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Maturation in peas. I. A visual method of maturity assessment

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Summary

A method is described for assessing maturity in green peas which is based on the visually estimated maturity of the pods. This is in contrast with current methods by which maturity of shelled peas is measured chemically or mechanically.
The maturity of the crop as measured by the average maturity of the pods showed a high correlation with the maturity as measured by the average alcohol-insoluble solids of the peas, and the regression equations were reasonably stable. More should be known about the behaviour of varieties under various conditions before this system can be used as a method to predict the optimal harvest date. The method may especially be useful for breeding work, since it would enable the plant breeder to follow the ripening process of pods of individual plants throughout the harvest period.

Introduction

Since in green peas quality attributes such as tenderness and flavour are strongly dependent on the maturity of the peas, the determination of maturity is generally used as a method to assess quality. Common methods to obtain a reliable indication of maturity are the determination of the average alcohol-insoluble solids of the peas (Kertesz, 1935) or to measure their average tenderness with the help of various instruments. Although many more or less satisfactory instruments have been developed (Christel, 1938; Doesburg en Grevers, 1952–53; Kramer et al., 1951; Makower, 1950), only a few are in general use. The most important are the tenderometer (Martin, 1937) and the maturometer (Lynch and Mitchell, 1950; Mitchell et al., 1954, 1961).
The validity of these methods is based on the degree of correlation between their results and the results of a sensorial assessment of quality. Reported correlation coefficients between alcohol-insoluble solids and quality are 0.90 or higher (Kertesz, 1935; Kramer et al., 1950; Kramer, 1954; Lee et al., 1954) although a correlation coefficient of only 0.83 was found by Torfason et al. (1956). Correlation coefficients between tenderometer values and quality reported by Kramer et al. (1950), Kramer (1954), Lee et al. (1954) and Torfason et al. (1956) are of the same magnitude.

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Although both types of methods give good results in most practical or scientific work, they cannot be used for selection in a breeding program because the peas under investigation are destroyed. Another drawback is that they do not give an indication of the spread in maturity which is present in the pea crop at the date of harvest. Therefore, a method was devised which does not have these drawbacks and which would be especially useful for pea breeding work.

Materials and methods

Plant material

1964. Peas of the varieties Dark Skin Perfection (Cooper's selection) (CDSP), Greenfeast (Gf), Victory Freezer (VF) and William Massey (WM) (= Kelvedon Wonder), and a selection from a cross WM × VF, called Line 2 (L2), were sown on 17 September at distances of 7.5 cm in rows 75 cm apart. During the period of maturation all pods from plants in 60 cm of row were harvested in duplicate, and harvests were repeated with intervals of at least two or three days.

1965. Above mentioned varieties were sown on 3 September in plots with the same distance between rows, but the distance in the rows was 5 cm. All pods from plants in rows of 180 cm length were harvested in sixfold. Harvest was repeated periodically during the period of maturation.

1966. Peas of a mixture of very similar 'top bearing' breeding lines from the cross WM × VF were sown on 18 August at distances of 5 cm within the row. They were harvested at five dates and consisted of picking, in duplicate, all pods of plants in 180 cm of row.

Method of maturity determination

Pods were classified according to their maturity as follows:

Stage a : Pods small and completely flat.

Stage b : Pods swelling but only in the dorsal region and cannot be split open.

(Both Stage a and Stage b are of no interest in this paper, but will be referred to in a subsequent paper.)

Stage c : Pods not fully filled, but they can be split open. Peas small, very tender, sweet and juicy.

Stage d : Pods of approximately normal shape and thickness, and evenly green and smooth. Peas tender, sweet and of approximately full size.

Stage e : Pods still green and smooth and completely filled, but losing chlorophyll in streaks along both sides of the ventral suture. Peas rather tender but losing their sweetness.

Stage f : Pods still rather green but losing more chlorophyll along the ventral suture. The whole surface of the pod losing its smoothness. Peas have lost most of their tenderness.

Stage g : Pods lose more chlorophyll and their surface is rough and reticulated.

Stage h : Pods yellowing.

Stage i : Pods completely yellow.

Stage j : Pods dry and leathery.

