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EFFICIENCY OF A FLAIL-TYPE MACHINE IN DESTROYING COTTON SQUARES DEPOSITED ON SOILS VARYING IN SURFACE MOISTURE AND ROUGHNESS[1]

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INTRODUCTION

Control of the boll weevil (Anthonomus grandis Boheman) obtained by destroying squares depends on the efficiency of the destruction operation. Fye and Hopkins[4] found that destroying or removing 90 percent of the infested fallen squares at 5-day intervals provided satisfactory control of the insect.

Burt et al.[5] recently tested a flail-type machine to determine its effectiveness in destroying fallen squares. The machine picked up and destroyed 84 percent of such squares and provided control of the boll weevil equal to that obtained with insecticides when migration of the insect was not a factor. Results of other tests that Burt et al.[6] made with a similar machine in an isolated area showed that boll weevils were controlled when 85 percent of the fallen squares were destroyed at 7-day intervals, initial populations were low, and no late-season migration occurred. A need was indicated for increased efficiency in picking up the squares in the drill area and for increased effective ground speed.

This report describes efforts of Agricultural Research Service during 1965 to increase the efficiency of the flail-type machine, and to determine the effects on its efficiency of soil-surface moisture and soil roughness.

DESCRIPTION OF MACHINE

The machine used in these tests (fig. 1) was a modified model of the flail-type machine described by Burt et al.[6] Our modifications were designed to improve the efficiency of the machine in picking up fallen squares in the drill area of the row and beneath the cotton plants. We used tractor-mounted, ground-driven, rotary cup brushes (fig. 2) to loosen and move the squares from the drill to the middles between rows so that the machine could pick them up. The brushes were powered from the rubber-tired wheel shown in the lower left-hand corner of figure 2. The bristles were 0.036-inch Tynex® nylon,[7] trimmed so that the bottom edge of the

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[4] Fye, R. E., and Hopkins, A. R. Boll Weevil populations as affected by removal of shed cotton forms. U.S. Dept. of Agr. Tech. Bul. 1277, 9 pp. 1962.

[5] Burt, E. C., Davich, T. B., Merkl, M. E., and Cleveland, T.C. Mechanical destruction of fallen boll weevil infested cotton squares. (Abstract) Assoc. South. Agr. Workers Proc. 61: 51. 1964. (Paper presented at meeting of Amer. Soc. Agr. Engin., SE Section, Atlanta, Ga., Feb. 4, 1964.)

[6] Burt, E. C., Merkl, M. E., and Davich, T. B. Boll weevil control in a field experiment with a machine designed to destroy shed cotton squares. U.S. Agr. Res. Serv., ARS 42-121, 6 pp. 1966.

[7] The trade name is used in this publication solely to provide specific information. Mention of the trade name does not constitute a guarantee or warranty by the U.S. Department of Agriculture and does not signify that the product is approved to the exclusion of other comparable products.

