**FINAL REPORT** **DURATION: 99-00**

**WTFRC Project#:** **ARS Project #:** 16614

**Project title:** Sampling apple culls to support the Systems Approach for quarantine

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**Organization:** USDA-ARS, Wapato, WA

**Objectives:**
The objectives of this research are: 1), to measure the efficacy of culling in the sorting line; 2), to validate culling in the packing house by following an examined lot from the dump tank to the packed cartons; 3), to measure mortality of codling moth larvae in culls after standard cold storage and 90-day controlled atmospheres-cold storage; 4). to compare visual inspection with examination by 30x microscope; 5), to evaluate the effectiveness of the proposed inspections that would be used in the Systems Approach.

**Significant findings:**

- Sorting efficacy was followed in 17 grower lots at six packing houses from the beg' of the packing line to the final pack. The number of fruits examined include 28,000 before sorting, 14,376 from the cull bin, and 12,539 in the final pack. Also, an additional 10%ofthesetotalswereexaminedusinga3Oxmicroscope. 'Fuji' was the most dominant cultivar, followed by 'Golden Delicious,' 'Delicious,' then 'Gala.'

- Only two (one alive) codling moths were found in the dump tank station, 26 (10 alive) were in the culls, and none were in the final pack. Codling moth damage was found in about 0. I% of the pre-sort, 1. 9% in the culls, and only one fruit in the final pack.

- Frequencies of codling moth and codling moth damage were about the same across cultivars, with the exception of codling moth damage being much lower in the 'Golden Delicious.'

- In the microscopic examination, only one dead codling moth was found in the dump tank fruits, four dead codling moths in the culls, and none in the final pack. Codling moth damage occurred in about 0.5% of the presort, 1.8% in culls, and none in the final pack.

- The most dominant arthropod collected was codling moth, followed by spiders. Neither oriental fruit moth nor apple maggot was found.

- With the microscopic examination, European red mites were the most dominant, particularly in the final pack, followed by spiders.

- In both the large survey and microscope examination, leafrollers caused the most fruit damage, followed by codling moth and cutworm.

- Microscopic examination increased efficacy of detecting codling moth from 0.0 I% to 0.03%in the presort but only fromO.17%toO.26%in the culls. Observations of codling moth damage increased from 0. 12% in the large survey to 0.98% in the microscope examination but was less with the culls from 1.90% to 1.77%, respectively. Overall, the microscopic examination was similar to the large survey of the same lots for codling moth damage, but not for the presence of codling moth.

- In both the large survey and in the microscope examinations, culling efficacy was found to be not directly influenced by packing line speed.

**Methods:**

A. Cull survey

1. Fruit sources

a. Sample freshly harvested apples, apples in standard cold storage, and apples in controlled atmosphere-cold storage.

b. Each survey from a single grower's lot, preferably export quality from area wide project; select major cultivars.

2. Procedures

a. Dump tank: sample -- 2,000 fruits accumulated from each bin in the lot and examine visually and using 3 Ox microscopes on IO% of sample; record observations, determine infestation rate, return all samples.

a. Culls: examine all fruits visually and using 3 Ox microscopes on IO% of sample; dissect if necessary.

b. Final pack: sample - 1,000 fruits before packed; examine them visually and using 3 Ox microscopes on IO% of sample; return fruits after observation.

3. Data collection

a. Categorize each fruit for the following for quality, damage, disease, and presence.

b. Among the insect damaged fruits, record: pest species (including oriental fruit moth and leafrollers), number and life stage, and type of damage

B. Data analysis

1. Determine the efficacy of culling in survey comparing fruit quality and infestation rate from three sampling locations.

2. Determine larval survival by life stage for cold treated fruits.

3. Compare survey with similar information from the Washington State Department of Agriculture.

**Results and discussion:**

The large survey emphasized sampling fruits at the beginning of the packing line where nearly 10,800 'Fuji' and 8,500 'Golden Delicious' were examined (Fig. 1). Surprisingly, very few codling moths were found at this sample station (called "Field" in Fig. 2). Even in the cull station, less than ) 25% of the fruits had codling moth. Codling moth damage was also low at the cull station (Fig. 3). No codling moths were found among the 12,539 fruits in the final pack, and only one fruit was found with codling moth damage.

