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BIOLOGY OF THE MEXICAN COTTON BOLL WEEVIL. VI.
Some Humidity and Temperature Effects on Development and Longevity[1]

By EDGAR F. GROSSMAN

The difficulty encountered in keeping cotton boll weevils (*Anthonomus grandis* Boh.) alive in low temperature incubators equipped with brine coils led to the determination of the optimum range of relative humidity necessary for successful weevil hibernation in artificially cooled environments. In order to secure and maintain a number of constant relative humidities, 200 cc. of varying percents of sulphuric acid and distilled water were placed in desiccators measuring seven inches in diameter. The sulphuric acid solutions were mixed in accordance with data presented by R. E. Wilson.[2]

The specific gravity of each solution was then recorded and subsequent determinations of the relative humidity of each desiccator were obtained by specific gravity measurements. Though the majority of the solutions remained constant, some of them, after being used for a month, varied by one half of one percent relative humidity. Allowances for temperature corrections were not made since the percent relative humidity varied but slightly between 21° C. and 27° C., and the series in which the temperatures were maintained at 15° C. and 2° C., respectively, showed no critical points of interest. Daily aeration of

[1]Contribution from the Department of Cotton Investigations, Florida Agricultural Experiment Stations.

[2]Wilson, Robert E. "Humidity Control by Means of Sulphuric Acid Solutions." Jour. Indus. and Engin. Chem. Vol. XIII, No. 4. pp. 326-29. 1921.

the desiccators eliminated the accumulative carbon dioxide generated by the insects, without noticeably changing the concentration of the sulfuric acid solutions. The following solutions were used:

Specific Gravity	Percent Sulfuric Acid	Approximate Relative Humidity
1.000	.00	100
1.039	6.00	98
1.080	12.00	95
1.124	18.00	90
1.163	23.00	85
1.202	28.00	79
1.243	33.00	70
1.286	38.00	61
1.321	42.00	53
1.366	47.00	43
1.405	51.00	35
1.435	54.00	29
1.477	58.00	21
1.520	62.00	14
1.565	66.00	9
1.599	69.00	6
1.646	73.00	3
1.681	76.00	2
1.716	79.00	1

Boll weevils freshly captured in a nearby cotton field were confined in small galvanized iron wire mesh cages to avoid the possibility of having the weevils fall into the sulfuric acid solutions. The cages were then placed in nineteen desiccators which were maintained at the specified relative humidities. The information presented in Table I is self-explanatory, the optimum range extending from 61 percent to 98 percent relative humidity for 27° C.; from 21 percent to 100 percent for 15° C.; and from 9 percent to 100 percent for 2° C. A decrease in temperature apparently minimizes the lethal effect which a low percent humidity exercises on adult boll weevils, whereas increased temperatures tend to narrow the range of optimum relative humidity.

Additional experiments were conducted with adult weevils in order to determine, by examination of the desiccators at two-day intervals, the longevity of weevils maintained at 27° C. over a range extending from 6 percent to 100 percent relative humidity, and also at 21° C. over a range extending from 1 percent to 100 percent relative humidity. Two sets of desiccators were

used for each temperature experiment, fresh cotton squares being supplied the weevils in one set and no food at all being supplied the weevils in the other set. A study of Tables II and III shows that, with the possible exception of relative humidities below 35 percent, both at 27° C. and 21° C., respectively, the presence of food increased the period of time through which adult weevils live. As in Table I, a decrease in temperature is accompanied by a widening of the range of the relative humidities which are non-lethal to the adult. An additional factor is the longevity records of weevils confined in desiccators maintained at 21° C., where a large number of weevils lived longest between 79 percent and 98 percent relative humidity, one weevil living over 161 days at 95 percent relative humidity. A large number of weevils confined at 13° C. with a range of relative humidity extending from 70 percent to 85 percent lived over 300 days, one weevil living 359 days under such conditions. When the relative humidity was maintained at 60 percent or less, weevils did not live so long, dying rapidly when 35 percent or less was reached.

In order to determine the range of optimum percents of relative humidity required for boll weevil transformation, fresh cotton squares into which boll weevils had oviposited were placed into desiccators daily. The egg-laden squares were kept at 21° C. and 27° C., respectively, the range of relative humidity extending from 1 percent to 100 percent in each of the two temperatures. The effect of the various relative humidities was more marked on the weevil transformation than on the adults. At 27° C. the range of non-lethal humidities was definitely restricted to limits extending from 21 percent to 95 percent relative humidity. At 21° C. the range widened. Though the boll weevil eggs developed into adults in a relative humidity as low as 21 percent and as high as 95 percent, the most rapid development at 27° C. took place at 79 percent and 85 percent relative humidity. (See Table IV.) Other tests conducted at the same temperature yielded similar results.

