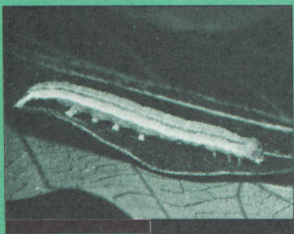
Degree-Day Maps for Management of Soybean Insect Pests in Alabama





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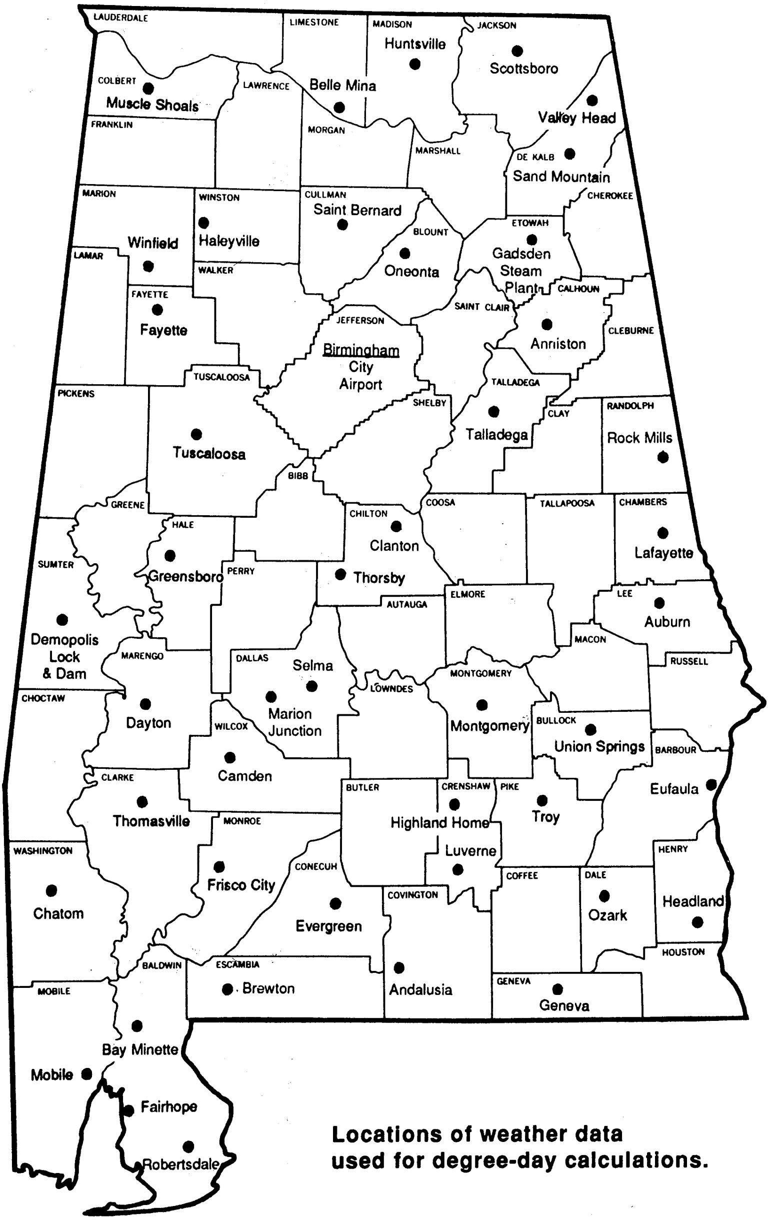

Locations of weather data used for degree-day calculations.

Degree-Day Maps for Management of Soybean Insect Pests in Alabama

D. A. Herbert, T. P. Mack, R. B. Reed, and R. Getz[1,2]

INTRODUCTION

THE CONCEPT OF relating phenological growth to temperature was first proposed by Reaumur (*9*). Commonly referred to as heat unit management (HUM), growing degree-days (GDD), or degree-days (DD), accumulation of daily mean temperatures above a threshold temperature has become an established tool in building of plant, insect, and disease models (*5*). For example, many insect models employ degree-day equations such as the following for calculating development rates: $DD = (x-dt)$, where DD = degree-days or cumulative heat units required for development, x = mean daily temperature, and dt = lower developmental threshold temperature. Once validated, these models can aid in predicting pest status or plant development.

Most insect models are designed for use within a single field or group of fields. This approach ignores population development on a larger scale, such as in an isothermic region within a state. Computer mapping of these regions has been used to aid in understanding insect population development (*2*). The mapping of isothermic regions would be especially useful for crops such as soybeans, which are grown in most of Alabama. Map-

[1]Respectively, Post Doctoral Fellow of Plant Pathology, Associate Professor of Entomology, Academic Computing Specialist III, and Agricultural Meteorologist, National Weather Service.
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ping degree-days can define "hot spots" within a state where insect pest populations would be most likely to develop at faster rates. Pest management scouts could be asked to concentrate their efforts on detecting high insect pest populations within identified hot spots, thereby increasing the probability of early detection of insect pest outbreaks within and adjacent to those areas. Farmers could also be alerted to the possibility of crop loss so timely pest management tactics could be initiated.

In the research reported here, environmental data for Alabama were used to map degree-days for five important soybean insect pests. This report analyzes degree-day maps and indicates where soybean insect pests would be most likely to develop for any of the months studied.