The microscope examinations were intended to verify the visual observations of the large survey. A subsample of 10% of the observed grower's lot were taken independently of the fruits used in the visual observations (Fig. 4). With increased magnification, greater detail can be observed than in the visual survey, such as for eggs or stings by early instars, which would presumably result in more records of codling moth. Yet, the fruits examined before sorting still had very low incidence of codling moth (Fig. 5). Frequency in cull fruits was higher, but none were found in the final pack. Frequency of codling moth damage increased fourfold for the presorted fruits, but remained about the same for the cull fruits (Fig. 6). Microscope examination found no codling moth damage in the final pack.

In this survey, we tried to observe as many fruits as possible from different grower lots and packed under different conditions. Yet, the damage was surprisingly consistent among the samples. The average incidence of codling moth among grower lots was $x \pm SEM = 0.01 \pm 0.01\%$ for presorted fruits and $x\text{-} \pm SEM = 0.22 \pm 0.08\%$ for culled fruits. These data suggest that growers are adept in controlling codling moth in the orchards and that packing houses are efficient in removing infested fruits. Although the market destinations varied from Asian exports to domestic, all the packing houses were very effective packing fruits clean of codling moth. Furthermore, even codling moth damaged fruits were removed before the final pack. The microscope examinations verify the visual survey. Slightly more infested fruits were observed entering the packing line ($x \pm SEM = 0.04 \pm 0.04\%$), but the culling efficiency remained about the same ($x \pm SEM = 0.27 \pm 0.15\%$). Line speeds, measured between 0.08 and 0.22 m/sec, were not related to changes in culling efficacy.

Codling moth, though not abundant, was the dominant arthropod found in the large survey (Fig. 7). Spiders were also found in field collected fruit. However. microscope examinations revealed European red mites, which were carried through to the final pack (Fig. 8). Most of the pest damage was caused by leafrollers (Fig. 9). However, the microscope examinations did not improve pest damage detection (Fig. 1 0).

Important information was obtained that demonstrate the effectiveness of field control and sorting in eliminating codling moth infestations in commercial apples. Negotiations involving the Systems Approach will be strengthened when supplemented with this information.
Replacing methyl bromide fumigation with the Systems Approach will result with the same quarantine security level, but with high fruit quality, reduced costs, lower environmental hazards, and improved worker safety.

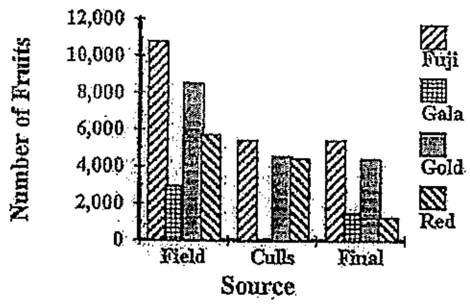


Fig 1. Numbers of fruits, by cultivar, sampled at three stations along packing line: beginning, cull, and final pack; from six packing houses