After separating the pods into the various maturity stages, the pods as well as the peas were counted and weighed. The alcohol-insoluble solids (AIS) content of the

peas of each maturity class was determined. In 1964 and 1965 a simplified determination of AIS was carried out as follows.
Peas of samples of 10 g were halved and extracted for half an hour in 200 ml of boiling 80% ethanol. The alcohol was filtered under suction through a weighed filter paper and the residue was dried overnight at 70°C. With this method the extraction of the alcohol-soluble solids was not complete, which was shown by the fact that a small part of the chlorophyll stayed in the peas, especially in the older ones. Comparison with the more reliable official method in which the peas are pureed in a blender before the extraction, showed that the percentage AIS found with the simplified method was generally 2–3 units higher than with the official method. The official method was followed in 1966.
Since the weight of the peas in each maturity class was known, it was possible to calculate the (weighted) average AIS of the crop at each harvest date.
The visual maturity of the crop at each harvest date was determined by multiplying the number of pods in Stage c by 1, in Stage d by 2, adding these products and dividing them by the total number of pods.

Results

Overall relation between AIS of seeds and maturity of pods during harvesting period
Correlation coefficients between average AIS of the seeds and average maturity of the pods were calculated for all individual field samples. These results as well as the regression equations are shown in Fig. 1.
Statistical analysis showed that differences in slope of the lines were insignificant,

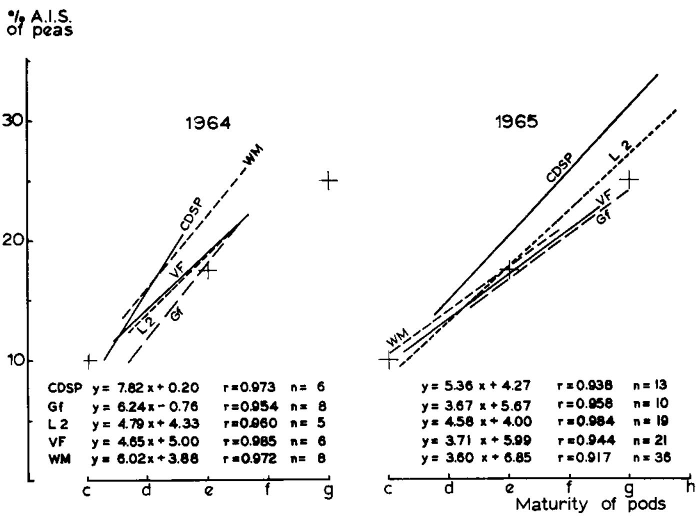

Fig. 1 Relation between average maturity of pods and average AIS of peas of field samples (all varieties)

but that the level of the line of 1966 was significantly lower than the level of the lines of 1964 and 1965. Undoubtedly this difference in level has been caused by the fact that in 1966 the extraction of the alcohol-insoluble solids was more complete than in 1964 and 1965, due to the difference in the extraction methods. The difference of 2–3 percentage units between both methods as found experimentally (see Methods) is visible in the difference in elevation in Fig. 1. Therefore it can be said that the average maturity of field samples based on a visual judgment of the maturity of the pods gave on the whole a reliable and stable indication of the average alcohol-insoluble solids of the peas.

Behaviour of the varieties

Although on the whole the relation between AIS of peas and visual maturity of pods seemed to be fairly constant, an important question is whether all varieties behave in the same way under different conditions. Therefore the correlation coefficients and regression equations have been calculated for the individual varieties (Fig. 2).

Two varieties showed significant differences between years. The regression line of Greenfeast (Gf) was significantly steeper in 1964 than in 1965 but the elevations were the same, whereas the line of William Massey (WM) was both steeper and on a higher level in 1964 than in 1965.

In 1964 the line of Cooper's Dark Skin Perfection (CDSP) was significantly steeper than those of Victory Freezer (VF) and Line 2 (L2), whereas in 1965 CDSP and L2 both showed steeper regression lines than the remaining varieties.

In 1964 the line of Gf was on a lower level than those of the remaining varieties, and the lines of CDSP and WM were on a higher level than L2 and VF. In 1965 the line of CDSP had a higher level than the remaining varieties, but also the differences in elevation between L2 and Gf was significant.

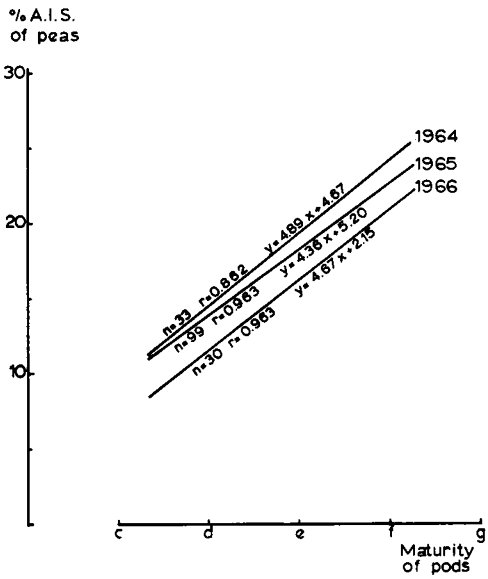

Fig. 2 Relation between average maturity of pods and average AIS of peas of field samples of different varieties

It seems that CDSP is a variety which differs in behaviour from the remaining ones. It has to be picked in an earlier stage than is indicated by the maturity of the pods. The results of WM were in agreement with Gf, L2 and VF in 1965, but not in 1964.