METHODS AND MATERIALS

Environmental Data

Degree-day normals for growing season months of May through October were derived for the 47 Alabama locations monitored by the National Weather Service (see map, inside cover), using a technique developed by Thom (*11*). This method converts adjusted mean monthly air temperature normals (as defined by the National Weather Service) to monthly degree-day normals. Thom's method permits degree-day computations above and below any threshold temperature. Normal mean monthly air temperature normals were based on 1951-80 data published by the National Climatic Center (*8*).

Compiled average monthly degree-day (AMDD) data were mapped using an 85 vertical cell X 107 horizontal cell grid fit onto a rectangular area enclosing Alabama state boundries. Data values for the grid cell vertices were interpolated from AMDD data using a bivariate spline method (*10*). Zones were then computed from interpolated values and plotted using contouring software (*10*).

Degree-day Calculations

Five economically important soybean insect pests were chosen for degree-day calculations: the corn earworm, *Heliothis zea* (Lepidoptera: Noctuidae); the soybean looper, *Pseudoplusia includens* (Lepidoptera: Noctuidae); the velvetbean caterpillar, *Anticarsia gemmatalis* (Lepidoptera: Noctuidae); the green cloverworm, *Plathypena scabra* (Lepidoptera: Noctuidae); and the southern green stink bug, *Nezara viridula* (Hemiptera: Pentatomidae). Degree-days required for development (shown in the table) were calculated from the literature, assuming an average lower developmental threshold of 15°C (58°F) for all except green cloverworm. A common threshold of 15°C was assumed because it is an average for most species and is used in the recently developed Auburn University Soybean Integrated Management Model (AUSIMM). A lower developmental threshold of 11°C (52°F) was assumed for green cloverworm, based on Hammond et al. (*3*).

RESULTS AND DISCUSSION

Egg to adult development of green cloverworm requires 486 degree-days (11°C developmental threshold), see table. Degree-day maps for the green cloverworm indicate that sufficient warming occurs within May for population development in most of Alabama, figure 1. The entire state is conducive to development by June, figure 2, and a second generation of larvae, requiring about 690 degree-days (486 for a first generation and 204 for second generation large larvae), appears to be possible in all but the northeastern-most Appalachian Plateau region. In July, a potential exists for two complete generations in parts of Wiregrass, Gulf Coast, and Coastal Plain regions, figure 3. Development of two generations of green cloverworm is limited in August to restricted areas within Gulf Coast and Coastal Plain regions, figure 4. A second generation of larvae per month is possible in the lower half of Alabama even in September, figure 5. By October, development of green cloverworm appears to be restricted to mainly Baldwin and Mobile counties, figure 6.

DEGREE-DAYS REQUIRED FOR DEVELOPMENT OF EGG TO ADULTHOOD FOR SEVERAL INSECT PESTS[1]

Insect	Threshold	Degree-days[2]	Source
Corn earworm	15°C	451	Isley (*6*)
Soybean looper	15°C	435	Estimated[3]
Velvetbean caterpillar	15°C	357	Johnson et al. (*7*)
Green cloverworm	11°C	486	Hammond et al. (*3*)
Southern green stink bug	15°C	423	Harris and Todd (*4*)

[1]Degree-days were calculated from listed source.
[2]Centigrade degree-days. To convert to Fahrenheit degree-days, it is best to use the source articles to recalculate accumulated heat units.
[3]Estimated by assuming egg, prepupal, pupal, and preovipositional degree-day requirements were similar to those of the corn earworm. Larval degree-day requirement of 187 degree-days was calculated from Boldt et al. (*1*)

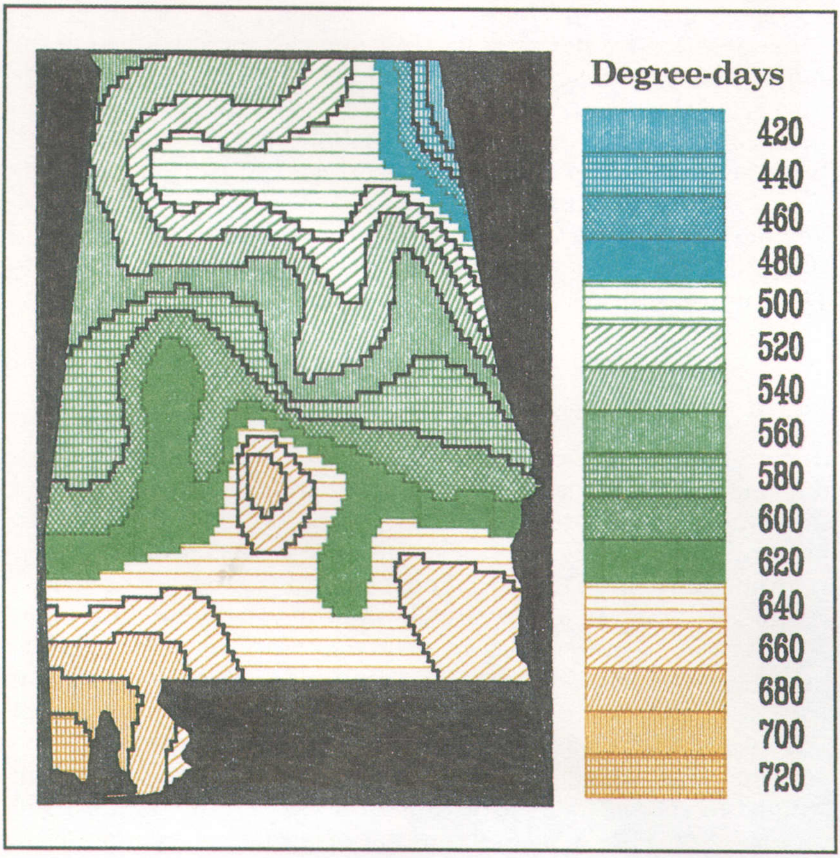

FIG. 1. 11°C threshold degree-day map for May, Alabama.

