Bulletin B-618

# A Field Laborer And Materials Carrier

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November, 1963

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# A Field Laborer And Materials Carrier

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Many man-hours of hand labor are still used in the production and harvest of most field-grown crops. Although some jobs will continue to be done by hand, there is an ever-present need for increasing the efficiency and improving the effectiveness of hand labor through the use of machines.

This bulletin describes the construction and field testing of a mechanical field laborer and materials carrier. The basic purposes of the machine were to allow workers to spend maximum time at a single designated task, to reduce the arduousness of the worker's task and to improve the quality of the work performed.

An evaluation of the machine's performance was made when harvesting strawberries. Although tests were made on harvesting operations of only one crop, with minor modifications the machine could be used for other crops or other field operations such as transplanting, crop thinning, or weeding.

## The Transport Machine

A self-propelled field laborer and materials carrier was built and tested. (Figure 1) The carrier was powered with a one-cylinder (6 h.p.) air-cooled engine mounted on a single steerable traction wheel located at the front of the machine. The outboard sub-frames of the carrier were hinged to facilitate movement over uneven ground. The sub-frames could be raised and secured to decrease the effective machine width for turning. The machine was designed to carry a maximum of 12 workers (two per row) at ground speeds ranging from 0 to 10 feet per minute. The carrier had horizontal padded platforms with adjustable head supports and sunshades for worker comfort.

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**Research reported herein was done under Station Project 1130.**

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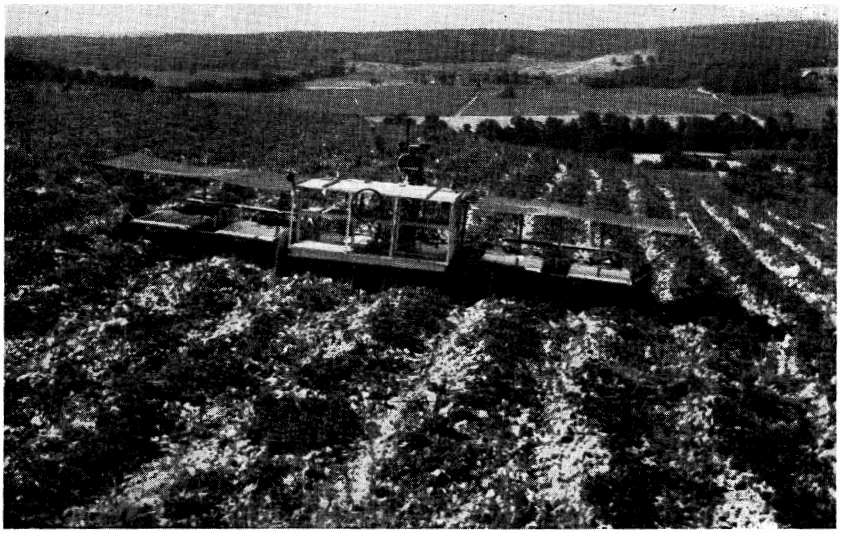

Figure 1. The self-propelled laborer and materials carrier used in the field studies.

When used for harvesting tests, 25-pound capacity lug boxes were provided for storage and transport of the harvested material. In addition, a plastic sheet, located immediately in front of the worker, served as a search-assistance device by parting the foliage and thereby exposing the fruit to the worker. (Figure 2) A lighting system was installed so that the carrier could be used for test work at night.

## Evaluation Procedures

An area of approximately one and three-quarter acres, in a three-year-old strawberry field, was selected for the machine evaluation studies. The test area was gently sloping, but the surface was irregular and rocky.

A machine operator-supervisor was in charge of the field operations. During the tests he controlled the movement of the machine, supervised the workers, and recorded the appropriate data.

