A deformity of apples of unknown origin

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In the 1978 season, deformed apple fruits with longitudinal furrows running from the calyx to stem end were observed in eleven cultivars in the Georgian Bay district and in one cultivar in the Simcoe district of Ontario. The most severely deformed cultivars were 'Idared', 'Cortland', and 'Jonadel'. Severely deformed fruits were acceptable only for juice, causing an estimated $500.000 loss to growers in the Georgian Bay area. The cause of the deformed fruit is not known, but fluctuating temperature during cold acclimation and/or low temperature injury to seeds in developing fruit are suspected.

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Au cours de la saison de 1978, des sillons longitudinaux allant de la cavite oculaire a la cavite pedonculaire sont apparus sur les fruits de onze cultivars de pommier dans les vergers de la region de la Baie georgienne (Ontario). La region de Simcoe a ete moins touchee. Les cultivars les plus gravement atteints etaient Idared. Cortland et Jonadel. Les fruits les plus forteinent deformes n'etaient plus bons que pour la production de jus, occasionnant ainsi des pertes de pres de $500 000 aux pomiculteurs de la region. La cause de la difformite est encore inconnue mais on soupçonne les fluctuations de temperature survenues au cours de la phase d'acclimatation au froid, ou encore des dégâts causes par le froid aux graines des fruits en cours de developpement.

Introduction

In 1966 Davidson and Allen reported the presence of deformed apple fruits in the Georgian Bay (Collingwood) area of Ontario. Deformed fruits were fluted at the blossom end with pronounced depressions to the fruit equator, and the stem cavity was often full. Deformed fruit were observed in six cultivars with most damage occurring on 'Delicious', and 'Cox's Orange Pippin', least on 'Golden Delicious' with 'McIntosh', 'Cortland' and 'Jonadel' showing an intermediate level. Damage was confined to the Georgian Bay district of Ontario.

In the early summer of 1978, it became obvious that as apple fruits developed across Ontario many were misshapen, particularly in the Georgian Bay and Eastern Ontario districts. There were also reports of sporadic winter injury to trees in these and other parts of the Province. In addition there were misshapen apple fruits in the Champlain Valley and Western New York districts of New York State (Blanpied and McNickolas, personal communication).

Because of the extent of the injury, a survey was carried out in two apple producing districts of Ontario. Fruit of the major cultivars were collected in these districts and examined in the laboratory, weather records were analyzed, and the economic loss was estimated.

Materials and methods

Apples were collected before harvest from four orchards in two apple producing districts of Ontario - Georgian Bay (Meaford/Clarksburg), 44°32.5'N, 80°28'W; and Simcoe, 42°51'N, 80°16'W, on the north shore of Lake Erie. In each orchard a 20 kg (1 bu) composite random sample was taken from four trees of each cultivar. The cultivars, 'McIntosh', 'Delicious' and 'Northern Spy' were sampled in all orchards, and in addition, samples of 'Cortland', 'Jonadel', 'Golden Delicious', 'Spartan', and 'Idared' were collected from some orchards.

These fruit were stored in cold storage at 1°C and 90 percent relative humidity until examined. Subsequently sub-samples of 20 fruit were taken from each sample and fruit length and diameter, stem length, deformity rating on a scale of: 1 - no deformity, to 5 - severe deformation (Fig. 1B), and the number of seeds in each fruit were determined.

The experiment was analyzed as a factorial in a completely randomized design.

Results and discussion

The major characteristic of the deformed fruit was longitudinal furrowing running from the calyx to the stem end (Fig. 1A). A range of severity of this furrowing was observed within cultivars and is illustrated for 'Idared' in Fig. 1B. The furrows were often so deep that the fruit were not only unacceptable for the fresh market but unsuitable for peeling as slices and sauce. This meant that they could be sold only as juice apples and therefore brought low returns to the grower

Economic loss

It is difficult to estimate economic loss. Insurance claims were made by some growers through the Ontario Ministry of Agriculture and Food's Crop Insurance Commission (Mr. W. Regan, personal communication). One packing-house reported an increase in cullage from

