COMPUTER MAPPING FOR ECOLOGICAL STUDY OF COTTON INSECTS

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COMPUTER MAPPING FOR ECOLOGICAL STUDY OF COTTON INSECTS

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INTRODUCTION

The role of computers in agricultural research is well-known. However, computers have not been used extensively in studying ecological characteristics of cultivated crops.

Instead of centering studies around a specific treatment, such as season of pesticide application, it would be useful to study insect population dynamics in relation to cotton plants on a geographical coordinate basis. That is, a method which would allow an investigator (or manager) to examine the population density of a pest and its variability over an entire field without extensive sampling, would be a valuable tool.

Conventionally, field data could be presented as contours by plotting a variable of interest on a field position map and connecting points of importance to form contours.

Following the formation of contour lines, a planimeter could be used to determine amount of area covered by a particular level of the variable, say, population density of the predator, **Collops** spp. However, the use of computer systems to evaluate and extend field data has been found to lessen the computational burden associated with numerical surface techniques and subsequent formation of contour lines (Bonham, 1969).

Data extension techniques, such as contouring, would be useful in studying certain crop and entomological characteristics over an entire field.

Therefore, techniques developed by Bonham (1969) were used in an intensive study of a small cotton field in order to evaluate such an approach for entomological purposes. The results presented below will illustrate the use of the computer mapping techniques and provide the basis for examples of comparisons and associations which might be made utilizing the techniques.

METHODS FOR COMPUTER MAPPING

Computer contouring of a variable over a two-dimentional plane has been reported by various investigators (McAdams and Picciano 1966). However, computer contouring of ecological characteristics over a known geographical plane has been accomplished only recently (Bonham, 1969).

Such contouring of a variable can be acquired by using an orthogonal set of linearly combined functions to fit a response surface through the field data points. That is,

$$Z = f\ (X, Y) \qquad (1)$$

Where Z = response variable (e.g. **Collops** density) and X and Y are the values of the coordinates assigned to the sample points (Figure 1). An orthogonal set found to be useful in mapping of ecological variables makes up the following function:

$$Z = b_0 + b_1X + b_2Y + b_3XY + b_4\ (3X^2-2) + b_5\ (3Y^2-2) + b_6X\ (3Y^2-2) + b_7Y\ (3X^2-2) \qquad (2)$$

The variables Z, X and Y are as previously defined and the b_i's are estimates of the equation coefficients. Solutions to equation (2) were obtained by the method of least squares for nine (9) data points at a time. This was accomplished by using a centroid value and selecting the eight (8) adjacent points as illustrated in Figure 1. This procedure allowed several estimates to be made of each interpolated point in each of the subregions.

These interpolated values were then averaged and levels of interest were printed out to form contour maps (e.g. Figs. 2-65).

FIELD METHODS

The field data were taken in a 40-acre field of Deltapine Smoothleaf cotton at Picacho, Arizona, during the 1968 season. The field was commercially grown cotton under a regular insecticide program for injurious insects.

Fifty-six individual plants were inspected on each date.

The sample points were arranged in a 7 x 8 grid with 165 ft. between points (Figure 1). The starting point was in the 25th row from the outside of the field and 82.5 feet from the end of the row.

Samples were taken at six additional points in the 25th row.

When the seventh point was reached and sampled, the checker moved 50 rows (= 165 ft.) and sampled seven additional points in the 75th row during his return to the original end of the field. He then moved 50 rows and repeated the procedure until 8 rows of 7 points each were sampled.

Each sample plant was examined for bollworms, **Heliothis zea** (Boddie), bollworm damage to squares, cabbage loopers, **Trichoplusia ni** (Hübner), beet armyworms, **Spodoptera exigua** (Hübner), **Collops** spp. adults, and **Chrysopa** spp. eggs on several dates through the growing season.

On September 12 specific plant characteristics were measured including distance between adjacent plants at each sample point (cm), plant height (cm), and plant canopy diameter (cm). Number of squares, blooms, dry bolls, and green bolls were also recorded for each plant.

Elemental nitrogen determinations were made by Kjeldahl procedures for roots, stems, leaves, and squares and expressed on a percent dry weight basis.

Soil samples were obtained from each point for determination of percent moisture and elemental nitrogen content (percent dry weight). The top 15 cm of soil was included in each soil core.

