Red Imported Fire Ant (Hymenoptera: Formicidae): Correlation of Ant Density with Damage to Two Cultivars of Potatoes (*Solanum tuberosum* L.)

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ABSTRACT Red imported fire ants, *Solenopsis invicta* Buren, damaged 12.2–26.1% of 'Sebago' and 'Russett' potatoes (*Solanum tuberosum* L.) in small-plot field tests in 1983–1985 and caused severe damage to commercial plantings of potatoes in the Hastings area of northeastern Florida. The extent of potato loss in both small plots and commercial fields was positively correlated with numbers of ants caught per bait trap. Average numbers of ants trapped varied from 2 to 205 per bait. The United States Standards for Grades of Potatoes define severe damage as that which results in the loss of >10% of the total weight of the potato; our data indicate severe damage occurs when the average ant catch per trap exceeds 80. This information can be useful to growers for determining when costs of ant control are economically feasible.

KEY WORDS Insecta, imported fire ants, economic damage, potatoes

THE RED IMPORTED fire ant (RIFA), *Solenopsis invicta* Buren, has long been known to infest cultivated fields throughout its range in the southern United States. Damage by the ants to a variety of crops was reported in the late 1940s with corn, potatoes, soybeans, cabbage, and sweet potatoes most severely affected (Lyle & Fortune 1948, Eden & Arant 1949, Smith 1949). Wilson & Eads (1949) reported that the ants ate large, elongate cavities out of the stems of potatoes (*Solanum tuberosum* L.), at or just below ground level and often severed the stems from the roots. Fire ants have been identified as general plant pests of potatoes in Brazil, causing extensive damage by attacking both plants and tubers (Boock & Lordello 1952, Gallo et al. 1978).

For undetermined reasons, reports of any type of crop damage by RIFA in the southern United States were very limited from the early 1950s to the mid-1970s. The widespread use of chlorinated hydrocarbon insecticides for a variety of pests in cultivated fields is thought to have suppressed RIFA populations to nondamaging levels during that period (Lofgren & Adams 1982). Increasing numbers of reports of crop damage to corn (Glancey et al. 1979), soybeans (Lofgren & Adams 1981, Adams et al. 1983, Apperson & Powell 1983), and eggplants (Adams 1983) began to appear by the late 1970s and early 1980s, as residues of these chemicals began to dissipate after registrations were cancelled by the Environmental Protection Agency.

Reports of damage to commercial plantings of potatoes were received through the University of Florida Agricultural Research and Education Center (AREC) at Hastings, Fla., in late 1982 (Anonymous, 1982). Wetumpka Fruit Company, the largest producer of table-grade potatoes in the Hastings area, reported that one load of potatoes (var. Sebago) had been rejected at the fresh produce market in New York City and a second one accepted only after a negotiated price reduction of $1,000. Both loads were heavily infested with RIFA.

These reports of damage to potatoes from the Hastings area and information derived from early reports prompted us to conduct studies to document more fully the type and extent of damage to potatoes by RIFA. Here we report the results of these studies.

Materials and Methods

Small-plot tests were conducted at the USDA–ARS laboratory, Gainesville, Fla., in 1983, 1984, and 1985. Additional data were obtained in 1984 and 1985 from commercial plantings at Hastings, Fla.

Small-Plot Tests. All the small-plot tests were conducted on two plots (10 by 30 m). One of the plots was maintained essentially ant-free by judicious use of hydramethylnon fire ant bait and the other was infested with RIFA at the equivalent of about 100 mounds per hectare.

The plots were tilled and prepared for planting in the same manner as larger commercial fields. The fields were fumigated for nematode and wireworm control before the 1984 and 1985 tests. Commercial fertilizer (8N:8P:8K) was broadcast on the plots at the rate of 400 kg/ha before planting. Lime was applied at 270–300 kg/ha before the 1984 and 1985 tests to adjust soil pH to the optimal level. Side-dressings of 68 kg/ha of an 8-8-8 analysis fer-

