HORTSCIENCE 30(2):234–235. 1995.

Mechanical Harvesting and Dehulling of Six Strawberry Cultivars after Four Hand-pickings

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Additional index words. Fragaria ×ananassa, fruit size, processing, breeding

Abstract. **An experiment was conducted to evaluate the mechanical harvesting and processing suitability of four standard strawberry [*Fragaria ×ananassa* (Duch.)] cultivars ('Kent', 'Glooscap', 'Bounty', and 'Midway') and the recent introductions 'Chambly' and 'Oka'. 'Kent', 'Glooscap', 'Oka', and 'Chambly' had the highest yields and heaviest fruit. Similar percentages of berries of all cultivars were destroyed by the harvester. 'Oka' and 'Midway' were not suitable for this type of mechanical harvesting due to their susceptibility to bruising during harvest. Based on total marketable fruit harvested mechanically, 'Chambly' was the most and 'Oka' was the least adapted cultivars for this particular harvester. 'Chambly' and 'Glooscap' were easiest to decap, followed by 'Bounty', 'Oka', and 'Midway'. None of the cultivars tested were suited ideally for machine harvesting, and further breeding is required to produce well-adapted cultivars.**

Canada imports 40,000 t of strawberries annually, of which ≈7000 t are frozen berries used for processing and are worth more than $6.5 million (Can. $9 million). These imports could be replaced by Canadian-grown fruit if improved cultivars, suitable for mechanical harvesting and processing and adapted to Canada's wide variety of climatic conditions, were available. Despite Quebec's position as a strawberry-growing region that produces one-third (10,000 t) of the total Canadian production [about $3.7 million (Can. $50 million) (Statistics Canada, 1991)], Quebec produces almost no strawberries for processing. Most Canadian-grown processing berries are produced in British Columbia. In 1991, the Quebec processing industry used 3000 t of imported frozen berries and pulp that could have been grown by local producers.

Received for publication 29 Nov. 1993. Accepted for publication 10 Sept. 1994. Agriculture Canada contribution no. 3. We thank Michel Johnson, Susan Féchette, and C. Guy-Adam for their technical assistance. This study was supported by research grant 1A1-675200117-003 from Entente Auxiliaire Canada-Quebec. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

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Mechanical harvesting and dehulling is a necessity in areas where there are labor shortages or where there is no outlet for smaller, pick-your-own or fresh-picked wholesale berries. There have been many attempts to develop strawberry harvesters (Booster, 1980; Hansen and Ledebuhr, 1980), and researchers have studied the feasibility (Lauro, 1986) and cost of mechanically harvesting strawberries (Seecharan et al., 1988). Several harvesters have been developed, and some of them have been commercialized (Hansen and Ledebuhr, 1980; Hecht, 1972; Morris et al., 1978). In most cases, it is necessary to have a flat, level bed to present the fruit to the harvester on a flat plane. Although once-over harvesting is often preferred (Dale, 1983; Ricketson, 1969), most producers would like to hand-pick early, high-quality, large fruit and only use a harvester for the later small fruit. Small berries are well suited to machine harvesting; large berries bruise more easily (Denisen and Buchele, 1967). Certain plant characteristics are prerequisites for successful mechanical harvesting: 1) brittle pedicels, 2) easy decapping, 3) concentrated ripening, and 4) firm fruit (Khanizadeh and Fanous, 1992; Khanizadeh et al., 1992b). Breeding programs select for these characteristics in an attempt to produce cultivars adapted to mechanical harvesting

Our study was conducted to determine if it is feasible to harvest the crop portion that often remains unharvested after three to four hand-pickings and to evaluate suitability for mechanical harvesting and dehulling (decapping) of the two recently released cultivars Chambly and Oka (Khanizadeh, 1994; Khanizadeh et al., 1990, 1992c) compared to four standard cultivars.

Materials and Methods

The experiments were conducted at Lavaltrie, Quebec (lat. 45°N), and at a 46-m altitude in a sandy soil and a continental climate. A randomized complete-block design with four replications was used to evaluate the four standard cultivars ('Kent', 'Glooscap', 'Bounty', and 'Midway') and the recent introductions 'Chambly' and 'Oka'. The field was prepared in 1990 and leveled to present the fruit to the harvester on a flat plane. Plants were set 30 cm apart in a single row in 30-m-long plots, spaced 120 cm apart and watered immediately with 250 ml of a fertilizer solution (10 N–52 P–10 K) per plant. Flowers were removed twice, and all runners kept and spaced within the 50-cm-wide matted row. In November, the plants were mulched with straw to a depth of 6 to 7 cm for winter protection. In early spring of each year, the rows were rolled to level the surface. 'Chambly', 'Glooscap', Kent', and 'Midway' (early and midseason cultivars) were hand-harvested on 18, 21, and 25 June, followed by a once-over machine harvest on 27 June. 'Oka' (an early midseason cultivar) was hand-harvested on 18, 21, 25, and 27 June, followed by a once-over machine harvest on 7 July. 'Bounty' (a late cultivar) was hand-harvested on 21, 25, and 27 June, followed by a once-over machine harvest on 7 July. A similar schedule was used in 1992; however, the harvest started 2 days earlier. The strawberry harvester used in our trials was a tractor-drawn prototype (Khanizadeh et al., 1994).

In each hand-harvest, we collected fruit from a 30-m-long bed in each block. Average fruit weight was calculated by averaging the weights of 50 randomly selected fruit in each harvest.