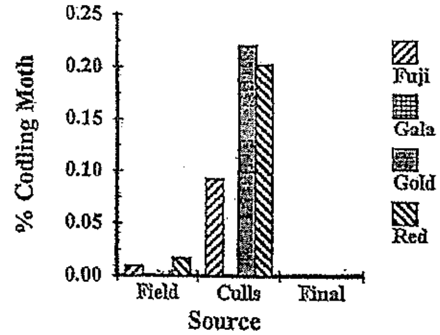


Fig. 2. Percent of codling moth found at sample stations, by cultivar

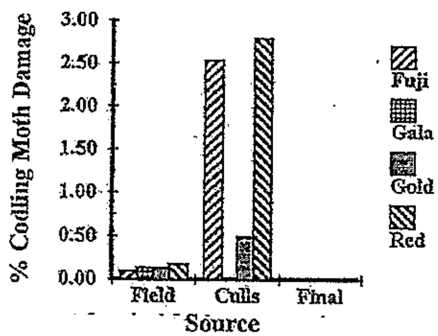


Fig. 3. Percent of codling moth damage found at sample stations, by cultivar

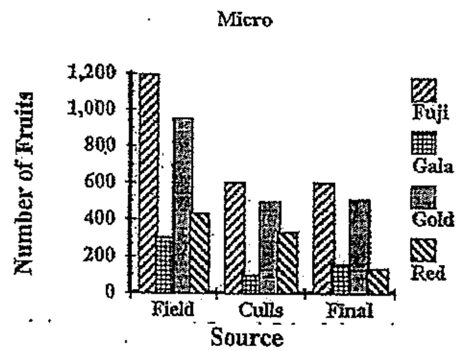


Fig 4. Numbers of fruits, by cultivar, sampled at three stations along packing line: beginning, cull, and final pack; examined using 30x microscope; from six packing houses

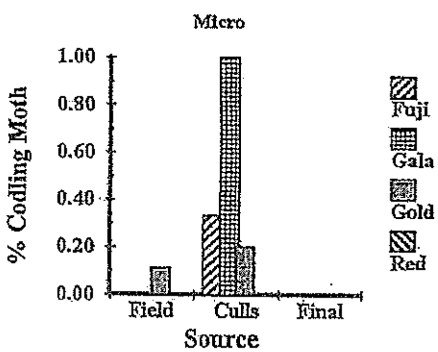


Fig. 5. Percent of codling moth from microscope examination found at sample stations, by cultivar

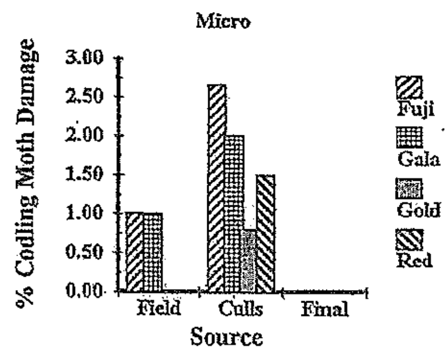


Fig. 6. Percent of codling moth damage from microscope examination found at sample stations, by cultivar

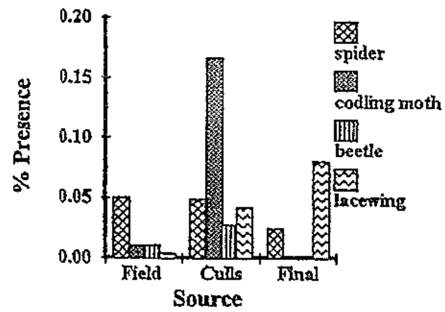


Fig. 7. Percent of fruits with arthropods, by sample station

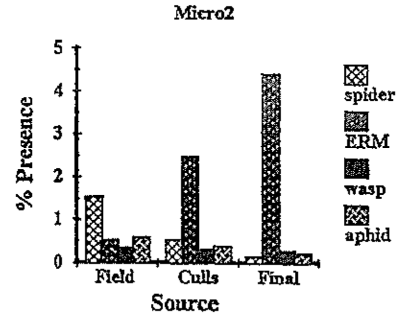


Fig. 8. Percent of fruits with arthropods from microscope examination, by sample station.

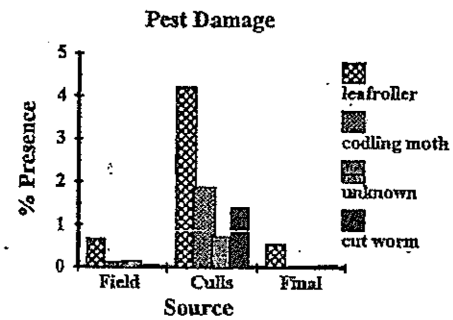


Fig. 9. Percent damage caused by arthropods, by sample station

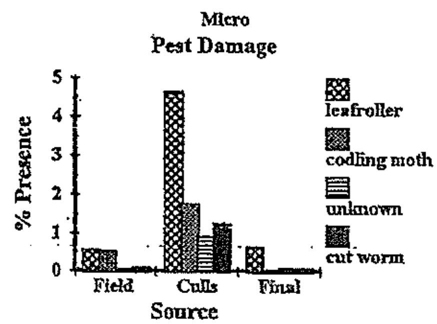


Fig. 10. Percent damage caused by arthropods from microscope examination, by sample station