Moisture percentage was determined by oven-drying soil samples at 108°C for 24 hours.

RESULTS

Figures 2 and 3 demonstrate that the computer mapping technique may be useful in expanding the population characteristics from a small sampling number of detected insects to include the entire field. The pattern of damaged squares depicted in Figure 2, for example, could well have been the damage resulting from the progeny of a single ovipositing female. The in-

side (field) borders of the contour area may represent the periphery of a single female's oviposition area.

Figure 3, on the other hand, may demonstrate the infiltration of **Collops** spp. into the borders of the field from the uncropped outside area.

Figures 4 to 14 represent the distributions of **Chrysopa** spp. eggs within the field for sampling dates from May 17 to June 19. These maps depict an increasing population between May 17 and June 11 with the heaviest egg levels occurring on the outer periphery of the field.

At the highest levels, the southeast corner of the field, has as many as 20 eggs per plant. Noteworthy also is the consistently high population in the southeastern portion of the field.

Figure 14 shows a marked decrease in the **Chrysopa** spp. egg population due to an insecticide application on June 13. The egg population on June 19 along the outer edges may represent the reentry into the sprayed field by females from sources outside the field.

Figures 15 to 25 depict a series of counts made on June 19. Figures 15 to 18 represent the squares occurring on cotton plants in the field and indicate that the field was squaring well with virtually all plants in the field having at least 10 squares present (Figure 15).

Comparison of Figure 17 with Figure 45 indicates that many of these early squares represented the early dry bolls on September 12. Comparison of Figure 18 with Figure 51 indicates that only restricted numbers of the early squares actually matured into harvestable bolls.

Figure 19 shows that pattern of the early bloom in the field. However, the numbers of blooms were not sufficient on June 19 to be reflected in the dry boll count obtained for September 12 (Figure 46). Figure 20 is a map of the bollworm larvae found on June 19, and Figures 21 and 23 show the relationship of the detected bollworms to the heaviest square damage in the field. Apparently the insecticide application of June 13 had eliminated all but a few bollworm larvae, but the damage inflicted by the larvae was still evident.

Figure 24 shows the distribution of **Collops** spp. adults in the field. No **Collops** spp. were found associated with the bollworm larvae. Although the data presented for insects are inadequate to establish relationships for the predator (e.g. **Collops** spp.) and prey (e.g. bollworms), further studies may find the mapping procedure facilitates determining such relationships.

Due to regular insecticide applications, the data collected in the study field between June 19 and September 12 were inadequate to establish any insect distribution patterns or to demonstrate other use for computer mapping.

Figures 26 to 65 present the maps of the data taken on September 12. Figures 25 to 27 represent distances between individual plants. The distance values ranged from 6 to 25 centimeters and the maps indicate that the planting and thinning of the field resulted in a relatively uniform stand with a desirable 15-20 cm between plants.

Due to the uniformity of plant density and consistent agronomic practices, the data on height (Figures 28 and 29) and plant diameter (Figures 30 and 31) show a marked consistency.

The maps of the various plant heights are of particular interest since contour lines may be drawn enabling the topographic features of the cotton stand to be visualized as individual cuts through the contours. Some indication of increased bushiness of plants with wider spacing is evident in a comparison of Figures 25 and 30.

Thus, computer mapping provides the entomological ecologist with a practical tool for studying the distribution of insects in relation to plant growth and provides insight into the modifications of the temperatures by shading of soil niches inhabited by insects.

No relation between percent soil moisture (Figures 32 and 33) and plant growth is evident by comparing the maps. However, the samples were taken approximately 3 to 4 weeks after final irrigation, and soil moisture had apparently become relatively constant. Likewise the relationship of soil nitrogen and crop growth is not evident from the mapping comparisons (Figures 34-35 and 28-31). However, a relatively consistent usage by cotton plants of the applied nitrogen fertilizer can be observed from the maps by noting that the depletion of the available nitrogen was even (Figures 34 and 35).

The maps illustrating squaring (Figures 54 to 59) indicate that although irrigations had been discontinued three weeks earlier, squaring still continued in some portions of the field. In fact, as many as 20 squares per plant were found (Figure 37). However, slightly less than half the field had ten squares of various sizes or less (Figure 36). These squares may or may not be of commercial value depending upon grower practice in regard to water and fertilizer applications. However, such squares do provide food and oviposition sites for many of the insect pests present in Arizona cotton and subsequently, present an entomological hazard.

