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Worker-Crop Contact Analysis as a Means of Evaluating Reentry Hazards

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Time and motion studies have been employed to evaluate work rate and efficiency in industry. The same principle should be applicable to agricultural worker exposure studies. Investigators have documented reentry poisonings that occurred due to extensive contact with pesticide resiudes on crops (MILBY et al. 1964, MILBY 1974, MADDY et al. 1978). The purpose of this study is to estimate the amount of contact between the worker and treated crops from an evaluation of carefully timed moving pictures of selected worker groups in several crop situations.

POPENDORF & SPEAR (1974) described the work habits of California grape, peach, and citrus harvesters. Minor details, including break times, personal habits and field conditions, were extremely variable.

Work rate could affect the potential exposure to workers. When a larger number of treated plants are handled, more chemical residues may adhere to the skin. However, FREDRIKSSON (1958) demonstrated that the area of skin exposed, not an excess amount of poison, determines the dermal toxicity of organophosphorus pesticides.

METHODS

Five field workers engaged in normal work activities requiring extensive hand labor in each of 5 crops (tobacco, cotton, sweet corn, peaches, and blueberries) were filmed at 5 consecutive 3.5 min intervals by means of a movie camera. The total time of contact between a specific anatomic region and the crop was recorded. Work rates were calculated for tobacco, cotton, and sweet corn.

Standardized times of exposure for each anatomic region in contact with tobacco, cotton, peach, blueberry, or sweet corn foliage and/or fruit were calculated on the basis of the percentage of worker contact with the crop in 17 min of film time. It was assumed that

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the time the worker is in contact with a crop was equivalent to potential exposure to dislodgeable pesticide residues on that crop. Workers were filmed only while they were performing normal work activities. General labor practices are standard for most major crops.

RESULTS AND DISCUSSION

The distribution of clothing worn by workers in this study is shown in Table 1. Protective clothing may partially protect workers from excess dermal exposure (WOLFE et al. 1972, WOLFE et al. 1975), but contaminated clothing may act as an occlusive dressing and thus increase the absorption of pesticides (MILBY 1974). Failure to clean parathion-contaminated clothing properly has resulted in acute illness (REICHERT & KLEMMER 1978). The apparel usually worn by field workers was shown to be an inefficient barrier to parathion, paraoxon, and methyl parathion (SPEAR et al. 1977, KAWAR et al. 1978). In view of the exposure to the legs of cotton scouts, long pants are recommended. In this study only 40% wore long plants. Similarly, long-sleeved shirts and gloves are recommended for tobacco harvesters and peach thinners. The apparel of blueberry pickers in this study appeared to be adequate. Gloves are recommended for sweet corn packers. WICKER et al. (1979) have demonstrated that workers wearing

TABLE 1

Precent of Workers Wearing Different Items of Clothing

Clothing Item	Tobacco %	Cotton %	Peaches %	Blue-berries %	Sweet Corn %
Long-sleeved shirts[a]	40	0	60	60	40
Long pants[b]	100	40	80	80	100
Hats[c]	100	20	40	80	100
Shoes	100	100	100	100	100
Socks	100	20	100	80	100
Gloves	0	0	0	0	0

[a]Other workers wore short-sleeved or no shirts
[b]Other workers wore short pants or skirts
[c]Hats include scarves and bandanas

gloves while packing sweet corn treated with methyl and ethyl-parathion excreted $\leq$ 0.1 ppm of p-nitrophenol, while those workers not wearing gloves excreted an average of 0.4 ppm.

Description of worker activities. Approximately 70% of the tobacco in North Carolina is hand harvested. In non-mechanized operations, tobacco harvesters pick 2 to 4 leaves per stalk with the right hand and place them between the left arm and side of the body. The left hand helps to hold the leaves in place. After accumulating 40 to 120 leaves, the worker crosses 1 to 4 rows of tobacco and delivers the leaves to a wagon. An experienced worker may harvest 1.5 acres a day. Work experience, plant maturity, interfering weeds, length of row, and distance to the wagon affected the work rate. The work rate was expressed as the number of leaves harvested per second (Table 2).

TABLE 2

Work Rates of Tobacco Harvesters, Cotton Scouts, and Sweet Corn Packers

Crop	Work Activity Timed[a]	Work Rate (Mean ± S.D.)
Tobacco	leaves picked per second	1.0 ± 0.2
Cotton	buds picked per second	0.10 ± 0.03
Sweet Corn	ears packed per second	0.5 ± 0.2

[a]Five workers per sample

Cotton scouts walk through 700 to 1400 acres of cotton per week, depending on size of the field and frequency of scouting, and examine leaves, flower buds, and bolls for insects and/or insect damage. The number of plants examined varies with the size of the field and maturity of the crop. These cotton scouts are exposed to the crop 8 to 10 h per day. There is little contact with the foliage in early growth stages, but some varieties later produce dense foliage that necessitates constant contact to the waist or above. Most of the workers in this study were inspecting low-growing cotton. The work rate was expressed as the number of flower buds or bolls picked per second (Table 2).

