52.8	6.71 *
Hill	- 5.95	- 7.674	14.266	71.8	15.25 ***
Ogden	-177.91	-15.824	36.457	96.1	147.83 ***
Bragg	-124.65	-14.002	30.424	95.8	137.15 ***
Wills	-239.00	-16.932	42.475	86.3	40.92 ***
K162	-178.81	- 8.908	29.855	97.5	134.45 ***
Daintree	-193.27	- 7.354	29.560	96.6	98.56 ***
Mamloxi	-332.47	-12.906	46.856	96.8	74.87 ***

*** = $P < 0.001$; ** = $P < 0.01$; * = $P < 0.05$.

Validity of the use of $X_{2,3}$ and X_4 as predictor variables, was confirmed by the significant t-test values for the partial regression coefficients $b_{2,3}$ and b_4 (Appendix 14.4). The respective negative and positive values of $b_{2,3}$ and b_4, indicate that rates of pod development were greatest under high temperatures and short days. An exception to this general pattern of response is evident in the cultivar Wayne, where daylength had a positive effect on the rate of pod development. However, being limited to the December and January sowings only, this cultivar was exposed to a relatively narrow range of daylengths during the podding phase.

The relative contributions made by $X_{2,3}$ and X_4 to the variation in Y, can be seen from the ratio of their standardised partial regression coefficients, as given in Table 15.

Table 15 Ratios of the standardised partial regression coefficients for temperature ($b'_{2,3}$) and daylength (b'_4)

Cultivar	$b'_{2,3}$	b'_4	$b'_{2,3}:b'_4$	
Acme	-2.2958	1.4307	1.60	increasing
Amsoy x T19	-2.8999	1.9964	1.45	importance
Bragg	-2.7893	2.1504	1.30	of X_4
Soysota x Mandarin	-3.6837	2.9305	1.26	(daylength)
Hill	-3.7225	3.1604	1.18	↑ ↓
Ogden	-4.1893	3.5642	1.17	
Wills	-4.4206	4.0446	1.09	
Wayne x PI-54-608-II	-6.9685	6.8361	1.02	
Dare	-3.7747	3.8374	0.98	increasing
K162	-1.2758	2.1880	0.58	importance
Wayne	-0.3544	-0.6273	0.56	of $X_{2,3}$
Daintree	-0.6495	1.4824	0.44	(temperature)
Mamloxi	-0.6863	1.6393	0.42	

As $X_{2,3}$ and X_4 were highly correlated for all cultivars, their contributions to the variation in Y were examined to determine if either variable was superfluous (Appendix 14.2). For the cultivar Wayne, daylength (as represented by X_4), had no significant effect on the variation in phase length additional to that explained by temperature ($X_{2,3}$). Conversely, with daylength as the primary variable, temperature had no additional significant effect on the duration of podding in the cultivar Mamloxi.

Interpretation of the responses during this phase is further confounded by the fact that Y represents both negative and positive growth changes: i.e. duration and rates of pod emergence and filling - and rates of pod senescence. Results from the pod emergence phase indicate that initial pod development rates are determined by daylength, temperature effects being relatively non significant. Although the effect of daylength on podfilling and senescence is not clear from the podding phase results, temperature would appear to have a dominant role in both these stages of development.

Variation existing between the thirteen cultivars in podding phase response, as described by the regression equation, is given in Table 16.

The regression eqations were homogeneous for cultivars within the following groups:

(a) Acme, Soysota x Mandarin, Amsoy x T19.
(b) Acme, Hill.
(c) Soysota x Mandarin, Dare.
(d) Dare, Hill.
(e) Dare, Bragg.
(f) Ogden, Bragg.
(g) Ogden, Wills.
(h) Wills, K162.
(i) Wills, Mamloxi.
(j) K162, Daintree.

For all other possible cultivar comparisons, the regression equations were heterogeneous. Results of these comparisons, given in Table 16, are summarised in Figures 12, 13 and 14, where, for cultivars within a box, differences are not significant at the 5% level - and between boxes, significantly different ($P < 0.05$).

Figure 12 Genotypic variation in podding duration - as measured by the partial regression coefficient 'a'.

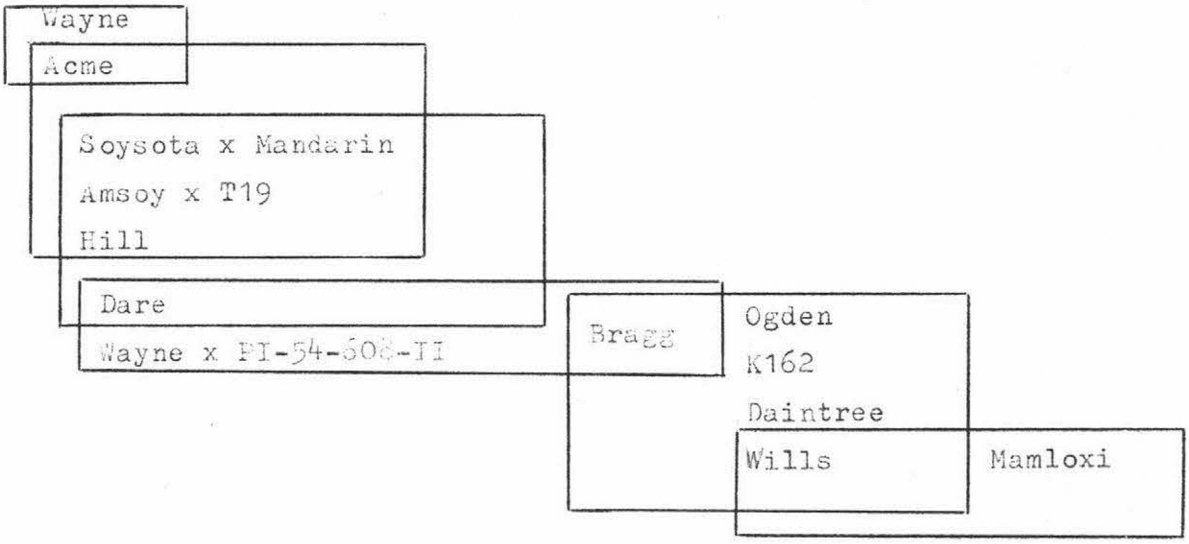


Figure 13 Phenotypic variation in podding duration response to average hourly temperature - as measured by the partial regression coefficient '$b_{2,3}$'.

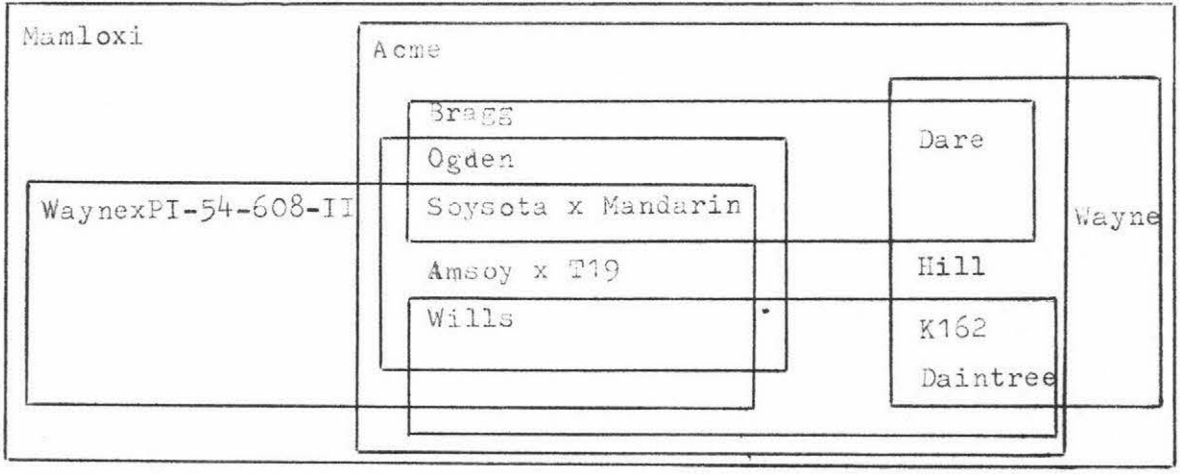


Figure 14 Phenotypic variation in podding duration response to daylength - as measured by the partial regression coefficent for the daylength at the start of the phase, 'b_4'.

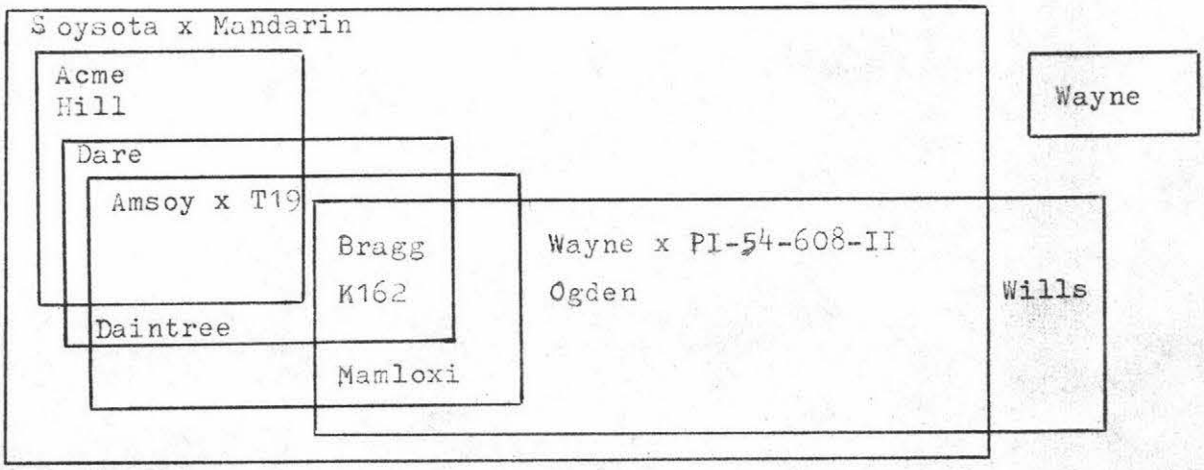


Table 16 Podding Phase (Cultivars no. 00 to 11 as per Table 1)

Between cultivar comparisons of the partial regression coefficients for the model

$$Y = a + b_{2,3}X_{2,3} + b_4X_4$$

where Y = the length, in days, of the podding phase
$X_{2,3}$ = the average hourly temperature, in °C, during the phase
X_4 = the daylength, in hours, at the start of the phase.

T-test significance levels: ** = $P < 0.01$; * = $P < 0.05$; ns = not significant at the 5% level. (For actual t-ratios, see appendix 14.5)

	00			0			1			2			3			4			5			6			7			8			9			10		
	a	$b_{2,3}$	b_4	a	$b_{2,3}$	b_4	a	$b_{2,3}$	b_4	a	$b_{2,3}$	b_4	a	$b_{2,3}$	b_4	a	$b_{2,3}$	b_4	a	$b_{2,3}$	b_4	a	$b_{2,3}$	b_4	a	$b_{2,3}$	b_4	a	$b_{2,3}$	b_4	a	$b_{2,3}$	b_4	a	$b_{2,3}$	b_4
00																																				
0	ns	ns	ns																																	
1	ns	ns	ns	ns	ns	ns																														
2	**	**	**	*	ns	ns	**	ns	*																											
3	ns	*	*	**	**	**	*	**	**	**	**	**																								
4	*	ns	ns	ns	ns	ns	ns	*	ns	ns	**	*	**	ns	*																					
5	ns	ns	ns	ns	*	ns	ns	**	ns	**	**	**	**	ns	*	ns	ns	ns																		
6	**	ns	**	**	ns	ns	**	ns	*	*	*	ns	**	**	**	*	*	*	**	**	**															
7	**	ns	**	*	ns	ns	**	ns	ns	ns	**	ns	**	**	**	ns	ns	ns	**	**	**	ns	ns	ns												
8	**	ns	**	**	ns	*	**	ns	*	**	ns	ns	**	**	**	**	*	**	**	**	**	ns	ns	ns	*	ns	ns									
9	**	ns	*	**	*	ns	**	**	ns	*	**	ns	**	ns	**	*	ns	ns	**	ns	**	ns	**	ns	ns	*	ns	ns	ns	ns						
10	**	ns	*	**	**	ns	**	**	ns	**	**	ns	**	ns	**	**	ns	ns	**	ns	**	ns	**	ns	*	**	ns	ns	ns	*	ns	ns	ns			
11	**	ns	**	**	ns	ns	**	ns	ns	**	ns	ns	**	ns	**	**	ns	*	**	ns	**	*	ns	ns	**	ns	ns	ns	ns	ns	*	ns	ns	*	ns	ns

3.6 APICAL BUD DISSECTIONS

For the cultivar Amsoy x T19, seventy-four plants were sampled over a 34 day period from the 3rd of December 1975, to the 6th of January 1976. During this time, daylength increased from 15.19 to 15.63 hours and average hourly day and night temperatures ranged from 17.2 to 19.3°C and 14.5 to 16.6°C, respectively.

Sampling of the pre-flowering phase in Dare extended from the 3rd of December 1975, to the 10th of February 1976, during which time one hundred and twenty-eight plants were examined. Daylength ranged from 14.62 to 15.63 hours and the average hourly day and night temperatures from 17.0 to 21.7°C and 13.9 to 20.2°C, respectively - during the 69 day sampling period.

For the regression models examined (Appendices 17.3 and 18.3), those shown in Table 17 were selected as best describing the variation in floral initiation and bud development during the pre-flowering phase. Model solution was confounded by the close relationship that existed between daylength and temperature during this period (Appendices 17.2 and 18.2).

With the exception of the curvilinear relationship between plant average and maximum reproductive state, in Amsoy x T19 during bud development, all the floral growth responses measured were linear.

(i) Pre-initiation phase

In the cultivar Amsoy x T19, the rate of floral initiation increased with rise in daylength and temperature. For Dare, bud reproductive state increased under declining daylengths, the rate of transition from the vegetative to the reproductive state being greatest in young plants, age having the dominant effect.

(ii) Post-initiation phase

Following floral initiation in Amsoy x T19, rate of bud primordia development declined as plants aged and night temperatures rose. For the whole plant, rates of reproductive development increased as days lengthened. In the cultivar Dare, the rate of bud primordia development increased as plants aged, day temperature and daylength

Table 17 Apical bud dissection regression data

Cultivar	Regression Model	a	b_1^* (b_1')	b_2 (b_2')	b_3 (b_3')	b_4 (b_4')	$100R^2$	F
A. PRE-INITIATION PHASE								
Amsoy x T19	$Y_1 = a + b_6X_6$	3.485	0.4838				70.5	45.38 ***
Dare	$Y_1 = a + b_6X_6 + b_4X_4$	2.369	0.4040	-0.1700			70.7	63.89 ***
			(0.8880)	(-0.2203)				
Amsoy x T19	$Y_2 = a + b_5X_5 + b_2X_2$	90.882	1.4443	-4.6750			76.3	29.04 ***
			(0.8231)	(-0.2421)				
	$Y_2 = a + b_5X_5 + b_3X_3$	71.920	1.4513	-4.2826			76.4	29.14 ***
			(0.8362)	(-0.2433)				
Dare	$Y_2 = a + b_5X_5 + b_4X_4 + b_1X_1$	-241.990	1.7105	0.5077	15.4900		76.3	55.67 ***
			(0.7784)	(0.2993)	(0.1602)			
Amsoy x T19	$Y_3 = a + b_5X_5 + b_1X_1$	- 91.006	0.0743	5.993			91.0	90.84 ***
			(0.5483)	(0.8082)				
	$Y_3 = a + b_5X_5 + b_2X_2$	- 20.664	0.0722	1.2138			90.6	86.68 ***
			(0.5328)	(0.8051)				
Dare	$Y_3 = a + b_8X_8 + b_6X_6 + b_5X_5 + b_4X_4$	0.940	1.6431	0.1429	-0.2466	-0.0768	89.7	111.11 ***
			(0.7939	(1.0897)	(-0.8556)	(-0.3453)		
Amsoy x T19	$Y_4 = a + b_5X_5 + b_2X_2$	- 16.544	0.0629	0.9330			89.4	75.52 ***
			(0.5758)	(0.7676)				
Dare	$Y_4 = a + b_7X_7 + b_5X_5$	- 0.501	0.2166	0.0700			73.7	74.23 ***
			(0.4483)	(0.5026)				

* subscripts refer to the position in model - i.e. first, second, third or fourth (b) partial regression coefficient

Table 17 continued:

B. POST-INITIATION PHASE								
Amsoy x T19	$Y_1' = a + b_6X_6 + b_3X_3$	2.290	0.0072	-0.0751			74.7	73.89 ***
			(0.7549)	(-0.3037)				
Dare	$Y_1 = a + b_6X_6 + b_1X_1 + b_1X_4$	342.830	0.5395	-23.1100	0.3983		90.0	202.92 ***
			(0.5522)	(-0.2895)	(0.2255)			
Amsoy x T19	$Y_2 = a + b_5X_5 + b_4X_4$	21.627	0.6575	0.9504			71.2	61.87 ***
			(0.5957)	(0.3752)				
Dare	$Y_2 = a + b_5X_5 + b_4X_4 + b_2X_2$	- 21.445	0.7272	0.3341	2.1262		86.1	139.88 ***
			(0.7105)	(0.1848)	(0.1731)			
Amsoy x T19	$Y_3 = a + b_6X_6 + b_4X_4 + b_3X_3$	27.752	0.1130	-0.2214	- 1.7343		76.0	51.60 ***
			(0.7485)	(-0.5958)	(- 0.4559)			
Dare	$Y_3 = a + b_8X_8 + b_4X_4 + b_1X_1$	- 14.907	0.8475	1.1544	1.0128		77.8	79.48 ***
			(0.6665)	(7.6080)	(0.1477)			
Amsoy x T19	$Y_4 = a + b_7X_7 + b_6X_6 + b_5X_5 + b_1X_1$	- 87.468	0.7242	-0.0773	0.1460	5.5431	95.5	254.59 ***
			(0.7038)	(-0.5121)	(0.8762)	(0.1172)		
Dare	$Y_4 = a + b_7X_7 + b_5X_5 + b_6X_6$	2.445	0.7472	0.1172	- 0.1083		68.9	50.34 ***
			(0.9501)	(1.7349)	(- 1.6408)			

where X_1 = the average daylength, in hours

$*** = P < 0.001$

X_2 = the average hourly day temperature, in °C

X_3 = the average hourly night temperature, in °C

X_4 = plant age (days from emergence)

X_5 = A, the average floral state of the whole plant $= Y_1$ $(Y_1' = \log_{10} Y_1)$

X_6 = R, the maximum floral state of any bud on a plant $= Y_2$

X_7 = the daily change in R $= Y_3$

X_8 = the daily change in A $= Y_4$

effects also being positive, although relatively minor, in the case of the latter.

In both cultivars, sensitivity to daylength, temperature and plant age, increased as the reproductive state of the plant intensified. Rates of reproductive change declined with the approach of flowering onset. This may have been a function of the grading scale used, being based on morphologically distinct changes which were not necessarily ontogenetically equidistant. i.e. If intrinsically curvilinear, grade scores would decrease in value with increase in size.

Chapter Four GENERAL DISCUSSION

4.1 GERMINATION

For the range of average hourly air temperatures of 13.4°C to 21.8°C, the general response exhibited by the thirteen cultivars followed that as reported by Hatfield and Egli in 1974. That is, temperature effecting a positive and exponential increase in the rate of germination.

Inhibition of germination, noted by Gilman et al. (1973), as occurring in some cultivars at temperatures above 20°C, was observed in Wayne x PI-54-608-II, Dare, Ogden, and Wills. Prediction from the regression equation for Amsoy x T19, homogeneous with that of Acme, Soysota x Mandarin, Wayne, Hill, Bragg, K162, Daintree and Mamloxi, indicated that inhibition would occur in these cultivars at temperatures above 25°C. For example, at 20°C, seed of Amsoy x T19 emerged in 3.5 days, in 3.3 days at 25°C and in 3.8 days at 30°C.

Temperature sensitivity during germination did not appear to be related to genetic lateness of maturity in the cultivars tested.

4.2 FLOWERING

4.2.1 Floral initiation and bud development

Transition from the vegetative to the reproductive state was accelerated by declining daylengths and rising temperatures. This follows the gereral response pattern observed in cultivars of *Glycine max*. (L) Merrill, by Garner and Allard (1930), Borthwick and Parker (1939), Parker and Borthwick (1943), Van Schaik and Probst (1958), Johnson et al. (1960), Lawn and Byth (1973), Major et al. (1975) and others.

For all cultivars, the rate of transition from the vegetative to the reproductive state appeared to increase as the rate of decline in daylength increased. Failure of flower bud opening in Daintree and Mamloxi under daylengths of less than 11 hours, may have been due to inadequate rates of decline as daylength approached its minimum of 10.3 hours. Under short days, photosynthate supply also may have been a limiting factor. Borthwick and Parker (1939), observed low tissue levels of carbohydrate accompanying incomplete corolla expansion in Biloxi soybeans grown under 8 hour days.

Low temperatures also influence floral bud development (Parker and Borthwick, 1940; Struckmeyer, 1940; Johnson et al., 1960). Flowering in Daintree and Hamloxi commenced under average hourly temperatures less than 16-17°C, reported as the 'biological minimum' for the formation of reproductive organs in soybeans, by Enken in 1959 (Holmberg, 1973). Unlike daylength, temperature response during the pre-flowering phase showed no consistent association with maturity group progression among the cultivars.

The relationship of temperature response with daylength sensitivity has been reported as both negative (Lawn and Byth, 1973) and positive (Polson, 1972) in effect. According to Major et al. (1975), during the pre-flowering phase, the relative importance of daylength and temperature varies, depending upon their respective sizes and on the morphological state of the plant at the time. This was borne out in the apical dissection results for the cultivars Amsoy x T19 and Dare.

4.2.2 Apical bud dissections

For the respective daylength ranges of 14.18 and 14.83 hours to 15.63 hours, the pre-flowering phase length response in the cultivars Dare and Amsoy x T19 was essentially day-neutral..

Although the length of the pre-flowering phase remained constant for each cultivar, rates of floral initiation and subsequent bud development were affected by time of sowing (Table 18).

Table 18 Length of the floral initiation and bud development phases (during the period from emergence to flowering)

Sowing date (1975)		2/11	12/11	22/11	2/12
Cultivar	Growth phase	Mean phase length (days)			
Amsoy x T19	Emergence to floral initiation	24	17	5	8
	Initiation to first open flower	12	17	29	26
	Emergence to first open flower	36	34	34	34
Dare	Emergence to floral initiation	38	29	-	18
	Initiation to first open flower	33	41	-	52
	Emergence to first open flower	71	70	-	70

Table 18 shows that, in both cultivars, the hastening effect of delayed sowing on floral initiation was negated by the subsequent retardation of bud development, associated with plant juvenility.

Floral initiation in both Amsoy x T19 (Maturity Group 1), and Dare (Group 4), occurred under increasing daylengths and generally rising temperatures. In the absence of the declining daylength stimulus, reproductive development remained a function of plant growth response to temperature and light, with time.

In the first three sowings of Amsoy x T19, floral bud development also took place under conditions of increasing daylength and rising temperatures. As the post-initiation phase in plants of the fourth sowing occurred at lower temperatures than that of the third sowing, the relative increase in rate of bud development could be attributed to the onset of the photoperiod stimulus, as daylength declined from 15.63 to 15.48 hours (Appendix 17.1). Although all bud development in the cultivar Dare took place under progressively declining daylengths, the rate of development decreased with delay in sowing. Under the conditions of the trial, plant age was the main determinant of bud development in Dare, rates increasing as plants aged. (Borthwick and Parker, 1938 and Wareing and Philips, 1970, also noted the progressive decline in long-day inhibition of flowering in Biloxi, with increase in plant age). As plant age at the start of bud expansion is determined by the length of the pre-initiation phase, increased rates of floral initiation would result in slower subsequent bud development. Thus, although daylength was declining, the photoperiod stimulus may have been:

(i) inadequate to elicit a floral response, or
(ii) the effect of any such response elicited, may have been negated by the age effect.

This would explain the small, but significant, positive effect of daylength on the rate of floral bud growth, higher rates being associated with older plants, sown at earlier dates, under longer days. Under these conditions the photoperiod stimulus would have been minimal, the effect of daylength being qualitative and associated with the positive response to day temperature.

4.2.3 Flowering duration

Unlike the onset of flowering, flowering duration was not associated with genetic lateness of maturity among the cultivars. Minimum and maximum phase lengths occurred in the Group 00 and Group 2 cultivars, Acme and Wayne x PI-54-608-II, respectively.

As with the transition to the reproductive state, flowering duration responded positively to increasing rates of decline in daylength. Except for the cultivars Acme (Group 00), Soysota x Mandarin (0), K162 (9), Daintree (10) and Mamloxi (11), where flowering commenced under increasing or relatively static daylengths, flowering duration was extended as daylength declined.

According to Van Schaik and Probst (1958), flower shedding is greater under long days than short - and this causes more flowers to be initiated and flowering to continue for a longer period. However, no explanation was given as to why flower shedding should stimulate floral initiation.

This inference of reduced flowering duration with the progressive decline in daylength, was observed by Lawn and Byth in 1973. Examination of their data showed however, that maximum phase length was associated with flowering commencing during the period of most rapid decline in daylength. As the cultivars Hill, Ogden, Bragg, Wills, K162, Daintree and Mamloxi, grown at Massey, were also included in Lawn and Byths' trial, this apparently opposite flowering duration response to daylength may have been attributable to differences in site latitude. At 27°37'S (Lawn and Byth), the total change in photoperiod during the period of maximum decline in daylength was approximately -2.3 hours, compared to -3.1 hours for the same period at 40°32'S (Massey). i.e. Except during this period, the daily rate of decline in daylength, at 27°37'S, may have been insufficient to maintain active bud development.

In the absence of an adequate photoperiod stimulus, the potentially inhibiting effect of declining temperature, as the season progressed, may have become the main determinant of flowering duration? Major et al. (1975), noted a reversal in the relative roles of daylength and temperature with advance in the growing season, temperature effects being dominant when the photoperiod stimulus was at a minimum. This did not appear to be the case during the Massey trial. Although separation of individual effects was confounded by the close relationship existing between daylength and temperature, daylength accounted for the greater proportion of the variation in flowering duration.

The positive effect of daylength on flowering duration may also be a quantitative response, light becoming limiting under short days, particularly with increasing pod sink demand for photosynthate.

4.3 PODDING

4.3.1 Pod emergence

The rate of pod emergence increased with decline in daylength in the Group 00 to Group 7 cultivars, although the response was not significant in Ogden (Group 6) and Bragg (7). Criswell and Hume (1972), also found a negative relationship between daylength and pod emergence rate, in cultivars from the 00 to 4 Maturity groups. The delaying effect of short days on pod emergence in the late flowering cultivars, Wills (Group 8), K162 (9), Daintree (10) and (non significant) Mamloxi (11), may have been due to light limiting photosynthate available for pod growth. No pod emergence was recorded after the seasonal daylength had declined to 11 hours.

The absence of additional significant temperature effects on pod emergence, may have been due to the dominance of the daylength response. Where significant, night temperature had a greater effect on pod emergence rate, than did day temperature (Table 19).

Table 19 Ratios of the standardised partial regression coefficients b'_2 (day temperature) and b'_3 (night temperature)

Cultivar	Maturity Group	$b'_3 : b'_2$
Amsoy x T19	1	3.66
Dare	4	2.37
Hill	5	1.66
Bragg	7	14.46

The minimum average hourly temperature recorded for the pod emergence phase was 12.7°C. According to Enken (1959), 13°C is the minimum temperature under which seed formation can take place in Glycine max. (L) Merrill. However, this minimum obviously varies from cultivar to cultivar, as Hesketh et al. (1972), reported complete inhibition of pod emergence in Wayne and Dare when the average hourly temperature fell below 18°C. At Massey, pod emergence in these two cultivars, (representing the maturity groups 3 and 4), continued under average hourly temperatures as low as 15.7°C.

Examination of flower buds where pods had failed to emerge, (in late sowings of K162, Daintree and Mamloxi), showed that pods had formed but failed to expand beyond the corolla. It is probable that both daylength and temperature were limiting factors involved in this inhibition of pod growth. However, the dominance of night temperature effects in K162, (model prediction being non significant in Daintree and Mamloxi), suggests that low temperatures were the main cause of growth cessation (Table 20).

Table 20 Standardised partial regression coefficients for daylength (b_1'), day (b_2') and night (b_3') temperature

Cultivar	b_1'	b_2'	b_3'	b' rank
K162	-0.2302	0.0915	-0.7428	3 1 2

4.3.2 Pod filling and senescence

Temperature was the main determinant of podding duration, rates of pod development decreasing with decline in average hourly temperature as the season progressed.

Although continuation of the short-day stimulus following flowering is essential for fruitset (Nielson, 1942; Fisher, 1962), declining daylengths retarded pod filling and maturation. This effect was probably related to the temperature response, although light may have been a limiting factor in the very late flowering cultivars.

Response to daylength and temperature during the podding phase was not associated with genetic lateness of maturity among the cultivars.

Lawn and Byth (1973), suggested that variation in the length of the podding phase depended largely on the range of photoperiod and temperature experienced by each cultivar during pod development. As this is primarily determined by time of flowering, with delay in flowering, the relative contributions of daylength and temperature, to pod development, could be expected to change. i.e.

(i) In early-flowering cultivars, where the photoperiod stimulus for rapid pod emergence may be absent due to increasing or relatively static daylengths, the effect of temperature on pod growth could be expected to dominate. ie. As observed in the cultivars Acme (Group 00), Soysota x Mandarin (0), Amsoy x T19 (1) and also in Bragg (8) - where pod emergence was unaffected by changing daylength (Table 11).

(ii) With delay in flowering, under declining daylengths the photoperiod stimulus for pod emergence would increase, but light and temperature may become limiting factors in subsequent pod development. The relative emportance of daylength and temperature would therefore depend on cultivar sensitivity to each of these parameters - and on their relative rates of change. Where flowering commenced under declining daylengths but relatively constant temperatures, the effect of daylength could be expected to determine podding duration, (for example, see Wayne, Table 11). In Wayne x PI-54-608-II (Group 2) and Dare (4), with both daylength and temperature declining, the hastening effect of daylength on pod emergence was negated by the approximately equivalent, but opposite, effect of falling temperatures in delaying pod growth. In the cultivars Hill (Group 5), Ogden (6) and Wills (8), flowering commenced during the period of maximum photoperiod stimulus (i.e. most rapidly declining daylength), for the latitude; here temperature dominance declined with progressive delay in flowering (Table 15).

(iii) In the very late flowering cultivars, daylength and temperature may, both qualitatively and quantivatively, become growth limiting factors. As the minimum temperatures permitting seed formation and ripening are 13°C and 8°C, respectively, (Enken, 1959), where temperatures permit seed formation, daylength could be expected to have the dominant effect on maturity date - through limiting light available for photosynthate production for pod filling. For example, as shown by the Group 9 to 11 cultivars K162, Daintree and Mamloxi, under daylengths of 11.2 to 10.4 hours.

4.4 CONCLUSIONS

From this experiment it can be seen that genotypic variation in sensitivity to daylength and temperature in Glycine max. (L) Merrill, is both diverse and complex.

Although daylength effects the most dramatic growth responses, temperature may indirectly determine the degree of plant response to daylength. Temperature not only affects the rate of germination, it also has a profound bearing on the time relations of such critical developmental stages as flowering - both onset and duration, (which in part, determine the vegetative frame size at maturity), pod fill and maturation. As reproductive growth responds not only to the length of the day, but also to the rate of decline in daylength, then temperature effects, in delaying or advancing reproductive events, may also determine the degree of daylength stimulus that a particular phase of growth is exposed to - and therefore the magnitude of the daylength response that is elicited.

Although in this trial, cultivars were shown to differ markedly in their sensitivity to daylength, this was associated with genetic lateness of maturity only during the pre-flowering phase of growth. This would explain the general inadequacy of cultivar selection based on U.S.A maturity ratings, for adaptation to New Zealand conditions. Obviously, both the idigent daylength and average seasonal temperature patterns of the area of origin should be considered, when selecting a cultivar for adaptation elsewhere.

The relative contribution of each growth phase and importance of rates and duration of development during these phases, to seed production, would need to be determined in order to define phase timing priority for maximum yield under New Zealand conditions.
The work reported in this thesis also highlights the need for further research into defining the precise morphological changes which are effected by daylength per se, from those which are merely growth responses to the quantity of radiation available during a particular daylength regime.