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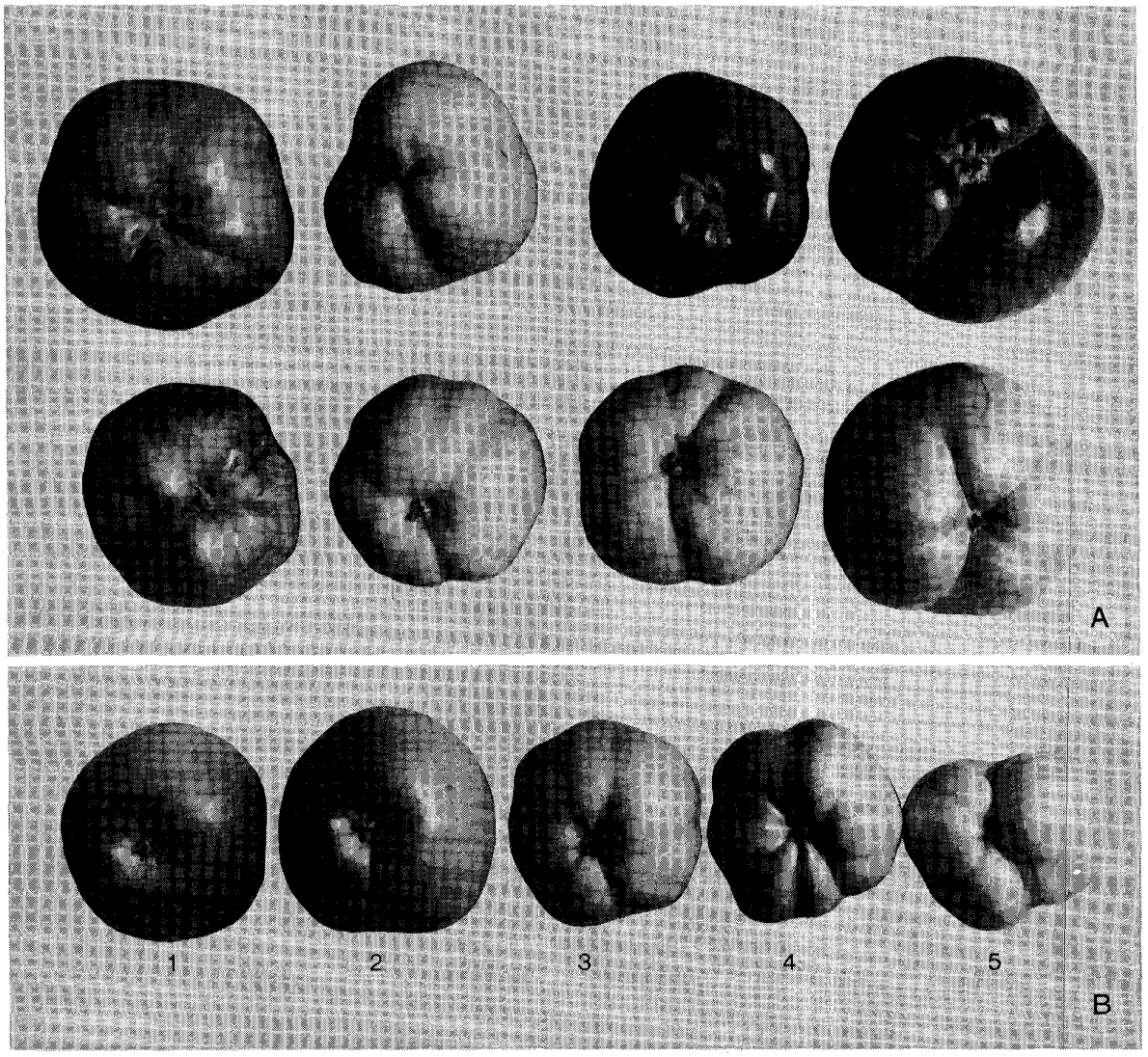

Figure 1 (A and B). (A) Misshapen apple fruits of eight cultivars from Georgian Bay, Ontario. Top row, left to right, McIntosh, Jonadel, Spartan, Cortland; bottom row, left to right, Delicious, Idared, Golden Delicious and Northern Spy. (B) Deformity rating scale using Idared as the example; 1, no deformity; to 5, extreme deformity.

the normal 20 percent to 50 percent (J. Denbok, personal communication). A conservative estimate of crop loss would be about 10 percent of the total crop in the Georgian Bay district. Translated into economic value this would be about $500,000.

Damage by districts

Fruit from Georgian Bay were more severely deformed than those from Simcoe (Table 1). Other differences in fruit occurred between districts. Fruit length and diameter were greater in Simcoe but this is only a measure of fruit size in relation to geographical location. Length-to-diameter ratios for fruit from Georgian Bay and Simcoe are essentially the same suggesting no difference in shape. Fruit pedicel length was also different in the two districts but the reason for this is not known.