Optimal harvest date

An important test of the usefulness of the visual maturity assessment is whether the optimum harvest date determined with this method gives sufficient agreement with the optimum harvest date calculated from the course of the average AIS of the crop. According to Scheltema et al. (1961) and Torfason et al. (1956) the optimum harvest date can be defined as the moment the average AIS of a crop is 12%. At an AIS of 14%, peas are only just acceptable. As the simplified determination of AIS gives values 2–3 units higher than the official method, the critical percentages were in our samples 15 and 17%. The harvest dates on which these percentages are reached are called optimal harvest date (OHD) and last possible harvest date (LHD). They have been found by interpolation in graphs in which the average AIS of the crop was plotted against date. The corresponding average maturity of the pods was found by similar graphs in which the average maturity of the pods was plotted against date. In Table 1 the results are shown.

As was to be expected from the regression lines in Fig. 2, the visual maturities of varieties showed clear differences at one and the same level of AIS content. In both years pods of CDSP had a younger appearance, whereas pods of Gf looked older than most other varieties. Some of the varieties, however, showed a behaviour which was not consistent, such as WM and L2.

On the average, pods had an older appearance in 1964 than in 1965 at the same level of AIS content, but esspecially at 14% AIS. From the graphs in which the average maturities of the pods of the field samples were plotted against the date, approximations of OHD and LHD were obtained. In principle, it would be necessary to use different levels of visual maturity for each variety in each year to find the exact OHD and LHD, but this would not be practical as long as it is not known whether there is any constancy in the relation between visual maturity and AIS within varieties grown under different conditions. Therefore constant levels of visual maturity were chosen to obtain an approximation. These levels were visual maturities of 2.20 and 2.60. Table 2 gives the resulting dates.

Table 1 Optimal harvest date (OHD) and last possible harvest date (LHD) of green peas as determined by the AIS of the crop, and the average maturity of the pods at these dates

Varieties	*OHD (= 12 % AIS) (... Dec.)*		*Average maturity* of pods at OHD*		*LHD (= 12 % AIS) (... Dec.)*		*Average maturity* of pods at LHD*	
	1964	*1965*	*1964*	*1965*	*1964*	*1965*	*1964*	*1965*
CDSP	16.4	11.9	1.97	2.03	19.0	12.7	2.16	3.52
Gf	19.5	12.7	2.38	2.38	21.0	13.7	2.54	3.02
L2	10.3	8.3	2.16	2.40	13.5	10.9	2.49	2.90
VF	16.3	9.1	2.15	2.12	18.5	11.0	2.55	2.70
WM	4.0	2.4	1.85	2.18	6.3	6.2	2.08	2.83

* Stage c = 1, Stage d = 2, etc.

Table 2 Approximation of the optimal harvest date (OHD) and last possible harvest date by application of the visual method of maturity determination, and the deviation in days from the dates as found by the AIS method

Varieties	*Average maturity* of pods 2.20 (... Dec.)*		*Later or earlier than OHD (days)*		*Average maturity* of pods 2.60 (... Dec.)*		*Later or earlier than OHD (days)*	
	1964	*1965*	*1964*	*1965*	*1964*	*1965*	*1964*	*1965*
CDSP	19.1	12.3	2.7	0.4	24.1	12.8	5.1	0.1
Gf	18.3	12.2	—1.2	—0.5	21.0	12.9	0	—0.8
L2	11.0	7.7	0.7	—0.6	14.2	9.9	0.7	—1.0
VF	16.6	9.4	0.3	0.3	18.9	10.8	0.4	—0.2
WM	7.1	2.0	3.1	—0.4	9.0	5.7	2.7	—0.5

* Stage c = 1, Stage d = 2, etc.

