Cracking of Golden Russet apples

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Extensive early season fruit cracking of Golden Russet apple was observed in the 1979 season in central and south-western Ontario. Cracking consisted of deep (up to 10 mm), long (up to 40.3 cm) and wide (up to 20 mm) equatorial furrows containing easily detached cork tissue, and occurred mainly on the stem half of the fruit. Similar cracking was observed on Roxbury Russet and a Minnesota selection (Minn. 1734) but not on Pomograte Russet (also called Swayzie Russet). Cracked fruit were suitable only for processing into juice. Fruit cracking was more severe in trees on the more dwarfing rootstocks, which were also younger and bore fewer fruits per cm of trunk circumference. Cracking appears to be related to crop load and fluctuating water supply in the early part of the growing season.

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Durant la periode de croissance de 1979, on a releve dans le centre et le sud-ouest le l'Ontario de nombreux cas de craquelure precoce du fruit qui consistait en l'apparition, surtout sur la moitie pedonculaire du fruit, de fissures equatoriales profondes (jusqu'à 10mm), longues (jusqu'à 40.3 cm) et larges (jusqu'à 20 mm) contenant du tissu subereux facilement detachable. Des symptômes semblables ont été observes sur la Roxbury Russet et une selection du Minnesota (Minn. 1734), mais non sur la Pomograte Russet (Swayzie Russet). Les fruits abimes ne se prêtaient qu'a la fabrication de jus. La craquelure était plus grave chez les arbres greffes sur porte-greffes les plus nanisants qui egalement etaient plus jeunes et qui portaient moins de fruits par centimetre de circonference du tronc. Cet accident serait associe à la charge de la recolte et à une fluctuation dans l'apport d'eau au debut de la periode de croissance.

Introduction

Golden Russet is an apple cultivar which is not grown extensively in Canada (Proctor, 1979) but brings high returns in the market place because of its high quality and easy consumer identification. Production of Golden Russet in 1976 was about 454 tonnes (1,000,000 lb) (Proctor, 1979), and the 1976 Ontario Fruit Tree Census for apples showed only 3,784 trees of this cultivar. For estimates of monetary returns a survey of Guelph supermarkets on January 2, 1980 showed that fancy grade Golden Russet apples cost 30 percent more than fancy grade McIntosh. Because of these high returns Golden Russet is being planted on size controlling rootstocks, although relevant data are not separated from "Other Varieties" in the 1976 Ontario Census (Ontario Ministry of Agriculture and Food, 1976).

From August to September 1979 we received numerous enquiries and fruit samples from growers of Golden Russet requesting an explanation for the relatively high incidence of fruit cracking. Because of the extent of the damage we surveyed a number of orchards in central and south-western Ontario, examined fruit in the laboratory, and analyzed weather records.

Materials and methods

Seven orchards in central and south-western Ontario were visited just prior to harvest and records of Golden Russet trees and fruits made (see Table 2 for details). Fruit from 4 trees of one orchard (at Vineland Station) were harvested and stored at 1°C and 90 percent relative humidity until examined. Subsequently fruit weight, length and diameter, crack location, length, width at the widest point, depth at the deepest point, severity rating on a scale of: 1- no cracking, to 5 - severe cracking (Figure 1), and the number of seeds in each fruit were determined. Water absorption of detached apples and related cracking were studied by weighing each apple, submerging it in water for 2 days at room temperature (22°C), reweighing and recording the number and length of any cracks that developed.

The ranked data for cracking were analyzed using Spearman's coefficient of rank correlation (Steel and Torrie 1960, page 409).

Results and discussion

The most prominent features of the cracked fruit were equatorial furrows which in some cases branched and overlapped (Figure 1). Most cracks contained flakes of cork. The class 2 crack (Figure 1) is uncharacteristic because it was longitudinal rather than equatorial but such cracking did occur sometimes. Some of the fruit received from home gardeners had scab lesions in the furrows indicating poor spray control programs.

The cracking and associated cork made the fruit unacceptable for the fresh market. Removal of the damaged area by automated peelers would mean excessive waste. This means that they could be sold only as apples for processing into juice and therefore would bring low returns to the growers. It is difficult to estimate economic loss because considerable variation in cracking occurred (see below and Table 2). Because of the premium prices paid for this cultivar in the fresh market, but not in the juice market, the loss per kg would be greater than for other cultivars such as McIntosh and Delicious.