ACKNOWLEDGEMENTS

I would like to thank Mr. A. G. Robertson (Agronomy Department, Massey University) for his interest and encouragement in this work.

I am also indebted to Dr. I. Gordon (Agronomy Department, Massey University), for his advice and criticism of the statistical analyses.

Special thanks are also due to the following people for:

1. Provision of seed - Dr. J. M. McEwan, Crop Research Division, D.S.I.R. Palmerston North; S. McCormack, Soil and Field Research Division, M.A.F. Hamilton; Dr. D. E. Byth, University of Queensland, Brisbane; Dr. O. Carter, University of Sydney, Sydney, Australia.
2. Rhizobia - Mr. O. Jarrett, Biological Laboratoriss, Palmerston North; Dr. M. Greenwood, D.S.I.R. Palmerston North.
3. The opportunity to carry out the apical dissection study - - Kaipara Co-operative Dairy Co., Helensville.

Thanks also to the many people who have assisted in various aspects of this work, particularly the technical staff (Farm Mechanisation) and members of the Agronomy Department (Massey University) and to Dr. R. J. Brook (Mathematics Department) and D. Coles (Massey University), for advice on Minitab programming.

Financial assistance for this study was provided by the following scholarships, which are greatfully acknowledged:

1. D.S.I.R. Genotype-Environment Interaction Study Grant, 1974.
2. Sir James Gunson Scholarship, 1974 and 1975.
3. D. J. McGowan Scholarship, 1975.

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APPENDICES

*** = $P < 0.001$

** = $P < 0.01$

* = $P < 0.05$

ns = not significant at the 5% level

Appendix 1 Field Soil Moisture Capacity

Method

Six 20cm soil cores were taken from each 1.8 x 6m sowing date block and bulked together. Two subsamples from each bulk sample were then tested, using the method as described by Peters (1965).

Results

Sowing date block	Field Moisture Capacity (%)	
A_1	20.2	20.3
A_2	19.0	22.9
B_1	23.8	22.4
B_2	22.3	23.7
C_1	20.8	23.9
C_2	18.8	23.8
D_1	21.2	21.1
D_2	22.4	21.8
E_1	21.7	21.8
E_2	21.2	21.6
F_1	20.8	22.5
F_2	19.3	21.0
G_1	20.1	22.1
G_2	22.4	22.7
H_1	22.3	23.0
H_2	22.3	23.3
Average Field Capacity	21.8%	

Date of sampling - 6/10/74

Appendix 2 Soil pH

Method

Each 20cm soil core was steeped in 50ml of distilled water for 24 hours before taking a pH measurement.

Sampling of the sowing date blocks:

I - one sample per block on 28/7/74
II - two samples per block on 6/9/74
III - four samples per block on 6/10/74

Results

Sowing date block	Soil pH						
	I plus P,K →	II		plus lime → III			
A_1	5.9	5.3	5.1	5.5	6.3	5.9	6.3
A_2	5.9	5.3	5.4	5.7	6.4	6.4	5.6
B_1	6.1	5.4	5.3	5.6	5.7	5.3	6.1
B_2	5.8	5.3	5.6	6.0	5.8	5.8	6.1
C_1	6.0	5.4	5.2	5.3	6.6	6.2	6.3
C_2	5.9	5.3	5.4	6.5	6.2	6.4	6.2
D_1	6.0	5.3	5.3	5.6	6.4	6.0	6.1
D_2	6.0	5.2	5.3	6.3	6.1	6.0	5.3
E_1	5.9	5.3	5.3	6.0	6.5	6.6	5.9
E_2	6.2	5.2	5.4	6.6	6.0	6.3	5.6
F_1	5.8	5.2	5.3	6.7	6.2	6.1	6.2
F_2	6.1	5.3	5.3	6.9	6.2	6.3	5.6
G_1	5.9	5.3	5.4	5.9	5.9	6.4	5.4
G_2	5.9	5.4	5.2	6.1	6.4	6.4	5.9
H_1	5.9	5.3	5.4	6.3	6.2	6.7	6.4
H_2	5.9	5.1	5.3	6.4	6.1	6.0	6.0
Average pH	5.95	5.3		6.1			

Appendix 3 Seed Germination

Method

Fifty seeds of each cultivar were germinated under non-limiting conditions of moisture at 20°C ± 2°C, for seven days. An interim count was taken on day four to give some measure of the relative vigour of the seed lines.

Results

Germination levels from the preliminary tests and the subsequent performance of each cultivar in the field, are given below:

	% Germination - room, 20°C		% Emergence - field															
	Counting date		Sowing dates															
	Day 4 1/10 1974	Day 7 4/10	12/10 1974		26/10		9/11		23/11		7/12		21/12		4/1 1975		18/1	
Blocks Cultivars			A_1	A_2	B_1	B_2	C_1	C_2	D_1	D_2	E_1	E_2	F_1	F_2	G_1	G_2	H_1	H_2
Acme	40	60	37	23	30	23	15	0	35	45	55	55	70	85	80	90	86	50
Soysota x Mandarin	96	96	.80	100	100	70	100	100	93	86	100	93	100	93	93	86	73	93
Amsoy x T19 (a) 69	92	92	70	80	70	80	73	73	66	80	66	93	86	80	93	80	100	73
Wayne x PI-54-608-II	82	82	90	100	60	40	93	93	93	86	100	100	93	93	93	86	73	66
Wayne	64	76	12	0	0	0	0	0	*85	90	73	93	60	93	80	80	86	66
Dare	68	80	60	86	53	46	80	75	65	75	80	80	90	75	80	75	75	60
Hill	80	96	50	60	60	50	70	55	70	60	85	45	60	40	60	85	75	55
Ogden	80	88	70	90	60	40	90	65	90	80	75	75	85	95	90	90	75	80
Bragg	88	96	90	80	80	90	93	100	86	80	93	100	93	66	86	86	86	73
Wills	92	96	90	80	90	80	80	93	86	86	100	86	100	73	93	93	73	70
K162	88	96	40	60	30	40	90	80	75	75	75	75	100	90	100	75	100	85
Daintree	88	92	70	60	60	80	73	66	73	66	73	66	86	73	80	86	73	73
Mamloxi	100	100	100	70	80	80	93	93	93	100	93	93	100	73	100	93	86	100

* new batch of seed

Appendix 4 Inoculum

Method

Each of the four strains of *Rhizobium japonicum* used in the inoculum was cultured on mannitol-yeast agar slopes.

Culture medium:

Brockwell's Yeast-Mannitol Agar

1.0g mannitol
0.5g K_2HPO_4
0.1g $MgSO_4$
0.2g NaCl
0.2g $CaCl_2$
0.001g $FeCl_3$
20g Davis agar
100ml yeast (baker's) extract solution
900ml distilled water

Rhizobial strains:

1. USDA 138
2. USDA 5A-43
3. YEMS 61A-72
4. CB 1809

Rhizobial strains 1, 2 and 3 were supplied by M. Greenwood, D.S.I.R. Palmerston North and strain 4 by O. Jarrett, Clinical Laboratories, Palmerston North.

Appendix 5

Planting Plan

Sowing date	Block	Plot Cultivar order	
		1	2
12/10/74	A	0 4 6 2 3 10 8 11 1 5 00 9 7	9 11 1 00 7 6 8 0 2 5 3 10 4
26/10/74	B	6 1 8 9 5 3 11 00 0 10 2 7 4	8 5 2 0 3 10 4 7 1 6 00 11 9
9/11/74	C	7 3 2 1 10 00 5 8 4 11 0 9 6	4 2 8 9 0 11 6 1 10 7 00 3 5
23/11/74	D	1 0 8 11 6 7 9 00 4 2 10 5 3	11 6 3 00 2 1 10 4 0 7 5 9 8
7/12/74	E	3 10 7 11 2 4 9 0 1 5 8 00 6	4 9 6 0 8 00 7 5 3 10 11 2 1
21/12/74	F	3 6 9 2 1 0 7 4 11 5 00 8 10	11 1 10 3 4 6 8 5 9 7 00 2 0
4/ 1/75	G	9 8 10 00 3 4 2 6 1 5 0 7 11	00 4 5 11 7 9 8 0 10 1 3 6 2
18/ 1/75	H	10 3 11 1 4 0 00 5 2 8 7 6 9	2 7 4 5 6 9 3 1 8 10 0 11 00

G = guard row —

Cultivar plot identification:

00 = Acme
0 = Soysota x Mandarin (a) 5
1 = Amsoy x T19 (a) 69
2 = Wayne x PI-54-608-II (a)
3 = Wayne
4 = Dare
5 = Hill
6 = Ogden
7 = Bragg
8 = Wills
9 = K162
10 = Daintree
11 = Mamloxi

Appendix 6 Trial soil moisture levels

Method

Soil moisture content was determined form 10cm cores taken at random from the trial area.

Results

Weekly means for maximum, minimum and average soil moisture levels are listed below:

	% Soil Moisture		
Sampling period 1974	Maximum	Minimum	Average
5/10 - 12/10	24.8	23.4	24.1
12/10 - 19/10	24.9	23.0	24.1
19/10 - 26/10	26.9	24.2	25.5
26/10 - 2/11	22.9	19.7	21.8
Irrigation commenced 2/11			
2/11 - 9/11	25.8	23.3	24.5
9/11 - 16/11	23.7	26.6	24.9
16/11 - 23/11	20.8	22.3	21.7
23/11 - 30/11	24.9	22.4	23.7
30/11 - 7/12	23.3	20.2	21.8
7/12 - 14/12	24.0	21.3	22.9
14/12 - 21/12	24.4	21.5	22.7
21/12 - 28/12	22.9	18.9	21.3
1975			
28/12 - 4/1	23.9	19.4	22.1
4/1 - 11/1	23.6	19.9	21.7
11/1 - 18/1	24.0	19.9	22.8
18/1 - 25/1	26.3	21.3	23.9
25/1 - 1/2	24.0	18.5	20.6
1/2 - 8/2	23.1	18.5	20.6
8/2 - 15/2	24.5	21.0	22.8
15/2 - 22/2	27.2	19.4	23.3
22/2 - 1/3	26.3	24.3	25.1
1/3 - 8/3	25.2	21.3	22.6
8/3 - 15/3	25.4	22.4	23.9
15/3 - 22/3	22.7	18.0	20.1
22/3 - 29/3	24.1	19.9	21.7
29/3 - 5/4	24.3	21.3	23.2
5/4 - 12/4	21.8	18.7	20.1
12/4 - 19/4	23.2	20.1	21.9
19/4 - 26/4	24.2	20.5	22.3
26/4 - 3/5	25.4	21.4	23.9
3/5 - 10/5	24.8	22.7	23.2
10/5 - 17/5	25.2	23.4	24.4
17/5 - 24/5	26.3	24.2	24.9
24/5 - 31/5	25.6	24.5	25.1
31/5 - 7/6	26.3	24.8	25.2
7/6 - 14/6	26.5	23.7	26.0
14/6 - 21/6	26.0	22.6	23.7

Appendix 7

*Daily photoperiod at 40°23'S - in hours

Day	October	November	December	January	February	March	April	May	June	July
1		14.8	15.9	16.0	15.1	13.9	12.4	11.3	10.5	10.4
2		14.9	15.9	16.0	15.1	13.8	12.4	11.3	10.5	10.4
3		14.9	15.9	16.0	15.0	13.8	12.3	11.2	10.5	10.4
4		15.0	15.9	16.0	15.0	13.7	12.3	11.2	10.5	10.4
5		15.0	16.0	15.9	14.9	13.7	12.3	11.2	10.5	10.4
6		15.0	16.0	15.9	14.9	13.6	12.2	11.1	10.4	10.4
7		15.1	16.0	15.9	14.9	13.6	12.2	11.1	10.4	10.5
8		15.1	16.0	15.9	14.8	13.5	12.2	11.1	10.4	10.5
9		15.2	16.0	15.9	14.8	13.5	12.1	11.0	10.4	10.5
10		15.2	16.0	15.9	14.7	13.4	12.1	11.0	10.4	10.5
11		15.2	16.1	15.8	14.7	13.4	12.0	11.0	10.4	10.5
12		15.3	16.1	15.8	14.7	13.3	12.0	10.9	10.4	10.5
13	14.0	15.3	16.1	15.8	14.6	13.3	12.0	10.9	10.4	
14	14.1	15.4	16.1	15.7	14.6	13.2	11.9	10.9	10.4	
15	14.1	15.4	16.1	15.7	14.5	13.2	11.9	10.8	10.3	
16	14.2	15.4	16.1	15.7	14.5	13.2	11.8	10.8	10.3	
17	14.2	15.5	16.1	15.7	14.4	13.1	11.8	10.8	10.4	
18	14.2	15.5	16.1	15.6	14.4	13.1	11.8	10.8	10.4	
19	14.3	15.5	16.1	15.6	14.3	13.0	11.7	10.8	10.3	
20	14.3	15.6	16.1	15.6	14.3	13.0	11.7	10.7	10.3	
21	14.4	15.6	16.1	15.5	14.2	12.9	11.6	10.7	10.3	
22	14.4	15.6	16.1	15.5	14.2	12.9	11.6	10.7	10.3	
23	14.4	15.7	16.1	15.5	14.2	12.8	11.6	10.6	10.3	
24	14.5	15.7	16.1	15.4	14.1	12.8	11.5	10.6	10.3	
25	14.5	15.7	16.1	15.4	14.1	12.8	11.5	10.6	10.3	
26	14.6	15.8	16.1	15.3	14.0	12.7	11.5	10.6	10.4	
27	14.6	15.8	16.1	15.3	14.0	12.7	11.4	10.6	10.4	
28	14.7	15.8	16.1	15.3	13.9	12.6	11.4	10.6	10.4	
29	14.7	15.8	16.1	15.2		12.6	11.4	10.5	10.4	
30	14.8	15.8	16.1	15.2		12.5	11.3	10.5	10.4	
31	14.8		16.0	15.2		12.5		10.5		

*sunrise to sunset, including civil twilight

Appendix 8

Average hourly *day temperature (^{o}C)

Day	October	November	December	January	February	March	April	May	June	July
1		13.1	19.4	21.8	20.6	17.2	20.6	16.4	13.1	8.8
2		16.0	19.6	22.6	20.9	17.0	20.9	15.6	13.1	8.3
3		13.4	19.8	21.9	21.0	19.8	16.1	15.4	12.6	7.9
4		15.2	19.6	22.9	19.5	21.3	16.9	12.9	14.8	7.5
5		16.4	17.5	23.0	19.7	19.5	17.5	14.6	13.3	7.3
6		18.9	16.1	21.0	18.3	17.6	16.5	13.9	15.5	8.4
7		15.4	16.2	23.2	19.7	20.0	18.4	11.2	13.6	9.0
8		17.0	14.7	24.7	19.0	20.1	16.1	10.6	10.3	9.1
9		16.6	14.7	24.1	20.3	20.6	17.9	14.0	10.2	11.0
10		16.1	14.1	22.2	22.2	20.3	17.5	13.4	11.5	12.1
11		15.4	16.3	24.0	21.9	17.5	17.3	12.8	9.6	12.3
12		15.9	19.1	24.2	21.9	18.6	15.3	13.8	8.7	12.0
13	16.6	16.2	19.8	23.2	23.8	23.6	15.9	13.2	9.2	
14	16.6	17.6	21.7	22.8	24.8	21.0	14.0	13.2	11.0	
15	16.1	19.8	17.6	22.0	22.5	22.4	14.9	15.1	13.4	
16	15.7	16.3	18.3	21.1	22.7	22.6	13.4	16.1	10.1	
17	16.5	19.4	19.7	19.9	17.5	18.3	16.5	17.0	8.2	
18	15.0	21.2	17.9	20.3	19.6	19.1	15.4	15.6	10.7	
19	15.0	16.7	20.7	20.6	20.8	21.5	16.8	17.2	12.7	
20	17.2	17.8	21.3	17.9	22.1	20.3	15.7	16.6	12.1	
21	17.2	16.3	23.9	19.6	22.4	22.0	18.2	14.5	11.7	
22	14.6	15.1	23.0	19.3	22.9	22.0	19.7	14.4	7.3	
23	13.2	15.0	18.1	20.3	23.0	21.9	18.2	13.4	6.6	
24	13.9	19.1	17.0	19.5	23.9	21.9	16.3	14.5	6.9	
25	12.1	18.1	19.2	22.9	19.0	19.7	13.4	15.2	8.0	
26	13.7	18.1	21.6	21.5	19.4	18.2	11.0	16.6	7.3	
27	13.4	19.5	22.2	22.2	21.9	18.1	14.5	10.9	7.5	
28	13.2	20.4	22.5	20.6	20.3	17.7	17.4	9.7	7.8	
29	13.7	19.1	22.6	20.0		17.2	15.8	11.7	5.7	
30	11.4	19.4	24.1	19.1		19.1	13.8	11.6	7.0	
31	11.9		23.1	18.6		17.1		11.4		

***meterological day - i.e. from sunrise to sunset, including civil twilight**

Appendix 9

Average hourly *night temperature (°C)

Day	October	November	December	January	February	March	April	May	June	July
1		9.3	16.2	18.8	14.6	15.2	16.0	11.9	11.6	1.5
2		10.6	16.4	14.8	11.8	11.1	18.9	9.0	11.3	8.5
3		11.6	14.4	16.6	17.3	14.7	14.2	13.6	8.7	4.3
4		8.9	15.6	15.3	17.0	13.9	13.3	11.6	10.4	6.0
5		12.1	16.7	17.5	17.6	18.1	11.8	8.9	7.3	0.7
6		13.1	13.6	19.8	12.4	17.7	8.3	10.9	9.8	1.0
7		13.3	14.0	19.7	17.3	14.6	13.6	11.2	12.5	3.4
8		14.7	14.3	21.0	13.9	13.8	13.7	8.0	8.9	1.7
9		13.8	13.5	20.5	12.1	18.2	12.5	7.8	2.0	5.3
10		13.9	11.8	18.9	18.5	16.6	9.7	8.0	7.2	8.1
11		13.6	10.0	18.4	18.1	16.3	11.4	11.8	5.6	8.0
12		14.3	12.5	19.5	17.8	15.8	13.9	12.9	1.6	6.2
13	14.5	14.2	11.4	19.6	18.0	19.5	9.4	12.1	2.1	
14	15.5	14.1	17.9	18.9	18.0	15.0	11.6	12.5	9.5	
15	13.7	16.6	17.9	18.7	19.0	14.5	7.9	13.3	12.0	
16	13.2	12.8	13.5	17.8	19.4	18.3	8.1	15.8	11.0	
17	13.6	13.7	14.8	16.7	20.2	17.2	12.1	13.3	3.0	
18	11.2	14.3	11.9	16.2	15.9	17.0	10.0	15.1	3.9	
19	14.5	13.7	18.1	16.0	16.2	16.3	8.4	15.8	9.5	
20	14.9	12.0	17.8	17.4	17.5	17.0	11.7	15.4	10.1	
21	12.0	13.5	14.8	15.8	18.7	18.5	12.6	14.9	9.8	
22	12.9	12.3	17.6	16.0	19.3	16.8	16.3	15.6	2.9	
23	11.3	10.9	20.4	15.1	18.2	15.9	16.2	10.6	5.3	
24	9.6	12.9	14.9	13.7	17.5	16.1	15.9	14.3	0.7	
25	11.1	13.2	17.1	15.8	16.4	16.4	14.2	14.8	6.9	
26	10.7	13.6	15.5	17.8	15.1	16.1	12.6	14.7	0.2	
27	14.1	14.5	18.0	16.9	19.0	14.5	3.8	12.2	4.6	
28	10.6	14.8	17.5	19.1	19.8	11.2	13.5	9.0	4.1	
29	10.5	16.2	15.7	17.7		12.6	14.4	8.8	0.3	
30	8.2	14.9	17.1	16.1		13.9	12.6	9.5	-1.4	
31	6.8		17.3	15.3		13.0		11.1		

*meterological night - i.e. sunset to sunrise, excluding civil twilight

Appendix 10 GERMINATION PHASE

Y = the length, in days, of the germination phase
X_1 = the average daylength, in hours, during the germination phase
X_2 = the average hourly day temperature, in °C, during germination
X_3 = the average hourly night temperature, in °C, during germination
$X_{2,3}$= the average hourly (24 hour day plus night) temperature, in °C.

Cultivar (Maturity Group)	Sowing date block	Period	Y	X_1	X_2	X_3
Acme	A_1	12/10-31/10	19	14.4	14.6	12.0
	A_2	12/10- 4/11	23	14.5	14.6	11.7
(00)	B_1	26/10-13/11	18	15.0	15.0	11.9
	B_2	26/10-10/11	15	14.9	14.8	11.4
	C_1	9/11-22/11	13	15.4	17.2	13.8
	C_2	no sample due to germination failure				
	D_1	23/11- 4/12	11	15.8	19.3	14.8
	D_2	23/11- 4/12	11	15.8	19.3	14.8
	E_1	7/12-17/12	10	16.1	17.6	13.8
	E_2	7/12-16/12	9	16.1	17.4	13.6
	F_1	21/12-26/12	5	16.1	19.8	17.1
	F_2	21/12-26/12	5	16.1	19.8	17.1
	G_1	4/1 - 8/1	4	15.9	23.0	19.5
	G_2	4/1 - 8/1	4	15.9	23.0	19.5
	H_1	18/1 -25/1	7	15.5	20.0	15.7
	H_2	18/1 -25/1	7	15.5	20.0	15.7
Soysota x Mandarin	A_1	12/10-28/10	16	14.3	15.0	12.7
	A_2	12/10-27/10	15	14.3	15.1	12.8
(0)	B_1	26/10- 9/11	14	14.9	14.7	11.3
	B_2	26/10-10/11	15	14.9	14.8	11.4
	C_1	9/11-16/11	7	15.3	16.8	14.2
	C_2	9/11-16/11	7	15.3	16.8	14.2
	D_1	23/11-28/11	5	15.8	19.0	13.8
	D_2	23/11-28/11	5	15.8	19.0	13.8
	E_1	7/12-14/12	7	16.1	17.3	13.1
	E_2	7/12-16/12	9	16.1	17.4	13.6
	F_1	21/12-27/12	6	16.1	20.2	17.2
	F_2	21/12-26/12	5	16.1	19.8	17.1
	G_1	4/1 - 8/1	4	15.9	23.0	19.5
	G_2	4/1 - 8/1	4	15.9	23.0	19.5
	H_1	18/1 -25/1	7	15.5	20.0	15.7
	H_2	18/1 -25/1	7	15.5	20.0	15.7
Amsoy x T19	A_1	12/10-28/10	16	14.2	15.0	12.7
	A_2	12/10-28/10	16	14.2	15.0	12.7
(1)	B_1	26/10-11/11	16	14.9	14.8	11.6
	B_2	26/10-10/11	15	14.9	14.8	11.4
	C_1	9/11-17/11	8	15.3	17.1	14.1
	C_2	9/11-17/11	8	15.3	17.1	14.1
	D_1	23/11-29/11	6	15.8	19.3	14.2
	D_2	23/11-30/11	7	15.8	19.1	14.3
	E_1	7/12-16/12	9	16.1	17.4	13.6
	E_2	7/12-16/12	9	16.1	17.4	13.6

Note: Data given = plot means

Appendix 10 continued:

Cultivar	Sowing date block	Period	Y	X_1	X_2	X_3
Amsoy x T19 continued	F_1	21/12-27/12	6	16.1	20.2	17.2
	F_2	21/12-27/12	6	16.1	20.2	17.2
(1)	G_1	4/1 - 8/1	4	15.9	23.0	19.5
	G_2	4/1 - 8/1	4	15.9	23.0	19.5
	H_1	18/1 -25/1	7	15.5	20.0	15.7
	H_2	18/1 -25/1	7	15.5	20.0	15.7
Wayne x PI-54-608-II	A_1	12/10-27/10	15	14.3	15.1	12.8
	A_2	12/10-27/10	15	14.3	15.1	12.8
(2)	B_1	26/10-12/11	17	14.9	14.9	11.7
	B_2	26/10-11/11	16	14.9	14.8	11.6
	C_1	9/11-16/11	7	15.3	16.8	14.2
	C_2	9/11-16/11	7	15.3	16.8	14.2
	D_1	23/11-29/11	6	15.8	19.3	14.2
	D_2	23/11-30/11	7	15.8	19.1	14.3
	E_1	7/12-14/12	7	16.1	17.2	13.1
	E_2	7/12-14/12	7	16.1	17.2	13.1
	F_1	21/12-26/12	5	16.1	19.8	17.1
	G_1	4/1 - 8/1	4	15.9	23.0	19.5
	G_2	4/1 - 8/1	4	15.9	23.0	19.5
	H_1	18/1 -24/1	6	15.5	19.5	15.7
	H_2	18/1 -24/1	6	15.5	19.5	15.7
Wayne	No blocks A to C due to germination failure					
(3)	D_1	23/11-29/11	6	15.8	19.3	14.2
	D_2	23/11-29/11	6	15.8	19.3	14.2
	E_1	7/12-15/12	8	16.1	17.2	13.7
	E_2	7/12-15 12	8	16.1	17.2	13.7
	F_1	21/12-27/12	6	16.1	20.2	17.2
	F_2	21/12-27/12	6	16.1	20.2	17.2
	G_1	4/1 - 8/1	4	15.9	23.0	19.5
	G_2	4/1 - 9/1	5	15.9	23.2	19.7
	H_1	18/1 -25/1	7	15.5	20.0	15.7
	H_2	18/1 -25/1	7	15.5	20.0	15.7
Dare	A_1	12/10-27/10	15	14.3	15.1	12.8
	A_2	12/10- 1/11	20	14.4	14.5	11.9
(4)	B_1	26/20-11/11	16	14.9	14.8	11.6
	B_2	26/10-12/11	17	15.0	14.9	11.7
	C_1	9/11-17/11	8	15.3	17.1	14.1
	C_2	9/11-18/11	9	15.4	17.5	14.2
	D_1	23/11-30/11	7	15.8	19.1	14.3
	D_2	23/11-30/11	7	15.8	19.1	14.3
	E_1	7/12-15/12	8	16.1	17.2	13.7
	E_2	7/12-16/12	9	16.1	17.4	13.6
	F_1	21/12-27/12	6	16.1	20.2	17.2
	F_2	21/12-27/12	6	16.1	20.2	17.2
	G_1	4/1 -10/1	6	15.9	23.0	19.6
	G_2	4/1 -10/1	6	15.9	23.0	19.6
	H_1	18/1 -25/1	7	15.5	20.0	15.7
	H_2	18/1 -25/1	7	15.5	20.0	15.7
Hill	A_1	12/10-27/10	15	14.3	15.1	12.8
	A_2	12/10-27/10	15	14.3	15.1	12.8
(5)	B_1	26/10-11/11	16	14.9	14.8	11.6
	B_2	26/10-10/11	15	14.9	14.8	11.4

Appendix 10 continued:

Cultivar	Sowing date block	Period	Y	X_1	X_2	X_3
Hill continued:	C_1	9/11-17/11	8	15.3	17.1	14.2
	C_2	9/11-18/11	9	15.4	17.5	14.2
(5)	D_1	23/11- 2/12	9	15.8	19.2	14.7
	D_2	23/11- 3/12	10	15.8	19.2	14.7
	E_1	7/12-16/12	9	16.1	17.4	13.6
	E_2	7/12-16/12	9	16.1	17.4	13.6
	F_1	21/12-27/12	6	16.1	20.2	17.2
	F_2	21/12-27/12	6	16.1	20.2	17.2
	G_1	4/1 - 8/1	4	15.9	23.0	19.5
	G_2	4/1 - 9/1	5	15.9	23.2	19.7
	H_1	18/1 -25/1	7	15.5	20.0	15.7
	H_2	18/1 -25/1	7	15.5	20.0	15.7
Ogden	A_1	12/10-29/10	17	14.4	14.9	12.6
	A_2	12/10-28/10	16	14.3	15.0	12.7
(6)	B_1	26/10-10/11	15	14.9	14.8	11.4
	B_2	26/10-15/11	20	15.0	15.3	12.2
	C_1	9/11-18/11	9	15.4	17.5	14.2
	C_2	9/11-18/11	9	15.4	17.5	14.2
	D_1	23/11-30/11	7	15.8	19.1	14.3
	D_2	23/11- 1/12	8	15.8	19.1	14.5
	E_1	7/12-18/12	11	16.1	17.6	13.6
	E_2	7/12-16/12	9	16.1	17.4	13.6
	F_1	21/12-26/12	5	16.1	19.8	17.1
	F_2	21/12-26/12	5	16.1	19.8	17.1
	G_1	4/1 -10/1	6	15.9	23.0	19.6
	G_2	4/1 - 9/1	5	15.9	23.2	19.7
	H_1	18/1 -24/1	6	15.5	19.5	15.7
	H_2	18/1 -24/1	6	15.5	19.5	15.7
Bragg	A_1	12/10-26/10	14	14.3	15.2	12.8
	A_2	12/10-27/10	15	14.3	15.1	12.8
(7)	B_1	26/10-10/11	15	14.9	14.8	11.4
	B_2	26/10-10/11	15	14.9	14.8	11.4
	C_1	9/11-18/11	9	15.4	17.5	14.2
	C_2	9/11-18/11	9	15.4	17.5	14.2
	D_1	23/11-30/11	7	15.8	19.1	14.3
	D_2	23/11- 1/12	8	15.8	19.1	14.5
	E_1	7/12-15/12	8	16.1	17.2	13.7
	E_2	7/12-16/12	9	16.1	17.4	13.6
	F_1	21/12-26/12	5	16.1	19.8	17.1
	F_2	21/12-27/12	6	16.1	20.2	17.2
	G_1	4/1 - 8/1	4	15.9	23.0	19.5
	G_2	4/1 - 8/1	4	15.9	23.0	19.5
	H_1	18/1 -25/1	7	15.5	20.0	15.7
	H_2	18/1 -25/1	7	15.5	20.0	15.7
Wills	A_1	12/10-26/10	14	14.3	15.2	12.8
	A_2	12/10-30/10	18	14.4	14.7	12.3
(8)	B_1	26/10-10/11	15	14.9	14.8	11.4
	B_2	26/10-10/11	15	14.9	14.8	11.4
	C_1	9/11-16/11	7	15.3	16.8	14.2
	C_2	9/11-16/11	7	15.3	16.8	14.2
	D_1	23/11-29/11	6	15.8	19.3	14.2
	D_2	23/11-29/11	6	15.8	19.3	14.2
	E_1	7/12-16/12	9	16.1	17.4	13.6

Appendix 10 continued:

Cultivar	Sowing date block	Period	Y	X_1	X_2	X_3
Wills continued: (8)	E_2	7/12-12/12	8	16.1	17.2	13.7
	F_1	21/12-26/12	5	16.1	19.8	17.1
	F_2	21/12-26/12	5	16.1	19.8	17.1
	G_1	4/1 - 9/1	5	15.9	23.2	19.7
	G_2	4/1 - 8/1	4	15.9	23.0	19.5
	H_1	18/1 -24/1	6	15.5	19.5	15.7
	H_2	18/1 -24/1	6	15.5	19.5	15.7
K162 (9)	A_1	12/10-27/10	15	14.3	15.1	12.8
	A_2	12/10-27/10	15	14.3	15.1	12.8
	B_1	26/10-14/11	19	15.0	15.1	12.0
	B_2	26/10-13/11	18	15.0	15.0	11.9
	C_1	9/11-17/11	8	15.4	17.1	14.1
	C_2	9/11-16/11	7	15.3	16.8	14.2
	D_1	23/11-30/11	7	15.8	19.1	14.3
	D_2	23/11-30/11	7	15.8	19.1	14.3
	E_1	7/12-15/12	8	16.1	17.2	13.7
	E_2	7/12-16/12	9	16.1	17.4	13.6
	F_1	21/12-27/12	6	16.1	20.2	17.2
	F_2	21/12-26/12	5	16.1	19.8	17.1
	G_1	4/1 - 8/1	4	15.9	23.0	19.5
	G_2	4/1 - 8/1	4	15.9	23.0	19.5
	H_1	18/1 -25/1	7	15.5	20.0	15.7
	H_2	18/1 -25/1	7	15.5	20.0	15.7
Daintree (10)	A_1	12/10-27/10	15	14.3	15.1	12.8
	A_2	12/10-28/10	16	14.3	15.0	12.7
	B_1	26/10- 9/11	14	14.9	14.8	11.3
	B_2	26/10-11/11	16	14.9	14.8	11.6
	C_1	9/11-21/11	12	15.4	17.4	13.9
	C_2	9/11-17/11	8	15.3	17.1	14.1
	D_1	23/11-30/11	7	15.8	19.1	14.3
	D_2	23/11-30/11	7	15.8	19.1	14.3
	E_1	7/12-16/12	9	16.1	17.4	13.6
	E_2	7/12-16/12	9	16.1	17.4	13.6
	F_1	21/12-26/12	5	16.1	19.8	17.1
	F_2	21/12-26/12	5	16.1	19.8	17.1
	G_1	4/1 -10/1	6	15.9	23.0	19.6
	G_2	4/1 -10/1	6	15.9	23.0	19.6
	H_1	18/1 -25/1	7	15.5	20.0	15.7
	H_2	18/1 -26/1	8	15.5	20.2	16.4
Mamloxi (11)	A_1	12/10-26/10	14	14.3	15.2	12.8
	A_2	12/10-27/10	15	14.3	15.1	12.8
	B_1	26/10-10/11	15	14.9	14.8	11.4
	B_2	26/10-14/11	19	15.0	15.1	12.0
	C_1	9/11-16/11	7	15.3	16.8	14.2
	C_2	9/11-16/11	7	15.3	16.8	14.2
	D_1	23/11-30/11	7	15.8	19.1	14.3
	D_2	23/11-30/11	7	15.8	19.1	14.3
	E_1	7/12-14/12	7	16.1	17.2	13.1
	E_2	7/12-16/12	9	16.1	17.4	13.6
	F_1	21/12-27/12	6	16.1	20.2	17.2
	F_2	21/12-27/12	6	16.1	20.2	17.2
	G_1	4/1 - 9/1	5	15.9	23.2	19.7
	G_2	4/1 - 8/1	4	15.9	23.0	19.5
	H_1	18/1 -24/1	6	15.5	19.5	15.7
	H_2	18/1 -24/1	6	15.5	19.5	15.7

