THE CARROT BEETLE, BOTHYNUS GIBBOSUS (DE GEER), PROBELM IN CULTIVATED SUNFLOWER IN THE TEXAS HIGH PLAINS

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The carrot beetle[1/], Bothynus gibbosus (De Geer), is a serious pest of oil-seed sunflower varieties grown in the Texas High Plains. Damage by this insect was observed in sunflower plots as early as 1963 but has become most severe within the last 2 or 3 years. In 1968, this insect completely destroyed several small experimental plots at the Texas A&M University Agricultural Research and Extension Center at Lubbock and caused extensive damage to many commercial fields in the High Plains area. Since no measures were available for combating this insect, virtually no commercial sunflower acreage was planted in 1969.

No information is available on the pest's life cycle or host plants in northwest Texas. The adult is a very common insect and often is attracted to porch lights at night. These brown beetles are sometimes mistakenly called "Junebugs" or May beetles"; however, they are slightly smaller than May beetles. The larvae are sluggishly white grubs about 0.75 inch in length which live in the soil.

The feeding behavior and damage to sunflower plants are as follows: The adult flies at night from an unknown source and enters a sunflower field. It attacks plants in all stages of growth and may be a problem throughout the growing season. The adult burrows into the soil near a plant stem at night covering its burrow with soil and feeding extensively on plant roots in a zone 1 to 4 inches below the soil surface. The feeding causes wilting and usually death of the plant. The length of time spent in the burrow is not known, and the authors do not know if the insect feeds on more than 1 plant before leaving the burrow. After feeding, the insect exits from a hole within 1 to 3 inches from the plant stem. No information is available to determine if the insect reburrows to attack more plants. Reproduction apparently does not occur in the sunflower field, since carrot beetle larvae have not been found in sunflower plots.

Due to the insect's seclusive habits, control in sunflower is difficult. Great numbers of adults may enter a field of sunflower and burrow under-

1/ Coleoptera:Scarabaeidae.

ground where they cause severe damage. Thus, a control method is needed to kill these adults when or immediately after they enter a sunflower field before feeding begins. In 1969, the authors investigated the efficacy of several insecticides applied by various methods for the control of this insect. This report includes results from field and greenhouse tests conducted at the Texas A&M University Agricultural Research and Extension Center at Lubbock.

Methods and Materials

Field Test 1:

Sunflower seeds 2/ were planted April 24 in plots consisting of 4 rows, 47 feet long, spaced 40 inches apart. Treatments of 6 insecticides and a check were replicated 4 times in a randomized block design.

Insecticides and application rates in pounds of actual toxicant per acre were: aldrin, 1.0; LANDRIN® (3,4,5-trimethylphenyl methylcarbamate, 75%; 2,3,5-trimethylphenvl methylcarbamate, 18%), 1.0; carbaryl (SEVIN®), 2.0; carbofuran (Furadan®), 2.0; heptachlor, 3.0; and chlordane, 2.0. Insecticides were applied in the seed-furrow at planting. All were applied as granular formulations with an applicator attached to the planter mounted on a row crop tractor. Plots were not irrigated during the study because of adequate precipitation (Table 1).

Five locations, each consisting of 50 consecutive plants, were selected in each plot and examined on May 20, 28 and June 6. The length in linear feet between the 1st and 50th plant was recorded for each location on May 20 to obtain plant stand or density measurements. The number of plants damaged by adult beetles was recorded for each location on each examination date. Plants were recorded as damaged if they had wilted or dried as a result of adult beetles feeding on the roots. Insecticide phytotoxicity ratings were made in each replication on May 20. The check plot of each replication was assigned the rating of 1, and plots of the various insecticide treatments were rated from 1 to 5 based on the visual appearance of plants compared to plants in the check. A plot rated 5 had the most insecticide damage as indicated by poor plant growth.

