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Mechanical Harvestability of Y-shaped and Pyramid-shaped 'Empire' and 'Delicious' Apple Trees

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Additional index words. *Malus domestica*, trunk recoil-impact shaking, fruit bruising, stem pulling, storage rot

Abstract. Mature 'Empire' and 'Redchief Delicious' apple trees (*Malus domestica* Borkh.) trained to a Y-shaped trellis (Y/M.26) or trained as pyramid-shaped central leaders (CL/M.7) were mechanically harvested with the Cornell trunk recoil-impact shaker during 4 years. With 'Empire', fruit removal from the Y/M.26 trees (85% to 90%) was significantly less than from the CL/M.7 trees (95% to 97%). With 'Delicious' there were no differences in fruit removal (90% to 95%) between the two tree forms in any year. When the catching pad was on the ground, fruit grade based on damage was only slightly better for the Y/M.26 trees than for the CL/M.7 trees. When the catching pad was raised up near the Y/M.26 canopy, fruit grade was significantly improved for the Y/M.26 trees and was better than the CL/M.7 trees. Fruit grade for both cultivars ranged from 83% to 94% Extra Fancy with 5% to 16% culls for the Y/M.26 trees and from 74% to 88% Extra Fancy and 11% to 21% culls for the CL/M.7 trees. Skin punctures, skin breaks, and number of large and small bruises were lower and the percentage of nondamaged fruit was higher with the Y/M.26 trees when the pads were close to the canopy than when the pads were on the ground. The CL/M.7 trees had higher levels of all types of fruit damage than did the Y/M.26 trees. Damaged fruit from the CL/M.7 trees was mainly from the top half of the tree, while fruit from lower-tier scaffold branches had low levels of damage. Mechanically harvested fruit from the Y/M.26 trees had lower incidences of fruit rot and flesh breakdown after a 6-month storage period than did fruit from the CL/M.7 trees. Stem pulling was high with both systems and averaged 60% for 'Delicious' and 30% for 'Empire'. The advantage of the single plane Y-trellis system for mechanical harvesting appears to be that the catching pads can be placed close to the fruit, thereby reducing fruit damage.

Considerable effort has been made in the study of mechanical harvesting of fresh fruits (Brown, 1980; Brown et al., 1983; O'Brien et al., 1983). In some fruit crops, especially those used in processing, harvest mechanization has become common, but with fresh-market fruits problems remain. The major obstacle to mechanical harvesting of apples is excessive fruit damage, particularly when fruit are intended for the fresh market. Most of the work with mechanical harvest of apples has focused on adapting the machines to existing tree forms, but the problem of fruit damage is too great with existing large trees. To reduce fruit damage, Tukey (1971) suggested the tree be molded to fit the machines.

Studies of the sources of bruising during the shake-catch mechanical harvest of apples have shown that about one-half of the damage occurs near the site of detachment and one-half arises when fruit falls through the tree and is caught (Millier et al., 1980, 1984; Pellerin et al., 1977). Damage from detachment and from fruit falling through the tree was reduced by

using a recoil-impact shaker instead of the common inertial shakers (Millier et al., 1980, 1984; Pellerin et al., 1979, 1982). The recoil-impact shaking concept has recently been added to a complete over-the-row harvester (Miller and Peterson, 1989; Peterson et al., 1985). These authors have also shown a reduction in damage levels from impact shaking compared to inertial shaking.

Damage resulting from fruit falling through tree canopies has been shown to increase logarithmically with increasing distance above the catching surface in standard tree forms (Lakso et al., 1978). This damage could be reduced by improved tree canopy designs that limit the distance of fall or distribute the fruit more horizontally. Lakso et al. (1978) removed the central leader of standard-sized 'McIntosh' trees, leaving short, relatively flat open-center trees, and found a substantial reduction in mechanical damage during shake-catch operations. However, such trees had lower total production and excessive vegetative growth (Lakso et al., 1978). Miller and Peterson (1989) have developed modified central leader trees for mechanical harvest with an over-the-row machine that have had lower fruit damage levels than larger central leader trees.

Further modifications of tree canopy form that place the fruiting zone predictably could offer further reductions in fruit damage levels (O'Brien et al., 1983). The Tatura Trellis, which is an inclined planar canopy in a V form, was developed for me-

Received for publication 3 Aug. 1989. 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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