Appendix 10.1 Correlation coefficients

Cultivar	Variable	X_1	X_2	X_3
Acme	Y	-0.863***	-0.905***	-0.889***
(n=15)	Y_1	-0.784***	-0.928***	-0.954***
	X_2	0.737**		0.972***
Soysota x Mandarin	Y	-0.863***	-0.851***	-0.743***
(n=16)	Y_1	-0.825***	-0.894***	-0.798***
	X_2	0.715**		0.938***
Amsoy x T19	Y	-0.849***	-0.918***	-0.836***
(n=16)	Y_1	-0.797***	-0.967***	-0.910***
	X_2	0.730**		0.956***
Wayne x PI-54-608-II	Y	-0.852***	-0.847***	-0.776***
(n=16)	Y_1	-0.845***	-0.915***	-0.863***
	X_2	0.710**		0.946***
Wayne	Y	0.023ns	-0.901***	-0.814***
(n=10)	Y_1	-0.005ns	-0.894***	-0.822***
	X_2	-0.215ns		0.941***
Dare	Y	-0.861***	-0.853***	-0.771***
(n=16)	Y_1	-0.862***	-0.899***	-0.829***
	X_2	0.723**		0.964***
Hill	Y	-0.816***	-0.919***	-0.890***
(n=16)	Y_1	-0.757***	-0.946***	-0.945***
	X_2	0.720**		0.967***
Ogden	Y	-0.792***	-0.860***	-0.795***
(n=16)	Y_1	-0.772***	-0.893***	-0.856***
	X_2	0.724**		0.961***
Bragg	Y	-0.857***	-0.936***	-0.880***
(n=16)	Y_1	-0.801***	-0.966***	-0.936***
	X_2	0.705**		0.962***
Wills	Y	-0.836***	-0.852***	-0.796***
(n=16)	Y_1	-0.813***	-0.908***	-0.868***
	X_2	0.723**		0.950***
K162	Y	-0.791***	-0.890***	-0.831***
(n=15)	Y_1	-0.777***	-0.950***	-0.919***
	X_2	0.691**		0.956***
Daintree	Y	-0.872***	-0.863***	-0.793***
(n=16)	Y_1	-0.844***	-0.864***	-0.824***
	X_2	0.711**		0.958***
Mamloxi	Y	-0.819***	-0.836***	-0.765***
(n=15)	Y_1	-0.778***	-0.895***	-0.843***
	X_2	0.696**		0.954***

Note: $Y_1 = \log_{10} Y$

Appendix 10.2 Germination phase regression models considered:

Model I $Y = a \cdot b_{2,3}^{X_{2,3}} \cdot b_1^{X_1}$

Cultivar	$F_{YX_{2,3} \cdot X_1}$	$F_{YX_1 \cdot X_{2,3}}$	$F_{Y \cdot X_{2,3} X_1}$	$100R^2$
Acme	117.03***	2.09ns	59.56***	90.8
Soysota x Mandarin	73.77***	8.38*	41.48***	86.3
Amsoy x T19	230.21***	6.25*	118.02***	94.8
Wayne x PI-54-608-II	146.88***	15.44**	81.15***	92.6
Wayne	25.65**	0.33ns	12.99**	78.8
Dare	98.40***	13.04**	55.72***	89.6
Hill	159.53***	2.38ns	80.94***	92.6
Ogden	62.64***	3.17ns	32.90***	83.5
Bragg	387.84***	13.00**	200.45***	96.9
Wills	90.65***	6.05*	48.36***	88.1
K162	182.60***	6.20*	94.46***	94.0
Daintree	70.77***	10.71**	40.75***	86.2
Mamloxi	65.07***	4.73*	34.89***	85.3

Model II $Y = a \cdot b_1^{X_1} \cdot b_2^{X_2^2}$ (where X_1 and $X_2 = X_{2,3}$)

Cultivar	$F_{YX_1 \cdot X_2}$	$F_{YX_2 \cdot X_1}$	$F_{Y \cdot X_1 X_2}$	$100R^2$
Acme	100.47***	0.09ns	50.29***	89.3
Soysota x Mandarin	65.12***	5.87*	35.50***	84.5
Amsoy T19	227.80***	6.06*	116.94***	94.7
Wayne x PI-54-608-II	175.59***	21.00***	98.28***	93.8
Wayne	24.77**	0.08ns	12.43**	78.0
Dare	351.24***	79.96***	215.61***	97.1
Hill	149.56***	1.42ns	75.47***	92.1
Ogden	128.44***	27.12***	74.30***	92.0
Bragg	242.88***	3.28ns	123.08***	95.0
Wills	202.20***	29.49***	115.86***	94.7
K162	228.77***	10.78**	119.76***	95.2
Daintree	70.98***	10.78**	40.87***	86.3
Mamloxi	81.80***	9.03*	45.41***	88.3

Model III $Y = a \cdot b_1^{X_1} \cdot b_2^{X_2^2} \cdot b_3^{X_3^3}$ (X_1, X_2 and $X_3 = X_{2,3}$)

Cultivar	$F_{YX_1 \cdot X_2 X_3}$	$F_{YX_2 \cdot X_1 X_3}$	$F_{YX_3 \cdot X_1 X_2}$	$F_{Y \cdot X_1 X_2 X_3}$	$100R^2$
Acme	95.52***	0.90ns	0.41ns	32.01***	89.7
Soysota x Mandarin	74.57***	6.72*	2.84ns	27.95***	87.5
Amsoy x T19	295.27***	7.86*	4.85*	102.66***	96.2
Wayne x PI-54-608-II	311.74***	32.29***	11.08**	120.03***	96.8
Wayne	242.87***	0.07ns	0.86ns	84.06***	80.8
Dare	423.73***	96.47***	3.68ns	174.59***	97.8
Hill	145.05***	1.38ns	0.60ns	49.02***	92.4
Ogden	199.10***	31.24***	8.15*	79.49***	95.2
Bragg	228.89***	3.09ns	0.25ns	77.40***	95.1
Wills	191.05***	27.87***	0.28ns	73.08***	94.8
K162	410.21***	19.32***	10.52**	146.65***	97.6
Daintree	73.48***	11.16**	1.46ns	28.69***	87.8
Mamloxi	103.40***	11.42**	4.17ns	39.64***	91.5

Appendix 10.3 Analysis of Variance for the regression model used - Model II in Appendix 10.2*

Cultivar	Source of Variation	df	SS	F(see*)
Acme	Total	15	14.90	
	Mean	1	14.05	
	Regression total	2	0.7625	
	Due to X_1 (adj. for X_2)	1	0.7618	
	Due to X_2 (addit.to X_1)	1	0.0007127	
	Residual	12	0.09098	
Soysota x Mandarin	T	16	12.81	
	M	1	12.18	
	Reg	2	0.5284	
	X_1	1	0.4847	
	X_2	1	0.04367	
	Res	13	0.09676	
Amsoy x T19	T	16	13.87	
	M	1	13.28	
	Reg	2	0.5578	
	X_1	1	0.5433	
	X_2	1	0.01446	
	Res	13	0.03101	
Wayne x PI-54-608-II	T	16	12.82	
	M	1	12.16	
	Reg	2	0.6185	
	X_1	1	0.5524	
	X_2	1	0.06607	
	Res	13	0.04089	
Wayne	T	10	6.333	
	M	1	6.257	
	Reg	2	0.05915	
	X_1	1	0.05897	
	X_2	1	0.0001827	
	Res	7	0.01666	
Dare	T	16	14.77	
	M	1	14.29	
	Reg	2	0.4696	
	X_1	1	0.3825	
	X_2	1	0.08708	
	Res	13	0.01415	
Hill	T	16	14.55	
	M	1	14.06	
	Reg	2	0.4469	
	X_1	1	0.4427	
	X_2	1	0.004201	
	Res	13	0.03848	
Ogden	T	16	14.67	
	M	1	14.05	
	Reg	2	0.5648	
	X_1	1	0.4882	
	X_2	1	0.07660	
	Res	13	0.04941	

Appendix 10.3 continued:

Cultivar	Source of Variation	df	SS	F(see*)
Bragg	Total	16	13.68	
	Mean	1	13.13	
	Regression total	2	0.5236	
	Due to X_1 (adj. for X_2)	1	0.5166	
	Due to X_2 (addit.to X_1)	1	0.006972	
	Residual	13	0.02765	
Wills	T	16	13.06	
	M	1	12.45	
	Reg	2	0.5799	
	X_1	1	0.5061	
	X_2	1	0.07382	
	Res	13	0.03254	
K162	T	15	13.19	
	M	1	12.53	
	Reg	2	0.6352	
	X_1	1	0.6067	
	X_2	1	0.02857	
	Res	12	0.03183	
Daintree	T	16	14.54	
	M	1	14.09	
	Reg	2	0.3933	
	X_1	1	0.3414	
	X_2	1	0.05186	
	Res	13	0.06252	
Mamloxi	T	15	11.83	
	M	1	11.43	
	Reg	2	0.3608	
	X_1	1	0.3250	
	X_2	1	0.03588	
	Res	12	0.04767	

Appendix 10.4 Significance of the partial regression coefficients for Model II (t-test ratios)

Cultivar	a	b_1	b_2
Acme	3.00*	- 1.11ns	0.31ns
Soysota x Mandarin	4.55***	- 3.04**	2.42*
Amsoy x T19	6.44***	- 3.62**	2.46*
Wayne x PI-54-608-II	7.90***	- 5.58***	4.58***
Wayne	0.79ns	0.02ns	-0.28ns
Dare	14.48***	-10.39***	8.94***
Hill	4.68***	- 2.15ns	1.19ns
Ogden	7.63***	- 5.39***	4.49***
Bragg	6.03***	- 3.03**	1.81ns
Wills	9.33***	- 6.57***	5.43***
K162	6.93***	- 4.39***	3.28**
Daintree	5.82***	- 3.94**	3.28**
Mamloxi	5.48***	- 3.69**	3.01**

Appendix 10.5 Between cultivar comparisons - homogeneity tests of the partial regression coefficients for the model

$$Y = a.b_1^{X_1}.b_2^{X_2^2}$$

Appendix 10.5.1 T-test ratios for the partial regression coefficient a

Cultivar	00	0	1	2	3	4	5	6	7	8	9	10
00												
0	1.2292ns											
1	0.7333ns	-0.7677ns										
2	2.1186*	0.6438ns	1.8788ns									
3	-0.9170ns	-1.8349ns	-1.5126ns	-2.4175*								
4	2.4614*	0.7683ns	2.5038*	0.0554ns	2.6533*							
5	0.0571ns	-1.3851ns	-0.8863ns	-2.6197*	1.0401ns	-3.3760**						
6	2.1703*	0.7199ns	1.9381ns	0.1088ns	2.5128*	0.0798ns	2.6579*					
7	0.3350ns	-1.1745ns	-0.5736ns	-2.4477*	1.2467ns	-3.3049**	0.3661ns	2.4886*				
8	2.0923*	0.5315ns	1.8777ns	-0.1944ns	2.4367*	-0.3189ns	2.6863*	-0.3067ns	2.5214*			
9	1.4750ns	0.0089ns	1.0269ns	-0.8123ns	2.0206ns	-1.0701ns	1.8113ns	-0.9003ns	1.5828ns	-0.6939ns		
10	1.4196ns	0.0493ns	0.9685ns	-0.6849ns	1.9827ns	-0.8632ns	1.6789ns	-0.7696ns	1.4572ns	-0.5626ns	0.0489ns	
11	1.2503ns	-0.1072ns	0.7559ns	-0.8698ns	1.8602ns	-1.0790ns	1.4669ns	-0.9499ns	1.2350ns	-0.7623ns	-0.1376ns	-0.1774ns

Appendix 10.5.2 T-test ratios for the partial regression coefficient b_1

Cultivar	00	0	1	2	3	4	5	6	7	8	9	10
00												
0	-1.4134ns											
1	-0.8843ns	0.8459ns										
2	-2.2804*	-0.5912ns	-1.9226ns									
3	0.6446ns	1.7839ns	1.3869ns	2.4452*								
4	-2.6985*	-0.7688ns	-2.6545*	-0.1418ns	-2.6983*							
5	-0.2317ns	1.4414ns	0.8620ns	2.6441*	-0.8912ns	0.9400ns						
6	-2.2848*	-0.6215ns	-1.9227ns	-0.0492ns	-2.4523*	0.0224ns	-2.6185*					
7	-0.4975ns	1.2486ns	0.5688ns	2.4920*	-1.1013ns	0.8407ns	-0.3443ns	2.4639*				
8	-2.2984*	-0.5127ns	-1.9767ns	0.1464ns	-2.4384*	0.0882ns	-2.7484*	0.1951ns	-2.6078*			
9	-1.5436ns	0.1406ns	-0.9338ns	0.9431ns	-1.8819ns	0.3680ns	-1.6967ns	0.9666ns	-1.4792ns	0.8832ns		
10	-1.6427ns	-0.0648ns	-1.0878ns	0.6088ns	-1.9641ns	0.2710ns	-1.7704ns	0.6400ns	-1.5707ns	0.5226ns	-0.2452ns	
11	-1.4797ns	0.0951ns	-0.8787ns	0.8064ns	-1.8369ns	0.3459ns	-1.5688ns	0.8331ns	-1.3581ns	0.7349ns	-0.0458ns	0.1826ns

Appendix 10.5 continued:

Appendix 10.5.3 T-test ratios for the partial regression coefficient b_2

00												
0	0.5797ns											
1	0.3063ns	-0.2674ns										
2	0.7710ns	0.1664ns	1.3698ns									
3	-0.1715ns	-0.6886ns	-1.0590ns	-1.5629ns								
4	0.8530ns	0.2354ns	1.7739ns	0.1427ns	0.4992ns							
5	0.1259ns	-0.4339ms	-0.5421ns	-1.2419ns	0.1486ns	-0.0992ns						
6	0.7876ns	0.1828ns	1.4018ns	0.0339ns	0.4714ns	-0.0074ns	1.4848ns					
7	0.1894ns	-0.3765ns	-0.3621ns	-1.1334ns	0.1793ns	-0.0905ns	0.1463ns	1.0230ns				
8	0.7577ns	0.1506ns	1.3927ns	-0.0349ns	0.4548ns	-0.0124ns	1.4631ns	-0.0611ns	1.7548ns			
9	0.5119ns	-0.0750ns	0.6147ns	-0.4974ns	0.3364ns	-0.0459ns	0.8777ns	-0.4673ns	0.9621ns	-0.7216ns		
10	0.6139ns	0.0413ns	0.9179ns	-0.2491ns	0.3967ns	-0.0285ns	1.1125ns	-0.2500ns	1.2404ns	-0.3225ns	0.2733ns	
11	0.5618ns	-0.0248ns	0.7305ns	-0.3846ns	0.3620ns	-0.0384ns	0.9654ns	-0.3693ns	1.0580ns	-0.5290ns	0.1182ns	-0.1071ns

00 = Acme
0 = Soysota x Mandarin
1 = Amsoy x T19
2 = Wayne x PI-54-608-II
3 = Wayne
4 = Dare
5 = Hill
6 = Ogden
7 = Bragg
8 = Wills
9 = K162
10 = Daintree
11 = Mamloxi

Appendix 11

PRE-FLOWERING PHASE

Y = the length, in days, of the pre-flowering phase
X_1 = the average daylength, in hours, during the pre-flowering phase
X_2 = the average hourly day temperature, in °C, during the phase
X_3 = the average hourly night temperature, in °C, during the phase
$X_{2,3}$ = the average hourly (24 hour day plus night) temperature, in °C
X_4 = the daylength, in hours, at the start of the phase
X_5 = the daylength, in hours, at the end of the phase

Cultivar (Maturity Group)	Sowing date block	Period	Y	X_1	X_2	X_3	X_4	X_5
Acme (00)	A_1	31/10-23/12	53	15.7	17.8	14.0	14.8	16.1
	A_2	4/11-25/12	51	15.7	18.1	14.4	15.0	16.1
	B_1	13/11-26/12	43	15.9	18.5	14.6	15.3	16.1
	B_2	10/11-28/12	48	15.8	18.5	14.7	15.2	16.0
	C_1	22/11-31/12	39	16.0	19.6	15.1	15.6	16.0
	C_2	No sample due to germination failure						
	D_1	4/12-12/1	39	16.0	20.5	16.3	15.9	15.8
	D_2	4/12-10/1	37	16.0	20.3	16.2	15.9	15.9
	E_1	17/12-18/1	32	15.9	21.9	17.6	16.1	15.6
	E_2	16/12-16/1	31	16.0	22.0	17.6	16.1	15.7
	F_1	26/12-30/1	35	15.7	21.8	17.5	16.1	15.2
	F_2	26/12- 2/2	38	15.7	21.7	17.2	16.1	15.1
	G_1	8/1 -14/2	37	15.3	21.1	16.8	15.9	14.6
	G_2	8/1 -14/2	37	15.3	21.1	16.8	15.9	14.6
	H_1	25/1 -25/2	31	14.7	21.0	16.9	15.4	14.1
	H_2	25/1 -25/2	31	14.7	21.0	16.9	15.4	14.1
Soysota x Mandarin (0)	A_1	28/10-18/12	51	15.6	17.1	13.3	14.7	16.1
	A_2	27/10-20/12	54	15.6	17.1	13.3	14.7	16.1
	B_1	9/11-23/12	44	15.8	18.2	14.4	15.2	16.1
	B_2	10/11-25/12	45	15.8	18.3	14.5	15.2	16.1
	C_1	16/11-31/12	45	15.9	19.0	14.9	15.4	16.0
	C_2	16/11- 2/1	47	15.9	19.2	14.9	15.4	16.0
	D_1	28/11- 8/1	41	16.0	20.0	15.9	15.8	15.9
	D_2	28/11-11/1	44	16.0	20.3	16.2	15.8	15.8
	E_1	14/12-17/1	34	16.0	21.7	17.4	16.1	15.7
	E_2	16/12-20/1	35	15.9	21.7	17.4	16.1	15.5
	F_1	27/12- 1/2	36	15.7	21.7	17.3	16.1	15.1
	F_2	26/12- 3/2	39	15.7	21.6	17.2	16.1	15.0
	G_1	8/1 -14/2	37	15.3	21.1	16.8	15.9	14.6
	G_2	8/1 -16/2	39	15.3	21.1	16.9	15.9	14.5
	H_1	25/1 -26/2	32	14.7	21.0	16.9	15.4	14.0
	H_2	25/1 -28/2	34	14.7	21.0	17.0	15.4	13.9
Amsoy x T19 (1)	A_1	28/10-16/12	49	15.5	17.1	13.3	14.7	16.1
	A_2	28/10-16/12	49	15.5	17.1	13.3	14.7	16.1
	B_1	11/11-26/12	45	15.8	18.4	14.6	15.2	16.1
	B_2	10/11-26/12	46	15.8	18.3	14.5	15.2	16.1
	C_1	17/11- 3/1	47	15.9	19.2	15.0	15.5	16.0
	C_2	17/11- 3/1	47	15.9	19.2	15.0	15.5	16.0
	D_1	29/11- 8/1	40	16.0	20.1	15.9	15.8	15.9
	D_2	30/11-10/11	41	16.0	20.2	16.1	15.8	15.9
	E_1	16/12-20/1	35	15.9	21.7	17.4	16.1	15.6
	E_2	16/12-19/1	34	15.9	21.8	17.4	16.1	15.6

Note: Data given = plot means

Appendix 11 continued:

Cultivar	Sowing date block	Period	Y	X_1	X_2	X_3	X_4	X_5
Amsoy x T19 continued:	F_1	27/12- 3/2	38	15.7	21.6	17.2	16.1	15.0
	F_2	27/12- 7/2	42	15.6	21.4	17.1	16.1	14.9
	G_1	8/1 -16/2	39	15.2	21.1	16.9	15.9	14.5
	G_2	8/1 -15/2	38	15.2	21.1	16.9	15.9	14.5
	H_1	25/1 -28/2	34	14.7	21.0	16.9	15.4	13.9
	H_2	25/1 - 2/3	36	14.6	20.8	16.8	15.4	13.8
Wayne x PI-54-608-II (2)	A_1	27/10- 2/1	67	15.7	18.1	14.1	14.6	16.0
	A_2	27/10-29/12	63	15.6	17.8	13.9	14.6	16.1
	B_1	12/11- 4/1	53	15.9	19.2	14.9	15.3	16.0
	B_2	11/11- 5/1	55	15.9	19.2	15.0	15.2	15.9
	C_1	16/11- 6/1	51	15.9	19.4	15.1	15.4	15.9
	C_2	16/11- 9/1	54	15.9	19.7	15.4	15.4	15.9
	D_1	29/11-17/1	49	16.0	20.5	16.4	15.8	15.7
	D_2	30/11-15/1	46	16.0	20.5	16.4	15.8	15.7
	E_1	14/12-26/1	43	15.9	21.4	17.1	16.1	15.3
	E_2	14/12-24/1	41	15.9	21.3	17.1	16.1	15.4
	F_1	26/12-12/2	48	15.5	21.4	17.0	16.1	14.7
	F_2	26/12- 7/2	43	15.6	21.3	17.1	16.1	14.9
	G_1	8/1 -18/2	41	15.2	21.0	17.0	15.9	14.4
	G_2	8/1 -20/2	43	15.2	21.0	17.0	15.9	14.3
	H_1	24/1 - 8/3	43	14.5	20.7	16.6	15.4	13.5
	H_2	24/1 - 7/3	42	14.5	20.7	16.7	15.4	13.6
Wayne (3)	No blocks A to C due to germination failure							
	D_1	29/11-23/1	55	15.9	20.4	16.4	15.8	15.7
	D_2	29/11-21/1	53	16.0	20.4	16.4	15.8	15.6
	E_1	15/12- 7/2	54	15.7	21.1	16.9	16.1	14.9
	E_2	15/12- 5/2	52	15.7	21.2	17.0	16.1	14.9
	F_1	27/12-19/2	54	15.4	21.0	17.1	16.1	14.3
	F_2	27/12-18/2	53	15.4	21.0	17.1	16.1	14.4
	G_1	8/1 -23/2	46	15.1	21.1	17.1	15.9	14.2
	G_2	9/1 -24/2	46	15.1	21.1	17.0	15.9	14.1
	H_1	25/1 -10/3	44	14.4	20.6	16.7	15.4	13.4
	H_2	25/1 -12/3	46	14.4	20.5	16.6	15.4	13.3
Dare (4)	A_1	1/11-15/2	106	15.6	19.7	15.6	14.8	14.5
	A_2	27/10-29/1	94	15.7	19.1	15.1	14.6	15.2
	B_1	11/11- 3/2	84	15.6	19.9	15.8	15.2	15.1
	B_2	12/11-14/2	94	15.6	20.1	15.9	15.3	14.6
	C_1	17/11-11/2	86	15.7	20.1	15.9	15.5	14.7
	C_2	18/11- 6/2	80	15.8	20.0	15.9	15.5	14.9
	D_1	30/11-17/2	79	15.6	20.6	16.5	15.8	14.4
	D_2	30/11-19/2	81	15.6	20.6	16.5	15.8	14.3
	E_1	15/12- 2/3	77	15.3	21.1	17.0	16.1	13.4
	E_2	16/12- 2/3	76	15.3	21.2	17.0	16.1	13.4
	F_1	27/12-11/3	74	14.9	21.1	17.0	16.1	13.4
	F_2	27/12-11/3	74	14.9	21.1	17.0	16.1	13.4
	G_1	10/1 -18/3	67	14.6	20.7	16.8	15.9	13.1
	G_2	10/1 -20/3	69	14.5	20.7	16.7	15.9	13.0
	H_1	25/1 -25/3	59	14.1	20.7	16.7	15.4	12.8
	H_2	25/1 -27/3	61	14.0	20.6	16.6	15.4	12.7

Appendix 11 continued:

Cultivar	Sowing date block	Period	Y	X_1	X_2	X_3	X_4	X_5
Hill (5)	A_1	27/10-16/2	112	15.5	19.4	15.3	14.6	14.5
	A_2	27/10-19/2	115	15.5	19.4	15.4	14.6	14.3
	B_1	11/11-23/2	104	15.5	20.2	16.1	15.2	14.2
	B_2	10/11-28/2	110	15.5	20.1	16.1	15.2	13.9
	C_1	17/11-22/2	97	15.6	20.3	16.1	15.5	14.2
	C_2	18/11-25/2	99	15.5	20.3	16.2	15.5	14.1
	D_1	2/12- 9/3	97	15.3	20.6	16.5	15.9	13.5
	D_2	3/12- 7/3	94	15.3	20.6	16.5	15.9	13.6
	E_1	16/12-12/3	86	15.1	21.0	16.9	16.1	13.3
	E_2	16/12-13/3	87	15.1	21.0	16.9	16.1	13.3
	F_1	27/12-17/3	80	14.8	21.1	16.9	16.1	13.1
	F_2	27/12-21/3	84	14.7	21.1	16.9	16.1	12.9
	G_1	8/1 -27/3	78	14.4	20.8	16.8	15.9	12.7
	G_2	8/1 -29/3	79	14.3	20.6	16.6	15.9	12.6
	H_1	25/1 - 5/4	70	13.8	20.3	16.1	15.4	12.3
	H_2	25/1 - 8/4	73	13.8	20.1	15.9	15.4	12.2
Ogden (6)	A_1	29/10-15/2	109	15.6	19.5	15.4	14.7	14.5
	A_2	28/10-13/2	108	15.6	19.3	15.3	14.7	14.6
	B_1	10/11-14/2	96	15.6	20.0	15.8	15.2	14.6
	B_2	15/11-22/2	99	15.6	20.2	16.1	15.4	14.2
	C_1	18/11-23/2	97	15.5	20.3	16.2	15.5	14.2
	C_2	18/11-23/2	97	15.5	20.3	16.2	15.5	14.2
	D_1	30/11- 1/3	91	15.4	20.6	16.6	15.8	13.9
	D_2	1/12-27/2	88	15.4	20.7	16.6	15.9	14.0
	E_1	18/12- 8/3	80	15.1	21.1	17.0	16.1	13.5
	E_2	16/12-10/3	84	15.1	21.1	16.9	16.1	13.4
	F_1	26/12-19/3	83	14.8	21.1	17.0	16.1	13.0
	F_2	26/12-18/3	82	14.8	21.1	17.0	16.1	13.1
	G_1	10/1 -22/3	71	14.5	20.7	16.8	15.9	12.9
	G_2	9/1 -19/3	69	14.5	20.7	16.8	15.9	13.0
	H_1	24/1 - 1/4	67	13.9	20.4	16.4	15.4	12.4
	H_2	24/1 -30/3	65	14.0	20.5	16.4	15.4	12.5
Bragg (7)	A_1	26/10-15/2	112	15.5	19.3	15.3	14.6	14.5
	A_2	27/10-14/2	110	15.6	19.3	15.2	14.6	14.6
	B_1	10/11-16/2	98	15.6	20.0	15.9	15.2	14.5
	B_2	10/11-22/2	104	15.5	20.1	16.0	15.2	14.2
	C_1	18/11-20/2	94	15.6	20.2	16.1	15.5	14.3
	C_2	18/11-23/2	97	15.5	20.3	16.2	15.5	14.2
	D_1	29/11- 3/3	94	15.4	20.6	16.5	15.8	13.8
	D_2	1/12- 5/3	94	15.3	20.6	16.5	15.9	13.7
	E_1	15/12- 8/3	83	15.2	21.0	16.9	16.1	13.5
	E_2	16/12- 7/3	81	15.2	21.1	16.9	16.1	13.6
	F_1	26/12-12/3	76	14.9	21.1	17.0	16.1	13.3
	F_2	27/12-16/3	79	14.8	21.1	16.9	16.1	13.2
	G_1	8/1 -21/3	72	14.5	20.8	16.9	15.9	12.9
	G_2	9/1 -24/3	74	14.4	20.8	16.8	15.9	12.8
	H_1	25/1 -27/3	61	14.0	20.6	16.6	15.4	12.7
	H_2	25/1 -27/3	61	14.0	20.6	16.6	15.4	12.7
Wills (8)	A_1	26/10- 2/3	127	15.4	19.2	15.5	14.6	13.8
	A_2	30/10- 8/3	129	15.3	19.7	15.7	14.8	13.5
	B_1	10/11- 8/3	118	15.2	20.1	16.0	15.2	13.4
	B_2	10/11-14/3	124	15.2	20.1	16.1	15.2	13.2

Appendix 11 continued:

