PROGRAMMING THE PRODUCTION AND HARVESTING OF PROCESS CROPS

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ABSTRACT

Continuity of supply of vegetable crops for processing is required to fully utilise harvesting and processing equipment. This is achieved by careful programming of crop sowing dates. Programming methods used in New Zealand for peas, beans, sweet corn and tomatoes for mechanical harvest are described. The accuracy of programming is reduced by variations between localities and fluctuations in weather so considerable reliance is placed on the experience of the processors' field officers.

INTRODUCTION

Efficiency in vegetable processing operation is dependent on a steady supply of vegetables harvested at peak quality throughout the processing season. Process vegetable crops are only at peak maturity for very limited periods ranging from a few hours to days for peas to perhaps a week for tomatoes. Continuity of supply of crops at peak maturity can only be achieved by successional sowings as there are no practicable methods of advancing or retarding maturity of vegetable crops (other than for tomatoes). Careful programming of sowing dates for process crops is therefore essential to ensure that a consistent area of crop reaches maturity on each day of the processing season. Inaccurate programming with some crops reaching maturity earlier or later than planned, results in days when the area to be harvested is less than processing plant capacity, and other days when capacity is exceeded and crops have to be diverted to other less profitable uses.

Major processing crops grown in New Zealand requiring accurate planning are peas, beans, mechanical harvest tomatoes and sweet corn. Methods used for process crop planning in New Zealand have not previously been described and we are indebted to the processors who provided us with information on their programming techniques.

BASIS FOR PROGRAMMING

The simplest basis for planning is the number of days which elapse between sowing and maturity. This very simple method can work quite well for crops grown in the warmer season of the year. This approach is not suitable for crops sown in early spring when the weather is more variable. Temperature is the most important single factor related to the rate of crop development, and hence an integration of temperature over time can be used to predict maturity dates during periods of fluctuating temperatures. Heat units, usually degree-days above some base temperature, are used world wide and in New Zealand for programming production of process crops. The heat unit summation in degree-days is defined as the mean of the maximum and minimum daily screen temperatures minus the base temperature, summed over the period from sowing to maturity.

The base temperature is determined empirically by statistical methods, using accumulated data from many successional sowings. The base temperature is not always equal to the minimum temperature for crop development but it is generally more reliable for predictive purposes than a physiologically selected base temperature. The empirical method of selecting the base temperature reduces errors caused by factors other than temperature. Arnold (1959) has discussed the accuracy of various methods of base temperature determination.

PROGRAMMING METHODS

Peas

Programming systems in New Zealand for peas are mostly based on the use of heat units, calculated from long term temperature records, using a base temperature of 4.4°C. Table 1 presents an example of part of a pea sowing and harvesting programme. The first harvest date is 1 December; the cultivar to be used is known to require 800 degree-days between sowing and maturity. The first sowing date is obtained by summing heat units from the temperature records

TABLE 1: Sowing and harvesting plan for process peas: an example showing heat unit accumulation.

Date	Harvest Heat Units	Period	Date	Sowing Heat Units	Total
Dec 1	10.7	1	Aug 1	3.2	
			2	3.8	
			3	4.1	11.1
2	10.8	2	4	2.0	
			5	4.3	
			6	3.3	9.6
3	10.9	3	7	1.9	
			8	4.1	
			9	4.7	10.7
4	10.9	4	10	6.8	
			11	5.7	12.5
5	11.0	5	12	3.4	
			13	3.5	
			14	2.9	9.8
6	11.0	6	15	3.4	
			16	4.9	
			17	3.8	12.1
7	11.1	7	18	1.8	
			19	1.2	
			20	2.9	
			21	5.5	11.4
Total	76.4				77.2

backward from 1 December until the total reaches 800 degree-days, in this case on 1 August. The table also shows the number of heat units expected for each day of the harvest season and the daily heat units expected each day after the first sowing date. Successive sowings can be simply scheduled by equating the heat unit difference between sowing dates to the heat unit difference between successive harvests. This quick calculation does in fact maintain a constant 800 degree-day interval between successive sowings and harvest. The system can be used for planning sowing dates, and for plan modification during the sowing season using actual, rather than expected, accumulated heat units between sowings. When several cultivars are to be included in the schedule, information on their relative harvest times is all that is required for programming. Cultivar B, maturing five days earlier than cultivar A, would be sown five sowing periods later than cultivar A for harvesting on the same day. Areas sown at each sowing day are based on estimated yields and the daily capacity of the processing factory.

This programming system undoubtedly has many limitations in that maturity over relatively large production areas is based solely on mean temperatures assessed inaccurately from maximum-minimum observations at a limited number of sites, ignoring factors such as soil type, irrigation and disease, and applied to many individual crop sites differing in micro-climate. Its widespread use by New Zealand processors is a tribute to the experience and judgement of their field staff in making allowances for these other factors.

Processors have observed that the number of degree-days required from sowing to maturity varies from early to late sowings and in different districts. Arnold (1959) has pointed out that such seasonal shifts are often due to the use of the wrong base temperature, and that local determination of base temperature is necessary. It seems likely that more accurate programming would be possible if base temperature and heat unit requirements were reassessed using local records.

Beans

Sowing schedules for processed green beans in New Zealand are generally arranged by calendar date based on previous experience. This gives an adequate succession of crops for practical purposes. Beans are processed by freezing, canning or dehydration, and as whole or sliced beans. Different maturity stages are acceptable in each product, and this allows some processors considerable flexibility in harvesting.

Seed size is an important indicator of maturity and the rate of seed growth is closely related to mean temperature (Table 2). Maturity can thus be predicted on the basis of expected mean temperature as the crops approach maturity and harvesting schedules adjusted accordingly.

TABLE 2: The effect of mean daily temperature on growth in length of bean seeds.

Mean Temperature (°C)	Length Growth mm/day
10	0.16
11	0.22
12	0.27
13	0.33
14	0.38
15	0.44
16	0.49
17	0.55
18	0.60
19	0.66
20	0.71
21	0.76
22	0.82

Tomatoes for mechanical Harvest.

Large areas of this crop are sown according to planned calender dates. Some use is made of a Californian system in which the first sowing is made when the soil temperature reaches 14°C for three consecutive days. Successive sowings are made when the first true leaves of the preceeding crop are 10mm long. This system is less reliable in New Zealand than in California as widely fluctuating temperatures can occur in the spring.

Chlorethephon is widely used to obtain the maximum yield of ripe fruit when mechanically harvesting. It is usually applied when 15% of the fruit is coloured and 55% are mature green. Recent results (Bussell, unpublished) suggest that the interval between application and peak yield is related to the number of heat units accumulated. This suggests a method of scheduling harvests still to be tested under field conditions. The duration of the harvesting period within which peak processing yield can be obtained varies with cultivar; cv Castlong is particularly useful in that it has good vine storage capacity and maintains suitable quality over a longer period of harvest than other cultivars.

Sweet Corn

Programmed sowings according to calendar date and experience provide sufficient continuity of harvest to meet local processors requirements. The two products, whole cob and stripped kernals, require different maturities and add flexibility to harvesting schedules.

CONCLUSIONS

The deficiencies of programming methods available to New Zealand processors are compensated for by local experience. Processors and growers in established processing districts have not requested research on methods of programming and hence must be reasonably satisfied with the methods at present available. The drive for increased horticultural exports is forcing an expansion of process crop production into more districts and into newer crops. Programming for these crops must be difficult on account of both paucity of temperature observations and lack of local experience. The need for research to improve predictive methods for both existing and new crops must be recognised, but it is difficult to assess the priority of this problem in relation to other problems limiting the expansion of process crop production.

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