Field Test 2:

Seventeen plots consisting of 2 rows, 33 feet long, spaced 40 inches apart, were seeded May 29. Treatments of 9 granular insecticides and a check were assigned to 10 of the plots replicated 2 times in a randomized block design. Treatments of 6 spray insecticides and a check were assigned to the other 7 plots replicated 2 times in a ransomized block design.

Granular insecticides were applied at planting in a band 10 inches wide over the center of the seed furrow and 0.5 inch below the soil surface. Application rates in pounds of actual toxicant per acre were:

2/ A high-oil Russian variety of sunflower, "Peredovik" (Cargill, Inc., 1967 seed lot), was used in this and other tests. Seeds were planted approximately 2 inches deep. Soil was Amarillo-Olton loam. Field Test 4 plots received a preplant application of fertilizer (140 lb. N). Fertilizer was not used in the other tests.

aldrin, 1.0; Landrin, 1.0; carbofuran, 2,0; disulfoton (Di-Syston®), 1.0; heptachlor, 3.0 and 4.5; chlordane, 2.0 and 3.25; and aldicarb (TEMIK®), 1.0.

Spray treatments were made June 18 with a hand sprayer calibrated to deliver an equivalent of 5 gallons of water-emulsion spray per acre. Spray was directed to the soil on both sides of the plants in 6-inch wide bands next to the plant stems. Application rates in pounds of actual toxicant per acre were: lindane, 3.0; diazinon, 3.0; chlordane, 2.0 and 3.0; malathion, 2.0; and carbaryl, 2.0. Carrot beetles had not entered the plots at the time of spray application.

Plots were irrigated with approximately 3 acre inches of water on June 1 and also received the precipitation shown in Table 1. Plots were examined June 24 and July 1 for carrot beetle infestations. On these dates, all plants in each plot were examined for carrot beetle damage.

Field Test 3:

Granular treatments, except lindane, and spray treatments used in Field Test 2 were evaluated again in plots seeded July 15. Insecticide and check treatments were replicated 3 times in a randomized block design in plots consisting of 2 rows, 15 feet long, spaced 40 inches apart. All treatments were made July 29. The procedures described for Field Test 2 were used for spray treatments. Granules were applied 0.5 inch below the soil surface on both sides of the plants in 5-inch bands next to the plant stems. Soil moisture was sufficient at the time of insecticide application, and plots were never irrigated. Precipitation during the study is shown in Table 1. Carrot beetles had not entered the plots at time of insecticide application. All plants in each plot were examined for carrot beetle damage on August 6-7.

Field Test 4:

Three rates of granular disulfoton were evaluated in plots seeded July 15. Treatments of disulfoton applied at rates of 0.5, 1.0 and 1.5 pounds of actual toxicant per acre and a check were replicated 2 times in a randomized block design in 4-row plots, 38 feet long, spaced 40 inches apart. Insecticides were broadcasted on the soil surface on July 31 with a hand-operated applicator. Plants ranged in stage of growth from seedlings up to 6 true leaves at that time. Carrot beetles had not entered the plots at time of application. Insecticide and check plots were irrigated with approximately 3 acre inches of water immediately after insecticide application and also received the precipitation shown in Table 1. All plants in each plot were examined for carrot beetle damage on August 11.

Light Trap Records:

A 15-watt black light trap located near the 4 field tests was inspected during the studies for adult carrot beetles. The number of beetles captured by the trap was recorded daily from April 22 to September 2.

Greenhouse Test:

A test was conducted in a greenhouse to determine phytotoxic effects and carrot beetle control of 10 granular insecticide treatments. Insecticide

Table 1. Precipitation at the Texas A&M University Agricultural Research and Extension Center at Lubbock during carrot beetle tests, 1969

