Climatic risk for sweet corn production in a cool, variable climate

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Summary. The risk of sweet corn crops failing to reach maturity due to cool seasons and/or early frosts was quantified for several cultivar maturities and planting dates using long-term temperature records from four locations on the east coast of New Zealand's South Island. Risk increased as maturity dates became progressively later with later maturing cultivars, later planting dates and more southerly location. The climate in the region is marginal for sweet corn, mainly because of temperature variability from season to season.

Introduction

Commercial sweet corn production is expanding into areas of New Zealand where the climate is cool and variable, and therefore likely to be marginal for reliable production of the crop (5). There is a significant risk, especially in cooler seasons, that some crops will not reach harvest maturity before the first autumn frosts. Risk can be minimised by using early maturing cultivars and planting early. However, in practice. plantings of cultivars with a range of maturities are scheduled during spring to maximise the length of the harvesting and processing period in autumn (2,3). This increases the risk that some of the later crops will not reach harvest maturity before the first frosts in autumn.

In this paper we analyse the risk of crop failure caused by cool seasons and/or early frosts on the east coast of New Zealand's South Island where temperatures are slightly cooler and more variable than in the vegetable cropping areas of northern Tasmania. The aim is to identify locations where risk is lowest, and to determine combinations of sowing date and cultivar maturity with acceptable levels of risk. The analysis consists of three parts: determination of the thermal time requirements of cultivars for development from sowing to maturity; analysis of long-term temperature records from four locations in the region; and combining phenology and climate information to determine the risk of failure to reach maturity for several combinations of location, cultivar and planting date.

Methods

Three cultivars with maturities in the range likely to be grown in the region were planted on several dates in the 1990-91 and 1991-92 seasons at two locations, Lincoln and Ashburton. Air temperatures were logged, plant emergence and 50% silk dates were recorded, and harvest maturity (72% kernel moisture content) dates were determined. The thermal time requirements from planting to silking and from silking to maturity were determined for each cultivar after estimating the base temperature by regressing 1/duration against mean temperature for the phase.

Climate analyses were performed for four locations. All had reliable long-term temperature records (from 17 to 25 seasons) and they represented a geographic distribution of areas in the eastern South Island where sweet corn could be grown. The following variables were determined for each location: mean temperature from 15 October to 30 April. the practical seasonal limits for sweet corn; thermal time accumulation above 6?C for the same period; and date of the first killing frost in autumn (air temperature < -1?C or grass minimum < -3?C).

The long-term thermal time records from each location were used to calculate harvest maturity dates for each season for all combinations of four planting dates (15 and 30 October. 15 and 30 November) and five cultivar maturities spanning the range likely to be used in the region (10(X). 1100, 1200. 13(X) and 1400 ?C days above 6?C). A crop was considered to fail either if its thermal time requirement was not met by 30 June or, much more likely, if it was frosted before the requirement was met.

This approach had an abrupt cut-off whereas, in fact, many "failed" crops were very close to maturity and could probably have been harvested successfully. Therefore, two criteria were used in the risk analysis to determine the success or failure of each crop. First, for each treatment combination (i.e. location, sowing date and cultivar) the date was determined by which there was 90% probability of crops reaching maturity. Second, at each location the dates were determined by which there were 10% and 30% probabilities of a frost occurring.

Results and discussion

Cultivar phenology from the field trials

The most appropriate base temperature was 6?C, the same value found for crops in the North Island (2). Thermal times above this base were much more stable than chronological durations for all cultivars (Table 1). Cultivars Jubilee and Rival had similar thermal requirements but both thermal and chronological durations were shorter for the earlier maturing cultivar Reward.

Table 1. Chronological and thermal times (days and ?C days above 6?C respectively). For Jubilee, Rival and Reward. n = 11.10 and 3 respectively.

		Plant to silk		Silk to maturity		Plant to maturity	
Cultivar		Time	TT_6	Time	TT_6	Time	TT_6
Jubilee	Mean	96	900	52	420	148	1320
	CV(%)	8.3	3.0	19.4	8.6	10.1	3.1
Rival	Mean	95	897	51	423	146	1320
	CV(%)	8.0	3.0	16.9	8.5	10.6	3.9
Reward	Mean	83	815	47	400	130	1215
	CV(%)	2.8	3.7	16.0	6.7	7.6	1.5

None of these cultivars was tested in the North Island experiments (1,2), so published values derived in the two regions cannot be compared directly. However, our planting to silking thermal durations were within the range reported for similar cultivars in the North Island (I), and our silking to maturity values agreed closely with the 410 ?C days found for 14 cultivars in the North Island (1,2). On the other hand, unpublished results from one North Island location suggested 1213 ?C days from sowing to maturity for Jubilee (I.R. Brooking, pers. comm.. 1987).

The results show that each cultivar's developmental response to temperature is stable. It is important to quantify these responses for all commercial cultivars, and to have a range of cultivars, including ones with low thermal time requirements. available for use in cool climates.