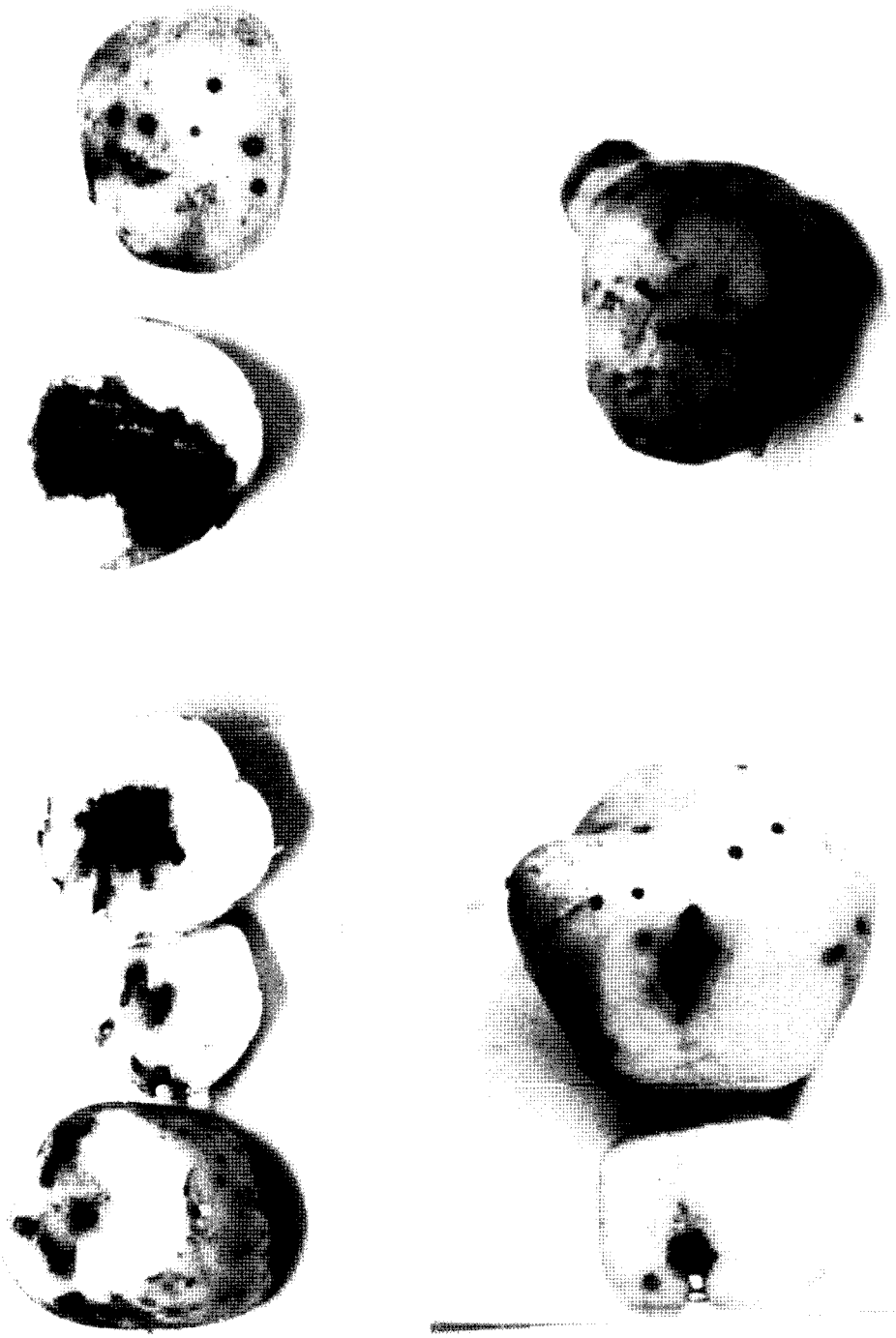

Fig. 1. Damage to potatoes by red imported fire ants.

tilizer were applied to the potatoes in each plot at 6 wk after planting.

Four rows each of 'Sebago' and 'Russett Centennial' in alternate rows were planted with 1-m row spacing in each plot in late January or early February. In 1983–84, three to four seed pieces were planted per meter of row at a depth of 8–10 cm. Whole seed potatoes were planted in 1985.

Table 1. Effect of RIFA infestations on potatoes

Year	Potato variety	Avg RIFA per trap	Mean wt (g) of potato sample	% damage
	Small-plot tests (Gainesville, Fla.)			
1983	Sebago	205	794.1	26.7
		10	1,010.0	2.8
	Russett	205	712.9	24.8
		10	1,045.3	0.0
1984	Sebago	191	1,346.0	21.2
		2	911.6	1.6
	Russett	191	655.2	26.1
		2	657.5	1.9
1985	Sebago	115	1,361.9	15.5
		4	1,489.2	0.0
	Russett	82	1,214.5	13.1
		4	1,322.6	0.0
	Commercial fields (Hastings, Fla.)			
1984	Sebago	231	3,364.8	30.0
		5	3,620.8	2.0
1985	Sebago	36	3,518.0	0.0
		11	3,323.0	0.0

Normal cultivation was maintained for 6–7 wk after planting. The plots were irrigated by overhead sprinklers as needed to maintain optimal soil moisture.