The strawberries were harvested for processing (freezing) and the calyx or cap was removed as the berries were picked. Harvesting proceeded in an orderly manner from one side of the test area to the other, returning to the first rows harvested for subsequent pickings. Ground speed was regulated according to the workers' hands: if they were near the trailing edge of the search-assistance device and/or if green berries

Figure 2. Picker in working position. Note container, search shield and weight boxes, and head support.

were appearing in the lugs, the speed was increased; if they were generally under the workers' bodies and far away from the shield, the speed was reduced. This procedure seemed to be a reasonable compromise between the harvesting rate (pounds per man-hour) and harvesting efficiency (percent of berries picked).

For the first five test days, two crews of workers were used. One crew was on duty from 7 a.m. to 4 p.m. while the second crew worked from 5 p.m. to 2 a.m. Workers were given a 5-minute rest period every working hour.

## Results

Figure 3 shows the average worker performance, machine ground speed, and crop yields. The relatively low harvesting rates at the beginning and end of the season were due primarily to the low yields. For the remainder of the season, harvesting rates in excess of 10 pounds per man-hour were maintained while working an average of 50-55 minutes out of each hour of the working day.

Results indicate that ground speed may be inversely proportional

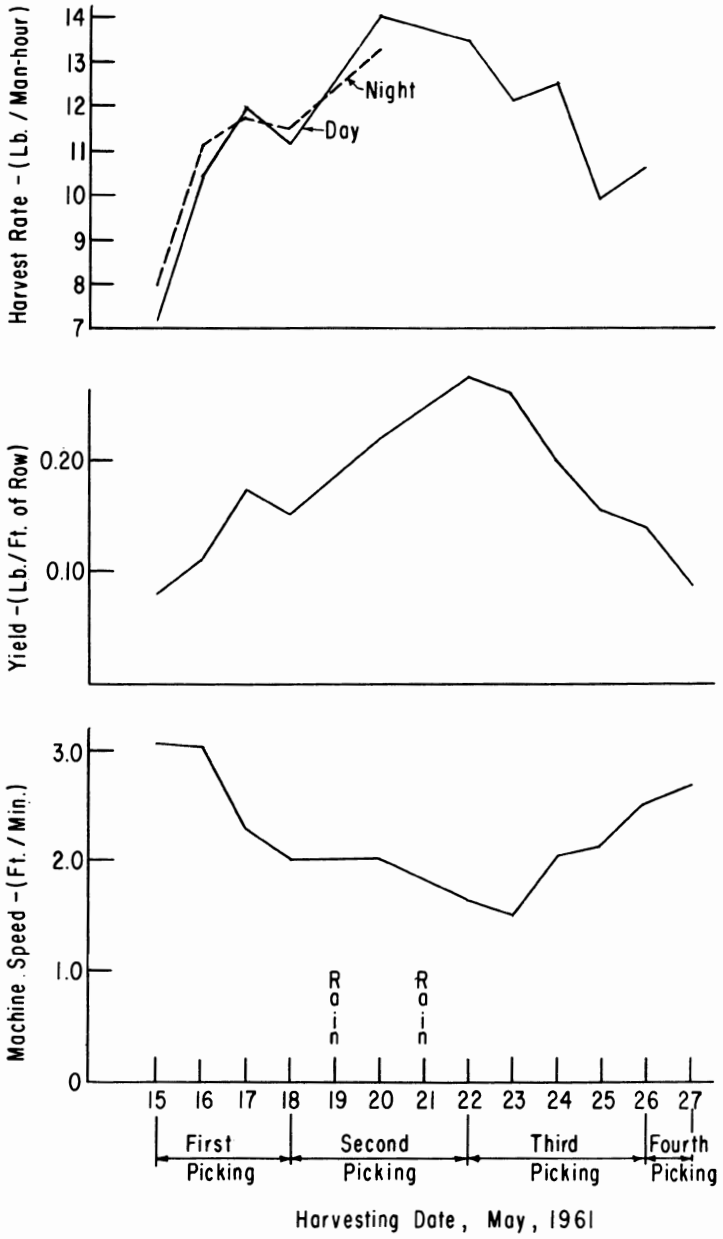


Figure 3. Average worker performance (harvesting rate), yield and machine speed for each day of the strawberry harvesting season.

to yield and harvesting rate. Thus, when the yield is high, the harvesting rate will be high and ground speed low.

