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A crop geography of late brussels sprouts[1]

H. G. Kronenberg

Department of Horticulture, Agricultural University, Wageningen, the Netherlands

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Summary

The producing areas of late brussels sprouts are restricted by the prevailing temperatures which determine first possible planting date, duration of the growing season and growth during this season, sprout forming and frost damage in autumn and winter.

In Europe two partly overlapping sprout growing areas can be distinguished: a large area of middle late sprouts in north-western Europe (growing period (May) June–October) and a smaller area of late sprouts near the Atlantic Ocean in southern England, the West of France and in northern Italy (July–November). Crop statistics show actual growing in these areas. Outside Europe sprouts can be grown in parts of USA, Canada, Japan, Australia, South Africa, New-Zealand, Chili, Argentina and Paraguay.

Introduction

Optimum production of crops can be defined as the art and science of so handling a crop as to produce the highest quantity and/or quality of the desired crop with a minimum of essential expenses. It is clear that production is determined by physiological and socio-economic relationships. Crop geography deals with the broad distribution of crop plants and with the underlying reasons for such distributions. These reasons can be ecological, but in addition the operation of economic, political, historical, technological and social forces must be recognized. Crop geography may be defined as the study of crop distribution in relation to their physiological and socio-economic environments. The main ecological factors such as the prevailing conditions of light and temperature and the availability of water and plant nutrition determine the physiological limits of crop production.

In this paper water relations and nutrition will not be discussed because it is presumed that on horticultural holdings, water and nutrients, if insufficient, will always be supplied.

Within the broad area where production of a given crop is ecologically possible,

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specific centres of crop production will be found. These are determined by economic forces such as demand, facilities for handling the crop, possibilities and cost of transportation, various labour problems and competition. There are always historical and political influences on a present distribution, but they are mostly difficult to weigh. Brussels sprouts need a long and cool growing season (Boswell, 1949). They are grown in rather restricted areas, mainly in western Europe; but they can be produced in parts of other continents. These restricted areas make it likely that it will be possible to trace physio-ecological conditions, which determine the limits within which a profitable production is possible. The boundaries of the areas of suitable ecological conditions can be drawn on a map, but in fact these will not be sharp: plants can of course be grown outside those borders, but their production will be lower and not so profitable.

As contrasted with ecological boundaries, socio-economic boundaries are sharp, because socio-economic conditions determine if, given the ecological possibilities, a crop actually will be grown.

Crop statistics are valuable to check if the results of physiological and socio-economic approximations are realistic.

Ecological relationships

Brussels sprouts is a biennial plant, used as an annual crop plant. It is planted in late spring or early summer and harvested in late autumn or winter. Late cultivars have distinct stages of development, because in these cultivars sprouts do hardly develop before a thick stem has formed. The following phases of development can be distinguished: a juvenile phase, an adult phase without axillary buds (sprouts) and a vegetative phase with sprouts. When temperatures are low enough in autumn plants form flower buds, which develop and bloom next spring. Every phase has its own optimum (daily average) temperature: a very young plant prefers 17–25 °C, a somewhat older plant 17 °C, an adult plant 21 °C, sprouts grow best at 12 °C, flower buds are initiated at 7 °C, while flower bud development and flowering need temperatures of about 11 °C. Young plants grow well at a global radiation of at least 12 MJ $m^{-2}day^{-1}$ (Kronenberg, 1975).

In the light of these requirements the following aspects will be discussed: the earliest possible planting date, the growing plant and the sprout forming plant. In the following, Europe will be looked at first; later other parts of the world will be taken into consideration.

If the growers should wait with planting until average temperatures have reached the required optimum (17–25 °C), planting would not start before June in mid and northern Europe, while sprout growing would not take place at all in England and Denmark. So brussels sprout plants are always planted before optimum temperatures occur. Minimum temperatures for growth of brussels sprout plants have not been published, but presumably 6 °C still permit some growth. Ellis (1966) and Hay (1972) call the month that the average temperature reaches 6 °C the beginning of spring, i.e. the beginning of growth in many plants. 12 MJ $m^{-2}day^{-1}$ is an ac-

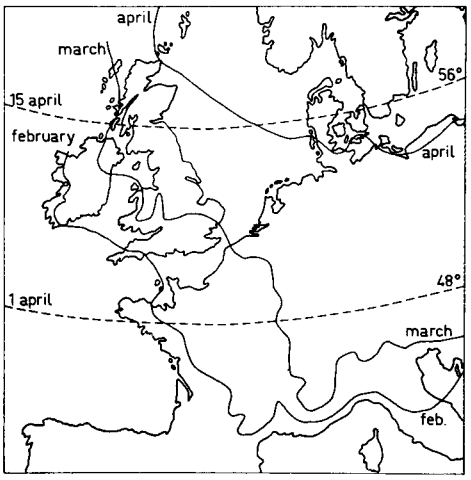

Fig. 1. Monthly 6 °C isotherms (drawn lines) and 12 MJ cm^{-2}day^{-1} radiation (broken lines).

ceptable light level. So it can be postulated that the earliest planting date will be if average monthly temperatures are at least 6 °C and radiation 12 MJ m^{-2}day^{-1}. These requirements are plotted together in Fig. 1 (Fig. 1 to 5 are based on Thran & Broekhuizen, 1965).