Cultivar	Sowing date block	Period	Y	X_1	X_2	X_3	X_4	X_5
Wills continued:	C_1	16/11-16/3	120	15.2	20.6	16.2	15.4	13.2
	C_2	16/11-12/3	116	15.3	20.3	16.1	15.4	13.3
	D_1	29/11-17/3	109	15.0	20.3	16.3	15.8	13.1
	D_2	29/11-15/3	107	15.0	20.3	16.3	15.8	13.2
	E_1	16/12-21/3	95	14.9	21.0	16.9	16.1	12.9
	E_2	15/12-20/3	95	14.9	21.0	16.8	16.1	13.0
	F_1	26/12-25/3	89	14.7	21.1	16.9	16.1	12.8
	F_2	26/12-30/3	94	14.5	20.9	16.8	16.1	12.5
	G_1	9/1 -31/3	81	14.3	20.6	16.5	15.9	12.5
	G_2	8/1 - 4/4	86	14.2	20.5	16.5	15.9	12.3
	H_1	24/1 - 9/4	75	13.8	20.1	16.0	15.4	12.1
	H_2	24/1 -15/4	81	13.6	19.8	15.6	15.4	11.9
K162	A_1	27/10-19/3	143	15.1	19.5	15.6	14.6	13.0
	A_2	27/10-18/3	142	15.2	19.5	15.6	14.6	13.1
(9)	B_1	No sample - plants lodged pre-flowering						
	B_2	13/11- 1/4	139	14.9	20.2	16.1	15.3	12.4
	C_1	17/11-30/3	133	15.0	20.2	16.1	15.5	12.5
	C_2	16/11-22/3	126	15.1	20.3	16.2	15.4	12.9
	D_1	30/11- 1/4	122	14.8	20.4	16.4	15.8	12.4
	D_2	30/11-10/4	131	14.7	20.2	16.1	15.8	12.1
	E_1	15/12- 5/4	111	14.6	20.7	16.5	16.1	12.3
	E_2	16/12-12/4	117	14.4	20.5	16.3	16.1	12.0
	F_1	27/12-24/4	118	13.9	20.1	15.8	16.1	11.5
	F_2	26/12-17/4	112	14.2	20.3	16.0	16.1	11.8
	G_1	8/1 -24/4	106	13.8	19.8	15.6	15.9	11.5
	G_2	8/1 -26/4	108	13.7	19.6	15.6	15.9	11.5
	H_1	25/1 -10/5	105	13.1	18.6	14.6	15.4	11.0
	H_2	25/1 - 9/5	104	13.1	18.7	14.7	15.4	11.0
Daintree	A_1	27/10-28/3	152	15.0	19.6	15.6	14.6	12.6
	A_2	28/10- 2/4	156	14.9	19.7	15.6	14.7	12.4
(10)	B_1	9/11-30/3	141	15:0	20.1	16.0	15.2	12.5
	B_2	11/11-30/3	139	15.0	20.1	16.0	15.2	12.5
	C_1	21/11- 6/4	136	14.8	20.2	16.1	15.6	12.2
	C_2	17/11- 4/4	138	14.9	20.2	16.1	15.5	12.3
	D_1	30/11-12/4	133	14.6	20.2	16.1	15.8	12.0
	D_2	30/11- 7/4	128	14.7	20.3	16.2	15.8	12.2
	E_1	15/12-17/4	122	14.3	20.3	16.0	16.1	11.8
	E_2	16/12-20/4	125	14.3	20.2	15.9	16.1	11.7
	F_1	25/12-26/4	122	14.0	20.0	15.8	16.1	11.5
	F_2	26/12- 1/5	126	13.8	20.0	15.6	16.1	11.3
	G_1	10/1 - 8/5	118	13.4	19.0	15.0	15.9	11.1
	G_2	10/1 - 8/5	118	13.4	19.0	15.0	15.9	11.1
		No H block samples - flowers failed to open						
Mamloxi	A_1	26/10-13/4	169	14.7	19.4	15.4	14.6	12.0
	A_2	27/10- 5/4	160	14.9	19.6	15.4	14.6	12.3
(11)	B_1	10/11- 5/4	146	14.9	20.0	16.3	15.2	12.3
	B_2	14/11- 8/4	145	14.8	20.0	16.3	15.4	12.2
	C_1	16/11-18/4	153	14.6	19.8	15.9	15.4	11.8
	C_2	16/11-12/4	147	14.7	20.0	16.2	15.4	12.0
	D_1	30/11-25/4	146	14.4	19.8	16.0	15.8	11.5
	D_2	30/11-19/4	140	14.5	19.9	16.1	15.8	11.7
	E_1	14/12- 2/5	139	14.0	19.8	15.6	16.1	11.3
	E_2	16/12- 5/5	140	14.0	19.7	15.5	16.1	11.2
	F_1	27/12-10/5	134	13.7	19.4	15.2	16.1	11.0
		No blocks F_2, G or H - flowers failed to open						

Appendix 11.1

Correlation coeficients

Cultivar	Variable	X_1	X_2	X_3	X_4	X_5
Acme	Y	0.337ns	-0.902***	-0.900***	-0.731**	0.641*
(n=15)	Y_1	0.367ns	-0.893***	-0.896***	-0.693**	0.651*
	X_2	-0.208ns		0.993***		
	X_5	0.894***			-0.251ns	
Soysota x Mandarin	Y	0.407ns	-0.905***	-0.925***	-0.743***	0.745***
(n=16)	Y_1	0.442ns	-0.892***	-0.914***	-0.708**	0.759***
	X_2	-0.201ns		0.997***		
	X_5	0.856***			-0.358ns	
Amsoy x T19	Y	0.359ns	-0.893***	-0.914***	-0.720**	0.695**
(n=16)	Y_1	0.369ns	-0.880***	-0.900***	-0.696**	0.691**
	X_2	-0.171ns		0.997***		
	X_5	0.856***			-0.351ns	
Wayne x PI-54-608-II	Y	0.370ns	-0.930***	-0.939***	-0.853***	0.674**
(n=16)	Y_1	0.398ns	-0.926***	-0.941***	-0.839***	0.691**
	X_2	-0.249ns		0.992***		
	X_5	0.884***			-0.401ns	
Wayne	Y	0.867**	0.006ns	-0.092ns	0.667*	0.803**
(n=10)	Y_1	0.870**	0.015ns	-0.084ns	0.675*	0.803**
	X_2	0.076ns		0.931***		
	X_5	0.966***			0.511ns	
Dare	Y	0.826***	-0.680**	-0.746***	-0.580*	0.811***
(n=16)	Y_1	0.868***	-0.651**	-0.722**	-0.524*	0.834***
	X_2	-0.509*		0.990***		
	X_5	0.906***			-0.585*	
Hill	Y	0.889***	-0.636**	-0.590*	-0.656**	0.940***
(n=16)	Y_1	0.915***	-0.589*	-0.543*	-0.607*	0.950***
	X_2	-0.278ns		0.989***		
	X_5	0.953***			-0.550*	
Ogden	Y	0.928***	-0.659**	-0.715**	-0.585*	0.945***
(n=16)	Y_1	0.947***	-0.605*	-0.665**	-0.526*	0.946***
	X_2	-0.438ns		0.987***		
	X_5	0.964***			-0.542*	
Bragg	Y	0.920***	-0.753***	-0.806***	-0.588*	0.952***
(n=16)	Y_1	0.944	-0.695**	-0.753***	-0.515*	0.958***
	X_2	-0.513*		0.991***		
	X_5	0.944***			-0.601*	
Wills	Y	0.904***	-0.461ns	-0.440ns	-0.659**	0.915***
(n=16)	Y_1	0.921***	-0.415ns	-0.392ns	-0.611*	0.923***
	X_2	-0.133ns		0.963***		
	X_5	0.976***			-0.496ns	
K162	Y	0.861***	0.242ns	0.357ns	-0.658**	0.852***
(n=15)	Y_1	0.874***	0.276ns	0.389ns	-0.631*	0.858***
	X_2	0.623*		0.982***		
	X_5	0.971***			-0.519*	
Daintree	Y	0.824***	0.168ns	0.291ns	-0.936***	0.857***
(n=14)	Y_1	0.843***	0.201ns	0.325ns	-0.927***	0.871***
	X_2	0.610*		0.988***		
	X_5	0.988***			-0.777**	
Mamloxi	Y	0.664*	-0.301ns	-0.141ns	-0.916***	0.684*
(n=11)	Y_1	0.682*	-0.272ns	-0.113ns	-0.919***	0.653*
	X_2	0.425ns		0.932***		
	X_5	0.980***			-0.843**	

Appendix 11.2 Pre-flowering phase regression models considered:

Model I $Y = a \cdot b_1^{X_1} \cdot b_{2,3}^{X_{2,3}} \cdot b_5^{X_5} \cdot b_4^{X_4}$

Cultivar	$F_{YX_1 \cdot X_{2,3}X_5X_4}$	$F_{YX_{2,3} \cdot X_1X_5X_4}$	$F_{YX_5 \cdot X_1X_{2,3}X_4}$	$F_{YX_4 \cdot X_1X_{2,3}X_5}$
Acme	9.90*	51.05***	1.67ns	0.70ns
Soysota x Mandarin	155.99***	540.89***	55.98***	33.00***
Amsoy x T19	24.81***	126.82***	19.11**	0.90ns
Wayne x PI-54-608-II	51.51***	239.56***	16.07**	6.82*
Wayne	49.89***	0.05ns	6.18ns	4.75ns
Dare	68.32***	5.63*	4.19ns	1.56ns
Hill	411.47***	57.63***	4.28ns	7.42*
Ogden	394.44***	20.39***	12.66**	1.67ns
Bragg	397.41***	26.79***	10.49**	0.02ns
Wills	539.63***	59.26***	26.65***	0.10ns
K162	332.03***	53.00***	37.54***	2.24ns
Daintree	1209.26***	303.83***	52.13***	128.41***
Mamloxi	64.57***	53.24***	7.23*	7.01*

Model II $Y = a \cdot b_1^{X_1} \cdot b_4^{X_4} \cdot b_5^{X_5} \cdot b_{2,3}^{X_{2,3}}$

Cultivar	$F_{YX_1 \cdot X_5X_4X_{2,3}}$	$F_{YX_4 \cdot X_1X_5X_{2,3}}$	$F_{YX_5 \cdot X_1X_4X_{2,3}}$	$F_{YX_{2,3} \cdot X_1X_4X_5}$
Acme	9.91*	44.99***	5.72*	2.71ns
Soysota x Mandarin	155.99***	503.61***	87.86***	38.43***
Amsoy x T19	24.94***	108.91***	4.81ns	33.09***
Wayne x PI-54-608-II	51.51***	239.96***	21.59***	1.78ns
Wayne	49.89***	0.51ns	1.56ns	8.91*
Dare	68.32***	7.59*	3.71ns	0.07ns
Hill	411.47***	59.50***	9.84**	-
Ogden	394.44***	22.59***	12.08**	0.04ns
Bragg	397.41***	22.82***	10.87**	3.62ns
Wills	539.63***	56.82***	12.46**	16.74**
K162	332.03***	49.16***	43.09***	0.53ns
Daintree	1209.26***	383.08***	88.82***	12.45**
Mamloxi	64.57***	54.30***	12.31*	0.87ns

Model III $Y = a \cdot b_5^{X_5} \cdot b_1^{X_1} \cdot b_{2,3}^{X_{2,3}} \cdot b_4^{X_4}$

Cultivar	$F_{YX_5 \cdot X_1X_{2,3}X_4}$	$F_{YX_1 \cdot X_5X_{2,3}X_4}$	$F_{YX_{2,3} \cdot X_5X_1X_4}$	$F_{YX_4 \cdot X_5X_1X_{2,3}}$
Acme	31.06***	16.76**	14.80**	0.70ns
Soysota x Mandarin	459.28***	128.67***	165.01***	33.01***
Amsoy x T19	87.29***	33.89***	49.69***	0.90ns
Wayne x PI-54-608-II	155.73***	67.92***	84.38***	6.82*
Wayne	42.46***	8.76*	4.86ns	4.75ns
Dare	63.12***	6.37*	8.64*	1.56ns
Hill	444.05***	0.44ns	29.96***	7.42*
Ogden	394.16***	7.42*	25.95***	0.17ns
Bragg	400.18***	9.94**	24.00***	0.02ns
Wills	542.18***	5.40*	77.92***	0.10ns
K162	320.41***	12.33**	89.79***	2.24ns
Daintree	1291.81***	24.91***	247.15***	128.29***
Mamloxi	58.84***	6.69*	59.33***	6.99*

Note: For $F_{Y.X_1X_5X_4X_{2,3}}$ and $100R^2$ (same for all models) - see Table 4.

Appendix 11.3 Analysis of Variance for the regression model used - Model I in Appendix 11.2*

Cultivar	Source of Variation	df	SS	F(see*)
Acme	Total	15	37.64	
	Mean	1	37.56	
	Regression total	4	0.07015	
	Due to X_1 (adj. for $X_{2,3}$, X_5, X_4)	1	0.01097	
	Due to $X_{2,3}$ (additional to X_1)	1	0.05656	
	Due to X_5 (addit.to X_1, $X_{2,3}$)	1	0.001850	
	Due to X_4 (addit.to X_1, $X_{2,3}$, X_5)	1	0.0007754	
	Residual	10	0.01108	
Soysota x Mandarin	T	16	41.47	
	M	1	41.40	
	Reg	4	0.06639	
	X_1	1	0.01318	
	$X_{2,3}$	1	0.04570	
	X_5	1	0.004730	
	X_4	1	0.002788	
	Res	11	0.0009294	
Amsoy x T19	T	16	41.63	
	M	1	41.58	
	Reg	4	0.04431	
	X_1	1	0.006434	
	$X_{2,3}$	1	0.03272	
	X_5	1	0.004931	
	X_4	1	0.0002311	
	Res	11	0.002838	
Wayne x PI-54-608-II	T	16	45.45	
	M	1	45.38	
	Reg	4	0.06351	
	X_1	1	0.01039	
	$X_{2,3}$	1	0.04832	
	X_5	1	0.003421	
	X_4	1	0.001376	
	Res	11	0.002218	
Wayne	T	10	28.92	
	M	1	28.90	
	Reg	4	0.01157	
	X_1	1	0.009484	
	$X_{2,3}$	1	0.000009295	
	X_5	1	0.001174	
	X_4	1	0.0009032	
	Res	5	0.0009506	
Dare	T	16	57.32	
	M	1	57.25	
	Reg	4	0.06030	
	X_1	1	0.05169	
	$X_{2,3}$	1	0.004259	
	X_5	1	0.003173	
	X_4	1	0.001180	
	Res	11	0.008323	

Appendix 11.3 continued:

Cultivar	Source of Variation	df	SS	F(see*)
Hill	T	16	61.34	
	M	1	61.27	
	Reg	4	0.06583	
	X_1	1	0.05633	
	$X_{2,3}$	1	0.007890	
	X_5	1	0.0005865	
	X_4	1	0.001016	
	Res	11	0.001506	
Ogden	T	16	59.81	
	M	1	59.73	
	Reg	4	0.07494	
	X_1	1	0.06887	
	$X_{2,3}$	1	0.003560	
	X_5	1	0.002210	
	X_4	1	0.0002915	
	Res	11	0.001921	
Bragg	T	16	59.81	
	M	1	59.71	
	Reg	4	0.09907	
	X_1	1	0.09057	
	$X_{2,3}$	1	0.006106	
	X_5	1	0.002391	
	X_4	1	0.000004547	
	Res	11	0.002507	
Wills	T	16	64.47	
	M	1	64.38	
	Reg	4	0.08840	
	X_1	1	0.07625	
	$X_{2,3}$	1	0.008374	
	X_5	1	0.003766	
	X_4	1	0.00001389	
	Res	11	0.001554	
K162	T	15	64.96	
	M	1	64.92	
	Reg	4	0.03253	
	X_1	1	0.02543	
	$X_{2,3}$	1	0.004059	
	X_5	1	0.002875	
	X_4	1	0.0001714	
	Res	10	0.0007659	
Daintree	T	14	62.96	
	M	1	62.94	
	Reg	4	0.01902	
	X_1	1	0.01358	
	$X_{2,3}$	1	0.003412	
	X_5	1	0.0005854	
	X_4	1	0.001442	
	Res	9	0.0001011	
Mamloxi	T	11	51.66	
	M	1	51.65	
	Reg	4	0.008113	
	X_1	1	0.003967	
	$X_{2,3}$	1	0.003271	
	X_5	1	0.0004445	
	X_4	1	0.0004304	
	Res	6	0.0003687	

Appendix 11.4 Significance of the partial regression coefficients for Model I (t-test ratios)

Cultivar	a	b_1	$b_{2,3}$	b_5	b_4
Acme	3.27**	1.35ns	- 1.65ns	- 1.31ns	- 0.84ns
Soysota x Mandarin	11.43***	9.37***	- 6.20***	- 9.16***	- 5.75***
Amsoy x T19	3.58**	2.45*	- 5.75***	- 2.78*	0.95ns
Wayne x PI-54-608-II	11.00***	5.45***	- 1.34ns	- 4.73***	- 2.61*
Wayne	2.27ns	0.21ns	- 2.98*	- 0.29ns	2.18ns
Dare	2.93*	3.71**	- 0.27ns	- 1.70ns	- 1.25ns
Hill	9.09***	5.62***	0.05ns	- 3.13**	- 2.72*
Ogden	4.95***	5.22***	- 0.19ns	- 3.14**	- 1.29ns
Bragg	4.86***	4.13**	- 1.90ns	- 2.49*	- 0.15ns
Wills	7.43***	7.86***	- 4.09**	- 5.12***	0.31ns
K162	5.56***	5.88***	- 0.73ns	- 6.23***	- 1.50ns
Daintree	23.58***	4.22**	3.53**	- 7.99***	-11.33***
Mamloxi	5.36**	0.56ns	0.93ns	- 3.59*	- 2.65*

Appendix 11.5 Between cultivar comparisons - homogeneity tests of the partial regression coefficients for the model:

$$Y = a \cdot b_1^{X_1} \cdot b_{2,3}^{X_{2,3}} \cdot b_5^{X_5} \cdot b_4^{X_4}$$

Appendix 11.5.1 T-test ratios for the partial regression coefficient a

Cultivar	00	0	1	2	3	4	5	6	7	8	9	10
00												
0	-0.6531ns											
1	-1.4938ns	-1.9116ns										
2	0.6612ns	3.2225**	4.0454**									
3	-2.7593*	-4.1880**	-2.1182*	-5.8885**								
4	-0.3968ns	0.1333ns	1.0607ns	-1.2474ns	2.4109*							
5	-0.3875ns	0.6801ns	2.2371*	-2.3213*	4.3527**	0.1385ns						
6	-1.1686ns	-1.2725ns	0.6248ns	-3.6246**	2.7731*	-0.7079ns	-1.6688ns					
7	-0.1151ns	0.7795ns	1.9073ns	-1.1372ns	3.5611**	0.3579ns	0.3755ns	1.4763ns				
8	-1.0306ns	-1.0853ns	1.0451ns	-3.8159**	3.3370**	-0.5453ns	-1.5511ns	0.3712ns	-1.3223ns			
9	0.0118ns	1.0821ns	2.2242*	-0.9978ns	3.9331**	0.5046ns	0.6289ns	1.7827ns	0.1724ns	1.6510ns		
10	2.1678*	8.9014**	7.5835**	3.5531**	9.0659**	2.8851**	6.7407**	7.4707**	3.4475**	8.7792**	3.4921**	
11	1.7387ns	2.9102**	3.5664**	1.6281ns	4.6876**	2.1725*	2.6247*	3.2950**	2.1387*	3.2276**	2.0643ns	0.3115ns

Appendix 11.5.2 T-test ratios for the partial regression coefficient b_1

00												
0	0.8470ns											
1	-0.5889ns	-3.8674**										
2	-0.5021ns	-4.8583**	0.3153ns									
3	-1.2089ns	-5.1052**	-1.4430ns	-2.0253ns								
4	-0.7795ns	-5.8769**	-0.5121ns	-1.2864ns	1.2935ns							
5	-0.6915ns	-5.9170**	-0.2503ns	-0.9661ns	1.5898ns	0.4793ns						
6	-0.4640ns	-4.5995**	0.4177ns	0.1631ns	2.0918*	1.3950ns	1.0967ns					
7	-0.4025ns	-3.8985**	0.5348ns	0.3451ns	2.0844*	1.3692ns	1.1058ns	0.2034ns				
8	-0.1841ns	-3.7722**	1.2747ns	1.4964ns	2.8908**	2.8277**	2.6964*	1.2628ns	0.8325ns			
9	-0.6872ns	-5.9421**	-0.2368ns	-0.9546ns	1.6087ns	0.5109ns	0.0291ns	-1.0861ns	-1.0951ns	-2.7064*		
10	-0.9968ns	-7.4303**	-1.2289ns	-2.7860**	0.7815ns	-1.2168ns	-2.1125*	-2.8049**	-2.4174*	-4.7678**	-2.1943*	
11	-1.2093ns	-6.6208**	-1.6834ns	-2.7703*	0.1078ns	-1.7147ns	-2.2308*	-2.8234**	-2.6446*	-4.0561**	-2.2681*	-1.0346ns

Appendix 11.5 continued:

Appendix 11.5.3 T-test ratios for the partial regression coefficient $b_{2,3}$

00												
0	-0.1246ns											
1	-1.1807ns	-2.0288ns										
2	0.4395ns	0.8086ns	1.9701ns									
3	-1.8877ns	-2.0380ns	-1.3869ns	-2.2304*								
4	0.4489ns	0.5496ns	1.0783ns	0.2182ns	1.7827ns							
5	1.2116ns	1.7872ns	2.7282*	0.8875ns	2.6816*	0.2639ns						
6	0.5358ns	0.6488ns	1.1899ns	0.3023ns	1.8735ns	0.0587ns	-0.1938ns					
7	-0.8764ns	-0.9165ns	-0.2630ns	-1.1944ns	0.8507ns	-1.0227ns	-1.6959ns	-1.1028ns				
8	-1.2607ns	-1.7504ns	-0.2976ns	-1.9115ns	1.1907ns	-1.1632ns	-2.6162*	-1.2710ns	0.1092ns			
9	0.5675ns	0.8547ns	1.7834ns	0.2037ns	2.2264*	-0.0926ns	-0.5766ns	-0.1693ns	1.2506ns	1.8026ns		
10	2.9043**	6.3802**	6.6795**	2.8190**	3.6811**	0.9471ns	1.3643ns	0.8905ns	2.6514*	5.2587**	1.9530ns	
11	1.6562ns	1.9888ns	2.6232*	1.4283ns	2.8778*	0.7772ns	0.7758ns	0.7246ns	2.0378ns	2.6274*	1.1811ns	0.0121ns

Appendix 11.5.4 T-test ratios for the partial regression coefficient b_5

00												
0	-0.8000ns											
1	0.4575ns	3.4279**										
2	0.5546ns	4.9178**	0.2480ns									
3	1.1556ns	5.0607**	1.6614ns	1.7931ns								
4	0.8701ns	5.0873**	1.0814ns	1.1452ns	-0.7820ns							
5	0.6889ns	5.0264**	0.6280ns	0.5582ns	-1.3469ns	-0.6207ns						
6	0.4894ns	3.8317**	0.0705ns	-0.1862ns	-1.7044ns	-1.1010ns	-0.5412ns					
7	0.3314ns	2.6212*	-0.2515ns	-0.4970ns	-1.7039ns	-1.1877ns	-0.7508ns	0.3254ns				
8	0.0080ns	2.4083*	-1.1943ns	-1.8447ns	-2.9056**	-2.5144*	-1.9192ns	-1.3756ns	-0.7528ns			
9	0.4846ns	4.9051**	0.0344ns	-0.3525ns	-2.0536ns	-1.4644ns	-0.7383ns	-0.0574ns	0.3294ns			
10	0.3301ns	4.3951**	-0.4482ns	-1.1419ns	-2.5187*	-2.0586*	-1.2987ns	-0.6077ns	-0.0558ns	1.1480ns	-0.8664ns	
11	0.6246ns	4.8743**	0.4468ns	0.3004ns	-1.5334ns	-0.8435ns	-0.2083ns	0.4091ns	0.6560ns	1.9817ns	0.6379ns	1.3487ns

Appendix 11.5.5 T-test ratios for the partial regression coefficient b_4

00												
0	-0.4548ns											
1	0.4933ns	2.4677*										
2	0.0611ns	1.4375ns	-1.0248ns									
3	1.8563ns	4.0452**	2.3708*	3.0987**								
4	0.4361ns	2.4559*	-0.1424ns	0.9255ns	-0.8748ns							
5	0.3340ns	2.8154**	-0.4753ns	0.7947ns	-0.9410ns	0.3285ns						
6	0.3988ns	2.2669*	-0.2180ns	0.8129ns	-0.8922ns	-0.0832ns	0.2147ns					
7	0.7326ns	2.9090**	0.5252ns	1.5207ns	-0.7062ns	0.6813ns	1.0754ns	0.7399ns				
8	0.8665ns	5.3333**	0.9960ns	2.5387*	-0.6701ns	1.2772ns	2.4459*	1.3199ns	0.2385ns			
9	0.5684ns	3.7219**	0.1514ns	1.4998ns	-0.8200ns	0.3465ns	0.9454ns	0.4318ns	-0.5019ns	-1.4068ns		
10	0.2281ns	3.0574**	-0.8637ns	0.5487ns	-1.0018ns	-0.7372ns	-0.5843ns	-0.5831ns	-1.4874ns	-4.8998**	-1.9239ns	
11	0.2824ns	2.4946*	-0.5904ns	0.6232ns	-0.9659ns	-0.4555ns	-0.1852ns	-0.3408ns	-1.1674ns	-2.4430*	-1.0697ns	0.2811ns

Appendix 12

FLOWERING PHASE

Y = the length, in days, of the flowering phase

X_1 = the average daylength, in hours, during the flowering phase

X_2 = the average hourly day temperature, in °C, during the phase

X_3 = the average hourly night temperature, in °C, during the phase

X_4 = the daylength, in hours, at the start of the phase

X_5 = the daylength, in hours, at the end of the phase

Cultivar (Maturity Group)	Sowing date block	Period	Y	X_1	X_2	X_3	X_4	X_5
Acme (00)	A_1	23/12- 2/2	41	15.7	21.5	17.1	16.1	15.1
	A_2	26/12- 2/2	38	15.7	21.7	17.2	16.1	15.1
	B_1	26/12- 2/2	38	15.7	21.7	17.2	16.1	15.1
	B_2	28/12- 2/2	36	15.7	21.6	17.2	16.1	15.1
	C_1	31/12- 2/2	33	15.6	21.5	17.2	16.0	15.1
	C_2	No sample due to germination failure						
	D_1	12/1 -26/2	45	15.0	20.9	16.8	15.8	14.0
	D_2	10/1 -18/2	39	15.2	20.9	16.9	15.9	14.4
	E_1	18/1 -12/3	53	14.5	20.4	16.5	15.6	13.3
	E_2	16/1 - 8/3	51	14.7	20.5	16.5	15.7	13.5
	F_1	30/1 -28/3	57	13.9	20.5	16.5	15.2	12.6
	F_2	2/2 -28/3	54	13.8	20.5	16.6	15.1	12.6
	G_1	14/2 -21/4	66	13.0	19.1	15.0	14.6	11.6
	G_2	14/2 -21/4	66	13.0	19.1	15.0	14.6	11.6
	H_1	25/2 - 4/5	68	12.5	18.0	14.0	14.1	11.2
	H_2	25/2 - 9/5	73	12.4	17.7	13.7	14.1	11.0
Soysota x Mandarin (0)	A_1	18/12- 2/2	46	15.7	21.5	17.2	16.1	15.1
	A_2	20/12-31/1	42	15.8	21.5	17.3	16.1	15.2
	B_1	23/12- 2/2	41	15.7	21.5	17.1	16.1	15.1
	B_2	25/12- 2/2	39	15.7	21.7	17.1	16.1	15.1
	C_1	31/12- 2/2	33	15.6	21.5	17.2	16.0	15.1
	C_2	2/1 - 6/2	35	15.5	21.2	17.1	16.0	14.9
	D_1	8/1 -23/2	46	15.4	21.1	17.1	15.9	14.2
	D_2	11/1 -27/2	47	15.0	21.0	17.0	15.8	14.0
	E_1	17/1 -10/3	52	14.6	20.5	16.5	15.7	13.4
	E_2	20/1 -11/3	49	14.5	20.9	16.9	15.6	13.4
	F_1	1/2 -27/3	54	13.9	20.6	16.6	15.1	12.7
	F_2	3/2 -30/3	55	13.8	20.5	16.5	15.0	12.5
	G_1	14/2 -10/4	55	13.3	19.8	15.8	14.6	12.1
	G_2	16/2 -19/4	62	13.0	19.1	14.9	14.5	11.7
	H_1	26/2 - 6/5	69	12.4	17.9	14.2	14.0	11.1
	H_2	28/2 - 6/5	67	12.4	17.8	14.0	13.9	11.1
Amsoy x T19 (1)	A_1	16/12-11/2	57	15.6	21.2	16.8	16.1	14.7
	A_2	16/12-11/2	57	15.6	21.2	16.9	16.1	14.7
	B_1	26/12-15/2	51	15.4	21.5	17.0	16.1	14.5
	B_2	26/12-17/2	53	15.4	21.5	17.2	16.1	14.4
	C_1	3/1 -17/2	45	15.3	21.3	17.2	16.0	14.4
	C_2	3/1 -20/2	48	15.2	21.2	17.2	16.0	14.3
	D_1	8/1 - 1/3	52	15.0	21.0	17.3	15.9	13.9
	D_2	10/1 - 2/3	51	14.9	20.9	16.9	15.9	13.8

Note: Data given = plot means

Appendix 12 continued:

Cultivar	Sowing date block	Period	Y	X_1	X_2	X_3	X_4	X_5
Amsoy x T19 continued:	E_1	20/1 -12/3	51	14.5	20.5	16.5	15.6	13.3
	E_2	19/1 -12/3	52	14.5	20.4	16.5	15.6	13.3
	F_1	3/2 -28/3	53	13.8	20.6	16.6	15.0	12.6
	$*F_2$	7/2 -26/3	47	13.8	20.8	16.8	14.9	12.7
	G_1	16/2 -20/4	63	13.0	19.0	14.9	14.5	11.7
	G_2	15/2 -18/4	62	13.1	19.2	15.1	14.5	11.8
	H_1	28/2 -13/5	74	12.3	17.3	13.4	13.9	10.9
	H_2	2/3 - 9/5	68	12.3	17.6	13.5	13.8	11.0
Wayne x PI-54-608-II (2)	A_1	2/1 -28/2	57	15.1	21.3	17.3	16.0	13.9
	A_2	29/12-27/2	60	15.2	21.0	17.2	16.1	14.0
	B_1	4/1 - 8/3	63	14.9	21.0	17.0	16.0	13.5
	B_2	5/1 - 3/3	57	15.0	21.1	17.1	15.9	13.8
	C_1	6/1 - 4/3	57	14.9	21.1	17.0	15.9	13.7
	C_2	9/1 - 1/3	51	14.9	21.0	17.0	15.9	13.9
	D_1	17/1 -20/3	62	14.4	20.5	16.5	15.7	13.0
	D_2	15/1 -10/3	54	14.6	20.5	16.5	15.7	13.4
	E_1	26/1 -29/3	62	14.0	20.5	16.7	15.3	12.6
	E_2	24/1 -25/3	60	14.1	20.4	16.7	15.4	12.8
	F_1	12/2 - 9/4	56	13.3	19.7	16.0	14.7	12.1
	F_2	7/2 -11/4	63	13.4	19.7	15.8	14.9	12.0
	G_1	18/2 - 5/5	76	12.6	18.4	14.3	14.4	11.2
	G_2	20/2 - 9/5	78	12.5	18.0	14.0	14.3	11.0
	H_1	8/3 -16/5	69	12.0	17.0	13.3	13.5	10.8
	H_2	7/3 - 9/5	63	12.2	17.4	13.4	13.6	11.0
Wayne (3)	No blocks A to C - due to germination failure							
	D_1	23/1 -19/3	55	14.3	20.6	16.6	15.5	13.0
	D_2	21/1 -19/3	57	14.3	20.6	16.6	15.5	13.0
	E_1	7/2 - 4/4	56	13.6	20.3	16.4	14.9	12.3
	E_2	5/2 -31/3	54	13.7	20.4	16.6	14.9	12.5
	F_1	19/2 -25/4	65	12.8	18.9	14.7	14.3	11.5
	F_2	18/2 -25/4	66	12.8	18.9	14.8	14.4	11.5
	G_1	23/2 - 9/5	75	12.5	17.8	13.8	14.2	11.0
	G_2	24/2 -10/5	75	12.4	17.6	13.7	14.1	11.0
	H_1	10/3 -22/5	73	11.9	16.8	13.3	13.4	10.7
	H_2	12/3 -21/5	71	11.7	16.6	13.0	13.3	10.7
Dare (4)	$*A_1$	15/2 - 2/4	46	13.4	20.2	16.4	14.5	12.4
	A_2	29/1 -20/3	50	14.1	20.6	16.6	15.3	13.0
	B_1	12/2 - 5/4	52	13.4	20.2	16.3	14.7	12.3
	B_2	11/2 - 6/4	54	13.4	20.2	16.2	14.7	12.2
	C_1	11/2 - 7/4	55	13.4	20.2	16.1	14.7	12.2
	C_2	6/2 - 7/4	60	13.5	20.2	16.1	14.9	12.2
	D_1	17/2 -30/4	72	12.8	18.6	14.6	14.4	11.3
	D_2	19/2 -29/4	69	12.7	18.6	14.5	14.3	11.4
	E_1	2/3 - 7/5	66	12.3	17.4	13.7	13.8	11.1
	E_2	2/3 -12/5	71	12.2	17.4	13.4	13.8	10.9
	F_1	11/3 -18/5	68	11.9	16.9	13.1	13.4	10.8
	F_2	11/3 -20/5	70	11.9	16.9	13.2	13.4	10.7
	G_1	18/3 -27/5	70	11.7	16.2	12.9	13.1	10.6
	G_2	20/3 -30/5	71	11.4	15.9	12.6	13.0	10.5
	H_1	25/3 - 5/6	72	11.4	15.3	12.1	12.8	10.5
	H_2	27/3 - 6/6	71	11.3	15.2	12.0	12.7	10.4

* Data from this sample excluded from the final regression equation - due to 'oversize' residual.