Date	Rainfall (inches)	Date	Rainfall (inches)
May 5	0.68	June 9	Trace
6	0.82	10	0.05
7	0.29	14	1.64
13	0.05	17	0.02
14	0.95	July 6	0.13
15	0.72	7	Trace
16	0.43	9	0.08
22	Trace	22	3.00
23	Trace	26	0.27
24	0.11	August 3	0.03
25	Trace	4	0.03
29	0.01		

and check treatments were replicated 3 times in a randomized block design. Each treatment served as a whole plot and was divided into 2 subplots consisting of different seed depths. Seeds were planted 1.75-inches deep in 1 subplot and 0.75-inch deep in the other subplot. Twelve seeds were planted in each 7-inch diameter pot containing a 2:1:1 (soil:peat:sand) mix filled to within 0.25-inch of the top. The soil mixture was fertilized with nitrogen (urea) and phosphorus (P_2O_5) previous to planting.

Granular insecticides were distributed throughout the same horizontal plane as seed placement at planting on June 3. Insecticides and the equivalent application rates in pounds of actual toxicant per acre were: aldrin, 1.0; Landrin, 1.0; aldicarb, 1.0; heptachlor, 3.0 and 4,5; chlordane, 2.0 and 3.25; carbofuran, 2.0; and disulfoton, 0.5 and 1.0. All plots were watered periodically as needed, and a temperature of approximately 80°F. was maintained in the greenhouse.

On June 12, each pot was examined to determine the number of plants which had emerged from the 12 seeds. Five plants were selected at random from each pot and were excised at soil surface level and weighed (oz.) and measured in height (inches) from the base of the excised stem to the top of the apical leaves. On July 1, plant height and weight measurements again were recorded for 5 plants per pot. In addition, the number of normal leaves (i.e., not showing insecticide phytotoxicity) was recorded for each plant.

On June 17, 5 adult carrot beetles were introduced into each pot and allowed to burrow into the soil. Soil for each pot was sifted thoroughly on July 3, and the number of dead beetles of those introduced on June 17 was recorded.

Results

Field Test 1:

Ratings for each insecticide treatment were higher than for the check and Landrin caused the greatest phytotoxicity to plants (Table 2). Plant density was slightly less in plots receiving insecticide treatments than in check plots, and aldrin caused the greatest reduction in plant stand.

Little carrot beetle damage was recorded on May 20 (Table 3). More than 30% of the plants in both insecticide treated plots and the check were damaged on May 28. Plants in most treatments were severely damaged on June 6. Carbofuran gave better control than other insecticides but did not effectively prevent severe plant damage.

Field Test 2:

Carrot beetle infestations were insufficient in this test to evaluate the efficacy of insecticides for control of the insect (Table 4). Slightly more damage was recorded, however, on June 24 and July 1 in check plots than in plots receiving subsoil applications of granular insecticides or surface applications of insecticide sprays.

Table 2. Effects of granular insecticides incorporated in the seed-furrow at planting on April 24 on plant stand and growth - Field Test 1.

Treatment	Formu-lation	Actual toxicant (lb/acre)	Rating 1/	Plant stand on May 20 (distance in feet between 50 plants.
Aldrin	20%G	1	3.5	25.5
Landrin	10%G	1	5.0	19.7
Carbofuran	10%G	2	2.8	17.5
Carbaryl	20%G	2	2.3	13.3
Heptachlor	10%G	3	2.5	13.7
Chlordane	25%G	2	2.3	11.3
Check	-	-	1.0	11.0

1/ Based on visual appearance of plants compared to check plots with a rating of 1 on May 20. Higher ratings indicate less vigorous plant growth than in check.

Table 3. Carrot beetle damage to sunflower plants receiving seed-furrow treatments of granular insecticides at planting on April 24 - Field Test 1.

