12-1959

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K. P. Pruess
Ohio Agricultural Experiment Station, Wooster

C. R. Weaver
Ohio Agricultural Experiment Station, Wooster

Published in *Journal of Economic Entomology* 52:6 (December 1959), pp. 1166–1167;
doi: 10.1093/jee/52.6.1166.

Accepted for publication June 8, 1959.

Effects of Moisture on the Clover Root Borer and Red Clover Yields

K. P. Pruess and C. R. Weaver[1]

Ohio Agricultural Experiment Station, Wooster, Ohio, USA

Abstract
Rainfall and populations of the clover root borer, *Hylastinus obscurus* (Marsham), were artificially controlled in pots of red clover grown under shelters in the field. Populations of clover root borer were higher under dry conditions. Although yield losses were high in borer-infested pots, yield reductions were no greater under dry than under wet conditions.

It is generally believed that the clover root borer, *Hylastinus obscurus* (Marsham), causes more damage in dry than wet seasons (Riley 1879, Folsom 1909, Rockwood 1926). Rockwood (1926) also thought development was more rapid and populations higher under dry conditions. Little experimental evidence is available to confirm these observations.

Procedure

To test these observations more accurately, red clover was grown under artificially controlled moisture conditions. Two shelters, each 40 feet long, 2 feet wide, and 18 inches high on the sides, were covered with gable-type celloglass roofs. Open sides on these shelters permitted free wind movement. The celloglass roof allowed light penetration while shedding most rainfall. Glazed tile pots, 9 inches in diameter, were buried to their rims under these shelters and filled with a mixture of sand and compost. Kenland red clover plants dug from a nearby field were reset in these pots. First-harvest-year plants were potted on April 15 for the 1955 test and seedling plants on September 12, 1955, for the 1956 test. Two

plants per pot were used in 1955 and four in 1956. The shelters were roofed, and artificial watering begun during April of both years.

Four moisture levels were used, each level with and without clover root borers. Treatments were applied in a randomized block replicated 10 times. Half the pots were treated with dieldrin granules at 2 pounds actual per acre to prevent root borer infestation. Ten adult root borers were released in each untreated pot prior to spring migration, and additional dead infested roots containing an unknown number of borers were placed in each pot to permit normal seasonal emergence of the adults. During the 2 years, only one plant became infested in all the dieldrin-treated pots.

Plants were watered twice weekly. Rates used in 1955 were equivalent to 1, 2, 4, and 6 inches of rainfall per month. It was found in 1955 that 6 inches was but little better for clover growth than 4 inches and that only 1 inch still permitted fair growth. Therefore 1956 rates were changed to 1/2, 1, 2, and 4 inches per month. Unfortunately driving rains blew under the shelters in 1956, obscuring moisture effects during the first two cuttings. No water was added to any pots between June 15 and July 17 and only to the higher levels after this period in a rather unsuccessful attempt to reestablish a moisture differential.

Three cuttings of hay were made each year; June 2, July 18, and August 25, 1955, and June 12, July 24, and September 12, 1956. Both green and dry yields were recorded for each pot. Immediately after the third cutting, roots were dug and dissected to determine the number and stage of root borers present.

Results

Analyses of green and dry yields gave almost identical results. Therefore only dry yield data are reported here. The analyses of variance are given in Table 1 and yield data in Table 2.

Table 1. Analyses of variance of yield data

		1955 Test		1956 Test	
Factor	Degrees Freedom	Mean Square	F	Mean Square	F
Water	3	1,919.7	47.40[a]	61.3	0.78
Borers	1	3,353.0	82.79[a]	2,136.0	27.28[a]
Cutting	2	11,400.5	281.49[a]	16,950.5	216.48[a]
W×B	3	25.3	0.62	161.0	2.06
W×C	6	339.0	8.37[a]	118.0	1.51
B×C	2	593.5	14.65[a]	135.0	1.72
W×B×C	6	16.5	0.41	280.5	3.58[a]
Error	207	40.5		78.3	

a. Significant at 1% level.