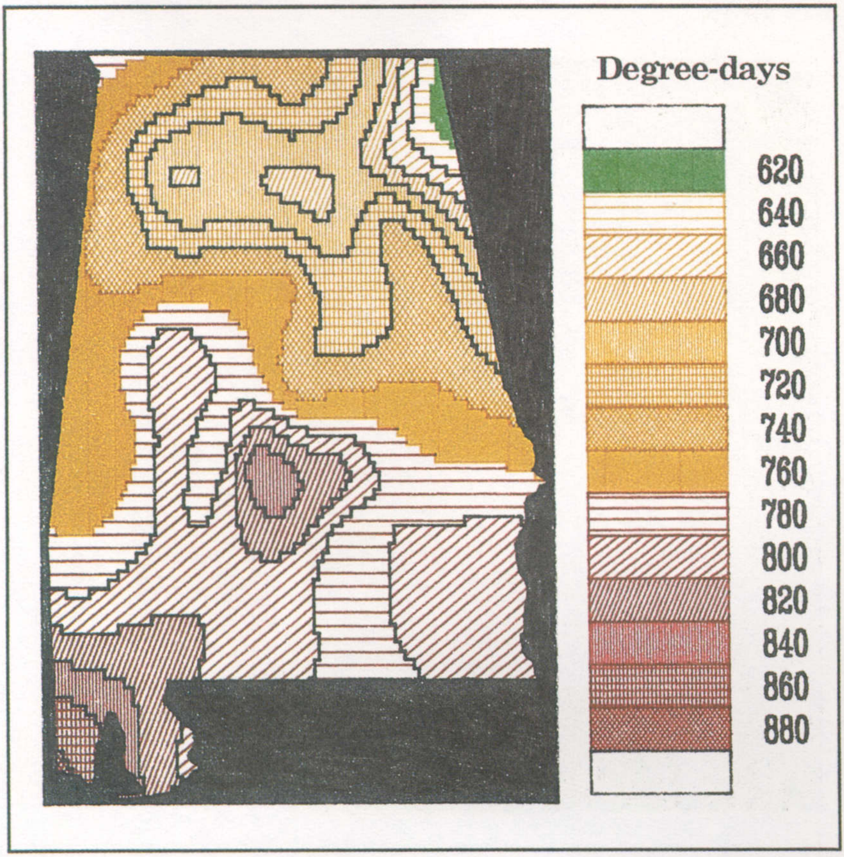

FIG. 2. 11°C threshold degree-day map for June, Alabama.

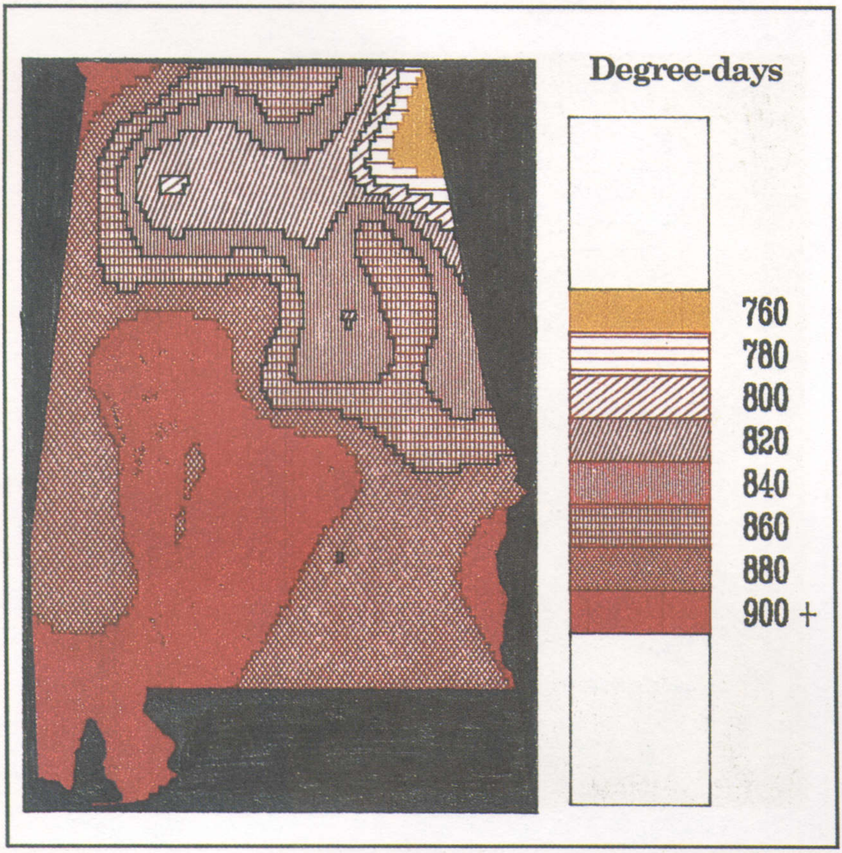

FIG. 3. 11°C threshold degree-day map for July, Alabama.