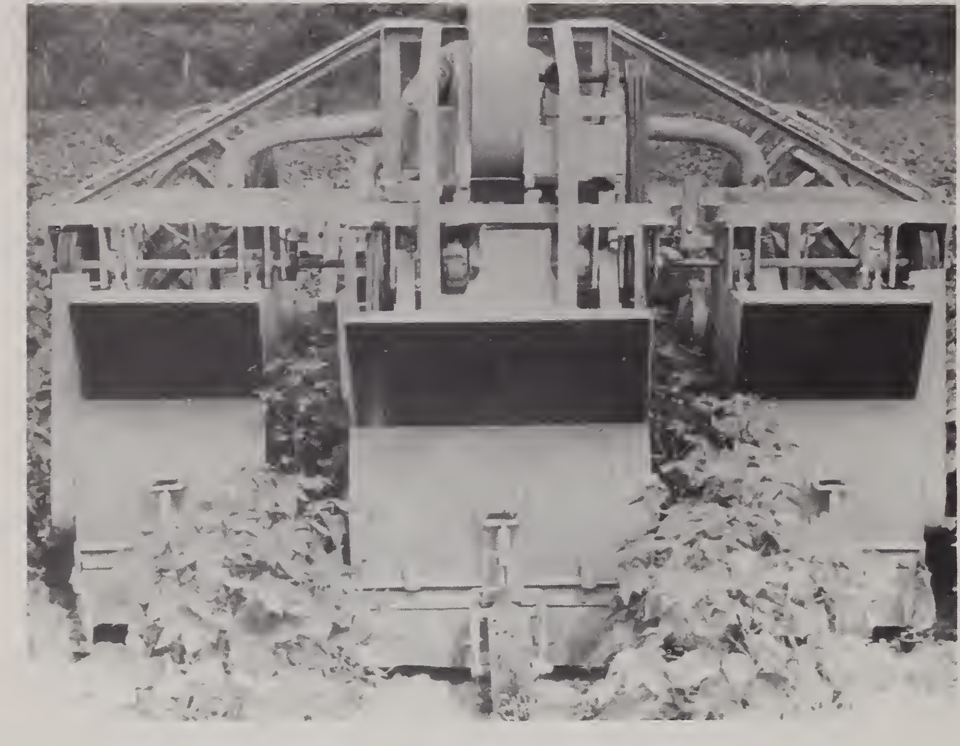

Figure 1.--Rear view of modified flail-type machine used to pick up fallen cotton squares.

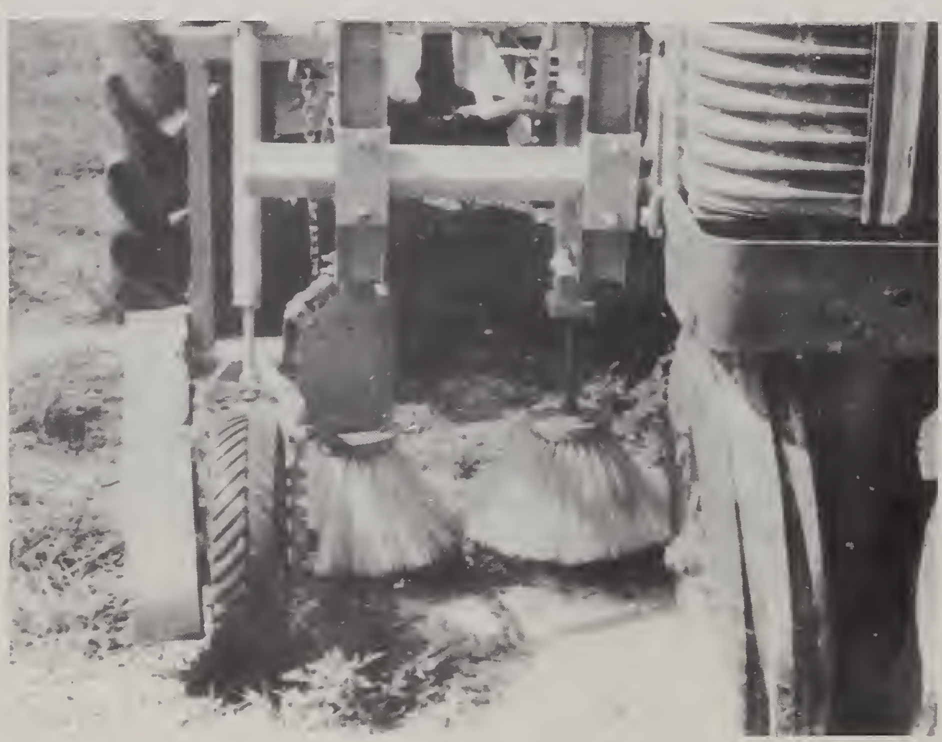

Figure 2.--The rotary brush units on flail-type machine for moving squares from drill area to row middle.