Berries were decapped on an older Canners Machinery model. For this type of decapper, berries must have a weak stem-end and calyx attachment like those in 'Glooscap' and 'Chambly'. In operation, washed strawberries move onto a conveyor, and a series of horizontally rotating rubber rollers grab and pull the calyx and stem end.

Data collected for each hand-harvest were combined for analysis of variance (ANOVA). Before ANOVA, percentage data were transformed using an arcsin, square-root, percent transformation. The ANOVA were done using the general linear model procedure (SAS, 1988). Least significant difference was used for mean separation between the cultivars.

Results and Discussion

Yields were similar in 1991 and 1992 (data not shown). 'Kent', 'Glooscap', 'Oka', and 'Chambly' had the highest field and fruit weights, but fruit weights were similar for

'Bounty', 'Chambly', and 'Kent' (Table 1). 'Bounty' and 'Midway' had poor yields, and 'Midway' also had low-weight fruit. 'Kent', 'Glooscap', and 'Chambly' produced the highest total marketable yield over all harvests (i.e., three or four hand-pickings + machine-harvested fruit).

Because there were differences between cultivars in terms of total yield, earliness, and concentration of ripening (Khanizadeh et al., 1992a), different quantities of berries were left in the field after the four hand-pickings. Due to its different production schedule, higher percentages of 'Bounty' strawberries were left in the field available to be mechanically picked, followed by 'Kent', 'Glooscap', and 'Chambly'.

To compare cultivar suitability for mechanical harvesting, an ANOVA was performed on the percentage of fruit left in the field after machine harvest. Similar percentages of berries of all cultivars were destroyed by the harvester (Table 2). 'Oka' and 'Midway' were not suitable for this type of mechanical harvesting due to their susceptibility to bruising during harvesting (Table 2). The percentage of nonmarketable fruit following mechanical harvesting did not differ significantly among cultivars, although 'Glooscap' had a lower percentage than the others (Table 2).

Based on total marketable fruit harvested mechanically, 'Chambly' was the most and 'Oka' was the least adapted cultivar for this particular harvester.

Because of insufficient fruit counts from each replication, mechanically harvested fruit from all the replications of a single cultivar were mixed before decapping. All the cultivars had a high proportion of berries with green stem ends (partially decapped) (Table 3). The proportion of partially decapped berries was high for 'Kent', 'Chambly', and 'Glooscap', followed by 'Oka', 'Bounty', and 'Midway'. Many 'Midway' and 'Oka' fruit were not decapped mechanically and required manual dehulling (Table 3). This result suggests that none of the cultivars tested are suited for machine harvesting, and further breeding is required to produce improved adapted cultivars.

Table 1. Total yield and fruit weight of the six strawberry cultivars that were hand-picked and that remained for a mechanical harvester in Lavaltrie, Quebec, Canada, 1991 and 1992.[z]

	Hand-picking		Berries remaining for mechanical harvesting	Hand-picked + mechanical harvesting yield[y]	
Cultivar	Yield	Individual fruit wt (g)		Nonmarketable	Marketable
Bounty	12.5 b	9.5 bc	12.8 a	3.9	18.7 c
Chambly	20.9 a	10.1 ab	7.1 bc	5.9	24.1 a–c
Glooscap	23.9 a	11.8 a	10.3 ab	4.4	29.8 a
Kent	24.6 a	11.3 ab	11.0 ab	7.0	28.6 ab
Midway	7.8 b	8.4 c	5.8 c	4.2	9.4 d
Oka	21.0 a	12.2 a	5.3 c	4.0	22.3 bc
$LSD_{0.01}$	5.4	2.9	4.3	NS	7.4

[z]Average of four replications.
[y]Yields in kilograms per 30 m of row.

Table 2. Fruit ripeness and marketability of six strawberry cultivars after using a harvester, 1991 and 1992.[z]

	Berries harvested mechanically			Berries remaining after using harvester			Fruit destroyed by harvester
	Marketable (%)			Marketable (%)		Nonmarketable	
Cultivar	Ripe	Green	Bruised	Ripe	Green	(%)	(%)
Bounty	18.7 bc	11.1 a	35.4 bc	12.3 ab	6.0 a	13.9 a	2.7 a
Chambly	38.7 a	7.9 ab	26.0 c	10.4 ab	2.1 c	11.2 a	3.6 a
Glooscap	28.7 ab	12.2 a	33.2 bc	13.6 ab	4.3 ab	5.5 a	2.5 a
Kent	25.9 b	3.5 bc	35.4 bc	17.0 a	2.6 bc	11.4 a	4.1 a
Midway	20.6 bc	2.3 c	45.8 a	10.5 ab	1.0 c	14.5 a	5.4 a
Oka	10.7 c	5.6 bc	56.0 a	8.1 b	4.5 a	14.4 a	6.6 a
$LSD_{0.01}$	12.1	4.5	19.3	7.8	1.8	9.5	4.3

[z]Average of four replications.

Table 3. Performance of six strawberry cultivars mechanically decapped using a Canners Machinery capper.[z]

	Decapped mechanically (%)			
Cultivar	Completely	Partially	Not decapped (%)	Nonmarketable (%)
Bounty	30	51	7	9
Chambly	2	75	3	20
Glooscap	6	75	8	11
Kent	9	80	8	3
Midway	12	41	17	31
Oka	26	53	11	10

[z]Analysis of variance was not performed on these data because the four replications were mixed to obtain a large quantity of berries for mechanical dehulling.

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