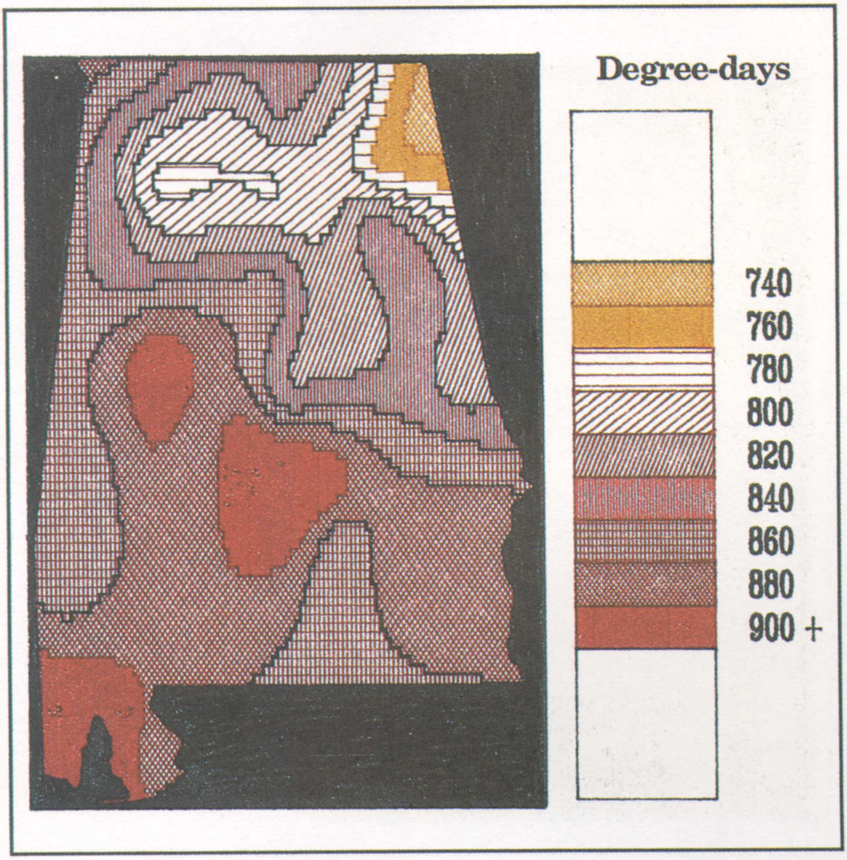

FIG. 4. 11°C threshold degree-day map for August, Alabama.

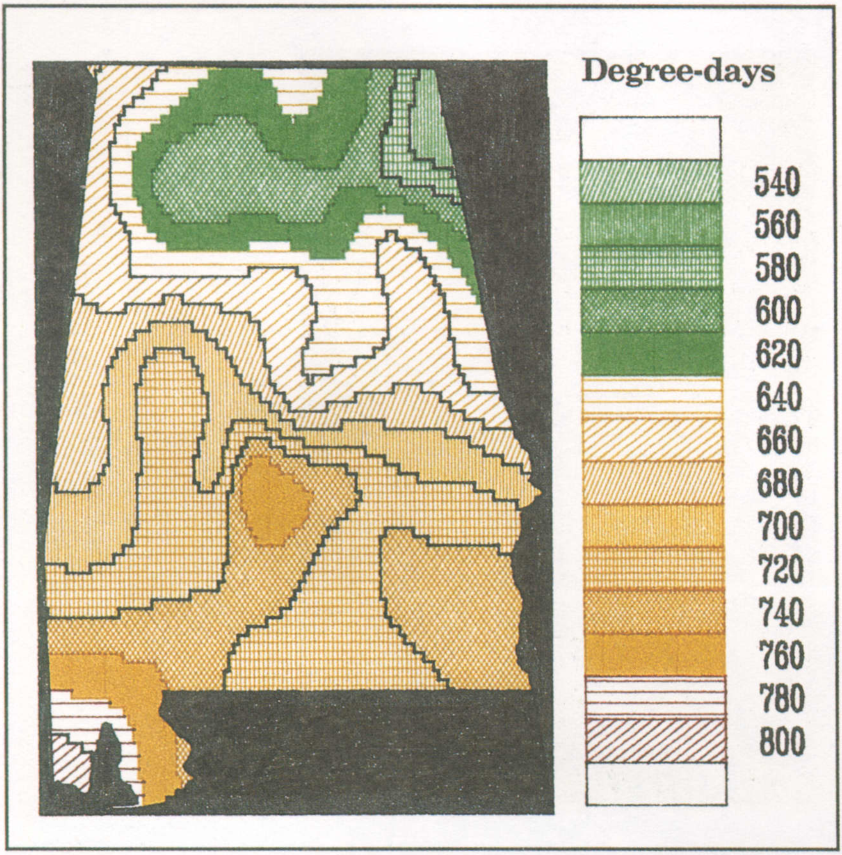

FIG. 5. 11°C threshold degree-day map for September, Alabama.