Fruits from Georgian Bay had fewer seeds than fruits from Simcoe (Table 1A). Seeds are known to play a role in fruit growth and development so the relationship between seed number and deformity class was investigated. In three of the cultivars there was a significant correlation coefficient in the regression analysis of deformity class on seed number (data not presented). This would suggest some relationship between seeds and fruit deformity. Some of the deformity may be due to seed injury early in the growing season possibly inducing an imbalance in the endogenous plant hormones involved in fruit growth.

Table 1 (A). Mean values by district for deformity class, seed number, pedicel length and fruit length and diameter. **All** paired values for locations are significantly different at the 0.05 level of significance.

District	Deformity class*	Seed number	Pedicel length (cm)	Fruit	
				length (cm)	diameter (cm)
Georgian Bay	2.50	6.23	21.38	5.39	6.54
Simcoe	1.05	8.41	19.19	5.58	6.87

(B). Cultivar differences by deformity class* in both districts.

Delicious	McIntosh	Northern Spy	Spartan	Golden Delicious	Idared	Cortland	Jonadel
1.57+	1.59	1.68	1.75	2.05	2.22	2.40	3.15

***Deformity classes - 1, no deformity, 5 extreme deformity. See Fig. 1B for examples of the classes.**
+Means underscored by the same line are not significantly different at the 0.05 level of significance.

The significant district x cultivar interactions for deformity class and seed number indicate more damage to the susceptible cultivars in the Georgian Bay area than in the Simcoe area.

Cultivar sensitivity

Deformed fruit were observed on 11 cultivars in the Georgian Bay district and only on 'Idared' in the Simcoe district (Fig. 1 and Table 1). Cultivars not included in Table 1 but which bore misshapen fruit were 'Lobo', 'Jerseymac' and 'Rhode Island Greening'. This extends Davidson and Allen's list of six cultivars to 12 and includes the "newer' cultivars 'Spartan' and 'Idared' (Proctor 1979). The deformity of 'Idared' in the Simcoe district has been observed there for 8 years (Proctor, unpublished data) and is particularly obvious during early fruit growth. 'Idared' was selected from the cross 'Jonathan' x 'Wagener' and since 'Wagener' fruit are sometimes misshapen (Beach 1905) 'Idared' may have inherited this characteristic from 'Wagener'. Other cultivars severely damaged were 'Cortland' and 'Jonadel' (Table 1B).

Within the Georgian Bay district fruit damage was less at 270 m elevation and remote from the lake, than at 210 m elevation and closer to the lake. This would suggest spring frost damage due to lack of drainage of cold air. Good air drainage within the affected orchards, deformed fruits at all heights within trees and temperature data at bloom time do not support the idea of damaging spring frosts.

Spontaneous sports. Einset and Pratt (1959) reviewed the histories and descriptions of sports with misshapen fruits. In general, sports are confined to a limb or limbs of a single tree and not to many whole trees within large producing areas hundreds of kilometers apart. In addition the major incidence of this deformity in 1966 (Davidson and Allen) and again in 1978, with occasional deformities occurring each year, does not support the definition of a sport which implies a new characteristic which is perpetuated. However, the susceptibility of cultivars to the conditions which cause this injury is obviously genetic in nature.

Temperature fluctuations during cold acclimation. This is another possible causal agent. During early November 1977 in Simcoe and Georgian Bay daily minimum temperatures were around **8°C** rather than the normal 0°C. About the middle of the month in both locations there was a sudden drop to around -5°C. Subsequently there were above normal maximum and minimum temperatures with a pronounced fluctuating temperature regime in the Georgian Bay area which continued into December. Ketchie and Beeman (1973) have shown the importance of sustained low temperature in development of cold resistance. It could be that the temperature fluctuations during November and December injured the overwintering flower buds in the Georgian Bay area. Certainly this was the case for vegetative growth during the 1977-1978 winter.

Conclusion

The incidence of this deformity appears to be related to fluctuating fall and early winter temperatures and subsequent failure of the seeds to develop. Further investigation of this phenomenon is needed. This can be achieved **by** careful documentation of the incidence of misshapen or deformed fruit as done initially by Davidson and Allen (1966) and analyses of pertinent weather records. The widespread nature of this disorder suggests that it could be economically important in some years. It may be possible to avoid some of this economic loss by choice of cultivar.

Acknowledgments

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