Planting of brussels sprouts in the open can start in northern Italy and southern France in March; in northern France, Belgium, England, the Netherlands and Germany in the first two weeks of April; in Scotland, Denmark and southern Sweden in April–May.

Sprout plants need a long growing season. If we accept that a 12 MJ m^{-2}day^{-1} radiation level is needed for good growth, the growing season lasts 4 months in latitude 56°, 5$^1/_3$ months in 48° and 6$^1/_3$ months in 41°.

It is difficult to give detailed temperature requirements. Optimum requirements are known (about 2 months at 17 °C and 1 month at 21 °C), but in the northern part of Europe 17 °C do not occur, while 21 °C are not reached in the western and north-western parts. It appears therefore that brussels sprouts not only are planted before temperatures are optimal, but in most areas also have to grow at suboptimal temperatures during the whole summer.

Temperature sums can give an estimate of the required length of the growing period. These sums are normally given as a range, because plant reactions to temperature are complex. If one starts with exact figures –as is done beneath– the boundaries of the sprout growing area become vague.

Growing sprouts optimal needs about 2 months of 17 °C and 1 month of 21 °C; so the sum of monthly temperatures is 55 °C. The northern limit of growing brussels sprouts can be the 17 + 17 + 21 = 55 °C temperature sum for the months of May, June, July and August.

Optimum growth of brussels sprout plants occurs if the sum of the average

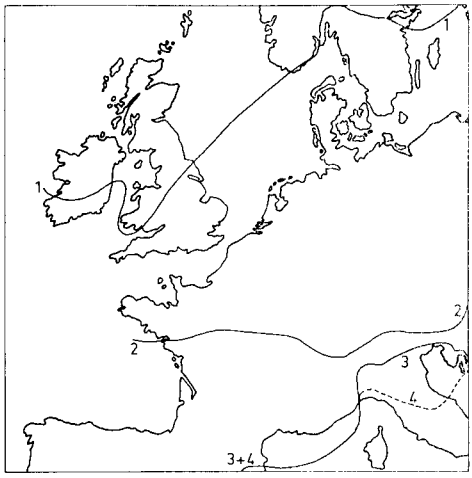

Fig. 2. A value of 55 °C for the sum of the monthly average temperatures over May, June, July and August (1) and in June, July and August (2); the 67 °C temperature sums in June, July and August (3, drawn line) and in July, August and September (4, broken line).

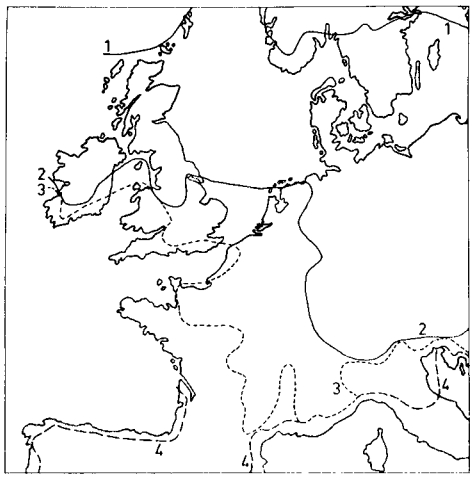

Fig. 3. Drawn lines: sum of the average monthly temperature over September–October equal to 18 °C (1) and 24 °C (2). Striped lines: sum of the average monthly temperature over October–November equal to 18 °C (3) and 24 °C (4).

temperatures of June, July and August or of July, August and September is 55 °C.

Kronenberg (1975) showed that if temperatures were 4 °C above the optimum, Brussels sprout plants reacted unfavourably. If during the above mentioned months temperatures are 4 °C above the optimum brussels sprout plants will not grow well any more. The 21 + 21 + 25 = 67 °C temperature sums during June, July and August or July, August and September form the southern border of the sprout growing area.

The above mentioned lines are plotted in Fig. 2: the 55 °C temperature sum over May, June, July and August; the 55 °C temperature sum over June, July and August, which coincides with the 55 °C temperature sum over July, August and September; the 67 °C temperature sum over June, July and August, which nearly coincides with the 67 °C temperature sum over July, August and September.