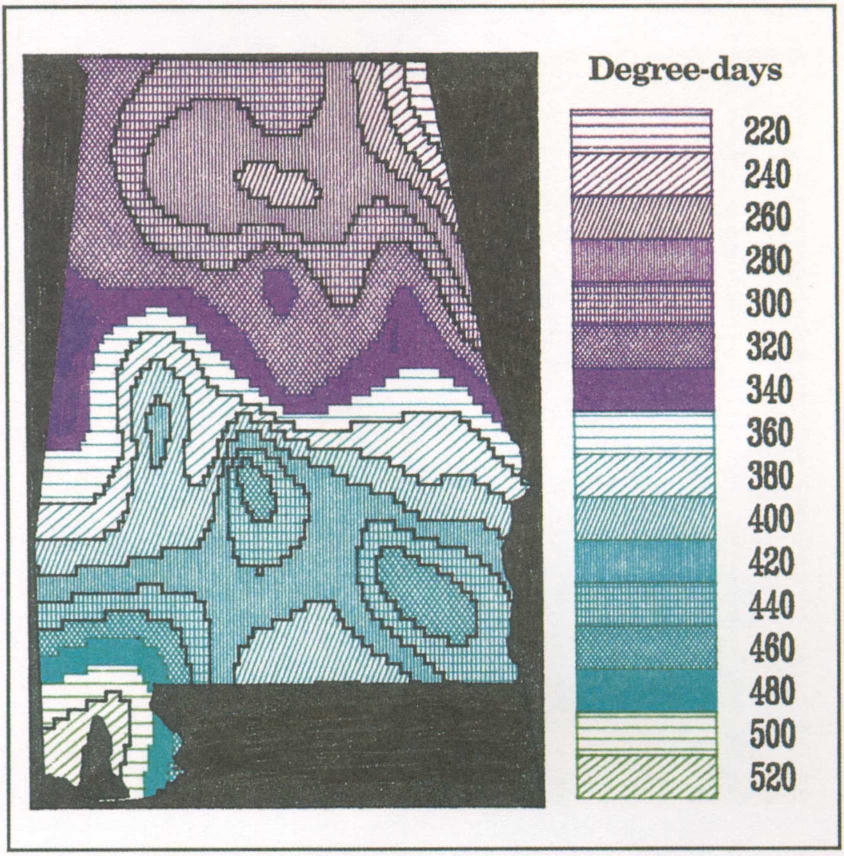

FIG. 6. 11°C threshold degree-day map for October, Alabama.

Several common soybean insect pests have 15°C developmental thresholds, including soybean looper, velvetbean caterpillar, corn earworm, and southern green stink bug. Approximately 425 degree-days are required for development of one complete generation for most of these insects, as shown by data in the table. Degree-day mapping indicates that all could be potential pests in Alabama as early as May in a southwestern area including Baldwin, Mobile, lower portions of Washington, Clarke, Monroe, and western Escambia counties, and in a southeastern zone including Henry, Houston, and Dale counties, figure 7. Earliest infestations could potentially occur in Baldwin and Mobile counties. In June, figure 8, one complete generation

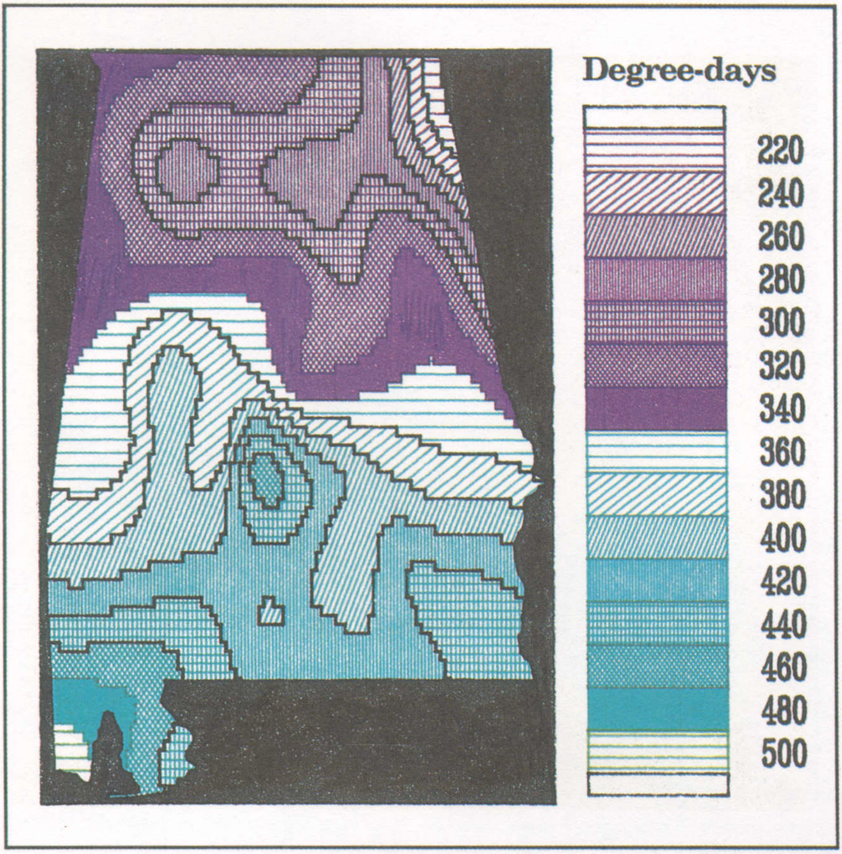

FIG. 7. 15°C threshold degree-day map for May, Alabama.

of these pests could develop throughout the State, with the exception of the northeastern-most corner of the Appalachian Plateau; a second generation of corn earworm and soybean looper larvae requiring about 595 degree-days (425 for a first generation and 170 for second generation large larvae) could develop in Baldwin and Mobile counties.