Table 2. Dry yield in grams for uninfested pots and percent yield reduction attributed to clover root borer

Cutting		Inches Water per Month					Mean
		0.5	1	2	4	6	
				1955			
1	Y[a]		11.5	16.6	26.0	29.0	20.8
	R[b]		21.8	22.3	22.7	9.7	18.0
2	Y		24.9	37.5	43.1	45.2	37.7
	R		39.8	44.8	30.9	33.8	36.4
3	Y		7.4	9.4	10.6	10.3	9.4
	R		58.1	52.1	50.0	52.4	52.8
Mean	Y		14.6	21.2	26.6	28.2	
	R		38.1	40.0	30.2	27.8	33.0
				1956			
1	Y	40.1	39.7	40.9	35.8		39.1
	R	9.3	15.1	34.2	22.1		19.6
2	Y	26.6	28.4	28.7	28.2		28.0
	R	3.8	32.7	40.4	25.5		26.0
3	Y	5.2	8.8	6.7	11.1		8.0
	R	13.5	59.1	34.3	33.3		37.4
Mean	Y	24.0	25.6	25.4	25.0		
	R	6.1	26.7	36.6	25.0		23.9

a. Mean yield of uninfested pots.
b. Percent reduction in yield attributed to borers.

In the 1955 test, root borers significantly reduced yields in all three cuttings with the percent loss being greatest in the third cutting and least in the first. Yields were increased as water was increased in the first two cuttings, but water had little effect in the third cutting. The interaction between borers and water was not significant, indicating that moisture had little, if any, effect on root borer damage.

Results for the 1956 test were similar to those in 1955 except that moisture effects were largely obscured by rain blowing under the shelters. Borer-infested pots yielded less during all three cuttings, with highest losses again occurring in the third cutting. In 1956, as in 1955, no interaction occurred between borers and moisture. The significant second order interaction between water, borers, and cutting probably reflects the decreased yields in borer-infested pots in the three high-water levels relative to the low level during the first two cuttings. Since a true moisture differential was not maintained during the first two cuttings, no explanation of this effect is available.

In general, losses were about the same regardless of soil moisture. It appears that while moisture has little effect on clover root borer damage, such damage has been most often noticed during dry seasons when the second cutting of red clover hay was small. During such seasons plants are most often examined for insects and, because of its presence, the clover root borer likely received much of the blame actually caused by climatic conditions.

Yield reductions were much greater during both seasons than would be expected from the low populations of clover root borers present (Pruess & Weaver 1958). It is possible that other factors obscured the true root borer effects. Meadow spittlebugs, *Philaenus leucophthalmus* (L.), were present in 1955 and were handpicked. The cornfield ant, *Lasius alienus americanus* Emery, became abundant during the summer of 1955, and a brown-sugar-Paris-green bait was used but proved rather ineffective. Only low populations of aphids and tarnished plant bugs, *Lygus lineolaris* (P. de B.), were observed in 1956, and no controls were used. Mealybugs were abundant on the roots in untreated pots during both seasons.

Clover root borer populations were highest in the low moisture levels and lowest at the high levels (Table 3). Similar findings were reported by Koehler & Gyrisco (1959). Root borer counts were transformed by the inverse hyperbolic sine transformation before analyzing. The inverse hyperbolic sine transformation, given by $x' = q^{-1/2}\sinh^{-1}(qx)^{1/2}$, appears appropriate for clover root borer data (Pruess & Weaver 1959). Differences among treatment means were just significant at the 5% level. An analysis of regression of root borers on water gave a highly significant regression coefficient of $b = -0.659$. It has been observed that number of borers per root tends to increase as root size increases (Newsom 1948, Pruess & Weaver 1958). However, measurements of crown diameters showed no differences in root size to exist among moisture treatments. This then could not explain differences in root borer populations in the moisture treatments. Koehler and Gyrisco (1959), however, believed that under field conditions, root size had a greater influence on borer numbers than soil moisture. If clover root borer populations are higher during dry seasons, as field observations made in Ohio have indicated, these larger populations may account for reduced yields. This appears to be a more logical explanation for reduced yields in dry seasons than a direct interaction between borers and moisture. Since nearly all borers were adults at the time roots were dug, no differences in stage of development owing to soil moisture could be detected in these tests.

Table 3. Mean number of clover root borers per pot in different moisture treatments

	Inches Water per Month				
Year	0.5	1	2	4	6
1955		5.0	2.2	3.3	1.5
1956	4.6	5.7	3.8	3.8	
Mean	4.6	5.4	3.0	3.0	1.5

Note

1. Research Assistant and Station Statistician, respectively, Ohio Agricultural Experiment Station, Wooster. The senior author is now Assistant Entomologist, University of Nebraska, North Platte Experiment Station, North Platte, Nebraska.

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