Periodic observations were made during the growing seasons each year for RIFA activity and evidence of damage to the plants. Density of foraging ants was determined immediately before potato harvest using two baits (hamburger and honey) at each collection site (Stringer et al. 1980). The baits were left in the field for 1 h, after which the bait and any ants were collected and placed in a sealed container. The RIFA workers were separated from any other ant species in the laboratory, and the numbers were recorded. Determination of potato damage was made 115–125 d after planting by harvesting all the potatoes in sections (1 or 2 m) of row. They were returned to the laboratory, washed, and examined for RIFA feeding. All potatoes with more than five scars or holes caused by RIFA feeding were considered seriously damaged, and their weight was deducted from the total sample weight to determine percentage damage. The number of ant collections and potato samples taken per plot for the years 1983, 1984, and 1985 were, respectively: ant collections (5, 10, 20); potato samples (5, 10, 15). In all cases, the sites of the collections and samples were determined by random selection.

Commercial Plantings. Assessment of RIFA damage to commercial plantings was made in 1984 in two fields managed by Wetumpka Fruit Company, Hastings, Fla. One field was partially abandoned by the grower because of the high density of RIFA, and the other averaged only five ants per trap. Two other fields were evaluated in 1985.

Twenty-five sample sites, each consisting of 1 m of row, were randomly selected for each field. All potatoes from each site were harvested, washed, dried, and sorted to determine those that were RIFA damaged and those that were marketable. The potatoes in each group were weighed, and the weight was recorded and tabulated as a percentage of the total for the field. Ant collections to determine density were made from 50 randomly selected sites in each field 1 wk after harvest. The collections were returned to the laboratory, and the number of RIFA was recorded.

Table 2. Analysis of variance for effects of RIFA on potato production

Source	F value	df	Pr > F
Infestation level	221.97	1	0.0001
Potato variety	0.85	1	0.36565
Location	11.94	2	0.0001
Year	6.17	2	0.0025

The data from the tests were analyzed using general linear models with the Statistical Analysis System (SAS Institute 1982). Analysis of variance (ANOVA) was performed with Duncan's multiple range test (Duncan 1951).

Results and Discussion

Ants were observed foraging along the rows of potatoes and around the bases of the plants in the small plots from 1 wk after planting throughout the growing season, but little damage to the plants was noted. However, damage to the tubers, ranging from small external feeding scars to extensive tunneling throughout the tubers (Fig. 1), was apparent at harvest. Data on damage caused by the ants and RIFA population levels are shown in Table 1.

The ANOVA (Table 2) revealed no significant difference in losses between the two cultivars; however, there were highly significant differences between RIFA infestation levels, plot locations ($P < 0.0001$), and test years ($P < 0.0025$). Duncan's multiple range test (Table 3) showed significant differences ($P < 0.05$) in damage between heavy (80 ants per trap) and light ant infestations in all years and at all locations. Damage in the heavily infested

Table 3. Duncan's multiple range test comparing potato losses in the presence of heavy and light RIFA infestations

Year	No. samples	df	Condition	Mean
		Small-plot tests		
1983	20	17	Heavy	0.5199a
			Light	0.0577b
1984	40	37	Heavy	0.4795a
			Light	0.0656b
1985	60	57	Heavy	0.3442a
			Light	0.0000b
		Commercial fields		
1984	50	48	Heavy	0.5578a
			Light	0.0813b

Means followed by the same letter are not significantly different ($P > 0.05$; Duncan's [1951] multiple range test).