Treatment	Forumlation	Actual toxicant (lb/acre)	% plants damaged by carrot beetles		
			May 20	May 28	June 6
Aldrin	20%G	1	2.1	43	93
Landrin	10%G	1	3.3	32	86
Carbofuran	10%G	2	5.2	35	69
Carbaryl	20%G	2	6.4	41	92
Heptachlor	10%G	3	3.0	43	97
Chlordane	25%G	2	3.5	40	93
Check	--	-	4.0	42	94

Table 4. Carrot beetle damage to sunflower plants in plots receiving surface spray or subsoil granular insecticide treatments - Field Test 2

Treatment	Formu-lation	Method of application	Actual toxicant (lb/acre)	% plants damaged by carrot beetles June 24	% plants damaged by carrot beetles July 1
Lindane	1.65 EC	Surface spray[1/]	3	0.0	0.0
Diazinon	4 EC	"	3	3.6	5.4
Chlordane	8 EC	"	2	0.9	2.5
Chlordane	8 EC	"	3	0.0	0.0
Malathion	5 EC	"	2	2.8	2.7
Carbaryl	80% WP	"	2	4.0	0.5
Check	-	-	-	4.3	9.0
Aldrin	20% G	Subsoil granule[2/]	1	1.8	2.0
Landrin	10% G	"	1	3.7	2.7
Carbofuran	10% G	"	2	0.0	1.6
Disulfoton	15% G	"	1	1.4	1.4
Heptachlor	10% G	"	3	2.5	2.1
Heptachlor	10% G	"	4.5	0.0	0.0
Chlordane	25% G	"	2	1.4	0.0
Chlordane		"	3.25	1.1	3.2
Aldicarb	10% G	"	1	0.0	0.0
Check	-	-	-	4.0	3.6

1/ Applied 6 inches to each side of plant row on June 18 when plants were approximately 4-inches tall.

2/ Incorporated below soil surface in a 10-inch band 1.5 inches above seed furrow at planting on May 29.

Field Test 3:

Insecticides applied as surface sprays or as subsoil granules in this test were not effective based on records taken August 6-7 (Table 5). Thirty-nine percent of the plants in plots receiving the most effective treatment, chlordane spray at 3 lb. of actual toxicant per acre, were damaged.

Field Test 4:

Disulfoton applied as a surface broadcast granular treatment was not effective in this test (Table 6). Damage to plants as shown by records taken on August 11 was about the same in check plots as in plots receiving various rates of disulfoton.

Light Trap Records:

Light trap records show that many adult carrot beetles were present during most of the spring and summer of 1969 (Figure 1). Two major seasonal periods of activity were noted, probably corresponding to the emergence of overwintered and first generation adults, respectively. These records demonstrate the need for effective control methods to combat this insect in all stages of plant growth since large numbers may attack plants during most of the growing season.

Greenhouse Test:

No great difference was noted among insecticide and check treatments in any of the plant measurements (emergence, weight, height and number of normal leaves) made to determine phytotoxic effects at the two seeding depths in the greenhouse (Table 7). Nor did any insecticide appear to noticeably control adult beetles introduced into the test pots. As shown by records of Field Test 2 (Table 2) several of the insecticides not phytotoxic in the greenhouse test caused plant damage in the field which resulted in reduced stand and poor plant growth. Interacting environmental variables not encountered under greenhouse conditions may have accounted for phytotoxicity noted in the field test.

Discussion

Results from these studies indicate that carrot beetles are extremely difficult to control in sunflower. Insecticides tested did not appear effective with the application methods evaluated here in preventing severe plant damage. The reasons for poor control recorded in 1969 are not known. Additional control tests with insecticides tested here and others are planned for 1970. Large numbers of carrot beetles captured in light trap collections show the need for effective control methods throughout the sunflower growing season of the High Plains. Unless these control methods are developed, infestations comparable to 1969 could limit future commercial sunflower production in the High Plains.