Again, when the temperature is kept constant at 21° C., the most rapid transformation takes place at 79 percent and 85 percent relative humidity. (See Table V.) A noticeable break occurs when the humidity drops below 21 percent, though several weevils managed to escape from the squares at 1, 3 and 6 percents, respectively. A large number of live weevils remained in the hardened, dry squares at 21° C., while none were found in

the series kept at 27° C. Both series, however, yielded but few live pupae and relatively few live larvae.

Boll weevil transformation at 27° C. is completed in an average of 12 days when the relative humidity is kept within a 70 percent to 90 percent limit. Above or below this range the transformation is retarded. At 21° C. the transformation is completed in an average of 21 days in the same range, higher or lower percents relative humidity retarding the transformation. For a period extending over several days adult weevils can withstand any percent relative humidity between 1 percent and 100 percent, though an optimum range limited to 61 percent low and 98 percent high is necessary for continued activity.

TABLE I.—Percent Adult Boll Weevils Surviving Confinement in Desiccators in Which Various Constant Temperatures and Humidities Were Maintained.

Approximate Relative Humidity	Not in Incubator 27° to 38° C., 1 Day 30 Weevils	Not in Incubator 27° to 40° C., 2 Days 30 Weevils	Incubator 27° C., 5 Days 15 Weevils	Incubator 27° C., 5 Days 15 Weevils	Incubator 27° C., 6 Days 15 Weevils	Incubator 27° C., 8 Days 30 Weevils	Incubator 27° C., 8 Days 40 Weevils	Incubator 27° C., 10 Days 30 Weevils	Incubator 15° C., 7 Days 15 Weevils	Incubator 15° C., 10 Days 25 Weevils	Incubator 15° C., 15 Days 30 Weevils	Incubator, 15° C., 1 Day 2° C., 15 Days 30 Weevils	Incubator, 15°C., 1 Day 2° C., 22 Days 8 to 30 Weevils
100	10.00	0	60.00	40.00	86.67	43.33	95.00	63.33	60.00	96.00	83.33	66.67	60.00
98	50.00	33.33	66.67	33.33	60.00	70.00	85.00	53.33	93.33	92.00	56.67	66 67	50.00
95	43.33	0	60.00	40.00	66.67	33.33	77.50	76.67	93.33	60.00	63.33	96.67	31.03
90	33.33	0	40.00	40.00	93.33	30.00	47.50	53.33	100.00	76.00	80.00	46.67	71.43
85	66.67	0	46.67	40.00	73.33	33.00	67.50	70.00	86.67	80.00	70.00	26.67	62.50
79	23.33	0	33.33	46.67	40.00	46 67	47.50	70.00	86.67	72.00	70.00	53.33	43.75
70	43.33	0	33.33	46.67	86.67	33.33	35.00	70.00	73.33	76.00	66.67	70.00	23.80
61	6.67	0	33.33	26.67	66.67	30.00	35.00	60.00	86.67	100.00	66.67	43.33	69.23
53	43.33	0	33.33	20.00	20.00	10.00	2.50	40.00	66.67	76.00	66.67	33.33	40.00
43	40.00	0	0	13.33	26.67	23.33	5.00	46.67	53.33	60.00	53.33	30.00	11.11
35	0	0	0	20.00	0	0	2.50	40.00	53.33	36.00	26.67	26.67	37.50
29	3.33	0	13.33	13.33	33.33	0	0	20.00	73.33	28.00	23.33	40.00	33.33
21	20.00	0	26.67	20.00	46.67	0	0	13.33	60.00	40.00	33.33	26.67	12.50
14	3.33	0	0	13.33	0	0	0	10.00	60.00	32.00	13.33	40.00	25.00
9	0	0	13.33	0	0	0	0	13.33	46.67	4.00	23.33	20.00	0
6	43.33	0	6.67	0	20.00	0	0	0	53.33	52.00	10.00	13.33	0
3	0	0	0	6.67	0	0	0	0	60.00	44.00	23.33	33.33	0
2	20.00	0	6.67	0	33.33	0	0	3.33	33.33	28.00	10.00	33.33	0
1	13.33	0	0	0	20.00	0	0	0	60.00	36.00	13.33	20.00	50.00

TABLE II.—Longevity of Adult Boll Weevils Confined in Desiccators Maintained at 27° C. and Varying in Relative Humidity from 6 to 100 Percent. Fifty Weevils were Placed in Each Desiccattor, the Number Living Being Recorded at Two Day Intervals.