The picking interval ranged from three to five days. This interval did not result in significant crop losses because the workers were able to harvest a high percent of the mature berries at each picking.

Worker performance was essentially the same for both day and night operations. Moreover, it was observed that the harvesting rate (pounds per man-hour) remained about the same within any given 8-hour shift. Dew caused no delay in harvesting either late at night or early in the morning since only the workers' hands were in contact with the foliage. Likewise, during night operation, the few insects attracted by the lights did not annoy the workers or reduce the quality of the harvested berries.

There were no difficulties with the functional or mechanical performances of the machine. Soft ground due to rain did not intefere with machine operation. Sufficient traction was developed by the single drive wheel to move the unit up the field slopes and over "double fist-size" rocks. Larger rocks were removed from the middles by the operator-supervisor or by the pickers working next to the wheel middles. Steering required little of the supervisor's attention except where there was appreciable cross-slope to the rows.

General requirements necessary for effective machine use in strawberry harvesting are: (1) uniformly-spaced rows cultivated to provide a bed width of about 30 inches; (2) minimum slope and cross-slope to rows; (3) row lengths of at least 300 to 400 feet with few point rows; (4) rows free of weeds, tall stumps, and large rocks; and (5) a field of such size that it can be completely worked according to a predetermined schedule.

# Worker Performance Studies

Prior to the designing and testing of the self-propelled field laborer and materials carrier already described, tests were carried out to establish a range of values for some of the important design parameters of such carriers.

A test unit was constructed that would transport workers and harvesting containers and permit variations in both ground speed and worker arrangement. (Figure 4)

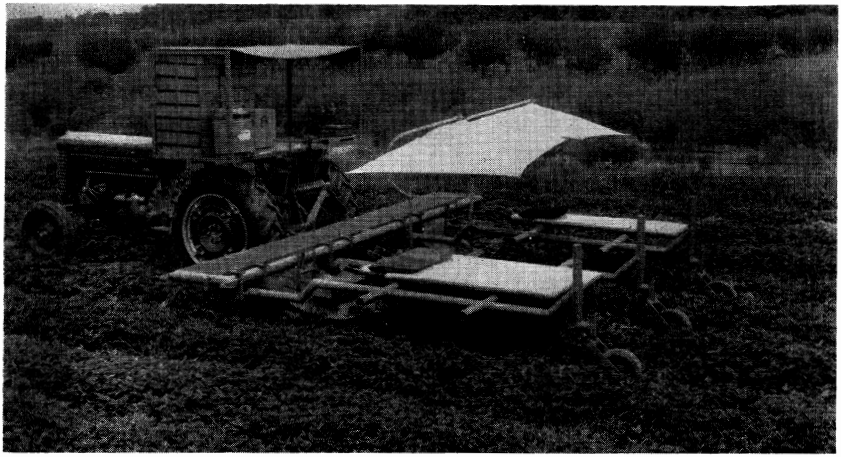

Figure 4. Test unit used in worker performance studies.

## Test Procedures

The workers were assigned one or two per row to determine the difference in worker output due to the worker arrangement. Several tests were conducted where only the harvesting containers were transported by the test unit. Ground speed for each of the worker arrangements was varied from 0.5 to 8 feet per minute. Each test was of approximately one-half hour duration. Interruptions between tests ranged from 5 to 20 minutes while losses were being gleaned from the previous test, workers were changing positions and preparations were being made for the next test.

The measurements for each test were: (1) distance, (2) time, (3) pounds harvested, (4) pounds gleaned, (5) size of individual strawberries or green beans (pounds per 100 berries or beans) from picked and gleaned samples.