The northern border of the sprout growing areas, determined by a temperature sum of 55 °C over four months, is partly situated more to the north than the 56° latitude, where the growing season lasts less than 4 months. The 55 °C temperature sum will not hold true there.

A late cultivar of Brussels sprout plants making sprouts has different temperature requirements. In an experiment in 1964 (unpublished) it was found that 12 °C is the optimum temperature for sprout growth, and that growth of sprouts does not have specific radiation requirements above 3.5 MJ $m^{-2}day^{-1}$.

The time between the end of the plant growth and the start of the harvest of late sprouts is about two months, during which period temperatures fall. Therefore, late sprout plants should produce a good crop of sprouts if the sum of the average temperatures of the 2 months following the plant growth period is 24 °C.

In Fig. 3 lines are plotted representing the September-October and the October-November temperature sums of 24 °C and of 18°C. East of the 24 °C September-October line sprout growth will stop too early in the season leading to depression up to 30 % or 3000–5000 kg/ha if temperatures decline 3 °C. This means that commercial sprout growing will stop quite near east of the September-October 24 °C line. In central England, the Netherlands, Belgium and western West-Germany sprouts develop well in September and October; in southern Ireland and England, the western departments of France and northern Italy they develop well in October and November.

Economical relationships

Late sprouts are marketed from October till March and are kept on the plants in the field all this time. However, they cannot stand severe frosts (—10 – —15 °C) (Huisman & Planting, 1951). The occurrence and the frequency of such frosts determine the anticipated profitability of sprout growing.

Prices of brussels sprouts partly depend on competition between the different kinds of autumn and winter vegetables, which competition diminishes later in the season. Partly they depend on the prevailing temperatures: the lower these temperatures, the bigger the demand. Normally, the longer the sprouts can stay on the plants, the more profitable the crop is.

It is rather difficult to state which frost frequency should be considered too high. In Hamburg, situated on the 0° January isotherm, in December a —10 – —15 °C frost happens every second year; in January it happens every year (Reidat, 1960).

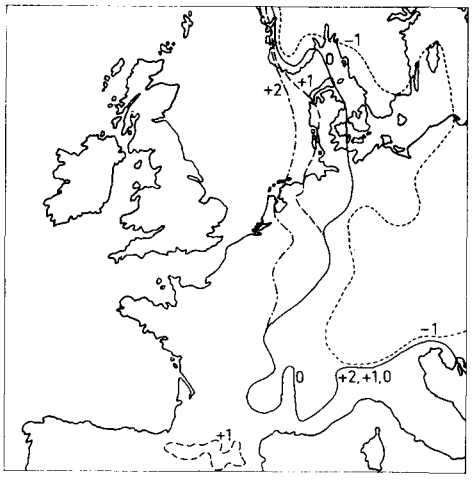

Fig. 4. The +2, +1, 0 and —1 °C January isotherms.

From this it is possible to postulate that everywhere on the 0 °C January isotherm sprouts certainly have to be harvested before 1 January. Following the same reasoning, on the —1 °C January isotherm harvest must be finished in the first weeks of December, while the +1 °C January isotherm allows two weeks in January. The 2 °C January isotherm, however, indicates that one may harvest till the end of the season in March.

In Fig. 4 all the four isotherms are given. The British Isles and the western parts of the Netherlands, Belgium and France and parts of northern Italy are the most profitable sprout growing areas. Profitability diminishes to the East.

The sprout producing areas in Europe

To find the sprout producing areas in western Europe the data of Fig. 1 to 4 should be brought together.

Two growing periods have to be distinguished which have both their own possibilities for production. The method in which plants grow in (May), June, July and August and sprouts are formed in September and October can be practised in a rather vast, middle late area (Fig. 5). The boundaries of this area are formed by the 55 °C temperature sum, the 56° latitude, and the several January isotherms of which the 1 °C isotherm (Fig. 4) nearly coincides with the 24 °C September-October temperature sum (Fig. 3). The eastern border of this area is vague because of the random occurrence of frost damage.

A method in which plants grow in July, August and September and sprouts are formed in October and November can be called late sprout growing. The much smaller area of this production method is given in Fig. 6. Boundaries are the 18 °C October-November temperature sum and the 67 °C July, August and September

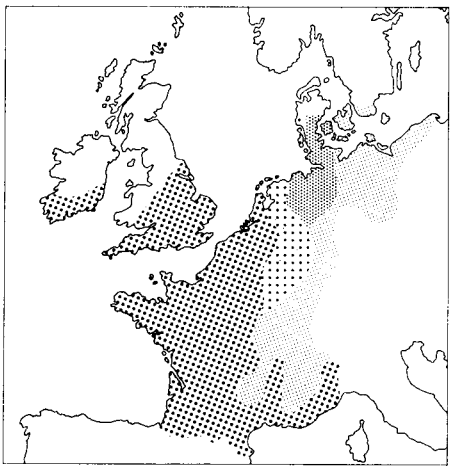

Fig. 5. The middle late brussels sprout producing area.