In July and August, one complete generation of soybean looper, velvetbean caterpillar, corn earworm, and southern green stink bug could develop throughout the entire State, figures 9 and 10. A second generation of corn earworm and/or soybean looper larvae could occur in all of the southern half as well as in the Upper Coastal Plain and Tennessee Valley areas of

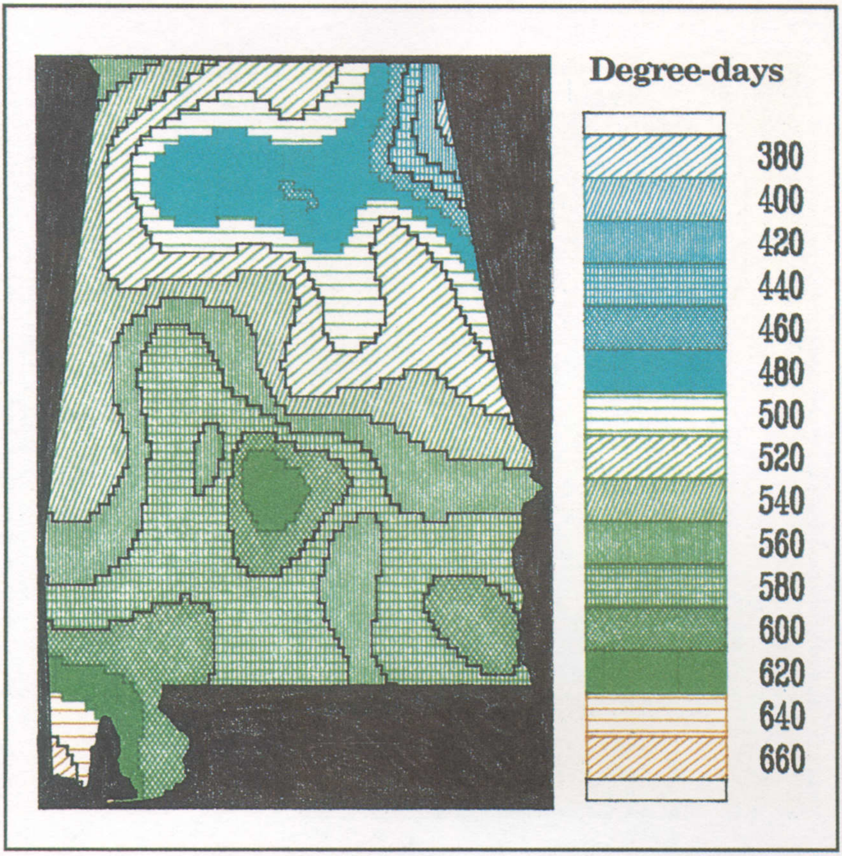

FIG. 8. 15°C threshold degree-day map for June, Alabama.

northern Alabama in July. By August, little potential should exist in the northern half of the State for complete development of a second generation of larvae. The development of two complete generations of corn earworm or soybean looper within either July or August appears to be improbable. By September, figure 11, development of a single generation, with no second larval generation, would be restricted to the lower half of the State. Development of a complete generation of these pests is unlikely in October, figure 12, because even the warmest areas of Alabama accumulate < 300 degree-days.

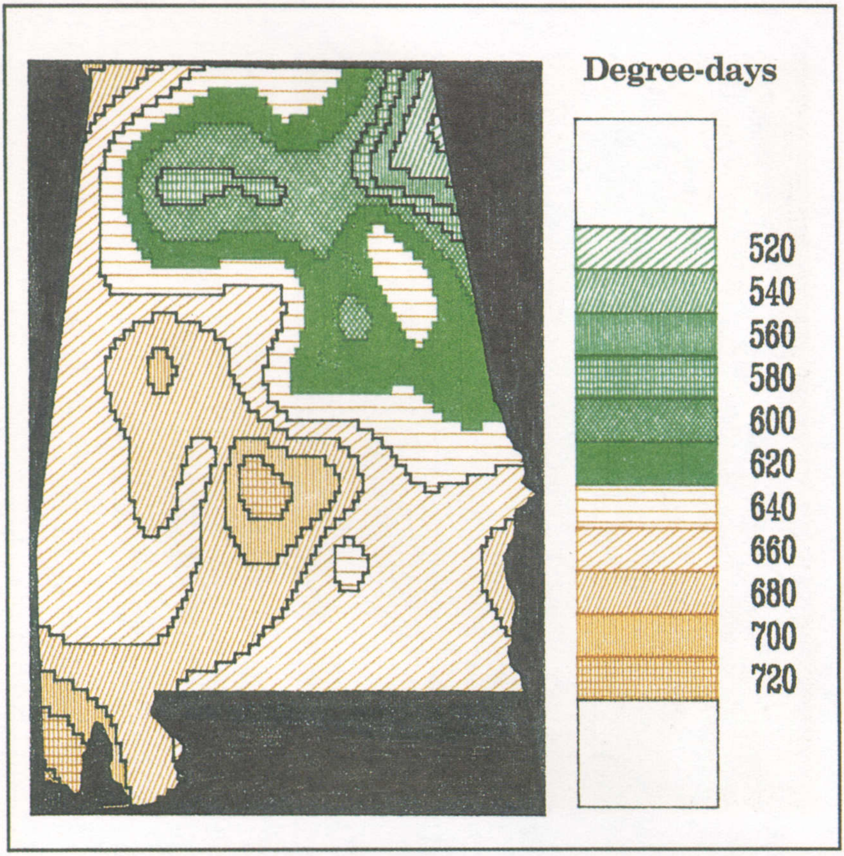

FIG. 9. 15°C threshold degree-day map for July, Alabama.