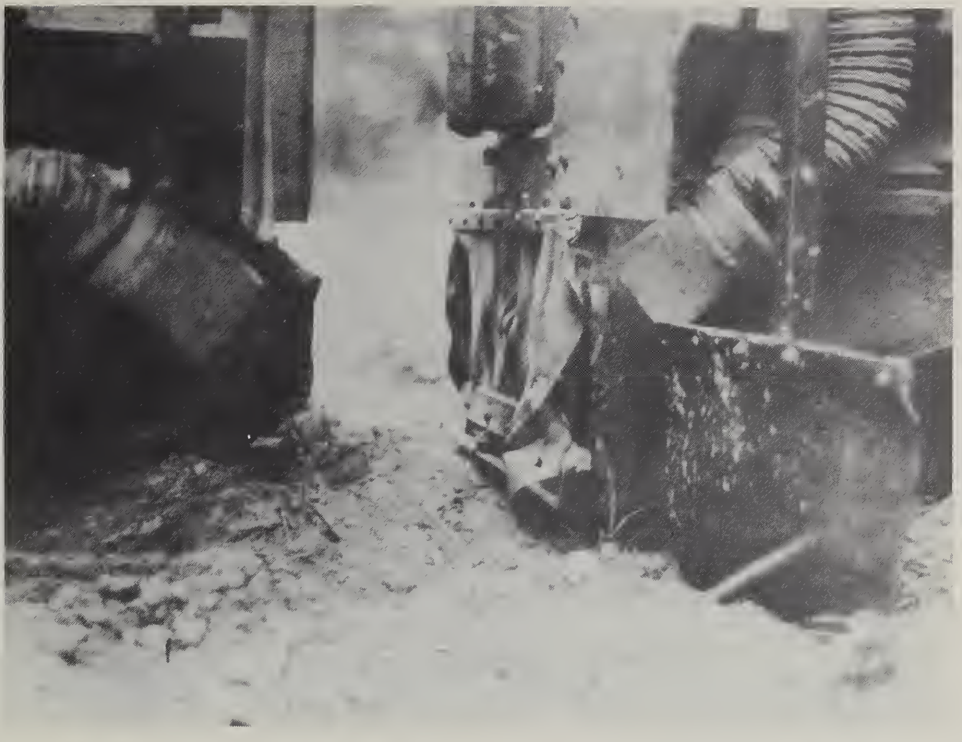

Figure 3.--Front view of the cross-row air nozzles on flail-type machine for moving squares from underneath cotton plants.

brush was 15 inches in diameter. The peripheral speed of the brushes was 4.25 m.p.h., rotated in a direction opposite the line of travel. When the tractor moved at a forward speed of 3 m.p.h., the relative velocity between a fallen form on the ground and the outside edge of the brush was 7.25 m.p.h.

We increased the blower capacity of the machine to 2,137 c.f.m. (at 1-inch static pressure) to accommodate two air nozzles per row (fig. 3). Rubberized canvas baffles prevented the squares from being moved by the air blast beyond the reach of the flail units.

We tested the machine during a 6-week period in four different fields, subjecting it to a variety of soils having variable surface moisture and roughness. The machine was operated at 3 m.p.h. with a flail speed of 1,800 r.p.m. For each test the sampling area was large enough to furnish from 200 to 300 fallen squares. Squares were counted and marked with an orange aerosol paint prior to treatment so that we could distinguish them from squares that fell as a result of plant movement during the treatment. To collect the squares that passed through the flail units, we attached cages to the flail housings; these were covered with 1/8-inch screen (fig. 4) and were 19-1/2 inches high, 20 inches deep, and as wide as the flail unit (20 inches for end units, 30 inches for the center unit). We then counted the painted squares remaining on the soil surface after the machine passed over the test area to determine its pickup efficiency.

Periodically we placed the fallen squares collected in the screened cages in emergence boxes to determine the percentage of immature weevils killed by the flail treatment. A sample of 50 untreated squares collected and placed in a separate box served as a check. We held both treated and untreated samples in the laboratory and examined them for adult weevils 4 weeks later.

We collected samples of soil containing different amounts of moisture at the different locations in the test area; these consisted of 300 to 500 grams of the top one-half inch of the soil surface. Samples were oven dried to determine the percentage of surface moisture (dry basis).

We used a microrelief meter[8] (fig. 5) to measure the roughness of the soil surface, centering the meter on the profile of an undisturbed row and recording the profile readings. We then

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[8] Luttrell, D. H. The effect of tillage operations on bulk density and other physical properties of the soil. 1963. [Unpublished doctor's thesis. Copy on file in Library, Iowa State Univ. of Sci. and Technol., Ames.]