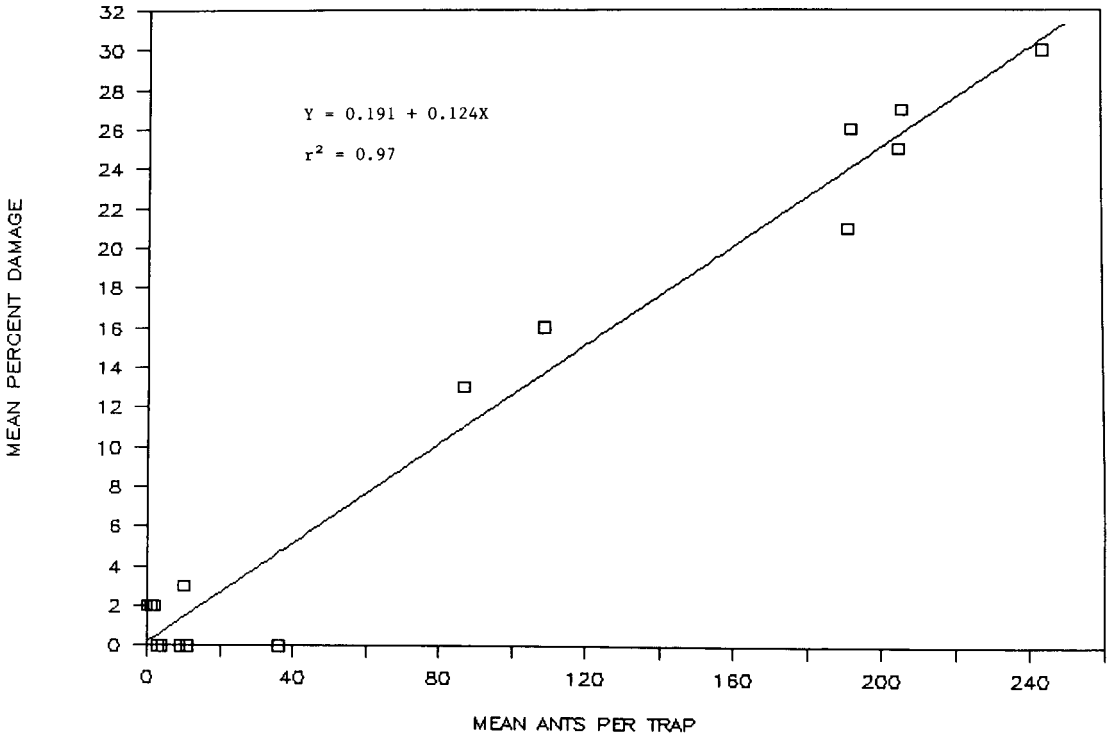

Fig. 2. Relationship of potato damage to level of fire ant infestation as reflected by bait collections.

plots ranged from 13.1 to 26.7%; the greatest damage (30.0%) was noted in a commercial potato field near Hastings, Fla. Damage in lightly infested fields did not exceed 2.8%.

The regression line ($r^2 = 0.97$; slope = 0.124 ± 0.0056) obtained when percentage of damage was plotted in relation to the number of ants captured per trap (Fig. 2) showed that increased ant populations resulted in increased damage to the potatoes. Serious damage (10% loss in weight, as established by the United States Standards for Grades of Potatoes [Anonymous 1982]) occurred when the number of ants captured exceeded 80 per trap.

The samples taken in 1984 in the heavily RIFA-infested (230 ants per trap) commercial field at Hastings showed that the percentage of damaged potatoes exceeded that in the lightly infested field (five ants per trap) by 28.0% (Table 1). The grower reported that the ants caused losses through reduced yield, increased culls, increased grading time, and abandonment of part of the field due to the heavy ant infestation (Table 1). Grower records showed that the yield was reduced by about 15% (19,046 kg/ha compared with >22,407 kg/ha average before RIFA infestation), resulting in a loss of 31,593 kg of expected yield. Culling of ant-damaged potatoes reduced the weight of salable potatoes an additional 34.7% (62,124 kg). Abandonment of 1.0 ha of the field because of the severity of ant damage resulted in loss of an expected yield of 22,407 kg. Total loss of potatoes caused by RIFA, when compared with previous average yield, was about 116,124 kg. The value of this loss, at the 1984 wholesale price of $0.187/kg for table grade potatoes, was $21,715.

In addition to the direct loss of potatoes, the severity of damage increased grading time 3 times for potatoes from the heavily infested field (4 h versus the normal 1.3 h was required to grade a 4,356-kg field cart). Labor costs for grading were $182 for a cart from the heavily infested field, compared with only $60.65 from the lightly infested field; grading costs were increased by $121.35 per cart for the 39.5 carts harvested from the heavily infested field. Added grading costs were approximately $4,793, and total losses caused by the ants in the heavily infested field were estimated at more than $30,460.