Cultivar	Sowing date block	Period	Y	X_1	X_2	X_3	X_4	X_5
Hill (5)	A_1	16/2 - 4/4	47	13.3	20.0	16.2	14.5	12.3
	A_2	19/2 -14/4	54	13.1	19.4	15.3	14.3	11.9
	B_1	23/2 -30/4	66	12.6	18.3	14.3	14.2	11.3
	B_2	28/2 -22/4	53	12.7	18.6	14.2	13.9	11.6
	C_1	22/2 -29/4	66	12.6	18.5	14.4	14.2	11.4
	C_2	25/2 -30/4	64	12.5	18.2	14.2	14.1	11.3
	D_1	9/3 - 8/5	60	12.2	17.4	13.5	13.5	11.1
	D_2	7/3 - 8/5	62	12.2	17.5	13.6	13.6	11.1
	E_1	12/3 -14/5	63	12.0	16.9	13.0	13.3	10.9
	E_2	13/3 -17/5	65	11.9	16.8	12.9	13.3	10.8
	F_1	17/3 -20/5	64	11.8	16.5	12.9	13.1	10.7
	F_2	21/3 -26/5	66	11.6	16.1	12.7	12.9	10.6
	G_1	27/3 -29/5	63	11.4	15.9	12.3	12.7	10.5
	G_2	29/3 -29/5	61	11.3	15.9	12.3	12.6	10.5
	H_1	5/4 -10/6	66	11.1	14.5	11.7	12.3	10.4
	H_2	8/4 -11/6	64	11.1	14.4	11.6	12.2	10.4
Ogden (6)	A_1	15/2 -17/4	61	13.1	19.2	15.2	14.5	11.8
	A_2	13/2 -10/4	56	13.3	19.9	15.9	14.6	12.1
	B_1	14/2 -26/4	71	12.9	18.9	15.0	14.6	11.5
	B_2	22/2 -27/4	64	12.7	18.5	14.4	14.2	11.4
	C_1	23/2 - 6/5	72	12.5	18.0	14.0	14.2	11.1
	C_2	23/2 - 4/5	70	12.6	18.1	14.1	14.2	11.2
	D_1	1/3 - 8/5	68	12.5	17.6	13.6	13.9	11.1
	D_2	27/2 - 8/5	70	12.4	17.7	13.7	14.0	11.1
	E_1	8/3 -25/5	78	11.9	16.8	13.4	13.5	10.6
	E_2	10/3 -23/5	74	11.9	16.8	13.2	13.4	10.6
	F_1	19/3 -29/5	71	11.6	16.0	12.7	13.0	10.5
	F_2	18/3 -28/5	71	11.6	16.1	12.8	13.1	10.6
	G_1	22/3 - 7/6	77	11.4	15.5	12.3	12.9	10.4
	G_2	19/3 - 6/6	79	11.5	15.7	12.5	13.0	10.4
	H_1	1/4 -13/6	73	11.2	14.5	11.3	12.4	10.4
	H_2	30/3 -14/6	76	11,2	14.6	11.4	12.5	10.4
Bragg (7)	A_1	15/2 - 1/5	75	12.8	18.6	14.7	14.5	11.3
	A_2	14/2 - 1/5	76	12.8	18.7	14.7	14.6	11.3
	B_1	16/2 - 4/5	77	12.7	18.4	14.5	14.5	11.2
	B_2	22/2 - 3/5	70	12.6	18.3	14.2	14.2	11.2
	C_1	20/2 - 5/5	74	12.6	18.3	14.2	14.3	11.2
	C_2	23/2 - 5/5	71	12.5	18.1	14.0	14.2	11.2
	D_1	3/3 - 8/5	66	12.3	17.6	13.6	13.8	11.1
	D_2	5/3 - 8/5	64	12.3	17.5	13.5	13.7	11.1
	E_1	8/3 -17/5	70	12.0	17.0	13.3	13.5	10.8
	E_2	7/3 -21/5	75	12.0	17.0	13.4	13.6	10.7
	F_1	12/3 -25/5	74	11.8	16.7	13.2	13.3	10.6
	F_2	16/3 -25/5	70	11.7	16.4	13.0	13.1	10.6
	G_1	21/3 - 6/6	77	11.5	15.6	12.3	12.9	10.4
	G_2	24/3 - 8/6	76	11.4	15.2	12.1	12.8	10.4
	H_1	27/3 -11/6	76	11.3	14.9	11.7	12.7	10.4
	H_2	27/3 - 9/6	74	11.3	15.0	11.8	12.7	10.4
Wills (8)	A_1	2/3 - 8/5	67	12.3	17.6	13.6	13.8	11.1
	A_2	8/3 - 7/5	60	12.2	17.5	13.5	13.5	11.1
	B_1	8/3 -10/5	63	12.2	17.3	13.3	13.5	11.0
	B_2	14/3 -10/5	57	12.0	17.0	12.9	13.2	11.0
	C_1	16/3 -12/5	57	11.9	16.7	12.7	13.1	10.9
	C_2	12/3 - 9/5	58	12.1	17.2	13.1	13.3	11.0

Cultivar	Sowing date block	Period	Y	X_1	X_2	X_3	X_4	X_5
Wills continued:	D_1	17/3 -15/5	59	11.9	16.5	12.7	13.1	10.8
	D_2	15/3 -13/5	59	12.0	16.7	12.8	13.2	10.9
	E_1	21/3 -26/5	66	11.6	16.1	12.7	12.9	10.6
	E_2	20/3 -26/5	67	11.6	16.2	12.8	13.0	10.6
	F_1	25/3 - 7/6	74	11.4	15.2	12.1	12.8	10.4
	F_2	30/3 - 9/6	71	11.2	14.9	11.8	12.5	10.4
	G_1	31/3 -12/6	73	11.2	14.7	11.5	12.5	10.4
	G_2	4/4 -14/6	71	11.2	14.3	11.1	12.3	10.4
	H_1	9/4 -14/6	66	11.0	14.1	11.0	12.1	10.4
	H_2	15/4 -15/6	61	10.9	13.9	11.1	11.9	10.3
K162	A_1	19/3 -25/5	67	11.7	16.2	12.8	13.0	10.6
	A_2	18/3 -28/5	71	11.6	16.1	12.8	13.1	10.6
(9)	B_1	No sample - plants lodged pre-flowering						
	B_2	1/4 -30/5	59	11.3	15.1	12.1	12.4	10.5
	C_1	27/3 - 1/6	66	11.3	15.3	12.2	12.7	10.5
	C_2	22/3 -30/5	69	11.5	15.7	12.5	12.9	10.5
	D_1	1/4 - 2/6	62	11.1	14.6	12.0	12.4	10.5
	D_2	10/4 - 2/6	53	11.2	14.7	11.7	12.1	10.5
	E_1	5/4 - 6/6	62	11.2	14.7	11.7	12.3	10.5
	E_2	12/4 -10/6	59	11.0	14.3	11.4	12.0	10.4
	F_1	24/4 -14/6	51	10.8	13.4	10.9	11.5	10.4
	F_2	17/4 -11/6	55	10.9	14.1	11.5	11.8	10.4
	G_1	24/4 -13/6	50	10.8	13.5	10.9	11.5	10.4
	G_2	26/4 -13/6	48	10.8	13.5	10.8	11.5	10.4
	H_1	10/5 -14/6	35	10.6	13.2	10.9	11.0	10.4
	H_2	9/5 -14/6	36	10.6	13.2	10.8	11.0	10.4
Daintree	A_1	28/3 - 1/6	65	11.4	15.2	12.2	12.6	10.5
	A_2	2/4 -28/5	56	11.4	15.1	12.1	12.4	10.6
(10)	B_1	30/3 - 1/6	63	11.2	15.1	12.0	12.5	10.5
	B_2	30/3 - 1/6	63	11.2	15.1	12.0	12.5	10.5
	C_1	6/4 - 2/6	57	11.2	14.8	12.0	12.2	10.5
	C_2	4/4 - 2/6	59	11.2	14.8	11.9	12.3	10.5
	D_1	12/4 - 2/6	51	11.1	14.5	11.9	12.0	10.5
	D_2	7/4 - 2/6	56	11.2	14.7	12.0	12.2	10.5
	E_1	17/4 - 7/6	51	11.0	14.4	11.9	11.8	10.4
	E_2	20/4 - 9/6	50	10.9	14.1	11.8	11.7	10.4
	F_1	26/4 -12/6	47	10.8	13.6	11.0	11.5	10.4
	F_2	1/5 -14/6	43	11.0	13.6	10.9	11.3	10.4
	G_1	8/5 -14/6	37	10.6	13.2	10.7	11.1	10.4
	G_2	8/5 -14/6	37	10.6	13.2	10.7	11.1	10.4
		No H block samples - flowers failed to open						
Mamloxi	A_1	13/4 - 6/6	54	11.0	14.4	11.8	12.0	10.5
	A_2	5/4 - 7/6	63	11.2	14.7	11.7	12.3	10.4
(11)	B_1	5/4 - 7/6	63	11.2	14.7	11.7	12.3	10.4
	B_2	8/4 - 7/6	60	11.1	14.6	11.7	12.2	10.4
	C_1	18/4 - 8/6	51	10.9	14.3	11.9	11.8	10.4
	C_2	12/4 - 6/6	55	11.1	14.5	11.7	12.0	10.5
	D_1	25/4 - 7/6	43	10.8	14.0	11.7	11.5	10.4
	D_2	19/4 - 8/6	50	10.9	14.3	12.0	11.7	10.4
	E_1	2/5 - 9/6	38	10.7	13.6	11.5	11.3	10.4
	E_2	5/5 -10/6	36	10.7	13.5	11.4	11.2	10.4
	F_1	10/5 -14/6	35	10.6	13.2	10.9	11.0	10.3
	No blocks F_2, G or H - flowers failed to open							

Correlation coefficients

Cultivar	Variable	X_1	X_2	X_3	X_4	X_5
Acme	Y	-0.980***	-0.948***	-0.926***	-0.962**	-0.985***
(n=15)	Y_1	-0.966***	-0.921***	-0.890***	-0.937***	-0.979***
	X_2	0.963***		0.990***		
	X_5	0.996***			0.976***	
Soysota x Mandarin	Y	-0.938***	-0.917***	0.896***	-0.924***	-0.949***
(n=16)	Y_1	-0.910***	-0.870***	0.845***	-0.887***	-0.930***
	X_2	0.948***		0.990***		
	X_5	0.993***			0.973***	
Amsoy x T19	Y	-0.814***	-0.900***	-0.927***	-0.852***	-0.807***
(n=15)	Y_1	-0.801***	-0.881***	-0.910***	-0.839***	-0.796***
	X_2	0.960***		0.989***		
	X_5	0.999***			0.988***	
Wayne x PI-54-608-II	Y	-0.709**	-0.710**	-0.725**	-0.632**	-0.760**
(n=16)	Y_1	-0.707**	-0.707**	-0.720**	-0.633**	-0.761**
	X_2	0.973***		0.995***		
	X_5	0.995***			0.969***	
Wayne	Y	-0.891***	-0.934***	-0.958***	-0.833**	-0.934***
(n=10)	Y_1	-0.896***	-0.935***	-0.962***	-0.838**	-0.938***
	X_2	0.974***		0.992***		
	X_5	0.990***			0.964***	
Dare	Y	-0.866***	-0.855***	-0.892***	-0.806***	-0.929***
(n=15)	Y_1	-0.864***	-0.850***	-0.888***	-0.803***	-0.928***
	X_2	0.988***		0.995***		
	X_5	0.985***			0.959***	
Hill	Y	-0.638**	-0.634**	-0.675**	-0.491ns	-0.754***
(n=16)	Y_1	-0.644**	-0.639**	-0.686**	-0.499*	-0.763***
	X_2	0.989***		0.982***		
	X_5	0.978***			0.929***	
Ogden	Y	-0.798***	-0.772***	-0.764***	-0.691**	-0.884***
(n=16)	Y_1	-0.794***	-0.770***	-0.766***	-0.685**	-0.885***
	X_2	0.992***		0.992***		
	X_5	0.972***			0.923***	
Bragg	Y	-0.181ns	-0.219ns	-0.136ns	-0.084ns	-0.295ns
(n=16)	Y_1	-0.180ns	-0.217ns	-0.134ns	-0.083ns	-0.295ns
	X_2	0.992***		0.993***		
	X_5	0.985***			0.965***	
Wills	Y	-0.561*	-0.565*	-0.479ns	-0.399ns	-0.668**
(n=16)	Y_1	-0.561*	-0.564*	-0.475ns	-0.398ns	-0.667**
	X_2	0.988***		0.985***		
	X_5	0.975***			0.924***	
K162	Y	0.899***	0.893***	0.883***	0.922***	0.766***
(n=15)	Y_1	0.869***	0.860***	0.842***	0.905***	0.723**
	X_2	0.988***		0.982***		
	X_5	0.929***			0.915***	
Daintree	Y	0.894***	0.965***	0.904***	0.980***	0.714**
(n=14)	Y_1	0.903***	0.967***	0.921***	0.977***	0.712**
	X_2	0.944***		0.955***		
	X_5	0.846***			0.830***	
Mamloxi	Y	0.985***	0.973***	0.620*	0.993***	0.429ns
(n=11)	Y_1	0.980***	0.986***	0.671*	0.993***	0.468ns
	X_2	0.965***		0.770**		
	X_5	0.505 ns			0.508 ns	

Appendix 12.2 Flowering phase regression models considered:

Model I

$$Y = a + b_5X_5 + b_3X_3$$

Cultivar	$F_{YX_5 \cdot X_3}$	$F_{YX_3 \cdot X_5}$	$F_{Y \cdot X_5X_3}$	$100R^2$
Acme	223.50***	1.42ns	112.53***	94.9
Soysota x Mandarin	127.76***	1.21ns	64.47***	90.8
Amsoy x T19	60.87***	37.36***	50.21***	88.3
Wayne x PI-54-608-II	17.77	0.00ns	8.88**	57.8
Wayne	74.76***	3.92ns	39.34***	91.8
Dare	70.27***	0.21ns	35.25***	84.4
Hill	25.45***	6.28*	15.87***	70.9
Ogden	59.66***	3.61ns	31.63***	83.0
Bragg	0.13ns	3.61ns	2.60ns	28.6
Wills	12.82**	2.88ns	7.85**	54.7
K162	34.85***	12.59**	23.72***	79.8
Daintree	31.66***	19.37**	25.51***	82.3
Mamloxi	0.65ns	4.58ns	2.62ns	39.5

Model II

$$Y = a + b_5X_5$$

Cultivar		$F_{Y \cdot X_5}$	$100R^2$
Acme		437.48***	97.1
Soysota x Mandarin		125.85***	90.0
Amsoy x T19		24.36***	65.2
Wayne x PI-54-608-II		19.13***	57.7
Wayne		54.78***	87.3
Dare		81.29***	86.2
Hill		18.48***	56.9
Ogden		50.29	78.2
Bragg		1.33ns	8.7
Wills		11.31**	44.7
K162		18.43***	58.6
Daintree		12.51**	51.0
Mamloxi		2.03ns	18.4

Model III

$$Y = a + b_5X_5 + b_4X_4$$

Cultivar	$F_{YX_5 \cdot X_4}$	$F_{YX_4 \cdot X_5}$	$F_{Y \cdot X_5X_4}$	$100R^2$
Acme	403.93***	0.00ns	202.05***	97.1
Soysota x Mandarin	116.91***	0.01ns	58.44***	90.0
Amsoy x T19	34.60***	6.46*	20.53***	77.4
Wayne x PI-54-608-II	31.11***	9.77**	20.43***	75.9
Wayne	95.87***	7.01*	51.44***	93.6
Dare	203.38***	20.52***	111.94***	94.9
Hill	66.53***	37.38***	51.95***	88.9
Ogden	89.88***	12.02**	50.96***	88.7
Bragg	4.43ns	33.52***	18.97***	74.5
Wills	25.70***	18.82***	22.26***	77.4
K162	62.71***	32.25***	47.48***	88.8
Daintree	842.78***	797.48***	820.21***	99.3
Mamloxi	225.08***	991.60***	608.29***	99.3

Appendix 12.3 Analysis of Variance for the regression model used - Model III in Appendix 12.2*

Cultivar	Source of Variation	df	SS	F(see*)
Acme	Total	15	40740.0	
	Mean	1	38300.0	
	Regression total	2	2365.0	
	Due to X_5 (adj. for X_4)	1	2365.0	
	Due to X_4 (addit.to X_5)	1	0.0176	
	Residual	12	70.26	
Soysota x Mandarin	T	16	40890.0	
	M	1	39200.0	
	Reg	2	1514.0	
	X_5	1	1514.0	
	X_4	1	0.01535	
	Res	13	168.4	
Amsoy x T19	T	15	47570.0	
	M	1	46700.0	
	Reg	2	668.9	
	X_5	1	563.6	
	X_4	1	105.3	
	Res	12	195.5	
Wayne x PI-54-608-II	T	16	61820.0	
	M	1	61010.0	
	Reg	2	612.3	
	X_5	1	466.0	
	X_4	1	146.3	
	Res	13	194.7	
Wayne	T	10	42530.0	
	M	1	41860.0	
	Reg	2	623.7	
	X_5	1	581.2	
	X_4	1	42.47	
	Res	7	42.43	
Dare	T	15	63780.0	
	M	1	62860.0	
	Reg	2	874.1	
	X_5	1	794.0	
	X_4	1	80.12	
	Res	12	46.85	
Hill	T	16	60970.0	
	M	1	60520.0	
	Reg	2	407.1	
	X_5	1	260.6	
	X_4	1	146.4	
	Res	13	50.92	
Ogden	T	16	80520.0	
	M	1	79950.0	
	Reg	2	506.8	
	X_5	1	447.0	
	X_4	1	59.79	
	Res	13	64.64	

Appendix 12.3 continued:

Cultivar	Source of Variation	df	SS	F(see*)
Bragg	T	16	85060.0	
	M	1	84830.0	
	Reg	2	171.6	
	X_5	1	20.06	
	X_4	1	151.6	
	Res	13	58.79	
Wills	T	16	66690.0	
	M	1	66180.0	
	Reg	2	397.4	
	X_5	1	229.4	
	X_4	1	168.0	
	Res	13	116.1	
K162	T	15	49060.0	
	M	1	47380.0	
	Reg	2	1492.0	
	X_5	1	985.2	
	X_4	1	506.6	
	Res	12	188.6	
Daintree	T	14	39660.0	
	M	1	38590.0	
	Reg	2	1068.0	
	X_5	1	548.9	
	X_4	1	519.4	
	Res	11	7.165	
Mamloxi	T	11	28390.0	
	M	1	27300.0	
	Reg	2	1086.0	
	X_5	1	201.0	
	X_4	1	885.5	
	Res	8	7.144	

Appendix 12.4 Significance of the partial regression coefficients for Model III (t-test ratios)

Cultivar	a	b_5	b_4
Acme	4.25**	-4.40***	0.05ns
Soysota x Mandarin	3.13**	-2.47*	-0.03ns
Amsoy x T19	4.42***	1.61ns	-2.54*
Wayne x PI-54-608-II	1.10ns	-4.40***	3.12**
Wayne	5.08**	-5.16**	2.65*
Dare	14.17***	-8.40***	4.53***
Hill	14.41***	-8.70***	6.11***
Ogden	15.66***	-6.86***	3.47**
Bragg	8.63***	-6.13***	5.79***
Wills	8.53***	-5.95***	4.34***
K162	1.60ns	-2.00ns	5.68***
Daintree	4.72***	-7.27***	28.24***
Mamloxi	-0.43ns	-3.07*	31.49***

Appendix 12.5 Between cultivar comparisons - homogeneity tests of the partial regression coefficients for the model:

$$Y = a + b_5X_5 + b_4X_4$$

Appendix 12.5.1 T-test ratios for the partial regression coefficient a

Cultivar	00	0	1	2	3	4	5	6	7	8	9	10
00												
0	-0.3227ns											
1	1.5552ns	1.7196ns										
2	-2.6135*	-1.9784ns	-3.4750**									
3	-1.0196ns	-0.5130ns	-2.3929*	2.1534*								
4	-0.5730ns	-0.0724ns	-2.1575*	3.2667**	0.9136ns							
5	-0.3723ns	0.0961ns	-2.0310ns	3.4976**	1.2211ns	0.5550ns						
6	0.5380ns	0.8630ns	-1.4531ns	4.5421**	2.5926*	2.8763**	2.3243*					
7	1.3483ns	1.5506ns	-0.7620ns	4.7250**	3.1027**	3.0509**	2.7541*	1.4292ns				
8	2.5165*	2.5971*	0.2105ns	5.5926**	4.2360**	4.2641**	4.0300**	2.9750**	1.5509ns			
9	1.1195ns	1.1725ns	0.7788ns	1.4971ns	1.2572ns	1.1924ns	1.1692ns	1.0627ns	0.9407ns	0.7441ns		
10	1.6896ns	1.8484ns	0.0685ns	3.6894**	2.5811*	2.3515*	2.2191*	1.6145ns	0.8823ns	-0.1317ns	-0.7628ns	
11	-2.5542*	-2.1749*	-3.4021**	-0.8693ns	-2.1300*	-2.5923*	-2.7121*	-3.2602**	-3.6620**	-4.4080**	-1.6552ns	-3.5436**

Appendix 12.5.2 T-test ratios for the partial regression coefficient b_5

00												
0	0.5664ns											
1	3.0371**	2.5589*										
2	-1.7333ns	-1.9942ns	-3.7904**									
3	-2.3330*	-2.5369*	-4.1768**	-0.4522ns								
4	-3.5150**	-3.5075**	-4.8087**	-0.8325ns	-0.3066ns							
5	-4.1810**	-4.1057**	-5.2012**	-1.4412ns	-0.9412ns	-0.8136ns						
6	-3.0979**	-3.1950**	-4.6312**	-0.7828ns	-0.2914ns	-0.0074ns	0.7265ns					
7	-4.5251**	-4.6249**	-5.7118**	-3.1344**	-2.8388**	-2.8594**	-2.4115*	-2.7726**				
8	-4.5396**	-4.6453**	-5.7134**	-3.3006**	-3.0297**	-3.0425**	-2.6385**	-2.9665**	-0.3626ns			
9	-1.7640ns	-1.8127ns	-2.2047*	-1.5697ns	-1.5098ns	-1.4793ns	-1.4045ns	-1.4772ns	-0.9567ns	-0.8656ns		
10	-5.6856*	-5.7453**	-6.6497**	-4.2510**	-3.9740**	-4.0660**	-3.6211**	-3.9526**	-1.0028ns	-0.5902ns	0.7185ns	
11	-1.6864ns	-1.8921ns	-3.3989**	-0.6060ns	-0.3073ns	-0.1455ns	0.2485ns	-0.1379ns	1.9805ns	2.2234*	1.4325ns	2.9164**

Appendix 12.5 continued:

Appendix 12.5.3 T-test ratios for the partial regression coefficient b_4

00												
0	-0.0068ns											
1	-2.3127*	-2.1468*										
2	2.3266*	2.1261*	3.7477**									
3	1.8307ns	1.6609ns	3.4437**	-0.6330ns								
4	2.1214*	1.8177ns	3.6194**	-0.8892ns	-0.1488ns							
5	2.5066*	2.1130*	3.8164**	-0.6388ns	0.1569ns	0.4789ns						
6	1.4908ns	1.2914ns	3.2850**	-1.5029ns	-0.8271ns	-1.0202ns	-1.6176ns					
7	3.5754**	3.1133**	4.4688**	0.7322ns	1.5585ns	2.2329*	1.9735ns	3.0956**				
8	2.9164**	2.5908*	4.1056**	0.2924ns	1.0250ns	1.4530ns	1.1813ns	2.1993*	0.4842ns			
9	3.9779**	3.5394**	4.7707**	1.3623ns	2.1544*	2.8178**	2.6067*	3.5474**	0.8216ns	1.2048ns		
10	5.1517**	4.1545**	5.0949**	1.4469ns	2.6164*	4.8969**	5.0050**	6.7417**	0.8064ns	1.3239ns	-0.3835ns	
11	5.7761**	4.6489**	5.4023**	1.9911ns	3.2426**	5.9971**	6.2835**	7.9366**	1.5801ns	1.9930ns	0.2402ns	2.3920*

Appendix 13 POD EMERGENCE PHASE

Y = the length, in days, of the pod emergence phase

X_1 = the average daylength, in hours, during the pod emergence phase

X_2 = the average hourly day temperature, in °C, during pod emergence

X_3 = the average hourly night temperature, in °C, during pod emergence

Data given = plot means

Cultivar (Maturity Group)	Sowing date block	Period	Y	X_1	X_2	X_3
Acme	A_1	23/12-31/12	7.8	16.1	21.5	16.6
	A_2	25/12- 1/1	7.8	16.1	22.6	17.1
(00)	B_1	26/12- 1/1	6.0	16.1	22.7	17.4
	B_2	28/12- 3/1	6.0	16.0	22.7	16.7
	C_1	31/12- 6/1	6.5	16.0	22.2	17.1
	C_2	no sample due to germination failure				
	D_1	12/1 -20/1	7.7	15.7	21.0	17.7
	D_2	10/1 -16/1	6.3	15.7	22.9	18.8
	E_1	18/1 -24/1	6.2	15.5	19.5	15.7
	E_2	16/1 -22/1	6.3	15.6	19.6	16.3
	F_1	30/1 - 5/2	5.7	15.0	20.0	15.6
	F_2	2/2 - 8/2	5.7	14.9	19.5	15.9
	G_1	14/2 -18/2	3.7	14.4	20.6	18.6
	G_2	14/2 -18/2	3.5	14.4	20.6	18.6
	H_1	25/2 - 3/3	5.9	13.9	19.3	15.8
	H_2	25/2 - 2/3	4.6	13.9	19.2	16.0
Soysota x Mandarin	A_1	18/12-28/12	10.0	16.1	20.9	17.2
	A_2	20/12-30/12	9.8	16.1	21.4	16.9
(0)	*B_1	23/12- 8/1	15.4	16.0	22.1	17.3
	B_2	25/12- 6/1	12.2	16.0	22.4	17.0
	C_1	31/12-13/1	12.2	15.9	23.0	18.5
	C_2	2/1 -12/1	10.2	15.9	23.1	18.7
	D_1	8/1 -17/1	9.2	15.8	22.6	18.8
	D_2	11/1 -21/1	9.6	15.7	21.2	17.7
	E_1	17/1 -27/1	9.8	15.5	20.4	16.1
	E_2	20/1 -30/1	10.2	15.4	20.5	16.4
	F_1	1/2 - 7/2	6.2	15.0	19.8	15.6
	F_2	3/2 -10/2	6.6	14.9	19.8	15.5
	G_1	14/2 -20/2	5.7	14.4	20.9	18.0
	G_2	16/2 -22/2	6.5	14.3	20.9	18.0
	H_1	26/2 - 4/3	5.2	13.8	19.6	15.6
	H_2	28/2 - 6/3	5.8	13.7	18.7	15.1
Amsoy x T19	A_1	16/12-26/12	10.5	16.1	20.2	16.3
	A_2	16/12-26/12	10.0	16.1	20.2	16.3
(1)	B_1	26/12- 5/1	10.3	16.0	22.7	16.9
	B_2	26/12- 6/1	11.0	16.0	22.5	17.1
	C_1	3/1 -12/1	9.2	15.9	20.6	19.0
	C_2	3/1 -11/1	7.8	15.9	20.1	18.9
	D_1	8/1 -16/1	7.6	15.7	22.9	19.0
	D_2	10/1 -16/1	6.8	15.7	22.9	18.8
	E_1	20/1 -28/1	8.4	15.4	20.7	16.3
	E_2	19/1 -29/1	9.6	15.4	20.4	16.5

Appendix 13 continued:

Cultivar	Sowing date block	Period	Y	X_1	X_2	X_3
Amsoy x T19 (1)	F_1	3/2 -10/2	7.2	14.9	19.8	15.5
	F_2	7/2 -15/2	8.1	14.7	22.1	16.9
	G_1	16/2 -20/2	4.4	14.3	20.0	17.4
	G_2	15/2 -20/2	5.2	14.4	20.5	17.8
	H_1	28/2 - 5/3	5.4	13.8	19.0	14.6
	H_2	2/3 - 7/3	5.2	13.7	19.6	15.8
Wayne x PI-54-608-II (2)	A_1	2/1 -10/1	7.6	15.9	22.9	18.7
	A_2	29/12- 9/1	10.3	16.0	22.9	18.0
	B_1	4/1 -14/1	10.2	15.9	23.2	19.4
	B_2	5/1 -14/1	8.6	15.8	23.3	19.6
	C_1	6/1 -14/1	7.4	15.8	23.5	19.6
	C_2	9/1 -16/1	7.5	15.8	22.8	18.8
	D_1	17/1 -26/1	8.5	15.5	20.2	16.0
	D_2	15/1 -23/1	8.2	15.6	19.9	16.4
	E_1	26/1 - 3/2	7.9	15.2	20.4	16.1
	E_2	24/1 - 2/2	9.3	15.2	20.7	16.1
	F_1	12/2 -18/2	6.4	14.5	21.8	18.4
	F_2	7/2 -13/2	5.9	14.7	21.5	16.4
	G_1	18/2 -26/2	5.8	14.2	21.7	17.4
	G_2	20/2 -26/2	5.6	14.1	21.8	17.5
	H_1	8/3 -14/3	5.7	13.3	20.3	16.9
	H_2	7/3 -12/3	5.8	13.4	19.4	16.1
Wayne (3)	No blocks A to C due to germination failure					
	D_1	23/1 - 3/2	10.9	15.2	20.6	16.0
	D_2	21/1 -31/1	9.1	15.3	20.4	16.3
	E_1	7/2 -14/2	7.0	14.7	22.0	16.6
	E_2	5/2 -13/2	8.1	14.8	20.9	16.0
	F_1	19/2 -26/2	6.4	14.2	21.8	17.5
	F_2	18/2 -24/2	5.8	14.2	22.5	17.9
	G_1	23/2 - 2/3	6.6	14.0	19.8	16.3
	G_2	24/2 - 2/3	5.7	13.9	19.1	16.1
	H_1	10/3 -17/3	7.2	13.2	20.6	16.7
	H_2	12/3 -18/3	6.1	13.2	21.2	16.9
Dare (4)	A_1	15/2 -26/2	11.2	14.2	21.2	17.7
	A_2	29/1 -11/2	13.3	14.9	20.1	15.5
	*B_1	12/2 -19/2	8.3	14.5	21.7	18.1
	B_2	14/2 -25/2	10.7	14.3	21.5	18.0
	C_1	11/2 -22/2	11.2	14.4	21.9	18.2
	C_2	6/2 -18/2	11.9	14.6	21.3	17.3
	D_1	17/2 -28/2	10.9	14.1	21.4	17.6
	D_2	19/2 - 3/3	12.2	14.0	20.7	16.9
	E_1	2/3 -12/3	9.9	13.5	19.5	16.0
	E_2	2/3 -12/3	9.8	13.5	19.5	16.0
	F_1	11/3 -20/3	9.4	13.2	20.8	16.7
	F_2	11/3 -19/3	8.6	13.2	20.9	16.7
	G_1	18/3 -29/3	10.7	12.8	20.1	15.6
	G_2	20/3 -30/3	9.6	12.7	19.8	15.2
	H_1	25/3 - 3/4	9.4	12.4	18.3	14.5
	H_2	27/3 - 7/4	10.8	12.4	18.0	13.3
Hill (5)	*A_1	16/2 -27/2	11.2	14.2	21.1	17.6
	*A_2	19/2 - 3/3	11.5	14.0	20.7	16.9
	B_1	23/2 - 5/3	9.5	13.9	19.9	16.1
	B_2	28/2 - 7/3	9.7	13.7	18.9	15.0
	C_1	22/2 - 3/3	8.4	14.0	20.2	16.3
	C_2	25/2 - 5/3	7.9	13.8	19.6	15.9

Appendix 13 continued:

Cultivar	Sowing date block	Period	Y	X_1	X_2	X_3
Hill continued:	D_1	9/3 -17/3	8.0	13.3	20.5	16.6
	D_2	7/3 -16/3	8.3	13.3	20.7	16.4
(5)	E_1	12/3 -21/3	9.0	13.1	21.2	17.0
	E_2	13/3 -21/3	8.6	13.1	20.9	16.7
	F_1	17/3 -26/3	9.0	12.9	20.7	16.7
	F_2	21/3 -30/3	9.7	12.7	19.5	14.8
	G_1	27/3 - 5/4	9.2	12.4	18.1	13.9
	G_2	29/3 - 8/4	9.7	12.3	17.9	13.7
	H_1	5/4 -17/4	12.4	12.0	16.1	11.0
	H_2	8/4 -20/4	12.4	11.9	15.9	10.6
Ogden	A_1	15/2 -28/2	12.3	14.2	21.2	17.9
	A_2	13/2 -25/2	11.1	14.3	21.8	18.0
(6)	B_1	14/2 -24/2	10.2	14.3	21.7	18.2
	B_2	22/2 - 3/3	8.5	14.0	20.2	16.3
	C_1	23/2 - 5/3	9.8	13.9	19.9	16.1
	C_2	23/2 - 5/3	10.0	13.9	19.9	16.1
	D_1	1/3 -12/3	10.3	13.6	19.3	15.5
	D_2	27/2 - 9/3	9.7	13.7	19.3	15.7
	E_1	8/3 -18/3	10.0	13.3	20.4	16.8
	E_2	10/3 -19/3	9.0	13.2	20.5	16.7
	F_1	19/3 -27/3	8.8	12.8	20.5	16.4
	F_3	18/3 -26/3	8.5	12.9	20.9	16.6
	G_1	22/3 - 1/4	9.8	12.6	19.1	14.6
	G_2	19/3 -29/3	9.8	12.8	19.9	15.5
	H_1	1/4 -13/4	12.4	12.2	17.2	12.6
	H_2	30/3 -12/4	12.5	12.2	17.5	13.1
Bragg	A_1	15/2 -24/2	9.7	14.3	21.7	18.1
	A_2	14/2 -26/2	11.3	14.3	21.3	17.8
(7)	B_1	16/2 -27/2	10.6	14.2	21.1	17.6
	B_2	22/2 - 5/3	10.8	13.9	20.2	16.3
	C_1	20/2 - 2/3	10.4	14.0	20.7	17.0
	C_2	23/2 - 7/3	12.1	13.8	19.7	16.1
	D_1	3/3 -12/3	9.3	13.5	19.5	16.1
	D_2	5/3 -14/3	9.2	13.4	19.9	16.4
	E_1	8/3 -18/3	10.2	13.3	20.4	16.8
	E_2	7/3 -16/3	8.7	13.3	20.7	16.4
	F_1	12/3 -21/3	8.9	13.1	21.2	17.0
	F_2	16/3 -25/3	9.0	12.9	20.7	16.8
	G_1	21/3 - 1/4	11.0	12.7	19.4	14.8
	G_2	24/3 - 4/4	10.8	12.5	18.3	14.5
	H_1	27/3 - 8/4	11.6	12.4	17.8	13.4
	H_2	27/3 - 9/4	12.3	12.3	17.8	13.3
Wills	A_1	2/3 -11/3	9.0	13.6	19.6	16.0
	A_2	8/3 -18/3	9.4	13.3	20.4	16.8
(8)	B_1	8/3 -17/3	9.2	13.3	20.5	16.8
	B_2	14/3 -23/3	8.3	13.0	21.1	16.8
	C_1	16/3 -26/3	10.0	12.9	20.5	16.7
	C_2	12/3 -23/3	10.6	13.1	21.3	16.9
	D_1	17/3 -25/3	8.3	12.9	21.0	16.7
	D_2	15/3 -24/3	8.4	13.0	21.1	17.0
	E_1	21/3 - 1/4	10.9	12.7	19.4	14.8
	E_2	20/3 -28/3	8.1	12.8	20.2	15.7
	F_1	25/3 - 3/4	9.0	12.5	18.3	14.5
	F_2	30/3 - 9/4	10.1	12.3	17.8	13.5
	G_1	31/3 -12/4	12.1	12.2	17.6	13.1
	G_2	4/4 -16/4	12.6	12.1	16.2	11.0

Appendix 13 continued:

Cultivar	Sowing date block	Period	Y	X_1	X_2	X_3
Wills continued:	H_1	9/4 -22/4	13.3	11.8	16.2	11.0
	H_2	15/4 -30/4	14.9	11.6	15.7	12.2
K162	A_1	19/3 -29/3	10.0	12.8	19.9	15.5
	A_2	18/3 -28/3	10.5	12.8	20.3	15.9
(9)	B_1	No sample - plants lodged pre-flowering				
	B_2	1/4 -12/4	11.0	12.2	17.3	13.2
	C_1	30/3 -10/4	11.6	12.3	17.8	12.9
	C_2	22/3 - 3/4	11.9	12.6	19.0	14.9
	D_1	1/4 -15/4	14.4	12.1	16.8	12.2
	D_2	10/4 -24/4	13.6	11.8	16.3	11.8
	E_1	5/4 -19/4	14.0	12.0	16.1	10.8
	E_2	12/4 -25/4	13.1	11.7	16.0	11.9
	F_1	14/4 -28/4	14.0	11.6	15.8	11.7
	No blocks F_2 to H_2 - pods failed to emerge					
Daintree	A_1	28/3 - 7/4	10.0	12.4	18.0	13.6
	A_2	2/4 - 9/4	6.7	12.2	17.1	12.5
(10)	B_1	30/3 - 8/4	8.7	12.3	17.8	13.6
	B_2	30/3 - 8/4	9.5	12.3	17.8	13.6
	C_1	6/4 -16/4	9.8	12.0	16.1	11.2
	C_2	4/4 -14/4	9.8	12.1	16.6	11.6
	D_1	12/4 -27/4	14.4	11.7	15.6	11.4
	D_2	7/4 -21/4	14.0	11.9	16.1	10.9
	E_1	17/4 -30/4	12.6	11.5	15.9	12.5
	E_2	20/4 - 2/5	12.1	11.4	15.9	12.8
	No blocks F to H - pods failed to emerge					
Mamloxi	A_1	13/4 -21/4	8.0	11.8	15.6	10.3
	A_2	5/4 -16 4	10.2	12.0	16.1	10.9
(11)	B_1	5/4 -16/4	10.0	12.0	16.1	10.9
	B_2	8/4 -21/4	13.4	11.9	16.1	10.7
	C_1	18/4 - 3/5	14.3	11.5	15.9	12.4
	C_2	12/4 -25/4	13.4	11.7	16.0	11.9
	D_1	25/4 - 9/5	14.0	11.2	14.1	10.7
	D_2	19/4 - 3/5	14.5	11.4	15.8	12.7
	NO blocks E to H - pods failed to emerge					

* Sample data excluded from final regression equation - due to 'oversize' residuals

Appendix 13.1 Correlation coefficients

Cultivar	Variable	X_1	X_2	X_3
Acme	Y	0.736**	0.376ns	-0.233ns
(n=15)	Y_1	0.726**	0.349ns	-0.309ns
	X_1		0.733**	0.122ns
	X_2			0.561*
Soysota x Mandarin	Y	0.887***	0.748**	0.468ns
(n=15)	Y_1	0.912***	0.741**	0.477ns
	X_1		0.734**	0.493ns
	X_2			0.874***
Amsoy x T19	Y	0.838***	0.381ns	0.050ns
(n=16)	Y_1	0.851***	0.400ns	0.079ns
	X_1		0.510*	0.472ns
	X_2			0.537*
Wayne x PI-54-608-II	Y	0.801***	0.327ns	0.241ns
(n=16)	Y_1	0.834***	0.325ns	0.247ns
	X_1		0.593*	0.480ns
	X_2			0.922***
Wayne	Y	0.715*	-0.144ns	-0.553ns
(n=10)	Y_1	0.714*	-0.134ns	-0.563ns
	X_1		0.068ns	-0.351ns
	X_2			0.755*
Dare	Y	0.707**	0.258ns	0.183ns
(n=15)	Y_1	0.699**	0.260ns	0.194ns
	X_1		0.730**	0.730**
	X_2			0.955***
Hill	Y	-0.725**	-0.867***	-0.910***
(n14)	Y_1	-0.724**	-0.855***	-0.897***
	X_1		0.708**	0.774***
	X_2			0.987 **
Ogden	Y	-0.140ns	-0.548ns	-0.514ns
(n=16)	Y_1	-0.121ns	-0.535ns	-0.498ns
	X_1		0.784***	0.806***
	X_2			0.970***
Bragg	Y	-0.033ns	-0.370ns	-0.343ns
(n=16)	Y_1	-0.033ns	-0.377ns	-0.349ns
	X_1		0.786***	0.858***
	X_2			0.970***
Wills	Y	-0.807***	-0.840***	-0.820***
(n=16)	Y_1	-0.786***	-0.830***	-0.815***
	X_1		0.879***	0.894***
	X_2			0.973***
K162	Y	-0.820**	-0.856**	-0.864**
(n=10)	Y_1	-0.828**	-0.863**	-0.869**
	X_1		0.972***	0.914***
	X_2			0.974***
Daintree	Y	-0.697*	-0.703*	-0.486ns
(n=10)	Y_1	-0.682*	-0.671*	-0.446ns
	X_1		0.879***	0.394ns
	X_2			0.774**

Appendix 13.1 continued:

Cultivar	Variable	X_1	X_2	X_3
Mamloxi	Y	-0.679ns	-0.228ns	0.663ns
	Y_1	-0.641ns	-0.205ns	0.653ns
(n=8)	X_1		0.747*	-0.420ns
	X_2			0.257ns

Note: $Y_1 = \log_{10} Y$

Appendix 13.2 Pod emergence phase regression model - see *Tables 11 and 12 for F values, $100R^2$ values - for the only model considered:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3$$

Appendix 13.3 Analysis of Variance for the regression model used - as shown in Appendix 13.2

Cultivar	Source of Variation	df	SS	F(see*)
Acme	Total	15	559.9	
	Mean	1	536.4	
	Regression total	3	15.23	
	Due to X_1(adj. for X_2,X_3)	1	12.73	
	Due to X_2(addit.to X_1)	1	1.351	
	Due to X_3(addit.to X_1,X_2)	1	1.142	
	Residual	11	8.299	
Soysota x Mandarin	T	15	1192.0	
	M	1	1113.0	
	Reg	3	66.43	
	X_1	1	62.27	
	X_2	1	1.622	
	X_3	1	2.546	
	Res	11	12.78	
Amsoy x T19	T	16	1070.0	
	M	1	1003.0	
	Reg	3	57.56	
	X_1	1	46.57	
	X_2	1	0.1944	
	X_3	1	10.80	
	Res	12	8.724	
Wayne x PI-54-608-II	T	16	948.1	
	M	1	910.5	
	Reg	3	25.43	
	X_1	1	24.16	
	X_2	1	1.278	
	X_3	1	0.001103	
	Res	12	12.18	
Wayne	T	10	555.9	
	M	1	531.4	
	Reg	3	15.56	
	X_1	1	12.53	
	X_2	1	0.9142	
	X_3	1	2.110	
	Res	6	8.933	

Appendix 13.1 continued:

Cultivar	Source of Variation	df	SS F(see*)
Dare	T	15	1720.0
	M	1	1698.0
	Reg	3	16.19
	X_1	1	10.70
	X_2	1	3.053
	X_3	1	2.442
	Res	11	5.203
Hill	T	14	1266.0
	M	1	1241.0
	Reg	3	22.41
	X_1	1	13.51
	X_2	1	6.433
	X_3	1	2.472
	Res	10	3.286
Ogden	T	16	1680.0
	M	1	1654.0
	Reg	3	6.219
	X_1	1	0.4477
	X_2	1	5.169
	X_3	1	0.6024
	Res	12	19.12
Bragg	T	16	1740.0
	M	1	1720.0
	Reg	3	12.02
	X_1	1	0.3880
	X_2	1	9.817
	X_3	1	1.819
	Res	12	7.711
Wills	T	16	1746.0
	M	1	1685.0
	Reg	3	44.46
	X_1	1	39.78
	X_2	1	4.579
	X_3	1	0.0962
	Res	12	16.64
K162	T	10	1563.0
	M	1	1540.0
	Reg	3	17.49
	X_1	1	15.63
	X_2	1	1.473
	X_3	1	0.3883
	Res	6	5.774
Daintree	T	10	1211.0
	M	1	1158.0
	Reg	3	30.32
	X_1	1	26.10
	X_2	1	1.896
	X_3	1	2.333
	Res	6	23.34

Appendix 13.3 continued:

Cultivar	Source of Variation	df	SS
Mamloxi	T	8	1238.0
	M	1	1196.0
	Reg	3	27.13
	X_1	1	19.52
	X	1	7.477
	X_3	1	0.1329
	Res	4	15.16

Appendix 13.4 Significance of the partial regression coefficients for the pod emergence model (t-test ratios)

Cultivar	a	b_1	b_2	b_3
Acme	-1.14ns	2.60*	-0.10ns	-1.23ns
Soysota x Mandarin	-5.39***	2.99**	1.87ns	-1.48ns
Amsoy x T19	-4.95***	7.93***	1.03ns	-3.85**
Wayne x PI-54-608-II	-2.34*	4.49***	-0.51ns	0.03ns
Wayne	0.40	1.59ns	0.56ns	-1.19ns
Dare	-1.64ns	5.41***	0.96ns	-2.27*
Hill	0.89ns	0.75ns	1.84ns	-2.74*
Ogden	1.43ns	0.15ns	-0.99ns	0.61ns
Bragg	0.33ns	3.06**	0.14ns	-1.68ns
Wills	3.19**	-0.99ns	-1.11ns	0.26ns
K162	1.04ns	-0.21ns	0.05ns	-0.64ns
Daintree	1.52ns	-0.93ns	0.60ns	-0.77ns
Mamloxi	0.71ns	-0.59ns	0.27ns	0.19ns

Appendix 13.5 Between cultivar comparisons - homogeneity tests of the partial regression coefficients for the model: $Y = a + b_1X_1 + b_2X_2 + b_3X_3$

Appendix 13.5.1 T-test ratios for the partial regression coefficient a

Cultivar	00	0	1	2	3	4	5	6	7	8	9	10
00												
0	-2.8374**											
1	-2.0445ns	1.1086ns										
2	-0.5846ns	2.5259*	1.6281ns									
3	0.7405ns	1.9731ns	1.5785ns	0.9944ns								
4	-0.1272ns	3.0285**	2.1851*	0.5185ns	-0.8063ns							
5	1.3974ns	3.8365**	3.2115**	1.9796ns	-0.0130ns	1.6061ns						
6	1.7189ns	2.9581**	2.5790*	1.9897ns	0.7289ns	1.8028ns	0.9577ns					
7	0.9331ns	3.2547**	2.6149*	1.4554ns	-0.2236ns	1.0966ns	-0.3642ns	-1.1581ns				
8	3.3651**	5.1811**	4.7310**	3.8383**	1.4181ns	3.5723**	2.1688*	0.5568ns	2.4129*			
9	1.2439ns	2.0220ns	1.7684ns	1.4036ns	0.6738ns	1.2857ns	0.7720ns	0.1345ns	0.9057ns	-0.2329ns		
10	1.6091ns	1.9283ns	1.8215ns	1.6729ns	1.3787ns	1.6245ns	1.4159ns	1.1300ns	1.4722ns	0.9857ns	1.0200ns	
11	0.7761ns	1.0060ns	0.9281ns	0.8213ns	0.6278ns	0.7863ns	0.6384ns	0.4461ns	0.6796ns	0.3316ns	0.3908ns	-0.3128ns

Appendix 13.5.2 T-test ratios for the partial regression coefficient b_1

Cultivar	00	0	1	2	3	4	5	6	7	8	9	10
00												
0	0.5620ns											
1	2.1090*	1.2465ns										
2	0.5732ns	-0.1074ns	-1.8370ns									
3	-0.1942ns	-0.6533ns	-1.8256ns	-0.6558ns								
4	0.8881ns	0.1600ns	-1.5330ns	0.3610ns	0.8964ns							
5	-1.4657ns	-1.9358ns	-4.1070**	-2.3265*	-0.9647ns	-2.7310*						
6	-1.0302ns	-1.3685ns	-2.2881*	-1.4139ns	-0.8021ns	-1.5979ns	-0.1658ns					
7	0.8446ns	0.3035ns	-0.7709ns	0.4514ns	-0.8949ns	0.2138ns	2.1240*	1.5455ns				
8	-1.8970ns	-2.1697*	-2.9702**	-2.2396*	-1.6541ns	-2.3959*	-1.1835ns	-0.8585ns	-2.3086*			
9	-0.5138ns	-0.6144ns	-0.8153ns	-0.6003ns	-0.4703ns	-0.6438ns	-0.2832ns	-0.2347ns	-0.6753ns	0.0807ns		
10	-1.0366ns	-1.0710ns	-1.1385ns	-1.0658ns	-1.0222ns	-1.0805ns	-0.9583ns	-0.9412ns	-1.0921ns	-0.8302ns	-0.8174ns	
11	-0.6986ns	-0.7325ns	-0.7987ns	-0.7271ns	-0.6847ns	-0.7416ns	-0.6215ns	-0.6055ns	-0.7533ns	-0.4969ns	-0.5003ns	0.3269ns

Appendix 13.5 continued:

Appendix 13.5.3 T-test ratios for the partial regression coefficient b_2

00												
0	1.7037ns											
1	0.6319ns	-1.4519ns										
2	-0.3868ns	-1.7592ns	-0.8526ns									
3	0.5464ns	-0.8446ns	0.2383ns	0.7563ns								
4	0.8621ns	-0.8276ns	0.5077ns	1.0369ns	0.1307ns							
5	1.6862ns	0.0342ns	1.4394ns	1.7497ns	0.8598ns	0.8424ns						
6	-0.9483ns	-1.5907ns	-1.1083ns	-0.7791ns	-1.1262ns	-1.2304ns	-1.5988ns					
7	0.1675ns	-1.1193ns	-0.1494ns	0.4172ns	-0.2843ns	-0.4455ns	-1.1291ns	0.9588ns				
8	-0.9469ns	-2.0937*	-1.3659ns	-0.5355ns	-1.1678ns	-1.4623ns	-2.0815*	0.5041ns	-0.8468ns			
9	0.0610ns	-0.5501ns	-0.0685ns	0.1835ns	-0.1506ns	-0.2126ns	-0.5631ns	0.6822ns	-0.0084ns	0.4075ns		
10	0.6026ns	0.4163ns	0.5654ns	0.6384ns	0.5362ns	0.5202ns	0.4114ns	0.8210ns	0.5794ns	0.7065ns	0.5626ns	
11	0.2803ns	0.0352ns	0.2307ns	0.3283ns	0.1940ns	0.1719ns	0.0290ns	0.5724ns	0.2511ns	0.4187ns	0.2403ns	-0.3125ns

Appendix 13.5.4 T-test ratios for the partial regression coefficient b_3

00												
0	-0.6913ns											
1	-1.1601ns	0.0062ns										
2	0.6491ns	1.0915ns	1.4593ns									
3	-0.8654ns	-0.5006ns	-0.5414ns	-1.1113ns								
4	-1.2268ns	-0.3504ns	-0.4995ns	-1.5362ns	0.3237ns							
5	-1.9491ns	-1.1325ns	-1.4184ns	-2.1476*	-0.1923ns	-0.8858ns						
6	0.8222ns	1.0378ns	1.0800ns	0.5768ns	1.2013ns	1.1942ns	1.5461ns					
7	-1.1227ns	-0.5377ns	-0.6371ns	-1.4188ns	0.1149ns	-0.2877ns	0.4340ns	-1.2649ns				
8	0.7521ns	1.1415ns	1.4028ns	0.1871ns	1.1748ns	1.5177ns	2.0924*	-0.4749ns	1.4534ns			
9	-0.2822ns	0.0927ns	0.0986ns	-0.5894ns	0.4802ns	0.3076ns	0.8444ns	-0.8615ns	0.4671ns	-0.6818ns		
10	-0.6528ns	-0.5108ns	-0.5184ns	-0.7702ns	-0.2793ns	-0.4336ns	-0.2102ns	-0.9738ns	-0.3442ns	-0.8131ns	-0.5238ns	
11	0.3146ns	0.4564ns	0.4619ns	0.1788ns	0.6421ns	0.5436ns	0.7731ns	-0.1462ns	0.6186ns	0.1241ns	0.3987ns	0.6958ns

Appendix 14 PODDING PHASE

Y = the length, in days, of the podding phase
X_1 = the average daylength, in hours, during the podding phase
X_2 = the average hourly day temperature, in °C, during the phase
X_3 = the average hourly night temperature, in °C, during the phase
$X_{2,3}$ = the average hourly (24 hour day plus night) temperature, in °C
X_4 = the daylength, in hours, at the start of the phase
X_5 = the daylength, in hours, at the end of the phase

Cultivar	Sowing date block	Period	Y	X_1	X_2	X_3	X_4	X_5
Acme	A_1	31/12- 6/3	65	15.0	21.1	17.1	16.0	13.6
(00)	A_2	1/1 - 6/3	64	15.0	21.1	16.8	16.0	13.6
	B_1	1/1 - 8/3	66	14.9	21.0	16.7	16.0	13.5
	B_2	3/1 - 3/3	59	15.0	21.1	17.1	16.0	13.8
	C_1	6/1 - 7/3	60	14.9	21.0	17.0	15.9	13.6
	C_2	No sample due to germination failure						
	D_1	20/1 -20/3	59	14.3	20.6	16.6	15.6	13.0
	D_2	16/1 -16/3	59	14.5	20.6	16.5	15.7	13.2
	E_1	24/1 -27/3	62	14.1	20.6	16.6	15.4	12.7
	E_2	22/1 -28/3	65	14.1	20.6	16.5	15.5	12.6
	F_1	5/2 -14/4	68	13.4	19.8	15.6	14.9	11.9
	F_2	8/2 -11/4	62	13.4	20.0	15.9	14.8	12.0
	G_1	18/2 -14/5	85	12.5	17.8	13.9	14.4	10.9
	G_2	18/2 -10/5	81	12.6	18.0	14.0	14.4	11.0
	H_1	3/3 -17/5	75	12.1	17.2	13.4	13.8	10.8
	H_2	2/3 -19/5	78	12.1	17.2	13.5	13.8	10.8
Soysota x Mandarin	A_1	28/12-13/3	75	14.9	21.1	17.0	16.1	13.3
(0)	A_2	30/12-16/3	76	14.8	21.1	17.0	16.1	13.2
	B_1	8/1 -15/3	66	14.7	20.8	16.8	15.9	13.2
	B_2	6/1 -15/3	68	14.7	20.9	16.9	15.9	13.2
	C_1	13/1 -25/3	71	14.4	20.6	16.6	15.8	12.8
	C_2	12/1 -21/3	68	14.4	20.6	16.7	15.8	12.9
	D_1	17/1 -29/3	71	14.2	20.4	16.4	15.5	12.3
	D_2	21/1 - 3/4	72	14.0	20.4	16.3	15.5	12.3
	E_1	27/1 - 3/4	66	13.8	20.3	16.4	15.3	12.3
	E_2	30/1 -10/4	70	13.6	20.0	15.9	15.2	12.1
	F_1	7/2 -18/4	70	13.2	19.5	15.3	14.9	11.8
	F_2	10/2 -19/4	68	13.2	19.4	15.2	14.7	11.7
	G_1	20/2 -15/5	84	12.4	17.7	13.8	14.3	10.8
	G_2	22/2 -21/5	88	12.3	17.4	13.8	14.2	10.7
	H_1	4/3 -24/5	81	12.0	17.0	13.5	13.7	10.6
	H_2	6/3 -31/5	86	11.8	16.6	13.2	13.6	10.5
Amsoy x T19	*A_1	26/12-11/3	75	15.0	21.1	17.0	16.1	13.4
(1)	A_2	29/12-10/3	71	14.9	21.1	17.0	16.1	13.4
	B_1	5/1 -13/3	67	14.8	20.9	17.0	15.9	13.3
	B_2	6/1 -14/3	67	14.7	20.9	16.9	15.9	13.2
	C_1	12/1 -16/3	63	14.6	20.8	16.7	15.8	13.2
	C_2	11/1 -17/3	65	14.6	20.7	16.7	15.8	13.1
	D_1	15/1 -24/3	68	14.3	20.6	16.6	15.7	12.8
	D_2	16/1 -25/3	68	14.3	20.6	16.6	15.7	12.8

Note: Data given = plot means

Appendix 14 continued:

Cultivar	Sowing date block	Period	Y	X_1	X_2	X_3	X_4	X_5
Amsoy x T19 continued:	E_1	28/1 - 6/4	68	13.7	20.2	16.1	15.3	12.2
	E_2	29/1 - 2/4	63	13.8	20.4	16.3	15.2	12.4
	F_1	10/2 -21/4	70	13.1	19.4	15.1	14.7	11.6
	F_2	16/2 - 1/5	74	12.8	18.6	14.6	14.5	11.3
	G_1	20/2 -19/5	88	12.3	17.6	13.9	14.3	10.8
	G_2	20/2 -19/5	88	12.3	17.6	13.9	14.3	10.8
	H_1	5/3 - 6/6	93	11.8	16.4	13.1	13.7	10.4
	H_2	7/3 - 3/6	88	11.8	16.4	13.1	13.6	10.5
Wayne x PI-54-608-II	A_1	10/1 -30/3	79	14.3	20.6	16.6	15.9	12.5
	A_2	9/1 - 4/4	85	14.2	20.5	16.5	15.9	12.3
(2)	B_1	14/1 - 1/4	77	14.2	20.4	16.4	15.7	12.1
	B_2	14/1 - 5/4	81	14.1	20.3	16.3	15.7	12.3
	C_1	14/1 - 3/4	79	14.1	20.3	16.4	15.7	12.3
	C_2	16/1 - 3/4	77	14.1	20.3	16.3	15.7	12.3
	D_1	26/1 -18/4	82	13.5	19.6	15.4	15.3	11.8
	D_2	23/1 - 8/4	75	13.8	20.2	16.1	15.5	12.2
	E_1	3/2 -18/4	74	13.3	19.5	15.5	15.0	11.8
	E_2	2/2 -16/4	73	13.4	19.4	15.7	15.1	11.8
	F_1	18/2 -28/4	69	12.8	18.7	14.6	14.4	11.4
	F_2	13/2 -29/4	75	12.9	18.8	14.8	14.6	11.4
	G_1	26/2 -20/5	83	12.2	17.3	13.6	14.0	10.7
	G_2	26/2 -26/5	89	12.1	17.1	13.7	14.0	10.6
	H_1	14/3 - 6/6	84	11.6	16.0	12.7	13.2	10.4
	H_2	12/3 -25/5	74	11.8	16.7	13.2	13.3	10.6
Wayne	No blocks A to C - due to germination failure							
	D_1	3/2 -12/4	68	13.5	19.9	15.8	15.0	10.9
(3)	D_2	31/1 - 5/4	64	13.7	20.3	16.0	15.2	11.2
	E_1	14/2 -24/4	69	13.0	19.1	15.0	14.6	11.5
	E_2	13/2 -25/4	71	13.0	19.1	15.0	14.6	11.5
	F_1	26/2 -13/5	76	12.3	17.4	13.6	14.0	10.9
	F_2	24/2 -12/5	77	12,4	17.5	13.6	14.1	10.9
	G_1	2/3 -20/5	79	12.1	17.2	13.5	13.8	10.7
	G_2	2/3 -23/5	82	12.0	17.1	13.5	13.8	10.6
	H_1	17/3 -14/6	89	11.4	15.4	12.0	13.1	10.4
	H_2	18/3 -11/6	85	11.4	15.5	12.2	13.1	10.4
Dare	*A_1	26/2 -16/5	79	12.3	17.3	13.6	14.0	10.8
	A_2	11/2 -16/5	94	12.6	18.0	15.6	14.7	10.8
(4)	B_1	19/2 -18/5	88	12.4	17.7	14.1	14.3	10.8
	B_2	20/2 -23/5	92	12.3	17.5	13.9	14.3	10.6
	C_1	22/2 -22/5	89	12.2	17.2	13.8	14.2	10.7
	C_2	18/2 -17/5	88	12.4	17.7	13.9	14.4	10.8
	D_1	28/2 -31/5	92	12.0	16.7	13.4	13.9	10.5
	D_2	3/3 -21/5	79	12.1	17.1	13.5	13.8	10.7
	E_1	12/3 - 6/6	86	11.6	16.2	12.8	13.3	10.4
	E_2	12/3 -29/5	78	11.7	16.5	13.1	13.3	10.5
	F_1	20/3 -17/6	89	11.5	15.0	11.7	13.0	10.4
	F_2	19/3 -19/6	92	11.3	15.0	11.7	13.0	10.3
	G_1	30/3 -26/6	88	11.1	13.9	10.6	12.5	10.4
	G_2	30/3 -28/6	90	11.1	13.8	10.5	12.5	10.4
	H_1	3/4 - 4/7	91	11.1	13.3	9.9	12.3	10.4
	H_2	7/4 - 2/7	86	10.9	13.1	9.9	12.2	10.4

Appendix 14 continued:

Cultivar	Sowing date block	Period	Y	X_1	X_2	X_3	X_4	X_5
Hill (5)	A_1	27/2 -12/5	74	12.3	17.4	13.5	14.0	10.9
	A_2	3/3 -11/5	69	12.2	17.4	13.4	13.8	11.0
	B_1	5/3 -17/5	73	12.1	17.1	13.3	13.7	10.8
	B_2	7/3 -17/5	71	12.0	17.1	13.3	13.6	10.8
	C_1	3/3 -18/5	76	12.1	17.2	13.4	13.8	10.8
	C_2	5/3 -17/5	73	12.1	17.1	13.3	13.7	10.8
	D_1	17/3 -24/5	68	11.7	16.4	12.9	13.1	10.6
	D_2	16/3 -24/5	69	11.7	16.4	13.0	13.2	10.6
	E_1	21/3 - 4/6	75	11.5	15.3	12.4	12.9	10.5
	E_2	21/3 - 3/6	74	11.5	15.3	12.4	12.9	10.5
	F_1	26/3 - 4/6	70	11.4	15.2	12.1	12.7	10.5
	*F_2	30/3 -24/6	86	11.1	14.0	10.8	12.5	10.3
	G_1	5/4 -21/6	77	11.2	14.0	10.9	12.3	10.3
	G_2	8/4 -26/6	79	10.9	13.4	10.3	12.2	10.4
	H_1	17/4 - 4/7	78	10.8	12.6	9.6	11.8	10.4
	H_2	20/4 - 4/7	75	10.7	12.4	9.6	11.7	10.4
Ogden (6)	*A_1	28/2 -19/5	80	12.2	17.2	13.5	13.9	10.8
	A_2	25/2 -22/5	86	12.2	17.3	14.0	14.1	10.7
	B_1	24/2 -25/5	90	12.1	17.2	13.7	14.1	10.6
	B_2	3/3 -29/5	87	11.9	16.8	13.4	13.8	10.5
	C_1	5/3 - 1/6	88	11.8	16.5	13.3	13.7	10.5
	C_2	5/3 -26/5	82	11.9	16.9	13.5	13.7	10.6
	D_1	12/3 - 8/6	88	11.6	15.8	12.8	13.5	10.4
	D_2	9/3 - 6/6	89	11.7	16.0	12.9	13.5	10.4
	E_1	18/3 -30/6	104	11.2	14.3	10.9	13.1	10.4
	E_2	19/3 -28/6	101	11.2	14.4	11.0	13.1	10.4
	F_1	27/3 - 5/7	100	11.1	13.4	10.1	12.7	10.4
	F_2	26/3 - 7/7	103	11.1	13.4	9.9	12.7	10.5
	G_1	1/4 - 6/7	96	11.1	13.1	9.8	12.4	10.4
	G_2	29/3 - 9/7	102	11.0	13.2	9.7	12.6	10.5
	H_1	12/4 -12/7	91	10.8	12.5	9.1	12.0	10.5
	H_2	10/4 -11/7	92	10.8	12.6	9.2	12.1	10.5
Bragg (7)	*A_1	24/2 -14/5	79	12.3	17.4	13.8	14.1	10.9
	A_2	27/2 -22/5	84	12.1	17.2	13.6	14.0	10.7
	B_1	27/2 -23/5	85	12.1	17.1	13.6	14.0	10.6
	B_2	5/3 -20/5	76	12.0	17.1	13.4	13.7	10.7
	C_1	2/3 -24/5	83	12.0	17.1	13.5	13.8	10.6
	C_2	7/3 -21/5	75	12.0	17.0	13.4	13.6	10.7
	D_1	12/3 -24/5	73	11.8	16.7	13.2	13.3	10.6
	D_2	14/3 -22/5	69	11.8	16.6	13.1	13.2	10.7
	E_1	18/3 - 6/6	80	11.5	15.5	12.5	13.1	10.4
	E_2	16/3 - 2/6	78	11.6	15.9	12.8	13.2	10.5
	F_1	21/3 -27/6	98	11.2	14.3	11.0	13.0	10.4
	F_2	25/3 -30/6	97	11.1	13.8	10.5	12.8	10.4
	G_1	1/4 - 4/7	94	11.0	13.2	10.0	12.4	10.4
	G_2	4/4 - 8/7	95	11.0	12.9	9.5	12.3	10.5
	H_1	8/4 - 6/7	89	11.0	12.8	9.5	12.2	10.4
	H_2	9/4 - 5/7	87	10.9	12.8	9.6	12.1	10.4
Wills (8)	A_1	11/3 -30/5	80	11.7	16.4	13.1	13.4	10.5
	A_2	18/3 -30/5	73	11.6	16.0	12.7	13.1	10.5
	B_1	17/3 -24/5	68	11.7	16.4	12.9	13.1	10.6
	B_2	23/3 - 6/6	75	11.4	15.4	12.2	12.8	10.4
	C_1	26/3 - 4/6	70	11.4	15.2	12.1	12.7	10.5
	C_2	23/3 - 2/6	71	11.5	15.5	12.4	12.8	10.5