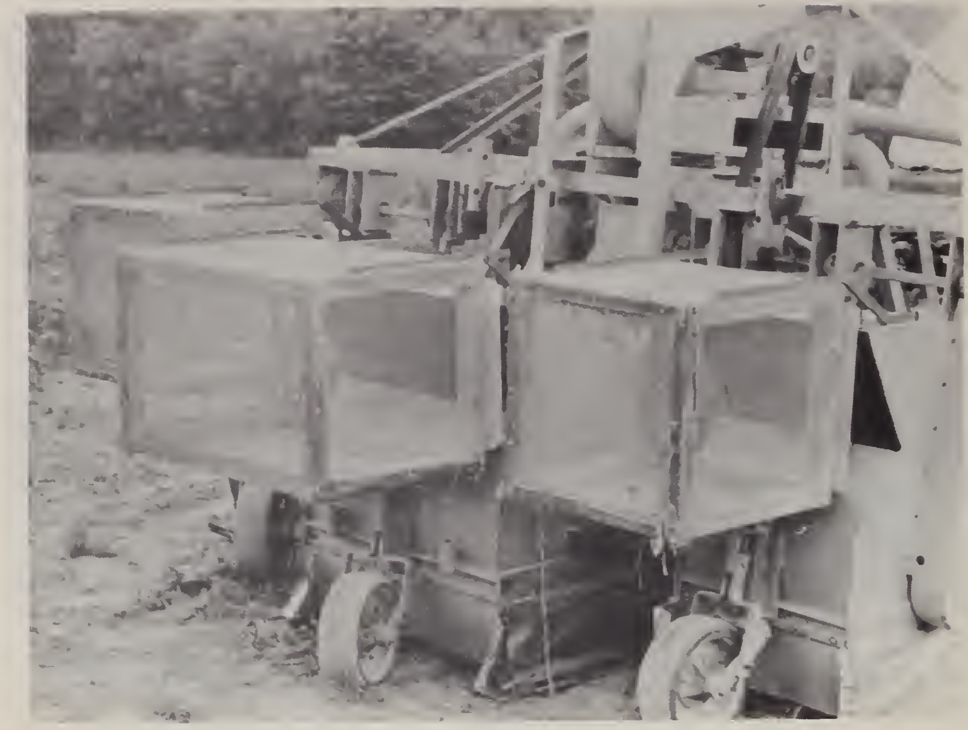

Figure 4.--Screened collection cages attached to the discharge of flail-type machine.