The bloom data (Figure 38) show that an average of less than 1 bloom per plant was observed on September 12 and many plants had no blooms.

Assuming that approximately 8 bolls per plant equals one bale of cotton per acre, Figure 39 indicates that at least one-half bale of cotton per acre was still immature in most areas of the field.

About a third of the field (Figure 40) had one bale per acre of immature cotton and small portions of the field (Figures 41 to 43) had plants bearing from 1.5 to 2.5 bales of immature cotton. Figures 44 to 46 present the data on dry bolls and indicate that in most of the field at least one-half bale had matured by September 12. About 63% of the field (Figure 45) had matured at least one bale of cotton and in about 10% of the field 1.5 bales of cotton had matured (Figure 46).

The total number of bolls per plant is presented in Figures 47 to 51. Figure 71 indicates that most of the field yielded more than one bale per acre.

Figures 72, 73, 74, and 75 indicate that the yield in 90% of the field was greater than 1.5 bales, 44% of the field yielded more than 2 bales per acre, 14% of the field yielded 2.5 bales per acre or better, and 4% of the field yielded more than 3 bales per acre. Thus the final yield was consistently distributed throughout the field.

Figures 52 to 58 present the representative results obtained from analysis of elemental nitrogen in the various components of the cotton plant.

Although no entomological significance is evident for nitrogen and insect relationships, the maps do suggest a potential method for studying the relationships of the

attraction of plants to the insects and the subsequent damage. An analysis of a potential attractant in sample plants might well indicate the underlying factors of the distribution of cotton insect populations within a given field. Moreover, it is of considerable interest that nitrogen levels in the various portions of the plant varied in several areas of the field.

Therefore, any further studies into computer-geographical mapping of insects should of necessity involve an accurate analysis of the portions of the plants attacked by a given species of insect on a given date.

Figures 59 to 62 are maps showing the various stages of injurious insects and their damage in mid-September. Of particular interest is the occurrence of these injurious insects in the same area of the field.

The factor which may have been responsible for this common attack on plants in a particular area of the field is not evident from the maps of the factors analyzed. However, it appears that any further analysis of populations of injurious insects should center in the area of the field where the factor responsible for this contagion may be most evident.

Figures 63 to 65 depict the distribution of the population of **Chrysopa** spp. eggs in the field on September 12. Comparison with Figures 4 to 14 indicates that the late season distribution differed from that in the early season. No association of the new positions with the old positions of the **Chrysopa** spp. females with the conformation of the cotton stand is evident.

Although the data are limited, it does suggest that the **Chrysopa** spp. females are unable to associate their eggs with available prey (Figures 59 to 62). Again, however, an opening exists for a practical analytical approach to be used in studying predator - prey relationships.

DISCUSSION

The maps presented here clearly indicate several potential advantages of computer mapping for ecological studies of insects in cotton. The accuracy of the projection from a limited number of gridded sample points is dependent upon the number of points sampled. Thus, the method responds well to an increased effort to obtain field data but also greatly improves small samples.

With an available program, factors which do not require elaborate analysis (e.g. insect densities) may be readily mapped within a very short period and analysis of areas of high (or low) population densities may be immediately investigated to determine the factors responsible for the concentration (or lack of) insect populations.

Inclusion in the samples of factors known or suspected to be responsible for the variability in insect populations will enable the entomologist to associate the factors with the insect population in his retrospective analysis of the population dynamics of the insects under study.

At the same time if no association of the various factors with the insect populations is apparent the entomologist will become aware that his analysis of factors has fallen short of his goal of determining the factors that affect the study populations.

The data presented in Figures 2-65 indicate the entomological potential of the computer mapping technique for:

1. Pinpointing areas with large insect densities.
2. Associating various climatic, agronomic and physiological factors with insect populations.
3. Associating predators with prey or parasites with hosts.
4. Relating insect damage with insect populations.
5. Plotting seasonal changes in insect populations.
6. Delineating study areas with high potential in large overall field situations.

References

Bonham, Charles D. 1969. A statistical study of basic ecological variations in a shortgrass site. AEC Tech. Prog. Report COO-1821-1.