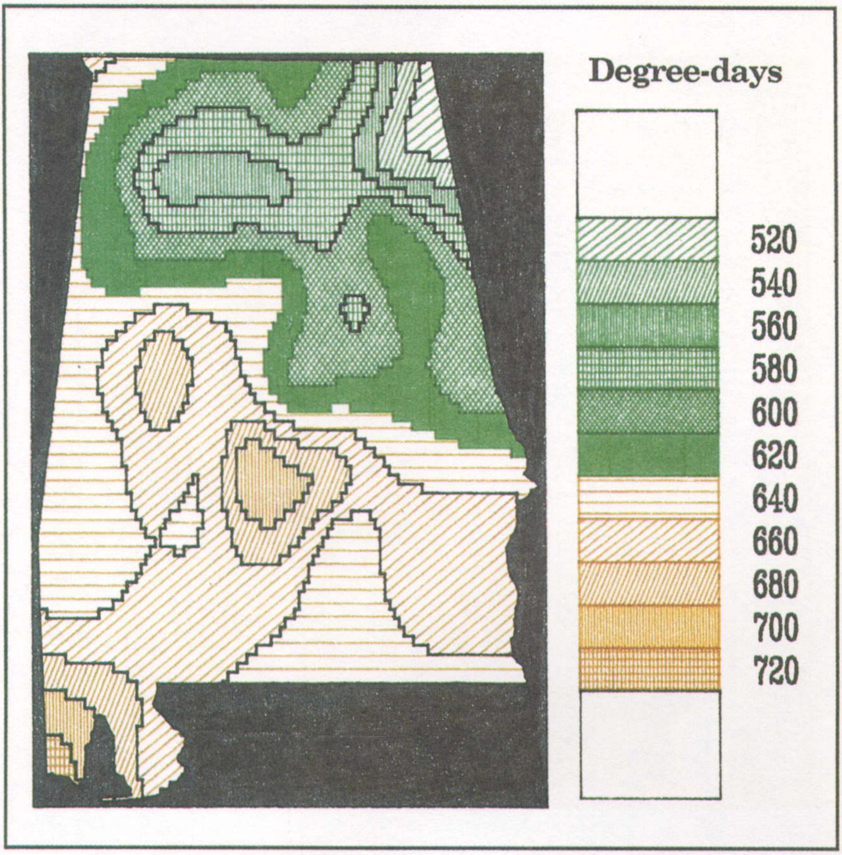

FIG. 10. 15°C threshold degree-day map for August, Alabama.

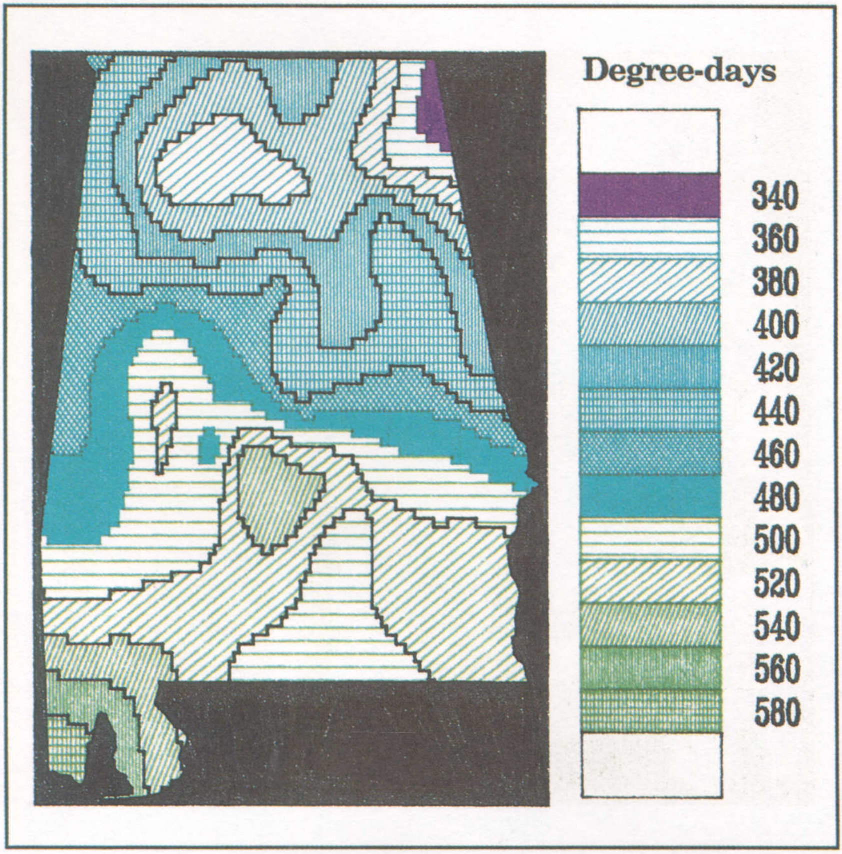

FIG. 11. 15°C threshold degree-day map for September, Alabama.