Long-term climate analysis

The key climate features at the four locations are summarised in Table 2. In general, locations further north were warmer, less variable and had later autumn frosts. Season mean temperatures ranged from 13.7 to 15.8?C and cumulative seasonal thermal times from 1525 to 1928 ?C days. The date of the first autumn frost was very variable.

Table 2. Seasonal mean temperature. cumulative thermal time (base = 6?C) from 15 October to 30 April and first frost date at the four locations.

Location	Latitude	Temperature (°C)		Thermal time (°C days)		First frost date	
		Mean	S.D.	Mean	S.D.	Mean	S.D. (d)
Blenheim	41°31'S	15.8	0.6	1928	113	16 May	15
Lincoln	43°39'S	14.6	0.7	1704	135	24 Apr	14
Winchmore	43°48'S	14.2	0.6	1615	122	20 Apr	20
Timaru	44°18'S	13.7	0.7	1525	143	8 May	19

Analysis of climatic risk

Results of the analyses for the four locations are shown in Fig. I. The graphs illustrate the sensitivity of crop success/failure to location. planting date, cultivar maturity and level of acceptable frost risk. The results should be interpreted bearing in mind that the thermal time requirement from planting to maturity of the main current commercial cultivar. Jubilee, is 1320 ?C days (Table 1).

Predictably, risk increased at all locations as maturity dates became progressively later with later maturing cultivars and later planting dates. Clearly, the region is at the climatic margin for reliable sweet corn production, mainly because of temperature variability from season to season. At Blenheim. the most northerly location, the risk of failure was very low irrespective of cultivar maturity or planting date (Fig. la). However, risk increased substantially at the more southerly locations. At Lincoln (Fig. lb). early sowing of all cultivars and late sowing of early cultivars had low risk levels but late sowing of mid and late maturing cultivars was more risky. Risk was much greater and similar at Winchmore and Timaru (Fig. lc and Id). where all combinations except early sowing of early maturing cultivars had high risk levels. These locations are therefore not considered to be suitable for reliable sweet corn production.

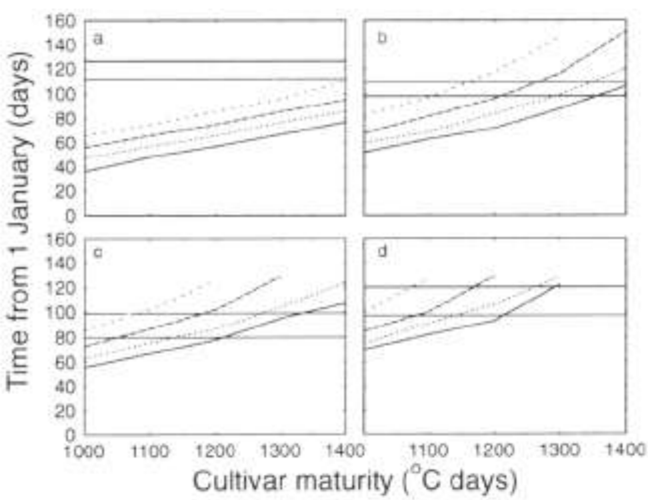

Figure 1: Time from I January to the date of 90% chance of reaching harvest maturity versus cultivar maturity at (a) Blenheim, (h) Lincoln, (c) Winchmore and (d) Timaru. The four plots on each graph represent the sowing dates: IS October (lower line), 30 October, 15 November and 30 November (upper line). The lower and upper horizontal lines indicate the dates by which there is a 10'X or 30% chance of a killing frost respectively.

Small temperature differences among locations and seasons are important for the viability of sweet corn production. The 6?C base temperature accentuates the differences when expressed in terms of thermal time accumulation. The crop's sensitivity to temperature and the marginal nature of the climate mean that any long-term warming trend in the future will substantially reduce risk and increase the viability of the crop. Historically, sweet corn production would have been much more risky before 1950 when the mean temperature in the region was about 0.5?C cooler (4) and the thermal time accumulation averaged about 100 ?C days less per season.

This analysis is a case study, and the results depend on the assumed risk criteria. These depend on several factors, and can be varied. The risk levels in the study were selected arbitrarily and may be too conservative. Crops are often close to maturity when frosted and are still harvestable soon after. The acceptability of risk criteria depends on who is taking the risk, and their aversion to it. For example, growers arc likely to be more averse to risk than processors because each individual stands to lose more in the event of crop failure. Growers usually do not have control of cultivar selection and time of planting. In contrast, processors want the harvest period to be as long as possible. and they achieve this through their control of the sowing schedule and selection of cultivars. Each year the mix of cultivars and sowing dates is planned for "average" conditions with the knowledge that some of the later ones are likely to be lost in a cooler season or if an early frost occurs. Ultimately, a balance has to be found in economic terms between exposure to risk of crop failure on the one hand and. on the other hand, the needs of growers and processors to use a range of cultivars. planting times and locations to achieve a long harvesting period in autumn.

References

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