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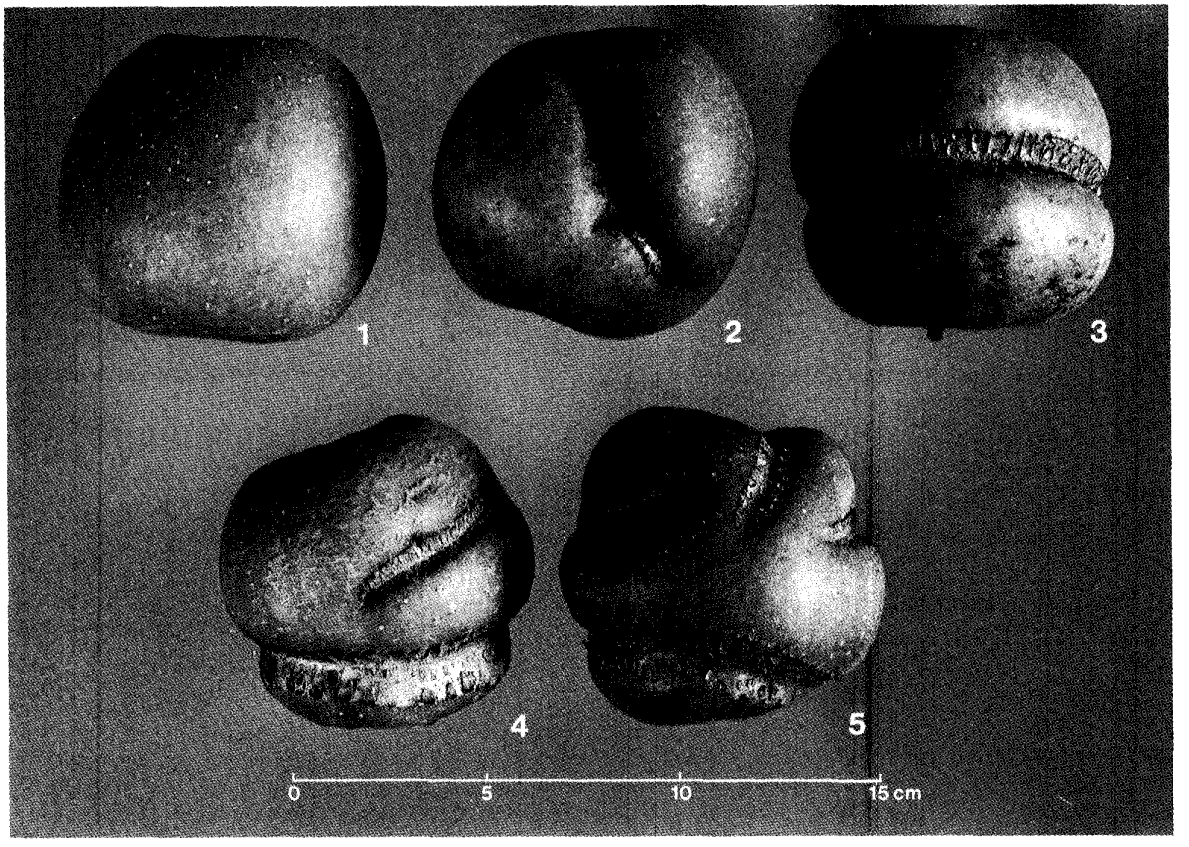

Figure 1. Cracked apples of Golden Russet arranged in a rating scale of 1, no cracking, to 5, extreme cracking,

Sixty percent of the Golden Russet fruit on 4 trees on M.26 rootstocks at Vineland Station had some cracking (Table 1), most falling in class 3 (Figure 1). Spearman's correlation coefficient for ranked data (Steel and Torrie 1960) showed significant relationships between crack rating and all the fruit and crack variables measured (Table 1B). The more damaged the fruit the smaller and lighter it was and the fewer seeds it contained (Table 1). Damage was mainly on the stem half of the fruit although cracks on severely damaged fruit covered the entire apple (see class 5 in Figure 1).

Induction of cracking *in* harvested apples. Previous work (Verner, 1935) has shown that cracking of detached Stayman Winesap apples could be induced by submerging harvested fruits in water for 2 days. In his work 66 percent of the fruit cracked and the average weight gain and total length of cracks were 2.32 percent and 3.11 cm, respectively. Using a similar technique with Golden Russet revealed that 20 percent of the fruit cracked, and the average length of the crack was 0.50 cm. The cracks were unlike those observed in the orchard, being longitudinal and more like those late season cracks seen on Orenco and illustrated for Stayman Winesap by Halfacre and Barden (1979).

Orchard survey. The survey of orchards (Table 2) showed relatively recent planting of trees on the newer, size controlling rootstock, M.26 (Proctor *et al,* 1974). These trees carried fewer fruit, even when expressed per unit trunk circumference, and had the highest percentage of cracked fruit.

The exact cause of the fruit cracking is not known. It is not thought to be due to a virus (T.R. Davidson, personal communication). The fruit cracking observed on Orenco and described for Stayman Winesap by Halfacre and Barden (1979) and Verner (1935) occurs late in the season just before harvest. In this work cracking of Golden Russet was observed in the orchard in late June and early July, and the wound healing and subsequent cork formation would confirm this. Bell (1938) reported that in early July in Golden Russet a cambium is initiated in the innermost cells of the epidermis and very quickly cells from it differentiate into cork. It could be that at this important stage of fruit growth and development, any stress leading to cracking and death of exterior tissues could result in stimulated activity of this cork cambium and abundant production of cork as seen here.