McAdams, H. T. and L. Picciano. 1966. Evaluation and development of test technology. (Unpublished manuscript). Cornell Aeronautical Laboratory, Buffalo, N. Y.

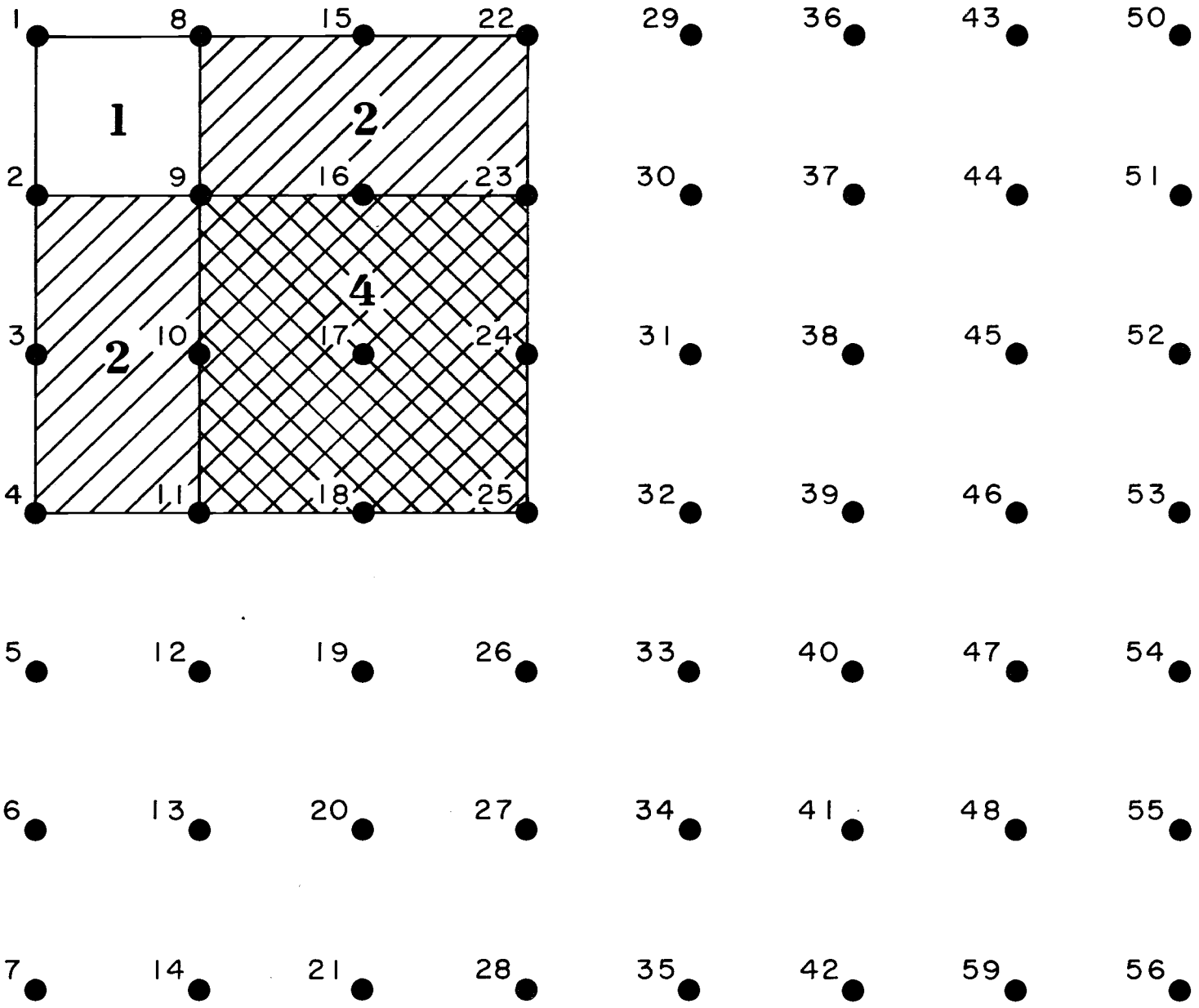


Fig. 1 Field Sampling Design and Computer Mapping Scheme.


