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Harvesting Semidwarf Freestanding Apple Trees with an Over-the-row Mechanical Harvester

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***Abstract.* Three years of mechanical harvesting (shake and catch) trials with two freestanding apple (*Malus domestica* Borkh.) cultivars on a semidwarf rootstock (M.7a) and two training systems (central leader and open center) yielded 64% to 77% overall harvesting efficiency. Mechanically harvested 'Bisbee Delicious' apples averaged 70% Extra Fancy and 10% Fancy grade, while two 'Golden Delicious' strains ('Smoothee' and 'Frazier Goldspur') averaged 40% Extra Fancy and 13% Fancy grade fruit. Mechanically harvesting fresh-market-quality apples from semidwarf freestanding trees was difficult and its potential limited. Cumulative yield of open-center trees was less than that of central-leader trees during the 3 years (sixth through eighth leaf) of our study. 'Golden Delicious' trees generally produced higher yields than 'Delicious' trees.**

Hand-harvesting the U.S. apple crop is labor intensive, and a supply of dependable, skilled labor is a concern of the fruit industry (LaCroix, 1989; Peterson, 1992a). Brown et al. (1983) documented that <5% of the apple crop is mechanically harvested, all of which is for processing. Excessive damage inflicted by commercial shake and catch harvesters prevents wider acceptance by the processing industry, and apples do not meet the high quality standards required by the fresh-market industry. In the past 40 years, considerable research has been directed toward developing mechanical apple harvesting equipment. Initial efforts focused on harvesting conventional low-density spreading trees 4 to 6 m high or more. Various prototype harvesters were developed to remove and collect fruit from these large or standard-sized trees (Diener and Adams, 1974; Markwardt et al., 1966; Millier et al., 1973; Whitney et al., 1963). Damaged fruit, primarily with severe bruises, cuts, or punctures, often exceeded 40% of the apples harvested when these machines were tested on large trees. Most of the damage was attributed to fruit falling through the canopy to the catching surface. Researchers suggested that fruit from smaller trees, possibly 2 to 3 m high, may be damaged less by the machines (Cain, 1971; Lakso, 1984). Several innovative machines were developed in the 1970s to harvest smaller freestanding trees (Berlage, 1973, 1982; McHugh et al., 1977) but were still not commercially acceptable because of fruit damage.

In 1980, a project was started at the Appalachian Fruit Research Station, Kearneysville, W.Va., to develop systems for mechanically harvesting fresh-market-quality apples. Emphasis was placed on adapting tree design and machine components. Conventional wisdom was that orchards would consist of semidwarf, freestanding trees at medium densities (≈500 to 1000 trees/ha) in the near future. An over-the-row continuously moving shake and catch harvester was developed that used an impact shaker to remove fruit (Peterson and Miller, 1989a). The unit harvested trees up to 3 m wide and 3 m high spaced 2 to 4 m within the row. The tree trunk received three sequential impacts of increasing energy to remove fruit. Falling fruit was intercepted and deflected to conveyors by inclined padded catching surfaces. A series of conveyors transferred the fruit to a tilted bin filler. Five cultivars and six training systems were evaluated for their adaptability to machine harvest (Miller and Peterson, 1989; Peterson and Miller, 1989b).

Results obtained from the initial studies indicated that selected cultivars of fresh-market-quality apples could be harvested from semidwarf freestanding trees trained to an open-center system. Tree growth habit also affected the quality of mechanically harvested apples. Fruit from spur-type trees consistently graded higher than fruit of the same cultivar from nonspur-type trees. Apples from 'Delicious' trees trained to an open center consistently graded at ≈80% Extra Fancy and Fancy. Apples from 'Golden Delicious' trees trained to an open center rarely achieved 60% Extra Fancy and Fancy. Damage occurred during detachment and falling through the tree canopy, on the catching surfaces, during feeding into the conveyors, and during bin filling. Fruit were also lost to the ground during harvesting. The objective of this research was to examine the results of a 3-year experiment on mechanically harvesting semidwarf freestanding apple trees of two cultivars and two training systems in relation to a) fresh-market fruit quality, b) identifying sources of fruit damage, and c) harvest efficiency. An additional objective was to follow the productivity of the selected cultivars from planting through the period during which trees were subjected to mechanical harvesting to determine the influence of training system on yield.

Materials and Methods

Harvester. The same basic harvester described by Peterson and Miller (1989a) was used in this study. The inclined padded catching surfaces were replaced with a roller decelerator catching surface (Peterson, 1992b) that showed potential in laboratory tests for reducing damage (Fig. 1). From the collecting conveyors, fruit were elevated through pairs of parallel, but offset, rotating foam cylinders to an inclined flat belt. Fruit were containerized using a bin filler (Jesperson; Agritech, Woodstock, Va.). Standard 0.73-m^3 wooden field bins (model ET4; Smalley Packing Co., Berryville, Va.) were used. Bins of harvested apples were transported by forklift to the grading facility and stored in a dry, shaded location for 3 to 7 days at ambient temperature before grading. A sorter (Omni Sort; Durand-Wayland, LaGrange, Ga.) was used to segregate fruit by grade and weight. Fruit were graded for damage (broken skin or bruises) only and classified according to U.S. Dept.

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