A possible stress in the 1979 growing season was water supply. There was no precipitation at Vineland Station from June 12 to June 26 (inclusive), an uncommon event. Brown *et al* (1968) predict for St. Catharines, the closest (about 10 km) weather station reported, that such a dry period will

Table 1 (A). Ranking at 274 Golden Russet apples from 4 trees on M. 26 at Vineland Station based on crack rating and the means for several characteristics of the fruits within the various ranks.

Crack Rating*	Percent Of Apples In Rank	Fruit			Crack				
		Weight (g)	Length (mm)	Diameter (mm)	Length (mm)	Width (mm)	Depth (mm)	Position+	Seed No.
1	40	188.90	64.10	74.29	0	0	0	0	5.48
2	8	172.80	62.77	72.23	88.86	8.95	3.41	S	5.23
3	20	153.73	62.38	68.71	176.00	10.78	5.46	S	4.78
4	15	149.37	62.46	68.54	208.88	11.49	6.03	S	4.93
5	17	147.57	60.91	68.36	276.87	12.62	6.24	S&C	4.38

(B). Regression data for crack rating with the variables listed. In all cases the number of apples was 274.

Variable	Spearman's Correlation Coefficient	Level Of Probability Of Obtaining A Greater Correlation Coefficient
Fruit Weight	−0.44	0.0001
Fruit Length	−0.22	0.0002
Fruit Diameter	−0.43	0.0001
Crack Length	0.95	0.0001
Crack Width	0.85	0.0001
Crack Depth	0.87	0.0001
Seed Number	−0.23	0.0001

"See Figure 1 for examples of the crack ratings.
+S = stem half of the fruit. C = calyx half of the fruit.

Table 2. Characteristics of Golden Russet trees and fruits at various locations in central and south-western Ontario at harvest in October 1979*.

Location	Soil Type	Tree			Fruit		
		Age	Root-stock	Trunk Circumference (cm) at 30 cm above soil	Number per tree	Percent cracked fruit	Rating of fruit crack-ing(+) per location
Delhi	Sandy loam	4	M.26	16.1 ± 0.9§	28.5 ± 11.2	11.0	2.0 ± 0.0
Vineland Station	Fine sandy loam	12	M.26	28.2 ± 4.1	68.7 ± 19.6	60.0	3.5 ± 0.3
Burlington	Silt loam	6	M.26	22.5 ± 1.2	172.0 ± 29.2	16.4	2.4 ± 0.2
Rockwood (1 tree)	Gravelly loam	10	M.7	33.0	80.0	20.0	2.5
Belwood 1	Fine sandy loam	15	M.7	50.2 ± 2.7	270.0 ± 14.1	25.2	2.5 ± 0.7
Belwood 2	Fine sandy loam	30	Sdlg	71.4 ± 8.7	1420.0 ± 168.1	3.4	2.0 ± 0.0
Guelph (1 tree)	Sandy loam	40	Sdlg	86.4	152.0	9.2	2.0
Simcoe	Clay	18	Sdlg	98.2 ± 8.7	755.0 ± 161.0	1.4	3.2 ± 0.3

*Data are the means for 4 trees except where noted.
+Rating of cracking - 1, no cracking to 5, extreme cracking. See. Figure 1 for examples of the classes.
§±Standard error.

occur only 5 times in 40 years. While the fine sandy loam at Vineland Station does not vary markedly in its water holding capacity with soils at other locations (Table 2), except possibly the clay at Simcoe, the unusual extended dry period at this time could result in a period of little change in fruit size which followed by the rain reported for 4 consecutive days could have resulted in rapid fruit enlargement and associated cracking. The smaller crop load on trees on M.26 rootstock and the sudden availability of water could also have been a factor inducing cracking.

Cracking of other cultivars. A survey of apple cracking in the Canadian Centennial Museum Orchard at the Horticultural Research Institute of Ontario, Vineland Station, revealed symptoms similar to that on Golden Russet on Roxbury Russet and a Minnesota selection (Minn. 1734) but not on Pomograte Russet (also called Swayzie Russet). For a complete listing of cultivars in this orchard see reference 5. A different type of cracking, illustrated by Halfacre and Barden (1979), and characteristic of Stayman Winesap, was observed on Orenco.

Conclusions

There will be continued production of Golden Russet apples in Canada to meet a continuing and increasing consumer demand resulting in a premium price in the market place. In some years fresh fruit may be suitable only for juice because of cracking presumably due to fluctuating water supply. However, if this is verified as the cause of cracking, more judicious choice of rootstock and soil type, and the use of irrigation may be crucial to, and sound economically, for growers of Golden Russet.

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