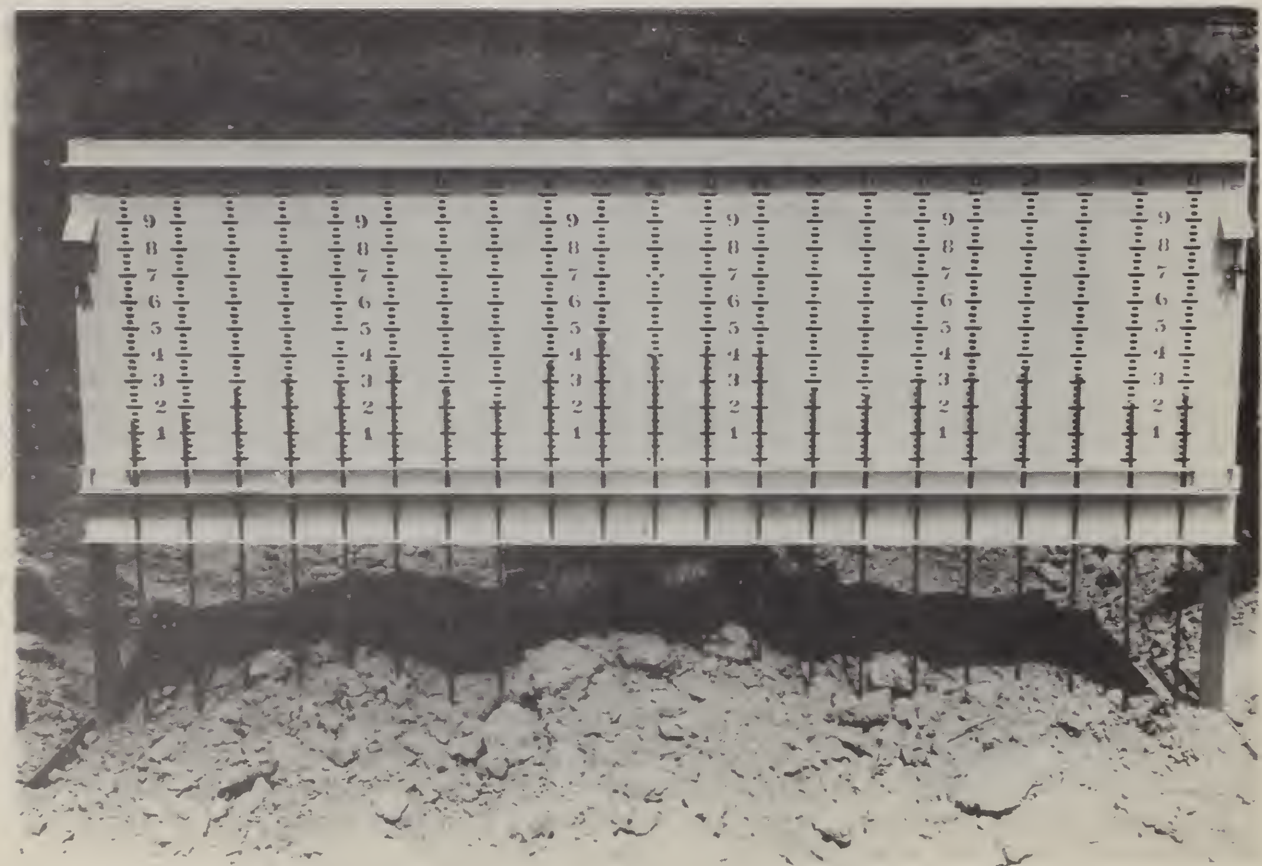

Figure 5.--The microrelief meter used to measure roughness of soil surface.

leveled the same area by hand to form a smooth-row profile and recorded the reading for the smooth surface. The sum of the absolute values of the differences between the readings before and after smoothing was considered the roughness coefficient.

RESULTS AND DISCUSSION

For all tests the mean pickup of squares was 88.1 percent. The values ranged from 59.2 percent, when many of the squares had fallen and been partially covered with soil during a heavy rainstorm, to 98.9 percent, when the squares had fallen on a smooth, dry surface. The values were below 80 percent in only 13.5 percent of the tests.

The efficiency of the machine in killing boll weevils is shown in table 1. An average of 94.8 percent of immature weevils in squares passing through the machine were killed.

To estimate the parameters affecting the efficiency of the experimental machine, we treated the data pertaining to the efficiency of the machine along with data relative to moisture and roughness of soil surface by the method of least squares. The model we used was as follows:

$$Y = a + b_1x_1 + b_2x_2 + b_3x_1^2 + b_4x_2^2 + b_5x_1x_2,$$

where Y = pickup efficiency, x_1 = percent surface moisture, and x_2 = roughness coefficient. When, however, as a result of testing the parameters b_4 and b_5 against the residual error, we assume they are zero and in consequence we use the model $Y = a + b_1x_1 + b_2x_2 + b_3x_1^2$, we find that the estimate of residual error is not significantly less (at the 5-percent-level "F" test) than that from the original model. The shortened model reduces the variability in pickup efficiency of the machine by 56.4 percent.

In figure 6 the regression equation is plotted within the range of the data, with the coefficient of roughness held constant at three different levels. The resulting curve shows that the pickup efficiency of the flail machine decreased as the surface moisture increased. In addition the shape of this curve implies that a further increase in moisture would have little effect on efficiency of the machine. However, differences in type of soil possibly could affect this relationship.

Figure 7 shows the same equation as in figure 6, but it is now plotted with constant percentages of surface moisture. The shape of this curve implies that roughness or unevenness affects the pickup efficiency of the machine but not as much as surface moisture. However, we conducted these tests on sandy soil and did not encounter extremely rough conditions.