Comparative data on conventional hand harvesting was obtained by having the pickers work without the test unit, picking into bulk containers and working for intervals of approximately one hour.

Three crops were selected for the worker performance studies: strawberries, green beans, and southern peas. The strawberry test area was picked four times with an average three-day picking interval. The caps were removed from the berries as they were harvested. The green beans were picked twice, with only the beans of marketable size har-

vested at each picking. The southern peas were picked only one time; only mature pods were harvested.

# Results

## Strawberries

Tables I and II show results of the worker arrangement tests. No appreciable change in individual worker output was attributed to worker arrangement when comparable ground speeds were considered. Thus, two workers per row at a ground speed of 4 feet per minute could accomplish what one worker per row could do at 2 feet per minute. A marked decrease in harvesting efficiency (percent of berries picked on a weight basis) occurred at a speed beyond which the workers were able to harvest 100 percent of the berries. Below this speed the harvesting

**TABLE I**

Average strawberry harvesting rate in relation to ground speeds and number of workers.

| Nominal Ground Speed (Feet per Minute) | WORKER ARRANGEMENT | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 Worker per Row | | | | 2 Workers per Row | | | |
| | Picking | | | | Picking | | | |
| | 1st | 2nd | 3rd | 4th | 1st | 2nd | 3rd | 4th |
| | Lbs. per man-hour | | | | Lbs. per man-hour | | | |
| 0.5 | 4.2 | — | — | — | — | — | — | — |
| 1.0 | 8.9 | 12.0 | 6.7 | 8.2 | — | 4.7 | 3.6 | 5.6 |
| 2.0 | 11.6 | 14.5 | 13.3 | 10.1 | — | 8.4 | 8.5 | 9.2 |
| 4.0 | 12.7 | 17.5 | 12.2 | 13.0 | 12.9 | 11.8 | 11.4 | 10.4 |
| 6.0 | — | 18.5 | 13.6 | 15.4 | 13.1 | 13.9 | 12.2 | 13.0 |

**TABLE II**

Average strawberry harvesting efficiency in relation to ground speeds and number of workers.

| Nominal Ground Speed (Feet per Minute) | WORKER ARRANGEMENT | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 Worker per Row | | | | 2 Workers per Row | | | |
| | Picking | | | | Picking | | | |
| | 1st | 2nd | 3rd | 4th | 1st | 2nd | 3rd | 4th |
| | Percent of berries picked on a weight basis | | | | | | | |
| 0.5 | 100 | — | — | — | — | — | — | — |
| 1.0 | 100 | 100 | 100 | 84.8 | — | 100 | 100 | 100 |
| 2.0 | 92.8 | 74.5 | 76.7 | 52.3 | — | 98.3 | 100 | 83.5 |
| 4.0 | 78.5 | 49.8 | 43.8 | 35.0 | 100 | 79.9 | 74.4 | 59.6 |
| 6.0 | — | 44.4 | 29.3 | 22.1 | 96.1 | 56.2 | 67.2 | 39.1 |