Although in 1964 harvest dates of CDSP and WM were clearly too late, if determined by the chosen levels of maturity of the pods, the general agreement is good — since the correlation coefficient over both years between optimal harvest dates and dates of maturity 2.20 was 0.967 and the one between the last possible harvest dates and dates of maturity 2.60 was 0.948 (n = 10).
To determine whether differences in earliness between varieties were significant, an analysis of variance was carried out with the results of both methods of determination of harvest dates. They gave virtually the same results. In 1964 the varieties CDSP, Gf and VF were significantly later than L2, and L2 was significantly later than WM both at OHD (or at maturity 2.20) and LHD (or at maturity 2.60). By determining the OHD with the help of the AIS content, an additional separation was that Gf was significantly later than both CDSP and VF, which was not found with the determination of visual maturity.
In 1965 the varieties Gf and CDSP were significantly later than the remaining varieties, of which WM was significantly the earliest. In this case an additional separation was given at maturity 2.20, i.e. that VF was significantly later than L2.
Another test for the usefulness of the method is whether during the harvesting period differences in increase in maturity between varieties are found by both methods, and whether the visual method shows sufficient agreement with the official one. In Table 3 the maturity increases at approximately the optimal harvest date are given.

Table 3 The increase in average AIS and in average maturity of the crop in the course of the harvesting period

Varieties	*Increase in average AIS per day*		*Increase in visual maturity per day*	
	1964	*1965*	*1964*	*1965*
CDSP	0.95	2.47	0.08	0.74
Gf	1.30	2.27	0.23	0.54
L2	0.80	0.73	0.14	0.21
VF	0.90	1.10	0.22	0.33
WM	0.95	0.57	0.20	0.21

As the correlation coefficient between both series of results in Table 3 is 0.954, it is clear that the agreement over both years is good. If results of both years are considered separately, it appears that the agreement was much better in 1965 than in 1964. Probably this has been caused by the small size of samples and the small number of replications in 1964. Also the fact that a variance analysis of the rate of maturation in 1964 did not show significant differences between varieties with either method, points in this direction. The variance analysis with the results of 1965, however, showed that the maturity of CDSP and Gf increased significantly faster than the maturity of the other varieties.

Discussion

The fact that in 1964 the harvest dates as determined by the visual method differed in some cases several days with the harvest dates as found by the AIS of the crop does not seem satisfactory. The reason for this may have been that in that year samples were small and the number of replications only two. Nevertheless, the regression lines in Fig. 2 show that the relation between maturity of pods and AIS of peas need not be the same for all varieties. It is possible that in future a better agreement is obtained by placing the limits of average maturity of pods at different levels for different varieties or groups of varieties.

Two important questions remain to be answered. The first is whether the relation between AIS and quality is a fixed one for all varieties. Literature on this subject, however, is scarce. Results of Kramer et al. (1950) point to the fact that this relation is not necessarily the same for all varieties. On the whole, they found a correlation coefficient between these characteristics of 0.90, but after splitting up their material into varieties, the correlation coefficients varied from 0.96 to 0.99. This means that the elevation or the slope (or both) of the regression lines of varieties differed, giving a swarm of dots which was wider for the whole material than for the varieties separately.

The other question is whether the agreement found between the results of the visual method and AIS is inferior to the one between the results of mechanical methods and AIS.

Kramer et al. (1950) found that at identical tenderometer values Alaska peas always had a higher AIS than peas of the variety Thomas Laxton. The results of Torfason et al. (1956) indicate that at a tenderometer value of 100 the variety Climax had an AIS of 11.0%, the variety Wisconsin Early Sweet a content of 11.7% and the variety Lincoln a content of 12.8%. This is entirely comparable with our results. In 1965, for instance, at an average pod maturity of Stage d, L2 had an AIS (determined by the simplified method) of 13.2%, WM 14.0% and CDSP 15.0%. Lee et al. (1954) found that at a tenderometer value of 110 the variety Wyola contained 11.9% AIS but the variety Thomas Laxton 14.4%. Similar results were obtained by Hoogzand et al. (1960–61). Scheltema et al. (1961) found differences in AIS content at the same maturometer value, depending on size of the peas and year.

This shows that the relation between AIS content and the results of mechanical methods — and, probably, also between AIS content and quality as assessed by sensory methods — is not as static as generally seems to be assumed, and that the method of visual maturity judgment is, in this respect, the same.

The advantage of assessing the maturity visually is that this method, in contrast with all other methods, is non-destructive. This means that the course of maturity can be followed for individual plants, without removing the pods. This might be of interest for selection work in breeding programs. An additional advantage is that with this method data can be obtained about the spread in maturity within a group or even on individual plants. This aspect, however, will be discussed in Part II (to be published in No 4 of this volume).

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