Approximate Relative Humidity	Food Supplied Weevils — Number Days															No Food Supplied Weevils — Number Days						
	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	1	3	5	7	9	11	13
100	23	19		19	16	14	9		4	3		2			0	13	5		1	0		
98	44		39	28	15	8		3	1		0					10	0					
95	45		29	20	13	7		7	5		1			0		36		16	4	0		
90	40		31	25	19	12		10	9		3			0		38		4	2	0		
85	41	34	30		28	24	22	21			14			0		39	12	5		0		
79		49	44	38	22		21	21		4			0				48	18	6	1		0
70		48	23	12	7		7	7		0							33	15	1	0		
61	46	39	34		28			3			0						45		13	0		
53		46	39		31			3			0						40		8	0		
43		48	38		14			0									29	1		0		
35		41		15	8			0									4		0			
29		47		36	25			1			0						19		0			
21		44		36	30			0									11		0			
14		9	1				0										2					0
9		5	0														6	0				
6		21	0														2	0				

TABLE III.—Longevity of Adult Boll Weevils Confined in Desiccators Maintained at 21° C. and Varying in Relative Humidity from 6 to 100 Percent. Fifty Weevils were Placed in Each Desiccator, the Number Living Being Recorded at Stated Intervals.

Approximate Relative Humidity	Food Supplied Weevils — Number Days						No Food Supplied Weevils — Number Days		
	4	31	46	55	83	161	5	31	46
100	39	17	5	2	0	.....	.....	.....	.....
98	48	28	21	17	3	0	.....	.....	.....
95	50	26	19	15	8	1	.....	.....	.....
90	46	12	5	4	1	0	.....	.....	.....
85	36	15	9	6	1	0	.....	.....	.....
79	39	16	14	12	3	0	.....	.....	.....
70	39	9	4	1	0	.....	.....	.....	.....
61	45	11	1	0	.....	.....	.....	.....	.....
53	35	5	0	.....	.....	.....	30	0	.....
43	35	3	0	.....	.....	.....	41	0	.....
35	39	1	0	.....	.....	.....	44	0	.....
29	32	0	.....	.....	.....	.....	38	4	0
21	33	0	.....	.....	.....	.....	40	0	.....
14	31	0	.....	.....	.....	.....	37	0	.....
9	24	0	.....	.....	.....	.....	50	0	.....
6	.....	.....	.....	.....	.....	.....	41	0	.....
3	.....	.....	.....	.....	.....	.....	43	0	.....
2	1	0	.....	.....	.....	.....	41	0	.....
1	23	0	.....	.....	.....	.....	.....	.....	.....

TABLE IV.—Boll Weevils Hatching from Eggs Laid in Fresh Cotton Squares Maintained at 27° C. but Subjected to Various Percents Relative Humidity.

Approximate Relative Humidity	Number Squares	Number Weevils Hatched and Number of Days Required								Number Additional Forms Found					
		Days								Adults		Pupae		Larvae	
		11	12	13	14	15	16	17	18	Live	Dead	Live	Dead	Live	Dead
100	17									0	0	0	0	0	17
98	19									0	0	0	0	0	19
95	21		3							0	0	0	0	0	18
90	21			3	1					0	0	0	1	0	16
85	20	1	1	3						0	0	0	0	0	15
79	19	1	5	1						0	0	0	1	0	11
70	23		5	1		1				0	0	0	0	0	16
61	22			2						0	0	2	0	0	18
53	21		1	1		3				0	0	0	0	3	13
43	21							2		0	1	0	0	2	16
35	19				2					0	0	0	0	3	14
29	20			1						0	1	0	0	3	15
21	37								3	0	3	0	0	11	20
14	22									0	4	0	0	2	16
9	23									0	0	0	0	2	21
6	26									0	2	0	0	0	24
3	29									0	5	0	0	4	20
2	19									0	0	0	0	0	19
1	25									0	0	0	0	0	25

TABLE V.—Boll Weevils Hatching from Eggs Laid in Fresh Cotton Squares Maintained at 21° C., but Subjected to Various Percents Relative Humidity.

Approximate Relative Humidity	Number Squares	Number Weevils Hatched and Number of Days Required															Number Additional Forms Found					
		19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	Adults		Pupae		Larvae	
																	Live	Dead	Live	Dead	Live	Dead
100	38			2			1	2	7	1	2		1				0	0	0	4	0	18
98	63			1	1	3	6	7	1								0	1	0	4	0	39
95	61			2		3	10	5	2			1					0	0	0	2	0	36
90	60		1	1	2	13	1		1								0	0	0	7	0	34
85	68	1	1	20	10	9	3	1	1								0	1	0	4	0	17
79	71			14	10	5	4	7	2								2	1	0	2	4	20
70	49					1		2		2	1	2		1			1	0	0	1	2	36
61	53		1	2				1	1		7	2	1		1	1	0	1	1	2	4	28
53	53				1	2											1	1	2	3	4	39
43	71								5	9	2	4					5	3	1	0	4	38
35	69					2	4	6	8	4	2	1	2	1			0	1	0	0	2	36
29	83			1	6	2	6	1	6	1		1					4	10	1	0	4	40
21	56										2	14	7		2		2	0	1	1	0	27
14	50																2	0	0	0	0	48
9	50																10	2	0	0	4	34
6	67					6			1				1				3	9	0	0	0	47
3	77													1	2	1	24	5	0	5	6	33
2	60																0	0	0	0	0	60
1	49									2			1				5	5	0	2	1	33