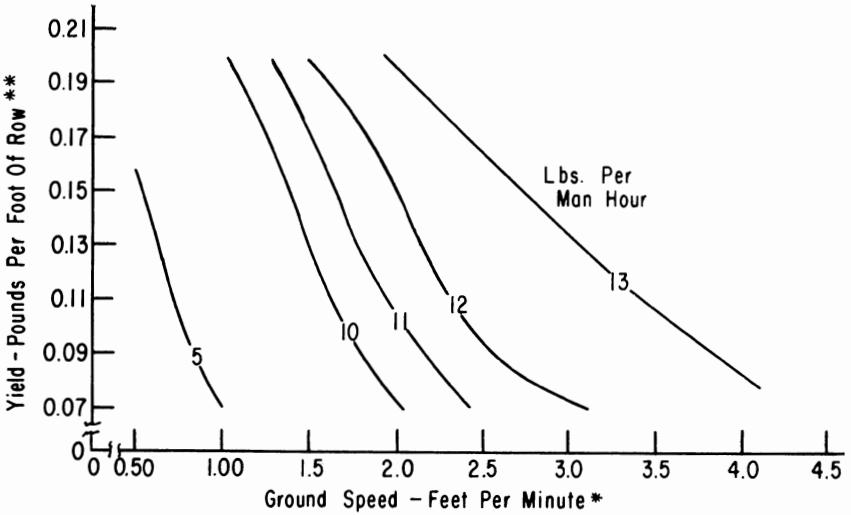


Figure 5. Strawberry harvesting rate (pounds per man-hour) expressed as a function of ground speed and crop yield.

*Data involving two workers per row were reduced to a one-worker-per-row equivalent by dividing the ground speed by two.

**Yield refers to the pounds of harvestable berries found per foot of row for a given picking.

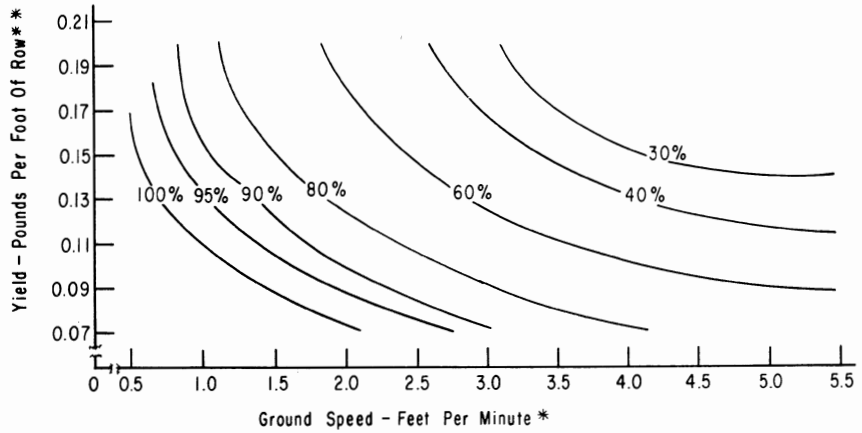


Figure 6. Strawberry harvesting efficiency (percent picked, weight basis) expressed as a function of ground speed and crop yield.

*Data involving two workers per row were reduced to a one-worker-per-row equivalent by dividing the ground speed by two.

**Yield refers to the pounds of harvestable berries found per foot of row for a given picking.

rate (pounds of berries picked per man-hour) decreased rapidly. Speeds above the speed at which the workers were able to harvest 100 percent of the berries resulted in a slight increase in harvesting rate. Thus, the optimum ground speed for a given harvesting condition must be the result of a compromise between harvesting rate and harvesting efficiency.

The amount of harvestable fruit at any picking was an additional variable influencing worker performance. In general, for a given speed, higher yields caused a decrease in harvesting efficiency and an increase in harvesting rate. (Figures 5 and 6)

When harvesting efficiency was at or near 100 percent, harvesting rate was directly related to berry size. At lower harvesting efficiencies, harvesting rates apparently were not affected by berry size. Under the latter circumstances, the smaller berries were not harvested, presumably because they were harder to find.

Transporting only the container with the worker following along behind proved to be particularly fatiguing, though it generally resulted in worker performance comparable to transporting worker and container. This arrangement of worker and container was so arduous that testing was discontinued.

The average harvesting rate for conventional hand harvesting was 9.2 pounds of capped berries per man-hour. The average speed along the row was 0.85 feet per minute where the berry yield averaged 0.19 pounds per foot of row.

## Green Beans

Results of the harvesting tests for green beans are shown in Figures 7 and 8. One worker was positioned over each row. Half-bushel baskets, supported between the rows, were used as harvesting containers.