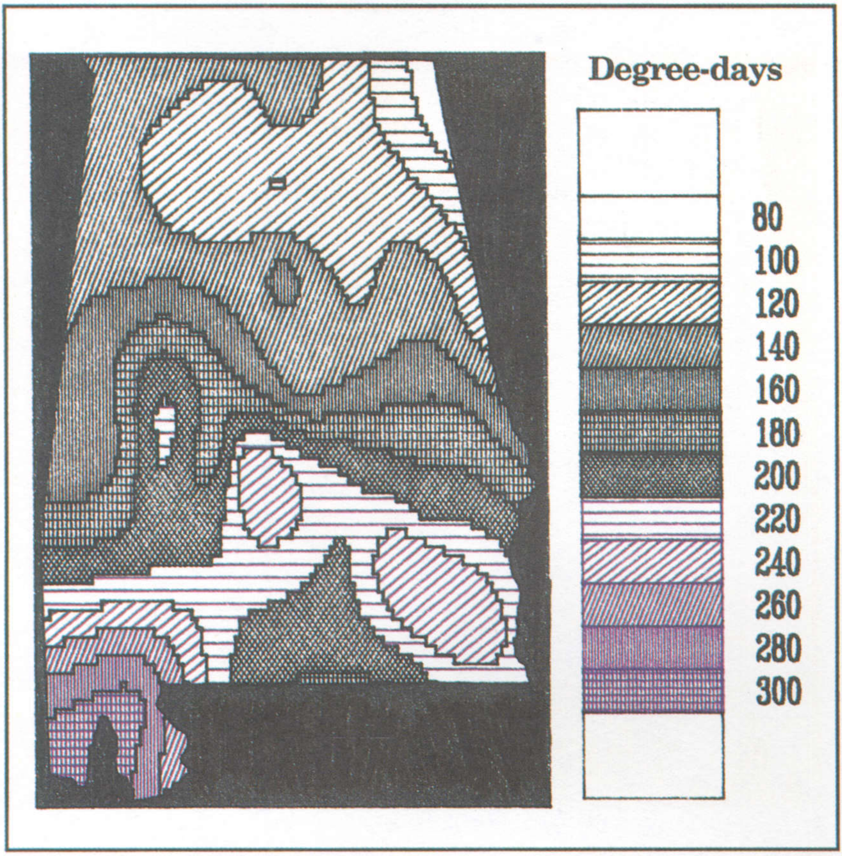

FIG. 12. 15°C threshold degree-day map for October, Alabama.

SUMMARY

Temperature is a widely recognized factor regulating insect development. Degree-day equations utilizing temperature data can be calculated from regional, statewide, or within-state zonal weather data. However, microclimate temperatures within crop canopies vary both among crops in a particular zone and within a crop as it matures. These variations can increase or decrease insect development rates, clouding degree-day and generation time calculations. Further, insect populations do not necessarily develop in discrete generations. Differences in individual development rates, prolonged ovipositional (egg laying) periods, and immigration and emigration of adults produce overlapping within-field generations. Degree-day maps developed from macroclimatic zonal data should, therefore, be used as an indication of relative not actual potential for numbers of generations.

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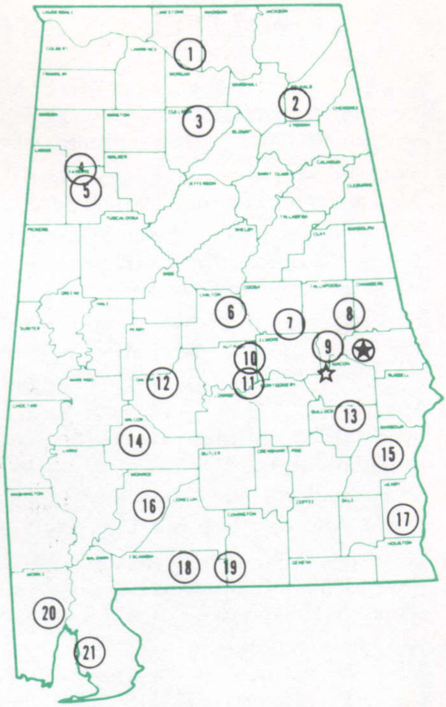

Research Unit Identification

★ Main Agricultural Experiment Station, Auburn.
☆ E. V. Smith Research Center, Shorter.

1. Tennessee Valley Substation, Belle Mina.
2. Sand Mountain Substation, Crossville.
3. North Alabama Horticulture Substation, Cullman.
4. Upper Coastal Plain Substation, Winfield.
5. Forestry Unit, Fayette County.
6. Chilton Area Horticulture Substation, Clanton.
7. Forestry Unit, Coosa County.
8. Piedmont Substation, Camp Hill.
9. Plant Breeding Unit, Tallassee.
10. Forestry Unit, Autauga County.
11. Prattville Experiment Field, Prattville.
12. Black Belt Substation, Marion Junction.
13. The Turnipseed-Ikenberry Place, Union Springs.
14. Lower Coastal Plain Substation, Camden.
15. Forestry Unit, Barbour County.
16. Monroeville Experiment Field, Monroeville.
17. Wiregrass Substation, Headland.
18. Brewton Experiment Field, Brewton.
19. Solon Dixon Forestry Education Center,
    Covington and Escambia counties.
20. Ornamental Horticulture Substation, Spring Hill.
21. Gulf Coast Substation, Fairhope.