BOLLWORM DSQ JUNE 10-11 (Damaged Squares)
* =VALUES ABOVE 1.00 UNITS. (Damaged Squares/plant)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES
SYMBOL COUNT = 43

Figure 2

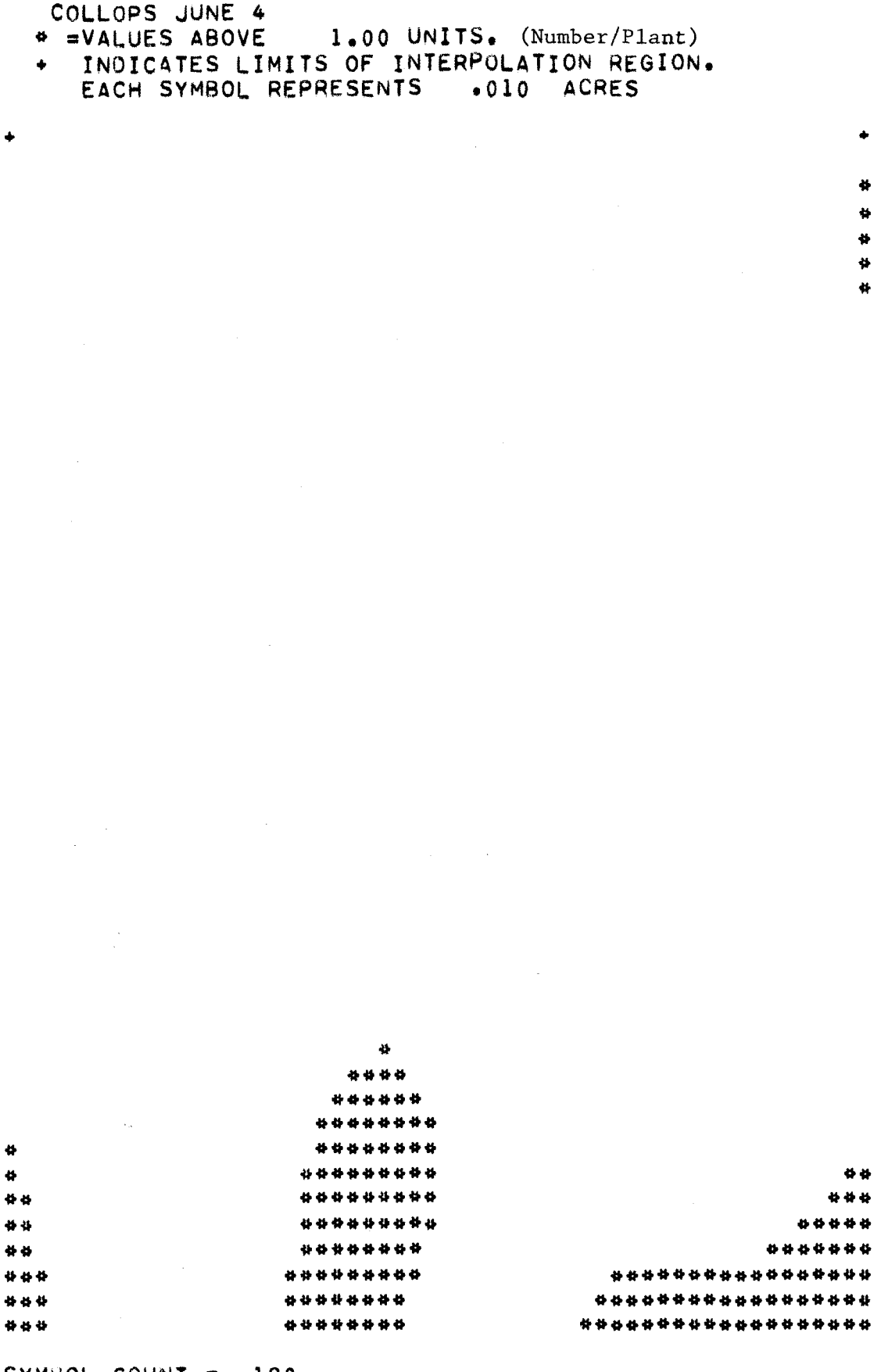

COLLOPS JUNE 4
* =VALUES ABOVE 1.00 UNITS. (Number/Plant)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES
SYMBOL COUNT = 180