The slowest ground speed (one foot per minute) apparently was not slow enough to enable the workers to achieve 100 percent harvesting efficiency. However, the average bean size of the gleanings was markedly smaller than that of the harvested beans. Thus, in gleaning the plots, the immature beans that were picked along with any remaining mature beans acted to reduce the harvesting efficiency.

Harvesting efficiency decreased rather slowly as ground speed increased, whereas the harvesting rate increased steadily as speed increased (Figure 6). Ground speeds were not fast enough to reach a point where the harvesting rate would no longer increase with an increase in speed.

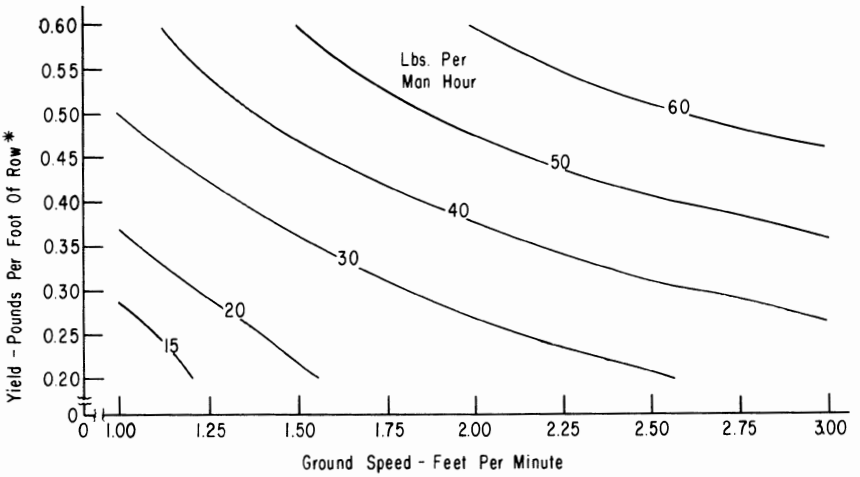


Figure 7. Green bean harvesting rate (pounds per man-hour) expressed as a function of ground speed and crop yield.

*Yield refers to the pounds of harvestable beans found per foot of row for a given picking.

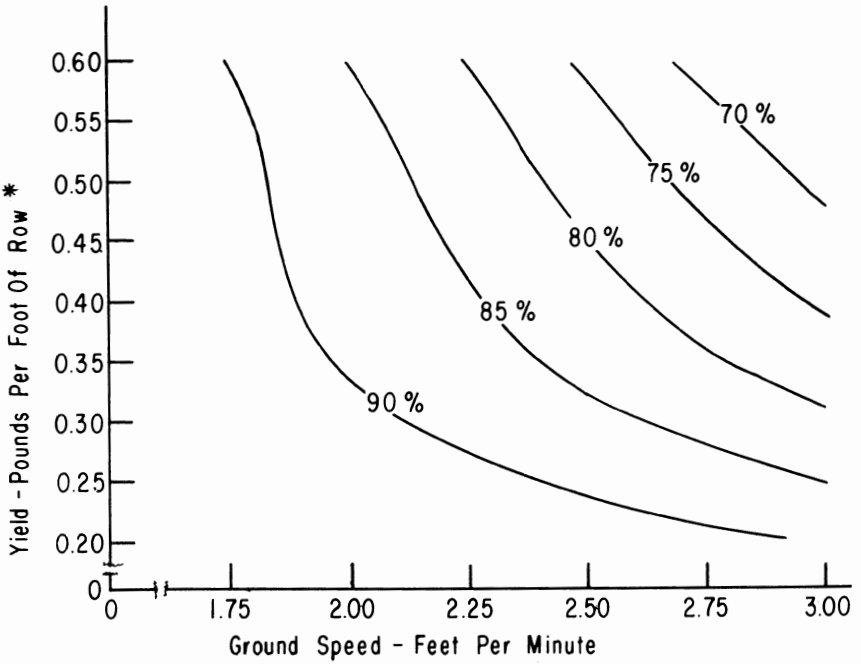


Figure 8. Green bean harvesting efficiency (percent picked, weight basis) expressed as a function of ground speed and crop yield.