Peach thinning involved removing immature peaches by hand. Of those varieties thinned, 75% of the fruit was removed. Workers usually thinned with both hands, catching the fruit with the fingertips, pulling it from the tree, and allowing it to drop onto the ground. One hand was sometimes used to pull down limbs that were hard to reach while the other hand was used to remove the peaches. During certain stages of fruit development, workers used rubber-tipped sticks to knock the fruit off heavily-ladened trees. No attempt was made to determine work rates for peach thinners because of the great variation in tree size, amount of fruit, and tree variety differences. In addition, workers sometimes worked in pairs, thinning the same trees.

Worker contact in blueberries was similar to that in peaches. Either the fingertips of both hands were used to gently roll the berries into the palms of the hand, or one hand was used to hold a limb while the other hand was used to pick berries. Handfuls of berries were dropped into a bucket or box tied around the waist or hung by a string around the neck. Workers in this study picked from 15-30 flats (12 pints per flat) per day, depending on the quantity of fruit per bush, previous work experience, and incentive to work. No attempt was made to determine the rate of work because of the short time periods covered by the films and the inconsistent availability of berries on different bushes.

Sweet corn ears were harvested mechanically and brought to the edge of the field. Workers then packed approximately 5 dozen ears of corn per crate. An experienced worker can pack 400 to 500 crates per day. The only contact to the crop is the hands. The work rate was expressed as the number of ears of corn packed per second (Table 2).

Tobacco harvesters exhibited the highest work rate of the activities timed, although peach thinners and blueberry pickers were in almost constant contact with those crops.

Worker-Crop Contact Analysis. The hands of peach thinners and blueberry pickers were in contact with the crop the greatest amount of time, followed by tobacco harvesters, cotton scouts, and sweet corn packers (Table 3). Based on an analysis of exposure pads and patches, SPEAR et al. (1977) estimated that the hands and forearms received approximately 50% of the entire dermal dose of dislodgeable parathion residues on citrus. The torso contributed 10%; the head-neck region, 10%; upper arms and shoulders, 10 to 15%; and

TABLE 3

Standardized Time (Minutes) of Exposure of Each Anatomic Region in Contact with Tobacco, Cotton, Peach, Blueberry, or Sweet Corn Foliage or Fruit

Worker	Right Hand (min)	Left Hand (min)	Right Arm (min)	Left Arm (min)	Trunk (min)	Legs (min)
Tobacco Harvesters						
Mean ± S.D.	13.3 ± 0.9	16.0 ± 0.3	15.9 ± 0.3	2.6 ± 1.1	15.9 ± 1.0	3.2 ± 1.0
Cotton Scouts						
Mean ± S.D.	11.4 ± 2.2	11.4 ± 2.2	1.3 ± 1.0	1.3 ± 1	0	8.2 ± 0.8
Peach Thinners*						
Mean ± S.D.	16.2 ± 0.3	16.1 ± 0.7	6.6 ± 1.4	7.3 ± 2.1	2.5 ± 1.8	0.3 ± 0.3
Blueberry Pickers						
Mean ± S.D.	16.2 ± 0.3	16.3 ± 0.3	3.5 ± 0.8	4.9 ± 1.0	1.1 ± 0.1	1.4 ± 1.2
Sweet Corn Packers						
Mean ± S.D.	14.5 ± 0.3	14.5 ± 0.3	0	0	0	0

*Only 4 films per worker considered in analysis

the legs, 15 to 20%. WOLFE et al. (1975) found twice as much parathion collected on the forearms than on the hands of workers thinning apples, even though the hands had more contact with the fruit. The forearms and hands of an average man have an area of 1.30 and 0.87 ft^2, respectively (DURHAM 1965).

Pesticide absorption through the skin varies with anatomic region of the body and with different pesticides (MAIBACH et al. 1970). The palms allow 1.3 times greater penetration than the forearms. Worker-crop contact was highest for the hands. Since the palms allow a greater amount of penetration than the arms, trunk, or legs, exposure to hands pose a greater worker hazard. Hairy areas of the scalp and forehead allow 4 times greater absorption of parathion than the forearms. FREDRIKSSON (1958) demonstrated that parathion penetrated into hair follicles and sebaceous glands to some extent but concluded that it was not the main route of absorption.

Analysis of the movies reflects differences in contact patterns in different crops (Table 3). For example, contact to hands is similar in tobacco, peaches, blueberries, and sweet corn, but significantly lower in cotton. Contact to the arms is approximately equal in peaches and blueberries and the left arm in tobacco. Contact is very high to the left arm of tobacco harvesters and seems to be negligible in cotton and sweet corn workers. Contact to the trunk of the body is high in tobacco, negligible in peaches and blueberries, and essentially zero in cotton and corn. Contact to the legs is highest in cotton, followed by tobacco, blueberries, peaches, and corn. These differences are the result of crop type and labor practices.

It is difficult to generalize overall hazards regarding different worker situations. In addition to worker contact (especially differences in more absorptive areas as palms), rate of activity (number of specific exposures) clothing differences for worker activities, frequency of crop treatment (3 time/week for sweet corn versus 1 or less for other crops), and the innate dermal toxicity of the insecticide are all important variables to the reentry problem.

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