Figure 3

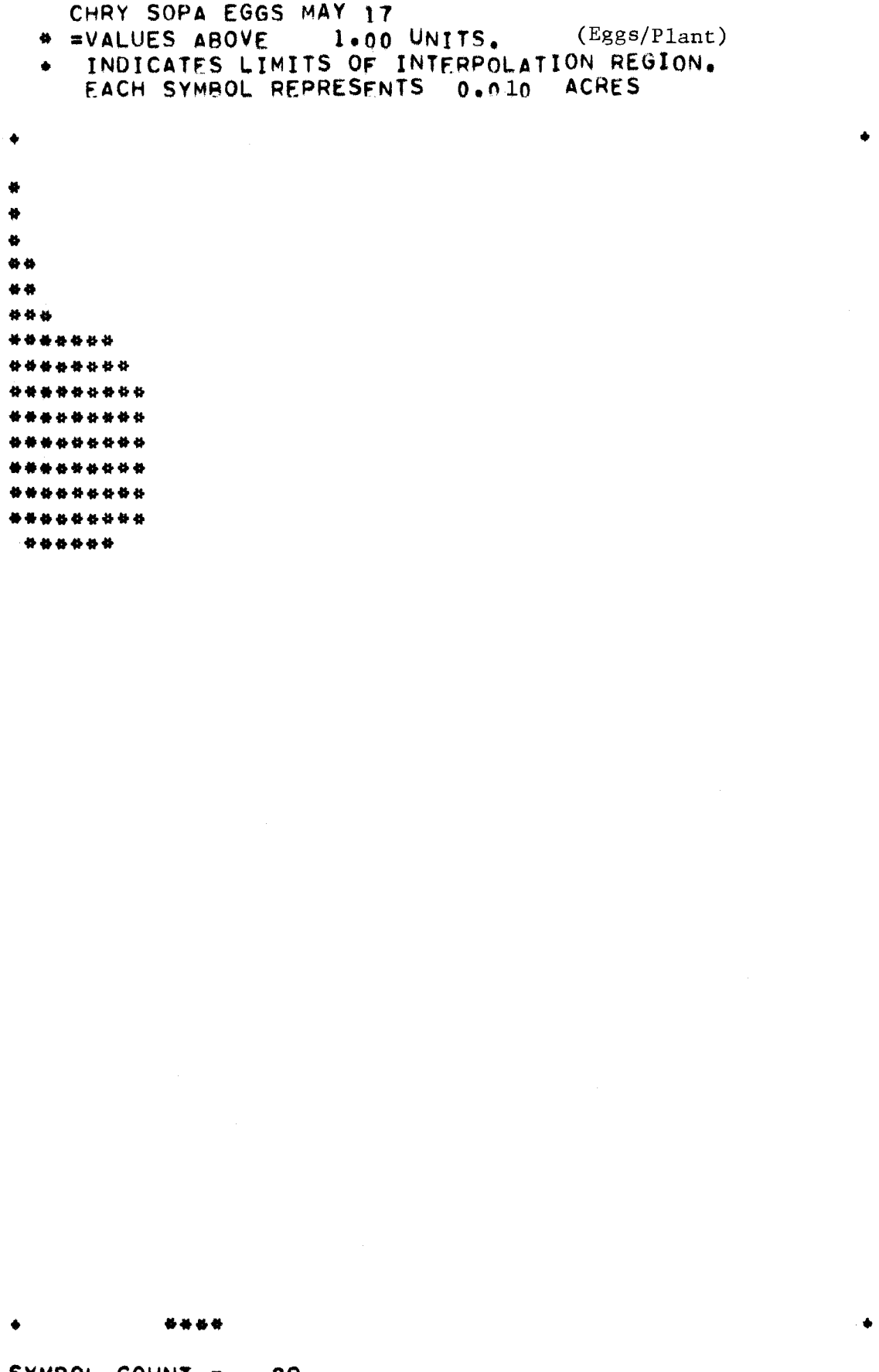

CHRY SOPA EGGS MAY 17
* =VALUES ABOVE 1.00 UNITS. (Eggs/Plant)
• INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS 0.010 ACRES
SYMBOL COUNT = 89

Figure 4

CHRY SOPA EGGS MAY 27

* = VALUES ABOVE 1.00 UNITS. (Eggs/Plant)

♦ INDICATES LIMITS OF INTERPOLATION REGION.