In 1985, no damage was observed in potatoes from two fields near Hastings where ant density was low (36.0 and 11.0 ants per bait). Our studies show that high density RIFA infestations can cause severe monetary losses for potato and other crops (Lofgren & Adams 1982). Further, they emphasize the need for effective control agents to use on cropland (none is currently registered). Although the costs of currently available technology using toxic baits is high ($10–20/ha), it represents only a small fraction of the potential loss from RIFA damage.

Approximately 8,000 ha of land in the Hastings area are planted to potatoes each year on a single crop system. Potatoes are planted in late January

or early February and harvested after 115–125 d. Harvest coincides with the time of major mating flights of RIFA. Past research suggests that newly mated RIFA queens found colonies most efficiently in disturbed soil. Following the potato harvest, the majority of the land is planted with grain sorghum as a cover crop. This combination of agricultural practices makes the land ideal for heavy infestations of RIFA.

Our data show that high densities of *S. invicta* will result in a reduction of profits caused by direct damage to the potatoes and increased time for grading. However, the total impact may vary depending on the final use for which the potatoes are marketed (baking potatoes, french fries, etc.). The grower must assess losses and control costs to determine when control is justified. The United States Standards for Grades of Potatoes (Anonymous 1972) states that serious damage is "any defect, or combination of defects, which seriously detracts from the edible or marketing quality . . . and which cannot be removed without a loss of more than 10% of the total weight of the potato." In our studies, 10% damage occurred when the mean RIFA per bait exceeded 80. Development of a standardized trapping procedure, such as we used, could aid potato farmers in deciding when treatment of RIFA populations is economically justified.

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References Cited

Adams, C. T. 1983. Destruction of eggplants in Marion Co., Florida by red imported fire ants. Fla. Entomol. 66: 518–520.

Adams, C. T., W. A. Banks, C. S. Lofgren, B. J. Smittle & D. P. Harlan. 1983. Impact of the red imported fire ant, *Solenopsis invicta*, on growth and yield of soybeans. J. Econ. Entomol. 76: 1129–1132.

Anonymous. 1972. United States standards for grades of potatoes. USDA, Food Safety and Quality Service, 37FR2745.

Anonymous. 1982. Fire ants sting potato profits. Fla. Grower Rancher 75(10): 30.

Apperson, C. S. & E. E. Powell. 1983. Correlation of the red imported fire ant with reduced soybean yields in North Carolina. J. Econ. Entomol. 76: 259–263.

Boock, O. J. & L. G. E. Lordello. 1952. Formiga "lava-pe," praga de batatinha—*Solanum tuberosum*. L. Rev. Agric. (Piracicaba) 27: 377–379.

Duncan, D. B. 1951. A significance test for differences between ranked treatments in an analysis of variance. Va. J. Sci. 2: 171–189.

Eden, W. G. & F. S. Arant. 1949. Control of the imported fire ant in Alabama. J. Econ. Entomol. 42: 976–979.

Gallo, D., O. Nakano, S. S. Neto, R. P. L. Carvalho, G. S. De Batista, E. Berti Filho, J. R. P. Parra, R. A. Zucchi & S. B. Alves. 1978. Manual de Entomologia Agricola. Editora Agronomica Ceres Limitada, São Paulo, Brazil.

Glancey, B. M., J. D. Coley & F. Killebrew. 1979. Damage to corn by the red imported fire ant. J. Ga. Entomol. Soc. 14: 198–201.

Lofgren, C. S. & C. T. Adams. 1981. Reduced yield of soybeans in fields infested with the red imported fire ant, *Solenopsis invicta* Buren. Fla. Entomol. 64: 199–202.

1982. Economic aspects of the imported fire ant in the United States, pp. 124–128. *In* M. D. Breed, C. D. Michener & H. E. Evans [eds.], The biology of social insects. Westview, Boulder, Colo.

Lyle, C. & I. Fortune. 1948. Notes on an imported fire ant. J. Econ. Entomol. 41: 833–834.

SAS Institute. 1982. SAS user's guide: statistics. SAS Institute, Cary, N.C.

Smith, M. R. 1949. Report on imported fire ant investigations. USDA Mimeo Report.

Stringer, C. E., W. A. Banks & J. A. Mitchell. 1980. Effects of chlorpyrifos and acephate on populations of red imported fire ants in cultivated fields. J. Ga. Entomol. Soc. 15: 413–417.

Wilson, E. O. & J. H. Eads. 1949. A report on the imported fire ant, *Solenopsis saevissima* var. *richteri* Forel, in Alabama. Alabama Department Conservation Special Report (mimeo).

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