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Table 5. Carrot beetle damage to sunflower plants in plots receiving surface spray or subsoil granular insecticide treatment - Field Test 3

Treatment	Formu-lation	Method of application	Actual toxicant (lb/acre)	% plants damaged by carrot beetles on August 6-7
Diazinon	4 EC	Surface spray[1/]	3	41
Chlordane	8 EC	"	2	42
Chlordane	8 EC	"	3	39
Malathion	5 EC	"	2	53
Carbaryl	80% WP	"	2	56
Aldrin	20% G	Subsoil granule[2/]	1	62
Landrin	10% G	"	1	60
Carbofuran	10% G	"	2	64
Disulfoton	15% G	"	1	50
Heptachlor	10% G	"	3	70
Heptachlor	10% G	"	4.5	55
Chlordane	25% G	"	2	75
Chlordane	25% G	"	3.25	53
Aldicarb	10% G	"	1	69
Check	-	-	-	60

[1/] Applied 6 inches to each side of plant rows on July 29 when plants were approximately 3-inches tall.

[2/] Incorporated 0.5 inch below soil surface on July 29 in 5-inch band to each side of plant row.

Table 6. Carrot beetle damage to sunflower plants in plots receiving broadcast treatments of granular disulfoton - Field Test 4

Treatment	Formu-lation	Actual toxicant (lb/acre)	% plants damaged by carrot beetles on August 11
Disulfoton	15%G	0.5	23
Disulfoton	15%G	1.0	24
Disulfoton	15%G	1.5	21
Check	-	-	19

1/ Disulfoton treatments made July 31 when plants ranged in stage of growth from seedlings up to 6 true leaves.

Table 7. Effect of granular insecticides on carrot beetles and sunflowers grown in the greenhouse - Greenhouse Test

Treatment and application rate (lb actual toxicant/ acre)1/	Seeding depth (inches)	No. plants on June 12 2/	Plant weight (oz) 3/ June 12	Plant weight (oz) 3/ July 1	Plant height (inches) 3/ June 12	Plant height (inches) 3/ July 1	No. normal leaves per plant on July 1 3/	No. dead carrot beetles per pot on July 3 4/
Aldrin (1)	0.75	12.0	.04	.24	2.56	13.35	6.9	0.3
	1.75	12.0	.04	.19	2.36	12.09	5.1	0.7
Landrin (1)	0.75	12.0	.05	.17	2.87	13.35	5.5	0.3
	1.75	12.0	.05	.15	2.76	13.27	5.2	0.7
Aldicarb (1)	0.75	11.7	.05	.18	2.60	12.17	5.1	0.3
	1.75	11.7	.04	.21	2.32	13.35	6.6	0.0
Heptachlor (3)	0.75	11.7	.05	.17	2.64	13.66	4.9	0.3
	1.75	12.0	.04	.21	2.52	14.02	6.1	0.3
Heptachlor (4.5)	0.75	11.7	.04	.16	2.72	13.86	5.1	0.3
	1.75	11.3	.05	.17	2.56	12.01	5.4	0.3
Chlordane (2)	0.75	12.0	.05	.20	2.68	13.94	5.9	0.5
	1.75	11.3	.04	.20	2.52	14.84	6.3	0.3
Chlordane (3.25)	0.75	12.0	.04	.17	2.76	13.07	4.9	0.3
	1.75	12.0	.04	.18	2.52	13.50	5.8	0.0
Carbofuran (2)	0.75	12.0	.04	.19	2.44	14.76	5.9	0.7
	1.75	12.0	.05	.17	2.80	13.58	5.4	0.3
Disulfoton (0.5)	0.75	12.0	.04	.19	2.72	13.50	5.9	1.0
	1.75	11.3	.04	.15	2.72	11.57	5.0	0.3
Disulfoton (1)	0.75	12.0	.05	.15	2.64	11.81	5.4	0.0
	1.75	11.3	.04	.16	2.56	12.09	5.7	0.3
Check	0.75	11.7	.05	.15	2.72	12.60	5.3	0.3
	1.75	11.7	.04	.15	2.76	12.24	5.1	0.7