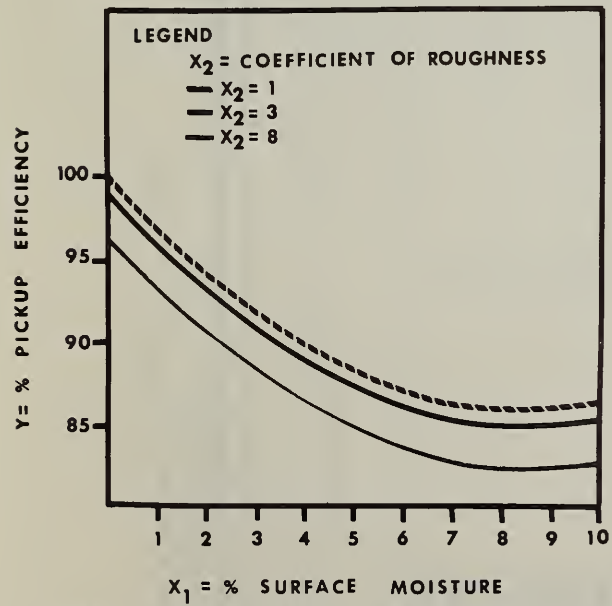

Figure 6.--The regression equation $\underline{Y} = 100.6 - 3.29\underline{x}_1 - 0.533\underline{x}_2 + 0.192\underline{x}_1^2$, plotted at 3 constant levels of soil roughness.

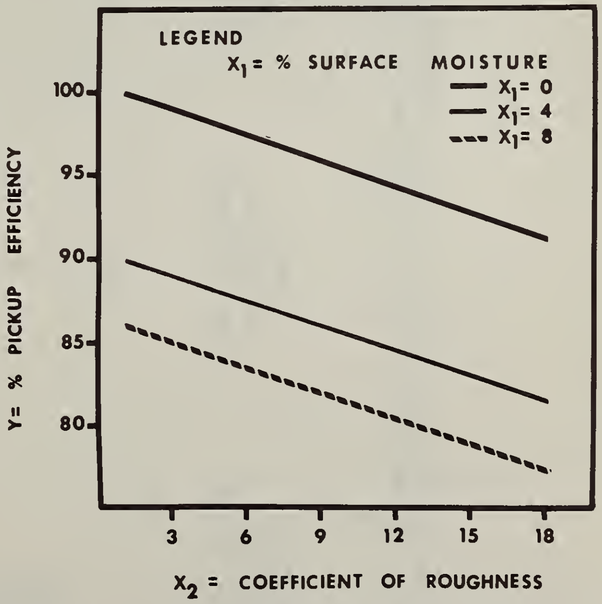

Figure 7.--The regression equation $\underline{Y} = 100.6 - 3.29\underline{x}_1 - 0.533\underline{x}_2 + 0.192\underline{x}_1^2$, plotted at 3 constant levels of soil surface moisture.

Table 1.--Number of squares picked up in tests with flail-type machine, number of boll weevils emerged at end of 4 weeks from these squares, with projected number of weevils that would have emerged and percentage that would have been killed as based on emergence in the check squares (50 sampled)

Squares picked up by machine in each test number	Weevils emerged from picked-up squares	Weevils emerged from 50 squares in check	Emergence of weevils in check	Weevils that would have emerged (if fallen squares had not been picked up by machine) [1]	Weevils that would have been killed [2]
	Number	Number	Percent	Number	Percent
146	1	19	38	55.5	98.2
432	9	6	12	51.8	82.6
293	3	7	14	41.0	92.7
300	8	8	16	48.0	83.3
215	3	[3]12	27	58.1	94.8
492	3	3	6	29.5	89.8
344	2	14	28	68.3	97.1
394	1	9	18	70.9	98.6
392	0	5	10	39.2	100.0
290	0	11	22	63.8	100.0
374	0	5	10	37.4	100.0
269	0	2	24	64.6	100.0
499	1	2	4	20.0	95.0
Mean					94.8

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[1] Computed from percentage of weevils that emerged in check squares times total number of fallen squares in test.

[2] Computed from number of weevils that would have emerged if fallen squares had not been picked up by machine minus number of weevils emerged from picked-up squares times 100.

[3] Number of weevils emerged from 44 squares.

CONCLUSIONS

Results of the tests allow us to draw the following conclusions:

1. The efficiency of the flail machine in picking up fallen squares decreased as the moisture in the surface of the soil or the roughness increased.
2. Moisture of soil surface affected efficiency of the machine in picking up fallen squares more than roughness of the surface.
3. The flail-type machine picked up enough of the fallen squares (88.1 percent) and killed enough immature weevils (94.8 percent) to provide satisfactory control of boll weevils. However, groundspeed should be increased to above the 3 m.p.h. used in these tests.

ACKNOWLEDGMENTS

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