*Yield refers to the pounds of harvestable beans found per foot of row for a given picking.

As with strawberries, when a worker encountered more beans than he could pick, the smaller beans were left. Since the workers could pick effectively using both hands, the weight of material harvested per man-hour was considerably greater than that for strawberries.

Pickers working without the test unit averaged 32.7 pounds per man-hour at a ground speed of 1.37 feet per minute in an area where the average bean yield was 0.405 pounds per foot of row.

## Southern Peas

Table III shows results of tests with southern peas. The one-worker-per-row arrangement resulted in poorer harvesting performance than two workers per row. The lower harvesting rates and efficiencies were due to excessive time spent searching over the wide rows. No appreciable gains in harvesting rates were found at the faster speeds for either worker arrangement. At ground speeds of 6 to 8 feet per minute, the workers did not have sufficient time for searching and thus had to quickly harvest the exposed pods before moving out of reach.

### TABLE III

Effect of varying ground speeds and worker arrangements on average worker performance in harvesting southern peas.

| | WORKER ARRANGEMENT | | | |
|---|---|---|---|---|
| | One Worker per Row | | Two Workers per Row | |
| Nominal Ground Speed (Feet per Minute) | Harvesting Rate (lb/man-hour) | Harvesting Efficiency (%) | Harvesting Rate (lb/man-hour) | Harvesting Efficiency (%) |
| 2 | 17.7 | 92.6 | — | — |
| 2.5 | 17.5 | 87.7 | — | — |
| 3 | 23.2 | 88.0 | — | — |
| 4 | 25.0 | 72.5 | 23.4 | 100.0 |
| 5 | — | — | 23.4 | 92.1 |
| 6 | — | — | 24.6 | 88.3 |
| 8 | — | — | 28.3 | 81.6 |

The harvesting rate increased with increased ground speeds up to about 3 feet per minute; beyond this speed little change was noted. (Figure 9) Harvesting efficiency (Figure 10) underwent the characteristic change with speed, decreasing slowly at low speeds and rather rapidly at higher speeds. In general, for a given speed, higher yield tended to cause lower harvesting efficiency and higher harvesting rates.

The average harvesting rate without the test unit was 17.4 pounds per man-hour at an average ground speed of 2.18 feet per minute where the crop yield averaged 0.137 pounds per foot of row.

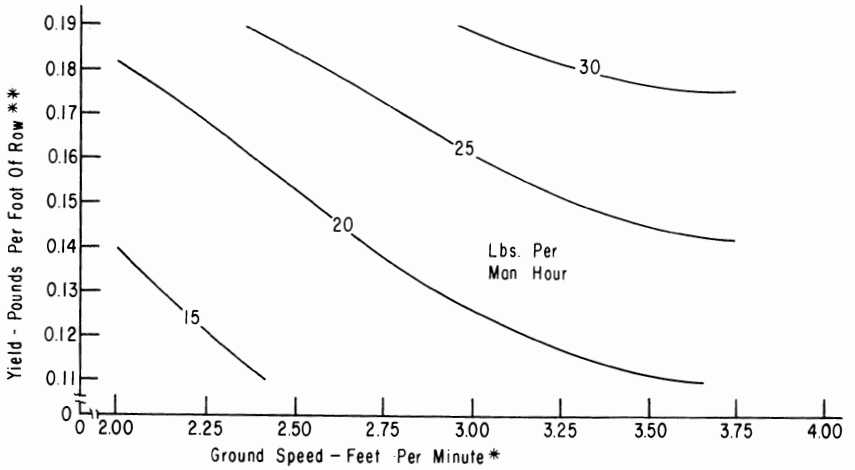


Figure 9. Southern pea harvesting rate (pounds per man-hour) expressed as a function of ground speed and crop yield.