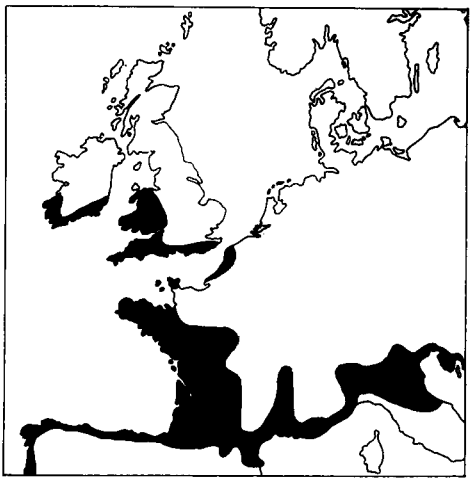

Fig. 6. The late brussels sprout producing area.

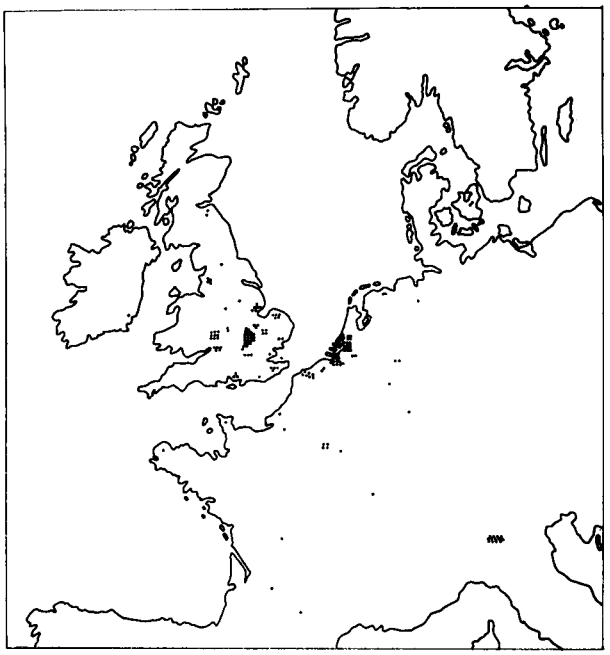

Fig. 7. The sprout producing area in western Europe (1 dot = 200 ha).

temperature sum. Both areas partly overlap; the late sprout area is situated more to the West, nearer to the Atlantic Ocean and more to the South.

Crop statistics

The spacing of brussels sprout production over Europe is given in Fig. 7 (based on Buishand, 1973, and Ellis, 1966). In eastern Germany the possibilities of sprout growing are being considered; in Poland they are being tried out (Soczek, 1974). There is a fair agreement between the areas in Fig. 5, 6 and 7, which means that the suggested postulates are (approximately) correct. In England and Scotland sprout growing is found a little more to the north than is shown in Fig. 5.

Possibilities outside Europe

Relationships between temperature and radiation are different between the European sprout growing area and other potential areas. These areas are all situated nearer the equator, which means that radiation never forms a minimum growing condition; possibilities are determined only by temperature. If we postulate that sprout growing needs a 3 (4) months growing period with temperature sums between 55–67 °C and after this period 2 months with 22—26 °C, the following potential areas are found:

1. North-America:
a. North-eastern USA and southern Canada near the big lakes (Boston, Portland, Burlington, Buffalo, Ottawa, Montreal), growing period June–October;
b. The coastal plain West of the Rocky Mountains in the USA and Canada (Eureka–Vancouver), June–October;
2. Japan: the northern part of Honchu (Aomori) and the eastern part of Hokkaido (Hakodate, Sapporo, Wakkanai), June–November;
3. Australia:
a. A narrow coastal region in southern Australia between Esperance in the West to Sydney in the East; from January–March to May–July;
b. Tasmania (Launceston, Hobart); December–May;
c. New-Zealand: parts of the South Island (Christchurch); December–May);
4. Three areas in South-Africa:
a. The coastal plain near Cape Town and Port Elisabeth; from February–March to June–July;
b. Oranje Vrijstaat (Upington, Kimberley, Grootfontein, Wepener, Umtata); from January–April to May–August;
c. Transvaal (Pietersburg, Zeerust, Germiston); from February–March to June–July;
5. South-America:
a. West of the Andes, Chili, from Antofagasta in the north to Ancud in the south (Antofagasta, Valparaiso, Santiago, Ancud); from February–March to April–July;
b. East of the Andes, parts of Argentina and Paraguay (Rosario, Parana, Buenos Aires, Montevideo, Santa Cruz); from November–March to April–July.

Acknowledgment

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