Cultivar	Sowing date block	Period	Y	X_1	X_2	X_3	X_4	X_5
Wills continued:	D_1	25/3 - 3/6	70	11.4	15.3	12.2	12.8	10.5
	D_2	24/3 - 8/6	76	11.4	15.2	12.1	12.8	10.4
	E_1	1/4 -21/6	81	11.1	14.2	11.0	12.4	10.3
	E_2	28/3 -19/6	83	11.2	14.4	11.2	12.6	10.3
	F_1	3/4 -24/6	82	11.0	13.8	10.6	12.3	10.3
	F_2	9/4 - 3/7	85	10.9	12.9	9.7	12.1	10.4
	G_1	12/4 - 7/7	86	10.8	12.6	9.3	12.0	10.5
	G_2	16/4 - 9/7	84	10.5	12.4	9.2	11.8	10.5
K162	A_1	29/3 -23/6	86	11.1	14.2	10.9	12.6	10.3
(9)	A_2	28/3 -21/6	85	11.2	14.4	11.1	12.6	10.3
	B_1	No sample - plants lodged pre-flowering						
	B_2	12/4 -30/6	79	10.8	12.9	9.8	12.0	10.4
	C_1	7/4 -29/6	83	10.9	13.1	10.0	12.1	10.4
	C_2	3/4 -23/6	81	11.0	13.9	10.7	12.3	10.3
	D_1	15/4 - 4/7	80	10.8	12.6	9.6	11.9	10.4
	D_2	24/4 - 1/7	68	10.7	12.3	9.4	11.5	10.4
	E_1	19/4 - 1/7	73	10.7	12.7	9.7	11.7	10.4
	E_2	25/4 - 5/7	71	10.7	12.0	9.1	11.5	10.4
	F_1	28/4 -10/7	73	10.6	11.8	8.7	11.4	10.5
	No blocks F_2, G or H - due to pod emergence failure							
Daintree	A_1	7/4 -27/6	81	10.9	13.4	10.3	12.2	10.4
(10)	A_2	9/4 -21/6	73	11.0	13.8	10.8	12.1	10.3
	B_1	8/4 -30/6	83	10.9	13.1	9.9	12.2	10.4
	B_2	8/4 - 2/7	85	10.9	13.0	9.8	12.2	10.4
	C_2	16/4 - 1/7	76	10.8	12.8	9.8	11.8	10.4
	D_1	14/4 -30/6	77	10.8	12.9	9.8	11.9	10.4
	D_2	27/4 -30/6	64	10.7	12.3	9.5	11.4	10.4
	E_1	21/4 -30/6	70	10.7	12.6	9.8	11.6	10.4
	E_2	30/4 - 5/7	66	10.6	11.8	8.9	11.3	10.4
	F_1	2/5 - 7/7	66	10.6	11.6	8.6	11.3	10.5
	No blocks F_2, G or H - due to pod emergence failure							
Mamloxi	A_1	21/4 - 5/7	75	10.7	12.3	9.4	11.6	10.4
(11)	A_2	16/4 - 3/7	78	10.8	12.7	9.7	11.8	10.4
	B_1	17/4 - 5/7	79	10.8	12.5	9.5	11.8	10.4
	B_2	21/4 - 5/7	75	10.7	12.3	9.4	11.6	10.4
	C_1	3/5 - 3/7	61	10.6	11.8	8.9	11.2	10.4
	C_2	25/4 -30/6	66	10.7	12.3	9.4	11.5	10.4
	D_1	9/5 - 4/7	57	10.4	11.4	8.6	11.0	10.4
	D_2	3/5 - 5/7	63	10.6	11.4	8.8	11.2	10.4

* Sample data excluded from final regression equation - due to 'oversize' residuals

Appendix 14.1 Correlation coefficients

Cultivar	Variable	X_1	X_2	X_3	X_4	X_5
Acme (n=15)	Y	-0.820***	-0.879***	-0.893***	-0.784***	-0.840***
	Y_1	-0.820***	-0.877***	-0.892***	-0.786***	-0.840***
	X_2	0.969***		0.996***		
	X_5	0.995***			0.977***	
Soysota x Mandarin (n=16)	Y	-0.718**	-0.809***	-0.791***	-0.702**	-0.742***
	Y_1	-0.708**	-0.798***	-0.782***	-0.692**	-0.732**
	X_2	0.978***		0.994***		
	X_5	0.996***			0.985***	
Amsoy x T19 (n=15)	Y	-0.881***	-0.941***	-0.921***	-0.865***	-0.885***
	Y_1	-0.879***	-0.938***	-0.919***	-0.862***	-0.884***
	X_2	0.976***		0.994***		
	X_5	0.998***			0.989***	
Wayne x PI-54-608-II (n=16)	Y	-0.128ns	-0.220ns	-0.176ns	-0.071ns	-0.215ns
	Y_1	-0.110ns	-0.204ns	-0.159ns	-0.054ns	-0.197ns
	X_2	0.989***		0.994***		
	X_5	0.989***			0.979***	
Wayne (n=10)	Y	-0.981***	-0.981***	-0.975***	-0.980***	-0.839***
	Y_1	-0.984***	-0.981***	-0.976***	-0.981***	-0.830**
	X_2	0.995***		0.998***		
	X_5	0.791**			0.799**	
Dare (n=15)	Y	0.077ns	-0.044ns	0.025ns	0.131ns	-0.043ns
	Y_1	0.068ns	-0.053ns	0.013ns	0.122ns	-0.048ns
	X_2	0.974***		0.984***		
	X_5	0.902***			0.866***	
Hill (n=15)	Y	-0.523*	-0.608*	-0.631*	-0.498ns	-0.489ns
	Y_1	-0.515*	-0.601*	-0.623*	-0.490ns	-0.482ns
	X_2	0.987***		0.989***		
	X_5	0.921***			0.920***	
Ogden (n=15)	Y	-0.682**	-0.688**	-0.696**	-0.545*	-0.520*
	Y_1	-0.689**	-0.697**	-0.703**	-0.554*	-0.529*
	X_2	0.987***		0.996***		
	X_5	0.555*			0.446ns	
Bragg (n=15)	Y	-0.696**	-0.733**	-0.742**	-0.511ns	-0.710**
	Y_1	-0.686**	-0.726**	-0.734**	-0.500ns	-0.711**
	X_2	0.988***		0.995***		
	X_5	0.873***			0.767***	
Wills (n=16)	Y	-0.483ns	-0.445ns	-0.466ns	-0.287ns	-0.546*
	Y_1	-0.478ns	-0.440ns	-0.459ns	-0.282ns	-0.557*
	X_2	0.985***		0.998***		
	X_5	0.162ns			0.076ns	
K162 (n=10)	Y	0.883***	0.869**	0.840**	0.945***	-0.692*
	Y_1	0.871**	0.859**	0.829**	0.937***	-0.678*
	X_2	0.973***		0.996***		
	X_5	-0.897***			-0.865**	
Daintree (n=10)	Y	0.767**	0.691*	0.549ns	0.925***	-0.219ns
	Y_1	0.774**	0.704*	0.565ns	0.929***	-0.233ns
	X_2	0.967***		0.979***		
	X_5	-0.688*			-0.500ns	
Mamloxi (n=8)	Y	0.860**	0.892**	0.915**	0.971***	—
	Y_1	0.873**	0.894**	0.921**	0.973***	—
	X_2	0.856**		0.985***		

Appendix 14.2 **Podding phase regression models considered:**

Model I $Y = a + b_4X_4 + b_{2,3}X_{2,3}$

Cultivar	$F_{YX_4 \cdot X_{2,3}}$	$F_{YX_{2,3} \cdot X_4}$	$F_{Y.X_4X_{2,3}}$	$100R^2$
Acme	56.87***	23.76***	40.32***	87.0
Soysota x Mandarin	47.53***	35.84***	41.86***	86.5
Amsoy x T19	83.22***	283.65***	183.48***	96.8
Wayne x PI-54-608-II	0.46ns	76.99***	38.73***	85.6
Wayne	0.19ns	177.14***	88.65***	96.2
Dare	0.44ns	13.01**	6.72*	52.8
Hill	10.55**	19.95***	15.25***	71.8
Ogden	91.28***	204.29***	147.77***	96.1
Bragg	74.72***	199.66***	137.19***	95.8
Wills	7.80*	74.06***	40.93***	86.3
K162	246.30***	22.62***	134.45***	97.5
Daintree	174.53***	22.59***	98.56***	96.6
Mamloxi	145.91***	3.80ns	74.87***	96.8

Model II $Y = a + b_{2,3}X_{2,3} + b_4X_4$

Cultivar	$F_{YX_{2,3} \cdot X_4}$	$F_{YX_4 \cdot X_{2,3}}$	$F_{Y.X_{2,3}X_4}$	$100R^2$
Acme	78.86***	10.78**	44.82***	88.2
Soysota x Mandarin	60.68***	22.68***	41.68***	86.5
Amsoy x T19	327.51***	39.46***	183.52***	96.8
Wayne x PI-54-608-II	3.53ns	74.11***	48.74***	85.6
Wayne	176.72***	0.59ns	88.65***	96.2
Dare	0.01ns	13.44**	6.72*	52.8
Hill	16.12**	14.38**	15.25***	71.8
Ogden	147.74***	147.96***	147.83***	96.1
Bragg	155.64***	118.66***	137.15***	95.8
Wills	19.87***	61.98***	40.92***	86.3
K162	202.44***	66.55***	134.45***	97.5
Daintree	79.42***	117.69***	98.56***	96.6
Mamloxi	128.04***	21.70**	74.87***	96.8

Appendix 14.3 Analysis of Variance for the regression model used - Model II in Appendix 14.2*

Cultivar	Source of Variation	df	SS	F(see*)
Acme	Total	15	68750.0	
	Mean	1	67740.0	
	Regression total	2	894.6	
	Due to $X_{2,3}$ (adj. for X_4)	1	787.0	
	Due to X_4 (addit. to $X_{2,3}$)	1	107.6	
	Residual	12	119.8	
Soysota x Mandarin	T	16	87810.0	
	M	1	87030.0	
	Reg	2	677.4	
	$X_{2,3}$	1	493.1	
	X_4	1	184.3	
	Res	13	105.6	
Amsoy x T19	T	15	82310.0	
	M	1	80810.0	
	Reg	2	1450.0	
	$X_{2,3}$	1	1294.0	
	X_4	1	155.9	
	Res	12	47.42	
Wayne x PI-54-608-II	T	16	99010.0	
	M	1	98600.0	
	Reg	2	352.8	
	$X_{2,3}$	1	15.27	
	X_4	1	337.5	
	Res	13	59.2	
Wayne	T	10	58340.0	
	M	1	57760.0	
	Reg	2	556.0	
	$X_{2,3}$	1	554.2	
	X_4	1	1.85	
	Res	7	21.95	
Dare	T	15	116800.0	
	M	1	116500.0	
	Reg	2	152.0	
	$X_{2,3}$	1	0.01308	
	X_4	1	152.0	
	Res	12	135.7	
Hill	T	15	80980.0	
	M	1	80810.0	
	Reg	2	117.4	
	$X_{2,3}$	1	62.06	
	X_4	1	55.36	
	Res	12	46.18	
Ogden	T	15	131200.0	
	M	1	130500.0	
	Reg	2	681.3	
	$X_{2,3}$	1	340.4	
	X_4	1	340.9	
	Res	12	27.65	

Appendix 14.3 continued:

Cultivar	Source of Variation	df	SS	F(see*)
Bragg	T	15	107500.0	
	M	1	106300.0	
	Reg	2	1116.0	
	$X_{2,3}$	1	633.0	
	X_4	1	482.6	
	Res	12	48.81	
Wills	T	16	95120.0	
	M	1	94560.0	
	Reg	2	488.2	
	$X_{2,3}$	1	118.5	
	X_4	1	369.7	
	Res	13	77.54	
K162	T	10	60550.0	
	M	1	60220.0	
	Reg	2	320.1	
	$X_{2,3}$	1	240.9	
	X_4	1	79.19	
	Res	7	8.332	
Daintree	T	10	55420.0	
	M	1	54910.0	
	Reg	2	491.4	
	$X_{2,3}$	1	198.0	
	X_4	1	293.4	
	Res	7	17.45	
Mamloxi	T	8	38870.0	
	M	1	38360.0	
	Reg	2	489.2	
	$X_{2,3}$	1	418.3	
	X_4	1	70.90	
	Res	5	16.34	

Appendix 14.4 Significance of the partial regression coefficients for Model II (t-test ratios)

Cultivar	a	$b_{2,3}$	b_4
Acme	1.89ns	- 5.22***	3.28**
Soysota x Mandarin	-0.45ns	- 5.99***	4.76***
Amsoy x T19	0.24ns	- 9.12***	6.28***
Wayne x PI-54-608-II	-4.41***	- 8.78***	8.61***
Wayne	3.05*	- 0.43ns	- 0.77ns
Dare	-1.38ns	- 3.61**	3.67**
Hill	-0.23ns	- 4.47***	3.79**
Ogden	-7.04***	-14.29***	12.16***
Bragg	-5.17***	-14.13***	10.89***
Wills	-5.53***	- 8.61***	7.87***
K162	-7.56***	- 4.76**	8.16***
Daintree	-9.90***	- 4.75**	10.85***
Mamloxi	-6.61***	- 1.95ns	4.66**

Appendix 14.5 Between cultivar comparisons - homogeneity tests of the partial regression coefficients for the model:

$$Y = a + b_{2,3}X_{2,3} + b_4X_4$$

Appendix 14.5.1 T-test ratios for the partial regression coefficient a

Cultivar	00	00	1	2	3	4	5	6	7	8	9	10
00												
0	-1.6069ns											
1	-1.2540ns	0.5033ns										
2	-4.1793**	-2.1677*	-3.0779**									
3	1.9900ns	2.9317**	2.7390*	4.3380**								
4	-2.2422*	-0.7797ns	-1.2858ns	1.0188ns	-3.3275**							
5	-1.5813ns	0.2113ns	-0.3352ns	2.7659**	-2.9245**	1.0342ns						
6	-5.9617**	-3.9301**	-5.0232**	-2.2175*	-5.3663**	-2.6050*	-4.7495**					
7	-4.7004**	-2.6936*	-3.6537**	-0.6803ns	-4.6405**	-1.4957ns	-3.3552**	1.5243ns				
8	-5.6150**	-4.1288**	-4.8390**	-2.7978**	-5.5831**	-3.1315**	-4.6269**	-1.2203ns	-2.3116*			
9	-4.7004**	-4.0508**	-5.2110**	-2.3277*	-5.4244**	-2.6745*	-4.9333**	-0.0260ns	-1.6057ns	1.2227ns		
10	-5.6150**	-4.6666**	-6.0568**	3.0212**	-5.7348**	-3.1185**	-5.7779**	-0.4809ns	-2.2135*	0.9648ns	-0.4723ns	
11	-6.1515**	-5.2854**	-5.9572**	-4.1649**	-6.4335**	-4.3250**	-5.7713**	-2.7451*	-3.7260**	-1.4097ns	-2.7656*	-2.5803*

Appendix 14.5.2 T-test ratios for the partial regression coeficient $b_{2,3}$

00												
0	-1.2420ns											
1	-1.6935ns	-0.1726ns										
2	-3.2433**	-1.8254ns	-1.9677ns									
3	2.2657*	3.0820**	3.5273**	4.5810**								
4	0.7084ns	1.8191ns	2.3174*	3.7025**	-1.6531ns							
5	1.4892ns	2.6933*	3.6547**	4.9382**	-1.4034ns	0.5708ns						
6	-1.5275ns	0.1829ns	0.5120ns	2.6000*	-3.4852**	-2.2261*	-3.9805**					
7	-0.8274ns	0.8131ns	1.3907ns	3.2817**	-3.0592**	-1.6129ns	-3.1872**	1.2250ns				
8	-1.6536ns	-0.1690ns	0.0004ns	1.9295ns	-3.4880**	-2.2711*	-3.5396**	-0.4901ns	-1.3289ns			
9	1.0251ns	2.2532*	3.0426**	4.4314**	-1.6684ns	0.1735ns	-0.4856ns	3.1810**	2.4075*	0.8254ns		
10	1.6582ns	2.8701**	3.9562**	5.1848**	-1.3491ns	0.6924ns	0.1382ns	4.4441**	3.6147**	0.9910ns	0.6396ns	
11	-0.1382ns	0.4828ns	0.5856ns	1.4596ns	-1.4595ns	-0.4826ns	-0.7649ns	0.4347ns	0.1637ns	0.3467ns	-0.5812ns	-0.8166ns

Appendix 14.5 continued:

Appendix 14.5.3 T-test ratios for the partial regression coefficient b_4

00												
0	1.4705ns											
1	1.5851ns	-0.1197ns										
2	3.7766**	2.0118ns	2.4779*									
3	-2.1586*	-3.0622**	-3.1800**	-4.5526**								
4	0.7923ns	-0.5852ns	-0.5464ns	-2.5634*	2.5880*							
5	-0.1108ns	-1.6802ns	-1.8730ns	-4.2224**	2.1635*	-0.9428ns						
6	3.9581**	1.8561ns	2.4616*	-0.5062ns	4.5489**	2.4779*	4.6131**					
7	2.9098**	0.8786ns	1.2638ns	-1.6455ns	3.9432**	1.5556ns	3.4509**	-1.4726ns				
8	3.9102**	2.2915*	2.7240*	0.4611ns	4.6890**	2.8002**	4.2923**	0.9756ns	1.9857ns			
9	2.5613*	0.7283ns	1.0256ns	-1.6017ns	3.7673**	1.3709ns	2.9708**	-1.3951ns	-0.1236ns	-1.9371ns		
10	2.7665*	0.7381ns	1.0922ns	-1.8195ns	3.8603**	1.4251ns	3.2954**	-1.7032ns	-0.2218ns	-2.1392*	-0.0647ns	
11	2.8841**	1.9021ns	2.0769ns	0.6891ns	3.9661**	2.2664*	3.0239**	0.9870ns	1.5682ns	0.3827ns	1.5825ns	1.6536ns

Appendix 15 Trial details for the apical bud dissection study

1.	Location	Helensville, 36°.39'S
2.	Design	Randomised complete block, with four replications.
3.	Plot size	1.3m x 16m.
4.	Sowing dates	November 2nd, 12th, 22nd; December 2nd, 1975. The cultivar Dare was not included in the sowing of the 22nd November.
5.	Planting pattern	Inoculated seed was sown to a depth of 3cm, in rows 30cm apart, with an approximate intra-row spacing of 10cm.
6.	Air temperature	This was monitored continuously at the trial site, using a screened thermohygrograph.
7.	Daylength	Meterological daylengths for the site latitude of 36°.39'S., were obtained from the 1975 and 1976 editions of the British Nautical Almanac. Daylength measurements included civil twilight.
8.	Soil moisture	The trial was not irrigated. Gravimetric tests from 15cm soil core samples, reported a minimum soil moisture level of 19.4% for the trial period.
9.	Notation used	X_1 = the average daylength (hours) X_2 = the average hourly day temperature (°C) X_3 = the average hourly night temperature (°C) X_4 = plant age (days from emergence) X_5 = A, the plant average floral state (Y_1) with $\bar{A}$ being the population mean X_5' = $\log_{10} X_5$ X_6 = R, the plant maximum floral state (Y_2) with $\bar{R}$ being the population mean X_6' = $\log_{10} X_6$ X_7 = the daily change in R (Y_3) X_7' = $\log_{10} X_7$ X_8 = the daily change in A (Y_4) X_8' = $\log_{10} X_8$

Appendix 16 Meterological data for the apical bud dissection study - Daylength $(X_1)^*$, average hourly day (X_2) and night (X_3) temperatures at 36°39'S during November 1975 - February 1976.

Day	November			December			January			February		
	(X_1) hours	(X_2)	°C (X_3)	(X_1) hours	(X_2)	°C (X_3)	(X_1) hours	(X_2)	°C (X_3)	(X_1) hours	(X_2)	°C (X_3)
1				15.42	17.2	16.1	15.57	19.3	15.9	14.78	18.5	14.6
2	14.57	15.7	15.5	15.45	18.6	13.2	15.55	19.5	17.2	14.75	19.5	13.0
3	14.60	17.7	13.9	15.47	19.1	15.4	15.52	19.9	16.2	14.72	21.1	15.1
4	14.63	17.4	16.4	15.48	18.4	14.2	15.50	18.4	15.2	14.67	19.4	16.3
5	14.66	18.1	15.8	15.50	18.9	13.7	15.50	20.1	14.8	14.63	19.8	12.7
6	14.72	16.5	14.7	15.52	18.7	16.6	15.48	20.1	16.7	14.60	19.6	17.5
7	14.75	16.4	15.7	15.53	19.8	14.1	15.45	21.1	17.5	14.57	17.6	19.8
8	14.80	16.5	15.1	15.55	19.5	14.8	15.45	20.3	19.6	14.53	18.6	15.5
9	14.83	15.5	13.8	15.57	19.8	15.2	15.43	18.4	19.5	14.50	17.8	12.6
10	14.87	15.9	12.7	15.58	19.7	15.6	15.42	21.9	19.3	14.47	19.1	14.8
11	14.92	15.7	11.8	15.60	19.1	18.2	15.40	20.6	19.8	14.43	20.5	14.6
12	14.95	16.8	14.9	15.60	18.7	15.6	15.38	22.2	22.3	14.40	20.1	15.1
13	14.97	17.6	15.0	15.62	19.4	13.9	15.35	20.5	21.5	14.35	19.9	16.9
14	15.00	17.1	15.6	15.62	18.9	19.1	15.33	22.7	21.8	14.32	19.8	18.1
15	15.02	16.6	14.4	15.62	18.7	15.6	15.32	21.6	19.9	14.28	18.7	15.8
16	15.05	15.9	13.2	15.62	18.8	15.9	15.28	24.0	21.2	14.25	18.3	14.5
17	15.08	17.4	15.0	15.63	20.1	18.8	15.27	22.2	21.7	14.22	20.3	14.0
18	15.12	17.3	14.6	15.62	20.7	17.9	15.23	20.6	18.4	14.18	19.3	14.3
19	15.15	16.5	12.9	15.62	20.9	20.5	15.20	21.5	18.0			
20	15.17	16.6	15.6	15.62	19.7	17.4	15.18	21.4	16.9			
21	15.17	16.0	14.4	15.63	19.7	17.0	15.15	20.4	16.0			
22	15.20	15.0	12.2	15.63	17.6	17.0	15.12	20.9	19.5			
23	15.22	16.4	13.2	15.63	18.1	15.9	15.10	20.4	16.1			
24	15.25	17.2	15.6	15.63	16.6	14.1	15.07	19.3	18.9			
25	15.28	18.0	15.6	15.63	17.2	16.7	15.03	21.2	16.3			
26	15.32	18.2	14.3	15.63	16.4	14.5	15.00	21.7	20.2			
27	15.33	17.0	17.6	15.63	16.8	14.1	14.97	20.0	22.5			
28	15.35	18.2	14.3	15.62	17.2	14.9	14.93	21.0	18.2			
29	15.37	18.5	14.1	15.62	16.7	13.4	14.90	20.8	18.7			
30	15.38	19.5	16.8	15.60	17.7	14.1	14.87	19.8	18.6			
31				15.58	18.2	15.0	14.83	18.7	17.2			

* meterological daylength - i.e. sunrise to sunset, including civil twilight

Appendix 17 Amsoy x T19 Floral Bud Dissections

Appendix 17.1 Dissection data

I Pre-initiation phase

Sowing Block - Date	Emergence Date*	Sampling Date	Period (days)	X_1	X_2	X_3	X_4	X_5	$\bar{A}$	X_6	$\bar{R}$	X_7	X_8
A 2/11/75	9/11/75	3/12/75	24	15.19	17.2	14.5	24	20.0		30		1.25	0.83
A 2/11/75	9/11/75	3/12/75	24	15.19	17.2	14.5	24	6.6		20		0.83	0.28
A 2/11/75	9/11/75	3/12/75	24	15.19	17.2	14.5	24	42.9		80		3.33	1.79
A 2/11/75	9/11/75	3/12/75	24	15.19	17.2	14.5	24	16.7		30		1.25	0.70
A 2/11/75	9/11/75	3/12/75	24	15.19	17.2	14.5	24	26.7		40		1.66	1.11
A 2/11/75	9/11/75	3/12/75	24	15.19	17.2	14.5	24	40.0		80		3.33	1.67
A 2/11/75	9/11/75	3/12/75	24	15.19	17.2	14.5	24	20.0		40		1.66	0.83
B 12/11/75	18/11/75	5/12/75	17	15.32	17.6	14.7	17	15.0		30		1.76	0.88
B 12/11/75	18/11/75	5/12/75	17	15.32	17.6	14.7	17	20.0		40		2.35	1.18
B 12/11/75	18/11/75	5/12/75	17	15.32	17.6	14.7	17	32.5		70		4.12	1.91
B 12/11/75	18/11/75	5/12/75	17	15.32	17.6	14.7	17	23.3		40		2.35	1.37
B 12/11/75	18/11/75	5/12/75	17	15.32	17.6	14.7	17	24.0		30		1.76	1.41
B 12/11/75	18/11/75	5/12/75	17	15.32	17.6	14.7	17	7.5		30		1.76	0.44
B 12/11/75	18/11/75	5/12/75	17	15.32	17.6	14.7	17	25.0		40		2.35	1.47
B 12/11/75	18/11/75	5/12/75	17	15.32	17.6	14.7	17	24.0		40		2.35	1.41
D 2/12/75	9/12/75	17/12/75	8	15.61	19.2	16.6	8	28.3		35		4.38	3.54
D 2/12/75	9/12/75	17/12/75	8	15.61	19.2	16.6	8	33.3		40		5.00	4.16
D 2/12/75	9/12/75	17/12/75	8	15.61	19.2	16.6	8	26.7		40		5.00	3.34
D 2/12/75	9/12/75	17/12/75	8	15.61	19.2	16.6	8	22.5		30		3.75	2.81
D 2/12/75	9/12/75	17/12/75	8	15.61	19.2	16.6	8	12.0		30		3.75	1.50
D 2/12/75	9/12/75	17/12/75	8	15.61	19.2	16.6	8	15.0		30		3.75	1.50
II Post-initiation phase													
	Sampling dates												
A	3/12/75	9/12/75	6	15.53	19.2	14.8	30	58.8	24.7	90	45.7	7.38	3.50
A	3/12/75	9/12/75	6	15.53	19.2	14.8	30	55.6	24.7	90	45.7	7.38	5.15
A	3/12/75	9/12/75	6	15.53	19.2	14.8	30	66.7	24.7	90	45.7	7.38	7.00
A	3/12/75	9/12/75	6	15.53	19.2	14.8	30	77.0	24.7	80	45.7	5.72	8.72
A	3/12/75	9/12/75	6	15.53	19.2	14.8	30	77.0	24.7	80	45.7	5.72	8.72
B	5/12/75	9/12/75	7	15.56	19.3	15.7	30	38.9	21.4	70	40.0	4.29	2.50
B	5/12/75	12/12/75	7	15.56	19.3	15.7	24	25.6	21.4	70	40.0	4.25	0.60
B	5/12/75	12/12/75	7	15.56	19.3	15.7	24	51.0	21.4	90	40.0	7.14	4.23
B	5/12/75	12/12/75	7	15.56	19.3	15.7	24	42.2	21.4	85	40.0	6.43	2.97
B	5/12/75	12/12/75	7	15.56	19.3	15.7	24	50.0	21.4	75	40.0	5.00	4.09
B	5/12/75	12/12/75	7	15.56	19.3	15.7	24	69.4	21.4	90	40.0	7.14	6.86
B	5/12/75	12/12/75	7	15.56	19.3	15.7	24	37.5	21.4	90	40.0	7.14	2.30

Appendix 17.1 continued:

B	12/12/75	12/12/75	7	15.56	19.3	15.7	24	40.0	21.4	70	40.0	4.25	2.66
B	12/12/75	17/12/75	5	15.62	19.2	16.7	29	65.7	44.3	90	80.0	2.00	4.28
B	12/12/75	17/12/75	5	15.62	19.2	16.7	29	47.1	44.3	90	80.0	2.00	0.56
B	12/12/75	17/12/75	5	15.62	19.2	16.7	29	47.1	44.3	90	80.0	2.00	0.56
B	12/12/75	17/12/75	5	15.62	19.2	16.7	29	56.0	44.3	90	80.0	2.00	2.34
C 22/11/75	28/11/75*	7/12/75	9	15.46	18.7	14.9	9	32.0		60		6.67	3.56
C 22/11/75	28/11/75*	7/12/75	9	15.46	18.7	14.9	9	32.5		60		6.67	3.61
C 22/11/75	28/11/75*	7/12/75	9	15.46	18.7	14.9	9	55.0		70		7.78	6.11
C 22/11/75	28/11/75*	7/12/75	9	15.46	18.7	14.9	9	60.0		70		7.78	6.67
C 22/11/75	28/11/75*	7/12/75	9	15.46	18.7	14.9	9	35.0		60		6.67	3.89
C 22/11/75	28/11/75*	7/12/75	9	15.46	18.7	14.9	9	55.0		60		6.67	6.11
C 22/11/75	28/11/75*	7/12/75	9	15.46	18.7	14.9	9	52.5		60		6.67	5.83
C 22/11/75	28/11/75*	7/12/75	9	15.46	18.7	14.9	9	26.7		40		4.44	2.97
C	7/12/75	17/12/75	10	15.60	19.3	16.3	19	17.1	43.6	40	51.3	-1.13	-2.65
C	7/12/75	17/12/75	10	15.60	19.3	16.3	19	41.4	43.6	70	51.3	1.87	-0.22
C	7/12/75	17/12/75	10	15.60	19.3	16.3	19	18.9	43.6	50	51.3	-0.13	-2.47
C	7/12/75	17/12/75	10	15.60	19.3	16.3	19	32.9	43.6	70	51.3	1.87	-1.07
C	7/12/75	17/12/75	10	15.60	19.3	16.3	19	25.5	43.6	45	51.3	-0.63	-1.81
C	7/12/75	17/12/75	10	15.60	19.3	16.3	19	30.0	43.6	40	51.3	1.13	-1.36
C	7/12/75	17/12/75	10	15.60	19.3	16.3	19	20.0	43.6	50	51.3	-0.13	-2.36
C	7/12/75	17/12/75	10	15.60	19.3	16.3	19	28.9	43.6	40	51.3	-1.13	-1.47
C	17/12/75	27/12/75	10	15.63	18.4	16.5	29	49.3	26.8	90	53.1	3.69	2.25
C	17/12/75	27/12/75	10	15.63	18.4	16.5	29	23.3	26.8	50	53.1	-0.31	-0.35
C	17/12/75	27/12/75	10	15.63	18.4	16.5	29	59.1	26.8	90	53.1	3.69	3.23
C	17/12/75	27/12/75	10	15.63	18.4	16.5	29	53.5	26.8	90	53.1	3.69	2.67
D	17/12/75	27/12/75	10	15:63	18.4	16.5	18	27.5	19.7	55	34.2	2.08	0.78
D	17/12/75	27/12/75	10	15.63	18.4	16.5	18	26.7	19.7	60	34.2	2.58	0.70
D	17/12/75	27/12/75	10	15.63	18.4	16.5	18	40.0	19.7	70	34.2	3.58	2.03
D	17/12/75	27/12/75	10	15.63	18.4	16.5	18	44.2	19.7	70	34.2	3.58	2.45
D	17/12/75	27/12/75	10	15.63	18.4	16.5	18	26.0	19.7	40	34.2	0.58	0.63
D	17/12/75	27/12/75	10	15.63	18.4	16.5	18	42.0	19.7	80	34.2	4.58	2.23
D	17/12/75	27/12/75	10	15.63	18.4	16.5	18	25.0	19.7	40	34.2	0.58	0.53
D	17/12/75	27/12/75	10	15.63	18.4	16.5	18	28.6	19.7	70	34.2	3.58	0.89
D	27/12/75	6/1 /76	10	15.55	18.7	15.3	28	47.3	32.5	80	60.1	1.99	1.48
D	27/12/75	6/1 /76	10	15.55	18.7	15.3	28	60.9	32.5	90	60.1	2.99	2.84
D	27/12/75	6/1 /76	10	15.55	18.7	15.3	28	62.4	32.5	95	60.1	3.49	2.99
D	27/12/75	6/1 /76	10	15.55	18.7	15.3	28	52.7	32.5	95	60.1	3.49	2.02
D	27/12/75	6/1 /76	10	15.55	18.7	15.3	28	65.8	32.5	90	60.1	2.99	3.33
D	27/12/75	6/1 /76	10	15.55	18.7	15.3	28	57.9	32.5	80	60.1	1.99	2.54
D	27/12/75	6/1 /76	10	15.55	18.7	15.3	28	64.6	32.5	90	60.1	2.99	3.21
D	27/12/75	6/1 /76	10	15.55	18.7	15.3	28	70.5	32.5	90	60.1	2.99	3.80

Appendix 17.2 **Amsoy x T19 Correlation Coefficients**

I Pre-initiation phase (n = 21)

Variables	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
X_1		0.992***	0.971***	-0.988***	-0.048ns	-0.277ns	0.781***	0.737***
X_2			0.994***	-0.960***	-0.030ns	-0.267ns	0.789***	0.750***
X_3				-0.923***	-0.013ns	-0.254ns	0.785***	0.752***
X_4					0.070ns	0.284ns	-0.755***	-0.704***
X_5						0.840***	0.509*	0.552**
$X_{5'}$	-0.025ns	0.034ns	0.042ns	-0.013ns		0.748***	0.501*	0.580**
X_6							0.355ns	0.190ns
$X_{6'}$	-0.218ns	-0.216ns	-0.212ns	0.215ns	0.869***		0.403ns	0.258ns
X_7								0.889***
$X_{7'}$	0.744***	0.737***	0.721***	-0.736***	0.551**	0.423ns		0.834***
X_8								
$X_{8'}$	0.672***	0.673***	0.664**	-0.657**	0.675***	0.343ns	0.881***	

II Post-initiation phase (n = 53)

Variables	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
X_1		-0.081ns	0.922***	0.439**	-0.287*	-0.011ns	-0.675***	-0.604***
X_2			-0.084ns	0.226ns	0.028ns	0.064ns	-0.006ns	-0.070ns
X_3				0.152ns	-0.461***	-0.186ns	-0.690***	-0.687***
X_4					0.485***	0.664***	-0.154ns	0.055ns
X_5						0.777***	0.497***	0.795***
$X_{5'}$	-0.292*	-0.005ns	-0.444***	0.451***		0.811***	0.546***	0.732***
X_6							0.459***	0.491***
$X_{6'}$	-0.042ns	0.051ns	-0.205ns	0.616***	0.768***		0.564***	0.576***
X_7								0.825***
$X_{7'}$	invalidated	by negative	values	for X_7				
X_8								
$X_{8'}$	invalidated	by negative	values	for X_8				

$X_{5'}$, $X_{6'}$, $X_{7'}$ and $X_{8'}$ = $\log_{10}$ forms of X_5, X_6, X_7 and X_8, respectively.