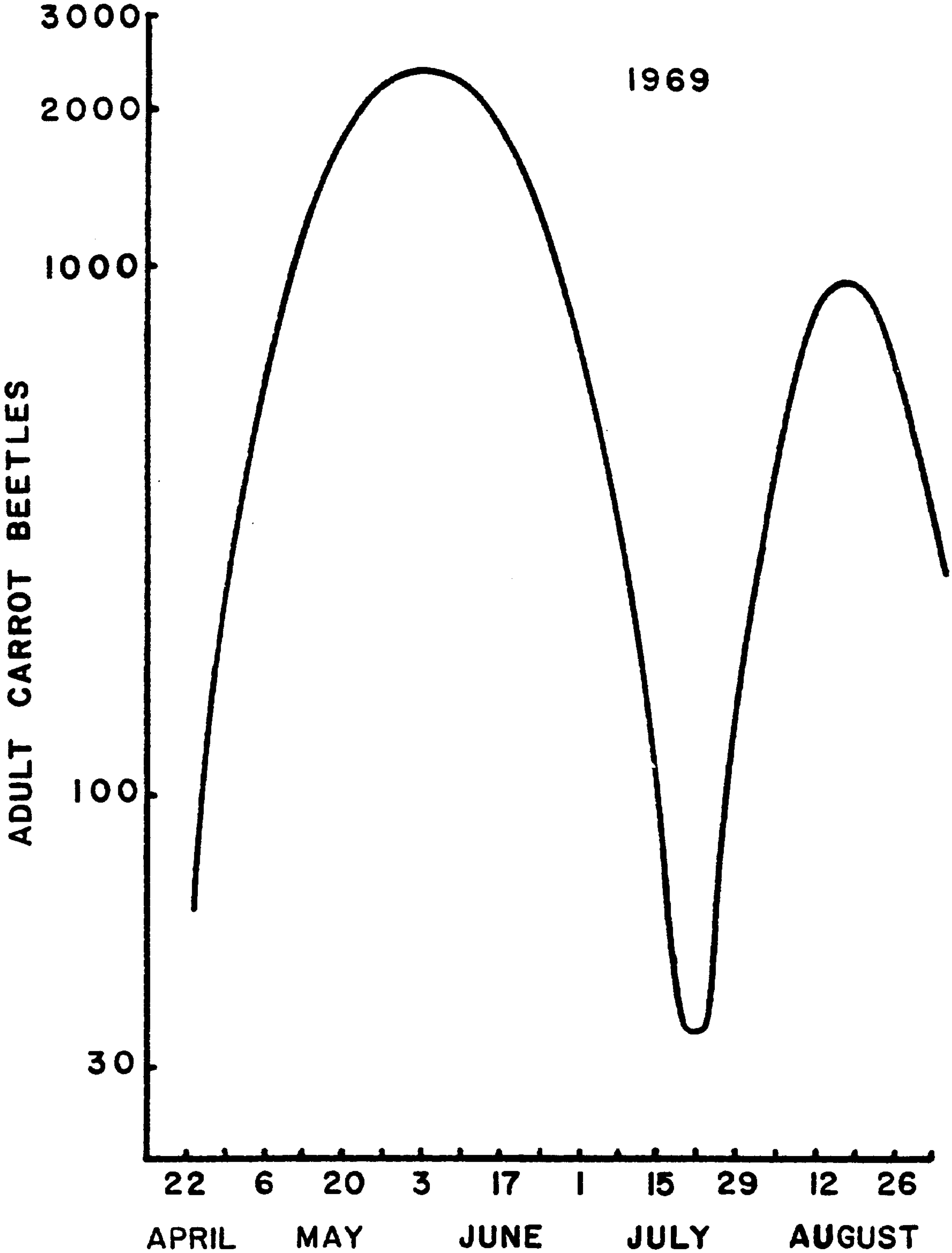
1/ Insecticides distributed throughout the same horizontal plane as seed at planting on June 3.

2/ Average emergence of 12 seeds per replication at each seeding depth.

3/ Average of 5 plants per replication at each seeding depth.

4/ Average of 5 beetles introduced into each replicated pot on June 17.

Figure 1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1969
ADULT CARROT BEETLES
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26
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MAY
JUNE
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AUGUST