*Data involving two workers per row were reduced to a one-worker-per-row equivalent by dividing the ground speed by two.

**Yield refers to the pounds of harvestable pods found per foot of row for a given picking.

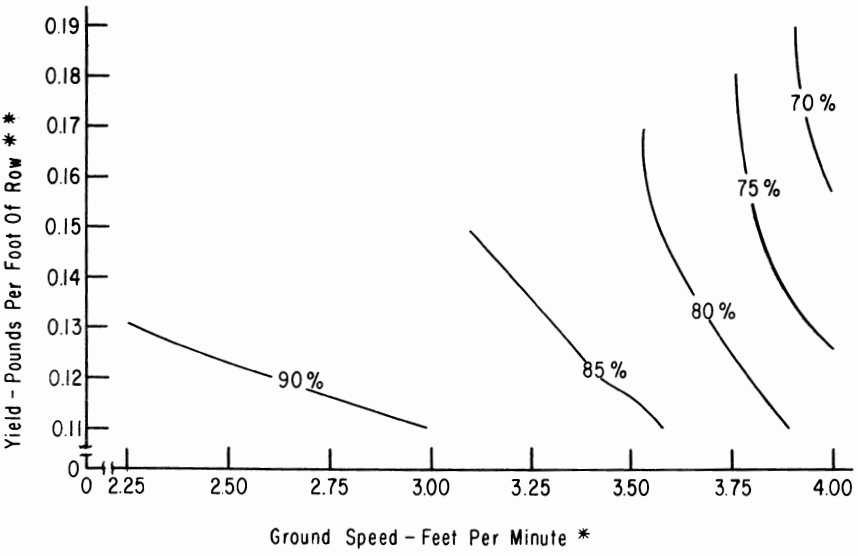


Figure 10. Southern pea harvesting efficiency (percent picked, weight basis) expressed as a function of ground speed and crop yield.

*Data involving two workers per row were reduced to a one-worker-per-row equivalent by dividing the ground speed by two.

**Yield refers to the pounds of harvestable pods found per foot of row for a given picking.

## Observation of Functional Performance

The functional performance of the test unit was satisfactory. The workers experienced some stiffness of chest and shoulder muscles at the outset, but this disappeared when they became accustomed to working in a horizontal position. The head supports performed satisfactorily after the workers learned to adjust them to a comfortable working position.

Excessive vertical arm movement was avoided by using one hand as temporary storage, i.e., filling one hand before dumping into the storage container.

Besides parting the foliage, the search-assistance device helped to define a working area. By working from side to side in an orderly manner, the worker probably used less energy in the searching process and increased his harvesting efficiency.

# Summary and Conclusions

A self-propelled laborer and materials carrier was constructed and tested. Results showed that the machine measurably improved the effectiveness of hand labor when harvesting strawberries by minimizizng lost time and conserving human effort. Night work resulted in satisfactory worker performance and quality of produce.

Values for some of the important design parameters of worker carriers were established in separate tests when harvesting strawberries, green beans, and southern peas. Two workers per row was found to be a desirable worker arrangement. Effective carrier ground speeds ranged from 0.5 to 5 feet per minute depending on the type of crop and crop condition. Relationships between carrier ground speed, crop yield, worker harvesting rate, and harvesting efficiency were established.

## Oklahoma's Wealth in Agriculture

Agriculture is Oklahoma's number one industry. It has more capital invested and employs more people than any other industry in the state. Farms and ranches alone represent a capital investment of four billion dollars—three billion in land and buildings, one-half billion in machinery and one-half billion in livestock.

Farm income currently amounts to more than $700,000,000 annually. The value added by manufacture of farm products adds another $130,000,000 annually.

Some 175,000 Oklahomans manage and operate its nearly 100,000 farms and ranches. Another 14,000 workers are required to keep farmers supplied with production items. Approximately 300,000 full-time employees are engaged by the firms that market and process Oklahoma farm products.

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