Appendix 17.3 Amsoy x T19 regression models considered:

I Pre-initiation phase

Model	$100R^2$	F	Non significant variables (F)
$Y_1=a+b_6X_6+b_4X_4+b_3X_3+b_1X_1+b_2X_2$	74.9	16.92***	$X_4(2.01)$ $X_3(0.91)$ $X_1(0)$ $X_2(0)$
$Y_1=a+b_6X_6+b_1X_1$	74.2	25.85***	$X_1(2.57)$
$Y_1'=a+b_6X_6+b_2X_2$	57.0	11.96***	$X_2(2.30)$
$Y_1'=a+b_6X_6+b_3X_3$	56.9	11.90***	$X_3(2.25)$
$Y_1=a+b_6X_6+b_4X_4$	73.6	25.04***	$X_4(2.10)$
$Y_1=a+b_6X_6$	70.5	45.38***	
$Y_2=a+b_5X_5+b_4X_4+b_3X_3+b_1X_1+b_2X_2$	76.4	18.35***	$X_4(3.67)$ $X_3(0.59)$ $X_2(0)$ $X_1(0)$
$Y_2=a+b_5X_5+b_1X_1$	76.1	28.66***	$X_1(4.23)$
$Y_2=a+b_5X_5+b_2X_2$	76.3	29.04***	
$Y_2=a+b_5X_5+b_3X_3$	76.4	29.14***	
$Y_2=a+b_5X_5+b_4X_4$	75.6	27.85***	$X_4(3.75)$
$Y_3=a+b_6X_6+b_5X_5+b_1X_1$	96.9	378.87***	$X_6(2.49)$if the sole variable
$Y_3=a+b_6X_6+b_5X_5+b_3X_3$	94.7	100.69***	$X_6(2.73)$if the sole variable
$Y_3=a+b_5X_5+b_1X_1$	91.0	90.84***	
$Y_3=a+b_5X_5+b_2X_2$	90.6	86.68***	
$Y_3=a+b_5X_5+b_3X_3$	88.6	69.64***	
$Y_3=a+b_5X_5+b_4X_4$	88.7	70.42***	
$Y_4=a+b_6X_6+b_1X_1$	71.1	22.12***	$X_6(2.24)$
$Y_4=a+b_5X_5+b_1X_1$	88.9	72.40***	
$Y_4=a+b_5X_5+b_2X_2$	89.4	75.52***	
$Y_4=a+b_5X_5+b_3X_3$	88.2	67.06***	
$Y_4=a+b_7X_7+b_5X_5+b_1X_1$	88.0	46.01***	$X_5(2.11)$
$Y_4=a+b_7X_7+b_1X_1$	79.5	34.80***	$X_1(0.04)$
$Y_4=a+b_7X_7+b_2X_2$	79.6	35.19***	$X_2(0.56)$
$Y_4=a+b_7X_7+b_3X_3$	79.8	35.47***	$X_3(0.68)$
$Y_4=a+b_5X_5+b_4X_4$	85.9	55.02***	
II Post-initiation phase			
$Y_1=a+b_6X_6+b_4X_4+b_3X_3+b_1X_1+b_2X_2$	72.2	24.37***	$X_4(0.30)$ $X_1(0)$ $X_2(1.07)$
$Y_1=a+b_6X_6+b_3X_3+b_4X_4$	71.5	41.04***	$X_4(1.23)$
$Y_1=a+b_6X_6+b_3X_3$	70.8	60.67***	

Appendix 17.3 continued:

II Post-initiation phase Model	$100R^2$	F	Non significant variables (F)
$Y_1'=a+b_6X_6+b_1X_1$	73.8	70.53***	
$Y_1'=a+b_6X_6+b_3X_3$	74.7	73.89***	
$Y_2=a+b_5X_5+b_4X_4+b_3X_3+b_1X_1+b_2X_2$	73.9	26.60***	X_3(0.30) X_1(3.10) X_2(1.40)
$Y_2=a+b_1X_1+b_4X_4+b_3X_3+b_5X_5$	73.9	32.63***	X_1(0.02) X_3(2.85)
$Y_2=a+b_5X_5+b_3X_3+b_4X_4$	71.4	40.75***	
$Y_2=a+b_5X_5+b_4X_4$	71.2	61.87***	
$Y_3=a+b_3X_3+b_1X_1+b_6X_6+b_4X_4+b_2X_2$	77.0	31.41***	X_1(2.13) X_2(1.19)
$Y_3=a+b_3X_3+b_6X_6+b_4X_4$	76.0	51.60***	X_4(0.50)
$Y_3=a+b_6X_6+b_4X_4+b_3X_3$	76.0	51.60***	
$Y_3=a+b_6X_6+b_1X_1+b_4X_4$	73.1	44.39***	
$Y_3=a+b_8X_8+b_4X_4+b_1X_1$	73.8	45.90***	X_1(3.06)
$Y_3=a+b_8X_8+b_5X_5+b_1X_1+b_4X_4$	76.9	39.93***	X_1(3.41) X_4(0.60)
$Y_3=a+b_8X_8+b_5X_5+b_3X_3+b_4X_4$	76.4	38.89***	X_3(2.96) X_4(0.01)
$Y_3=a+b_8X_8+b_5X_5+b_3X_3+b_1X_1$	76.6	39.32***	X_3(2.99) X_1(0.43)
$Y_4=a+b_3X_3+b_1X_1+b_5X_5+b_4X_4+b_2X_2$	81.8	42.21***	X_1(1.46) X_2(0.48)
$Y_4=a+b_5X_5+b_4X_4+b_3X_3$	81.5	72.12***	
$Y_4=a+b_7X_7+b_6X_6+b_5X_5+b_1X_1$	95.5	254.59***	
$Y_4=a+b_7X_7+b_6X_6+b_5X_5+b_3X_3$	95.3	245.70***	X_3(3.52)
$Y_4=a+b_7X_7+b_5X_5+b_1X_1+b_4X_4$	89.7	105.00***	
$Y_4=a+b_7X_7+b_5X_5+b_3X_3+b_4X_4$	89.9	106.90***	X_3(3.11)
$Y_4=a+b_7X_7+b_5X_5+b_1X_1+b_3X_3$	88.7	94.21***	X_1(4.03) X_3(0.06)

Note: $Y_1' = \log_{10} Y_1$

Appendix 18 Dare Floral Bud Dissections

Appendix 18.1 Dissection data

I Pre-initiation phase

Sowing Block - Date	Emergence Date	Sampling *Date	Period (days)	X_1	X_2	X_3	X_4	X_5	A	X_6	R	X_7	X_8
A 2/11/75	9/11/75	3/12/75	24	15.19	17.2	14.5	24	0		0		0	0
A 2/11/75	9/11/75	3/12/75	24	15.19	17.2	14.5	24	10.0		30		1.25	0.42
A 2/11/75	9/11/75	3/12/75	24	15.19	17.2	14.5	24	6.7		20		0.83	0.28
A 2/11/75	9/11/75	3/12/75	24	15.19	17.2	14.5	24	5.0		20		0.83	0.21
A 2/11/75	9/11/75	3/12/75	24	15.19	17.2	14.5	24	0		0		0	0
A 2/11/75	9/11/75	3/12/75	24	15.19	17.2	14.5	24	8.0		20		0.83	0.33
A 2/11/75	9/11/75	3/12/75	24	15.19	17.2	14.5	24	0		0		0	0
A	*3/12/75	9/12/75	6	15.53	19.2	14.8	30	0	3.7	0	11.2	- 1.87	- 0.62
A	*3/12/75	9/12/75	6	15.53	19.2	14.8	30	10.0	3.7	50	11.2	6.47	1.05
A	*3/12/75	9/12/75	6	15.53	19.2	14.8	30	10.0	3.7	40	11.2	4.80	1.05
A	*3/12/75	9/12/75	6	15.53	19.2	14.8	30	5.4	3.7	30	11.2	3.13	0.28
A	*9/12/75	17/12/75	8	15.61	19.2	16.6	38	12.5	6.3	30	30.0	0	0.78
A	*9/12/75	17/12/75	8	15.61	19.2	16.6	38	3.1	6.3	30	30.0	0	- 0.40
A	*9/12/75	17/12/75	8	15.61	19.2	16.6	38	10.0	6.3	30	30.0	0	0.46
A	*9/12/75	17/12/75	8	15.61	19.2	16.6	38	11.2	6.3	30	30.0	0	0.60
A	*9/12/75	17/12/75	8	15.61	19.2	16.6	38	3.0	6.3	30	30.0	0	0.41
A	*9/12/75	17/12/75	8	15.61	19.2	16.6	38	16.0	6.3	40	30.0	1.25	1.21
B 12/11/75	18/11/75	10/12/75	22	15.38	18.0	14.8	22	0		0		0	0
B 12/11/75	18/11/75	10/12/75	22	15.38	18.0	14.8	22	13.6		30		1.36	0.62
B 12/11/75	18/11/75	10/12/75	22	15.38	18.0	14.8	22	15.8		40		1.82	0.72
B 12/11/75	18/11/75	10/12/75	22	15.38	18.0	14.8	22	18.3		40		1.82	0.83
B 12/11/75	18/11/75	10/12/75	22	15.38	18.0	14.8	22	15.0		40		1.82	0.68
B 12/11/75	18/11/75	10/12/75	22	15.38	18.0	14.8	22	17.5		30		1.36	0.80
B 12/11/75	18/11/75	10/12/75	22	15.38	18.0	14.8	22	18.6		40		1.82	0.85
B 12/11/75	18/11/75	10/12/75	22	15.38	18.0	14.8	22	5.7		20		0.91	0.26
B	*10/12/75	17/12/75	7	15.61	19.1	16.7	29	0	13.1	0	30.0	- 4.29	- 1.87
B	*10/12/75	17/12/75	7	15.61	19.1	16.7	29	7.5	13.1	30	30.0	0	- 0.80
B	*10/12/75	17/12/75	7	15.61	19.1	16.7	29	3.3	13.1	30	30.0	0	- 1.40
B	*10/12/75	17/12/75	7	15.61	19.1	16.7	29	3.0	13.1	30	30.0	0	- 1.44
B	*10/12/75	17/12/75	7	15.61	19.1	16.7	29	32.1	13.1	60	30.0	4.25	2.71
B	*10/12/75	17/12/75	7	15.61	19.1	16.7	29	12.7	13.1	40	30.0	1.43	- 0.06
B	*10/12/75	17/12/75	7	15.61	19.1	16.7	29	7.8	13.1	30	30.0	0	- 0.76
D 2/12/75	9/12/75	17/12/75	8	15.61	19.2	16.6	8	0		0		0	0
D 2/12/75	9/12/75	17/12/75	8	15.61	19.2	16.6	8	20.0		30		3.75	2.50
D 2/12/75	9/12/75	17/12/75	8	15.61	19.2	16.6	8	20.0		30		3.75	2.50

Appendix 18.1	continued:												
D 2/12/75	9/12/75	17/12/75	8	15.61	19.2	16.6	8	12.5		30		3.75	1.56
D 2/12/75	9/12/75	17/12/75	8	15.61	19.2	16.6	8	0		0		0	0
D 2/12/75	9/12/75	17/12/75	8	15.61	19.2	16.6	8	7.5		30		3.75	0.94
D 2/12/75	9/12/75	17/12/75	8	15.61	19.2	16.6	8	0		0		0	0
D 2/12/75	9/12/75	17/12/75	8	15.61	19.2	16.6	8	0		0		0	0
D	*17/12/75	22/12/75	5	15.63	19.7	13.9	13	10.0	7.5	20	15.0	1.00	0.50
D	*17/12/75	22/12/75	5	15.63	19.7	13.9	13	8.7	7.5	25	15.0	2.00	0.24
D	*17/12/75	22/12/75	5	15.63	19.7	13.9	13	0	7.5	0	15.0	- 3.00	- 1.50
D	*17/12/75	22/12/75	5	15.63	19.7	13.9	13	5.0	7.5	20	15.0	1.00	- 0.50
D	*17/12/75	22/12/75	5	15.63	19.7	13.9	13	0	7.5	0	15.0	- 3.00	- 0.50
D	*17/12/75	22/12/75	5	15.63	19.7	13.9	13	12.0	7.5	30	15.0	3.00	0.50
D	*17/12/75	22/12/75	5	15.63	19.7	13.9	13	7.5	7.7	30	15.0	3.00	0
D	*22/12/75	27/12/75	5	15.62	17.0	15.3	18	17.0	5.4	30	16.3	2.74	2.32
D	*22/12/75	27/12/75	5	15.62	17.0	15.3	18	11.2	5.4	25	16.3	1.74	1.16
D	*22/12/75	27/12/75	5	15.62	17.0	15.3	18	7.5	5.4	20	16.3	0.74	0.42
D	*22/12/75	27/12/75	5	15.62	17.0	15.3	18	4.0	5.4	20	16.3	0.74	- 0.28
D	*22/12/75	27/12/75	5	15.62	17.0	15.3	18	6.0	5.4	30	16.3	2.74	0.12
D	*22/12/75	27/12/75	5	15.62	17.0	15.3	18	10.0	5.4	30	16.3	2.74	0.92
D	*22/12/75	27/12/75	5	15.62	17.0	15.3	18	0	5.4	0	16.3	- 3.26	- 1.08
D	*22/12/75	27/12/75	5	15.62	17.0	15.3	18	6.0	5.4	30	16.3	2.74	0.12
II Post-initiation phase													
	Sampling	dates											
A	17/12/75	27/12/75	10	15.63	18.4	16.5	48	20.7	9.3	40	31.7	0.83	1.14
A	17/12/75	27/12/75	10	15.63	18.4	16.5	48	24.2	9.3	40	31.7	0.83	1.49
A	17/12/75	27/12/75	10	15.63	18.4	16.5	48	25.0	9.3	50	31.7	1.83	1.57
A	17/12/75	27/12/75	10	15.63	18.4	16.5	48	23.6	9.3	40	31.7	0.83	1.43
A	17/12/75	27/12/75	10	15.63	18.4	16.5	48	21.4	9.3	50	31.7	1.83	1.21
A	17/12/75	27/12/75	10	15.63	18.4	16.5	48	34.2	9.3	55	31.7	2.33	2.49
A	17/12/75	27/12/75	10	15.63	18.4	16.5	48	35.7	9.3	50	31.7	1.83	2.64
A	27/12/75	6/1 /76	10	15.50	18.7	15.3	58	61.0	25.0	90	39.4	5.06	3.60
A	27/12/75	6/1 /76	10	15.50	18.7	15.3	58	44.8	25.0	75	39.4	3.56	1.98
A	27/12/75	6/1 /76	10	15.50	18.7	15.3	58	63.7	25.0	95	39.4	5.56	3.87
A	27/12/75	6/1 /76	10	15.50	18.7	15.3	58	55.0	25.0	80	39.4	4.06	3.00
A	27/12/75	6/1 /76	10	15.50	18.7	15.3	58	36.5	25.0	85	39.4	4.56	1.15
A	6/1 /76	14/1 /76	8	15.40	21.0	20.2	66	73.6	56.5	95	85.0	1.25	2.14
A	6/1 /76	14/1 /76	8	15.40	21.0	20.2	66	54.3	56.5	90	85.0	0.63	- 0.28
A	6/1 /76	14/1 /76	8	15.40	21.0	20.2	66	64.3	56.5	85	85.0	0	0.98
A	6/1 /76	14/1 /76	8	15.40	21.0	20.2	66	58.5	56.5	90	85.0	0.63	0.25
B	17/12/75	27/12/75	10	15.63	18.4	16.5	39	41.6	9.5	60	31.4	2.86	3.21
B	17/12/75	27/12/75	10	15.63	18.4	16.5	39	24.5	9.5	40	31.4	0.86	1.50

Dare Floral Bud Dissections

Appendix 18.1 Dissection data continued:

II Post-initiation phase continued:

Sowing Block - Date	Sampling dates		Period (days)	X_1	X_2	X_3	X_4	X_5	A	X_6	R	X_7	X_8
B	17/12/75	27/12/75	10	15.63	18.4	16.5	39	34.1	9.5	55	31.4	2.36	2.46
B	17/12/75	27/12/75	10	15.63	18.4	16.5	39	36.1	9.5	55	31.4	2.36	2.66
B	17/12/75	27/12/75	10	15.63	18.4	16.5	39	15.3	9.5	40	31.4	0.86	0.58
B	17/12/75	27/12/75	10	15.63	18.4	16.5	39	19.5	9.5	40	31.4	0.86	1.00
B	17/12/75	27/12/75	10	15.63	18.4	16.5	39	13.0	9.5	30	31.4	0.14	1.35
B	17/12/75	27/12/75	10	15.63	18.4	16.5	39	3.3	9.5	20	31.4	- 1.14	- 0.62
B	27/12/75	6/1 /76	10	15.50	18.7	15.3	49	41.2	23.4	60	42.5	1.75	1.78
B	27/12/75	6/1 /76	10	15.50	18.7	15.3	49	45.0	23.4	75	42.5	3.38	2.16
B	27/12/75	6/1 /76	10	15.50	18.7	15.3	49	42.7	23.4	75	42.5	3.38	1.93
B	27/12/75	6/1 /76	10	15.50	18.7	15.3	49	32.4	23.4	70	42.5	2.75	0.90
B	27/12/75	6/1 /76	10	15.50	18.7	15.3	49	40.3	23.4	70	42.5	2.75	1.69
B	6/1 /76	11/1 /76	5	15.43	20.5	19.1	54	64.6	40.3	85	70.0	3.00	4.86
B	6/1 /76	11/1 /76	5	15.43	20.5	19.1	54	40.3	40.3	75	70.0	1.00	0
B	6/1 /76	11/1 /76	5	15.43	20.5	19.1	54	50.5	40.3	75	70.0	1.00	2.04
B	6/1 /76	11/1 /76	5	15.43	20.5	19.1	54	57.6	40.3	85	70.0	3.00	3.46
B	11/1 /76	21/1 /76	10	15.27	21.7	19.8	64	57.6	53.2	90	80.0	4.00	0.44
B	11/1 /76	21/1 /76	10	15.27	21.7	19.8	64	60.6	53.2	90	80.0	4.00	0.74
B	11/1 /76	21/1 /76	10	15.27	21.7	19.8	64	55.8	53.2	90	80.0	4.00	0.26
B	11/1 /76	21/1 /76	10	15.27	21.7	19.8	64	60.4	53.2	90	80.0	4.00	0.72
D	27/12/75	6/1 /76	10	15.50	18.4	15.3	28	5.0	7.7	30	23.1	0.69	- 0.27
D	27/12/75	6/1 /76	10	15.50	18.4	15.3	28	16.4	7.7	50	23.1	2.69	0.87
D	27/12/75	6/1 /76	10	15.50	18.4	15.3	28	9.3	7.7	25	23.1	0.19	0.16
D	27/12/75	6/1 /76	10	15.50	18.4	15.3	28	9.5	7.7	25	23.1	0.19	0.18
D	27/12/75	6/1 /76	10	15.50	18.4	15.3	28	26.2	7.7	50	23.1	2.69	1.85
D	27/12/75	6/1 /76	10	15.50	18.4	15.3	28	11.9	7.7	50	23.1	2.69	0.42
D	27/12/75	6/1 /76	10	15.50	18.4	15.3	28	10.6	7.7	50	23.1	2.69	0.29
D	27/12/75	6/1 /76	10	15.50	18.4	15.3	28	8.9	7.7	20	23.1	- 0.31	0.12
D	6/1 /76	11/1 /76	5	15.43	20.5	19.1	33	40.0	12.2	60	37.5	4.50	5.56
D	6/1 /76	11/1 /76	5	15.43	20.5	19.1	33	28.7	12.2	70	37.5	6.50	3.30
D	6/1 /76	11/1 /76	5	15.43	20.5	19.1	33	35.2	12.2	70	37.5	6.50	4.60
D	6/1 /76	11/1 /76	5	15.43	20.5	19.1	33	45.9	12.2	65	37.5	5.50	3.37
D	6/1 /76	11/1 /76	5	15.43	20.5	19.1	33	42.9	12.2	60	37.5	4.50	6.14
D	6/1 /76	11/1 /76	5	15.43	20.5	19.1	33	32.1	12.2	60	37.5	4.50	3.98
D	6/1 /76	11/1 /76	5	15.43	20.5	19.1	33	26.0	12.2	60	37.5	4.50	2.76
D	6/1 /76	11/1 /76	5	15.43	20.5	19.1	33	20.5	12.2	60	37.5	4.50	1.66

Appendix 18.1 continued:

D	11/1 /76	21/1 /76	10	15.27	21.7	19.8	43	54.4	33.9	70	63.1	0.69	4.10
D	11/1 /76	21/1 /76	10	15.27	21.7	19.8	43	53.6	33.9	70	63.1	0.60	1.97
D	11/1 /76	21/1 /76	10	15.27	21.7	19.8	43	40.2	33.9	70	63.1	0.69	0.63
D	11/1 /76	21/1 /76	10	15.27	21.7	19.8	43	40.0	33.9	50	63.1	- 1.31	0.61
D	11/1 /76	21/1 /76	10	15.27	21.7	19.8	43	41.4	33.9	60	63.1	- 0.31	0.75
D	11/1 /76	21/1 /76	10	15.27	21.7	19.8	43	42.9	33.9	70	63.1	0.69	0.90
D	11/1 /76	21/1 /76	10	15.27	21.7	19.8	43	44.1	33.9	70	63.1	0.69	1.02
D	11/1 /76	21/1 /76	10	15.27	21.7	19.8	43	46.8	33.9	70	63,1	0.69	1.29
D	21/1 /76	31/1 /76	10	14.98	20.4	18.6	53	67.3	45.3	90	66.2	2.38	2.20
D	21/1 /76	31/1 /76	10	14.98	20.4	18.6	53	68.1	45.3	85	66.2	1.88	2.28
D	21/1 /76	31/1 /76	10	14.98	20.4	18.6	53	69.4	45.3	90	66.2	2.38	2.41
D	21/1 /76	31/1 /76	10	14.98	20.4	18.6	53	56.7	45.3	90	66.2	2.38	1.14
D	21/1 /76	31/1 /76	10	14.98	20.4	18.6	53	68.3	45.3	90	66.2	2.38	2.30
D	21/1 /76	31/1 /76	10	14.98	20.4	18.6	53	50.0	45.3	85	66.2	1.88	0.47
D	21/1 /76	31/1 /76	10	14.98	20.4	18.6	53	69.6	45.3	95	66.2	2.88	2.43
D	31/1 /76	10/2 /76	10	14.62	19.1	15.2	63	90.2	64.2	95	90.0	0.50	2.60
D	31/1 /76	10/2 /76	10	14.62	19.1	15.2	63	83.9	64.2	95	90.0	0.50	1.97
D	31/1 /76	10/2 /76	10	14.62	19.1	15.2	63	84.2	64.2	95	90.0	0.50	2.00
D	31/1 /76	10/2 /76	10	14.62	19.1	15.2	63	77.4	64.2	95	90.0	0.50	1.32

—— Insert:-

A 2/11/75 9/11/75 3/12/75 24 15.19 17.2 14.5 24 0 0 0 0

Appendix 18.2

Dare Correlation Coefficients

I Pre-initiation phase (n = 56)

Variables	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
X_1		0.578***	0.461***	-0.157ns	0.087ns	0.181ns	0.044ns	-0.028ns
X_2			0.280*	-0.016ns	0.044ns	0.115ns	0.003ns	-0.103ns
X_3				0.213ns	0.122ns	0.174ns	-0.030ns	0.108ns
X_4					0.075ns	0.333**	-0.139ns	-0.116ns
X_5						0.815***	0.629***	0.785***
$X_{5'}$	invalidated	by negative	values for	X_5				
X_6							0.716***	0.552***
$X_{6'}$	invalidated	by negative	values for	X_6				
X_7								0.764***
$X_{7'}$	invalidated	by negative	values for	X_7				
X_8								
$X_{8'}$	invalidated	by negative	values for	X_8				

II Post-initiation phase (n = 72)

Variables	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
X_1		-0.403***	-0.184ns	-0.447***	-0.749***	-0.650***	0.133ns	-0.029ns
X_2			0.929***	0.283*	0.472***	0.516***	0.059ns	0.075ns
X_3				0.191ns	0.315**	0.358**	0.050ns	0.107ns
X_4					0.785***	0.778***	-0.041ns	-0.062ns
X_5						0.916***	0.101ns	0.329**
$X_{5'}$	-0.583***	0.516***	0.395***	0.723***		0.896***	0.238*	0.425***
X_6							0.332**	0.264*
$X_{6'}$	-0.575***	0.525***	0.384***	0.712***	0.871***		0.393***	0.333**
X_7								0.581***
$X_{7'}$	invalidated	by negative	values for	X_7				
X_8								
$X_{8'}$	invalidated	by negative	values for	X_8				

$X_{5'}$, $X_{6'}$, $X_{7'}$ and $X_{8'}$ = $\log_{10}$ forms of X_5, X_6, X_7 and X_8, respectively.

Appendix 18.3 Dare regression models considered:

I Pre-initiation phase

Model	$100R^2$		Non signicicant variables (F)
$Y_1=a+b_6X_6+b_4X_4+b_3X_3+b_1X_1+b_2X_2$	72.7	26.58***	$X_3(0.04)$ $X_1(3.58)$ $X_2(0)$
$Y_1=a+b_6X_6+b_3X_3+b_4X_4$	70.7	43.18***	$X_3(0.07)$
$Y_1=a+b_6X_6+b_4X_4+b_1X_1$	72.0	44.50***	$X_1(2.37)$
$Y_1=a+b_6X_6+b_4X_4$	70.7	63.89***	
$Y_1=a+b_6X_6+b_1X_1$	66.7	53.18***	$X_1(0.60)$
$Y_2=a+b_5X_5+b_4X_4+b_3X_3+b_1X_1+b_2X_2$	76.8	33.03***	$X_3(0.08)$ $X_2(0.02)$
$Y_2=a+b_5X_5+b_4X_4+b_1X_1$	76.3	55.67***	
$Y_3=a+b_3X_3+b_1X_1+b_6X_6+b_4X_4+b_2X_2$	70.8	24.21***	$X_3(0.16)$ $X_1(0.73)$ $X_2(0)$
$Y_3=a+b_6X_6+b_5X_5+b_4X_4+b_3X_3$	68.6	27.84***	$X_5(1.01)$ $X_3(1.31)$
$Y_3=a+b_8X_8+b_6X_6+b_5X_5+b_4X_4$	89.7	111.11***	
$Y_3=a+b_8X_8+b_6X_6+b_5X_5+b_3X_3$	84.2	67.79***	
$Y_4=a+b_3X_3+b_1X_1+b_5X_5+b_4X_4+b_2X_2$	68.7	21.90***	$X_3(1.85)$ $X_1(1.24)$ $X_2(1.04)$
$Y_4=a+b_7X_7+b_6X_6+b_5X_5+b_4X_4$	88.9	101.97***	$X_6(0.02)$
$Y_4=a+b_7X_7+b_5X_5+b_4X_4$	74.6	50.86***	$X_4(1.82)$
$Y_4=a+b_7X_7+b_5X_5$	73.7	74.23***	
II Post-initiation phase			
$Y_1=a+b_6X_6+b_4X_4+b_3X_3+b_1X_1+b_2X_2$	90.2	121.26***	$X_3(0.01)$ $X_2(1.17)$
$Y_1=a+b_6X_6+b_1X_1+b_4X_4$	90.0	202.92***	
$Y_1=a+b_4X_4+b_1X_1+b_2X_2$	83.0	110.29***	
$Y_2=a+b_5X_5+b_4X_4+b_3X_3+b_1X_1+b_2X_2$	86.7	86.42***	$X_3(3.37)$ $X_1(0.08)$
$Y_2=a+b_5X_5+b_2X_2+b_3X_3+b_4X_4$	86.4	106.59***	$X_3(0.91)$
$Y_2=a+b_5X_5+b_2X_2+b_4X_4$	86.1	139.88***	
$Y_3=a+b_3X_3+b_1X_1+b_6X_6+b_4X_4+b_2X_2$	65.2	24.71***	$X_3(0.47)$ $X_1(3.97)$ $X_2(0.61)$
$Y_3=a+b_8X_8+b_6X_6+b_1X_1+b_4X_4$	77.8	56.74***	
$Y_3=a+b_8X_8+b_4X_4+b_1X_1$	77.8	79.48***	
$Y_4=a+b_3X_3+b_1X_1+b_5X_5+b_4X_4+b_2X_2$	70.1	30.94***	$X_3(2.51)$ $X_1(0.02)$
$Y_4=a+b_7X_7+b_4X_4+b_6X_6+b_5X_5$	72.9	44.95***	$X_4(0.36)$
$Y_4=a+b_7X_7+b_5X_5+b_6X_6$	68.9	50.34***	
$Y_4=a+b_7X_7+b_6X_6+b_5X_5+b_2X_2$	69.2	37.70***	$X_6(1.23)$ $X_2(0.65)$