EACH SYMBOL REPRESENTS .010 ACRES

SYMBOL COUNT = 1495

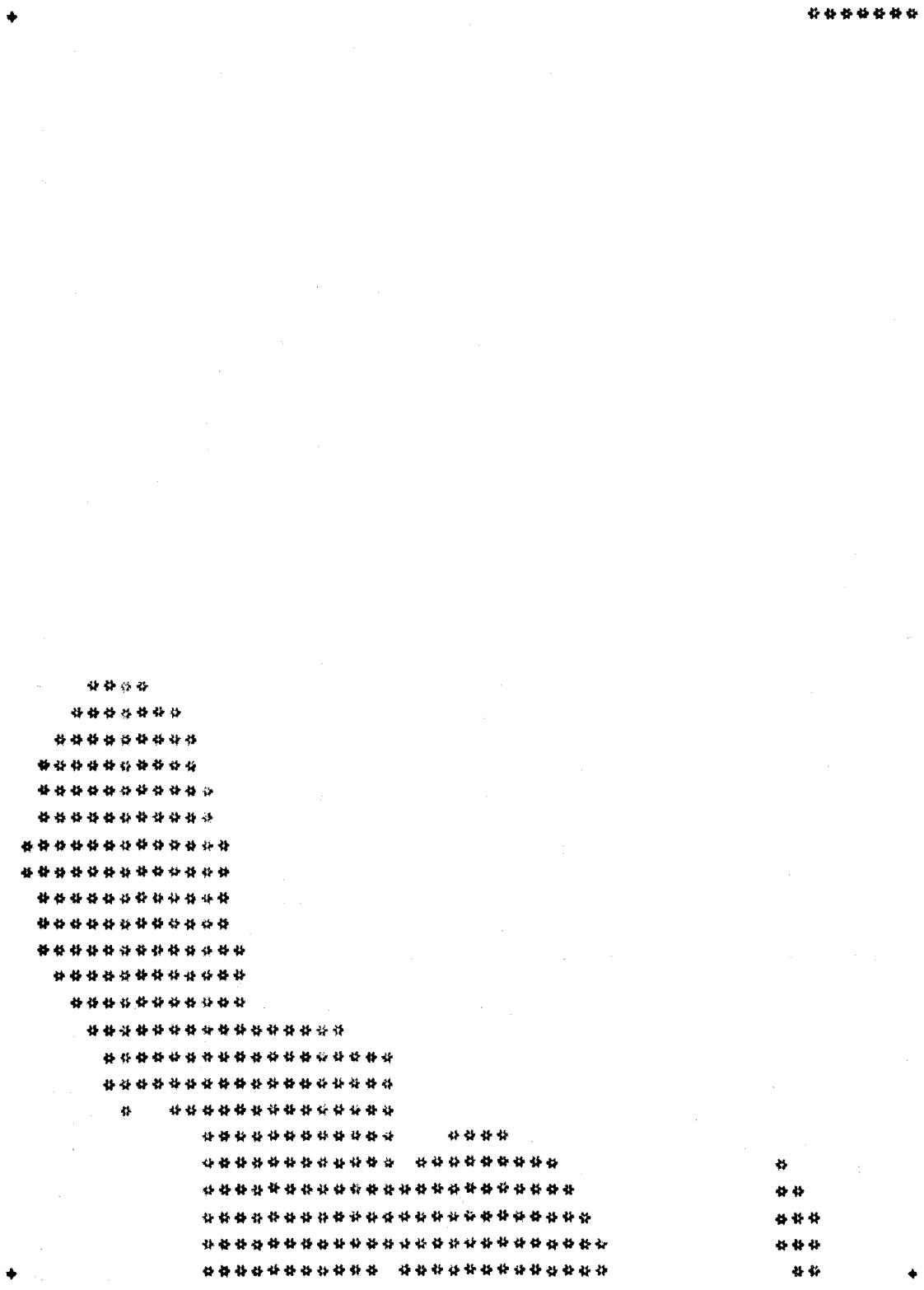
Figure 5

CHRY SOPA EGGS MAY 27

* = VALUES ABOVE 2.00 UNITS. (Eggs/Plant)

♦ INDICATES LIMITS OF INTERPOLATION REGION.

EACH SYMBOL REPRESENTS .010 ACRES



SYMBOL COUNT = 357

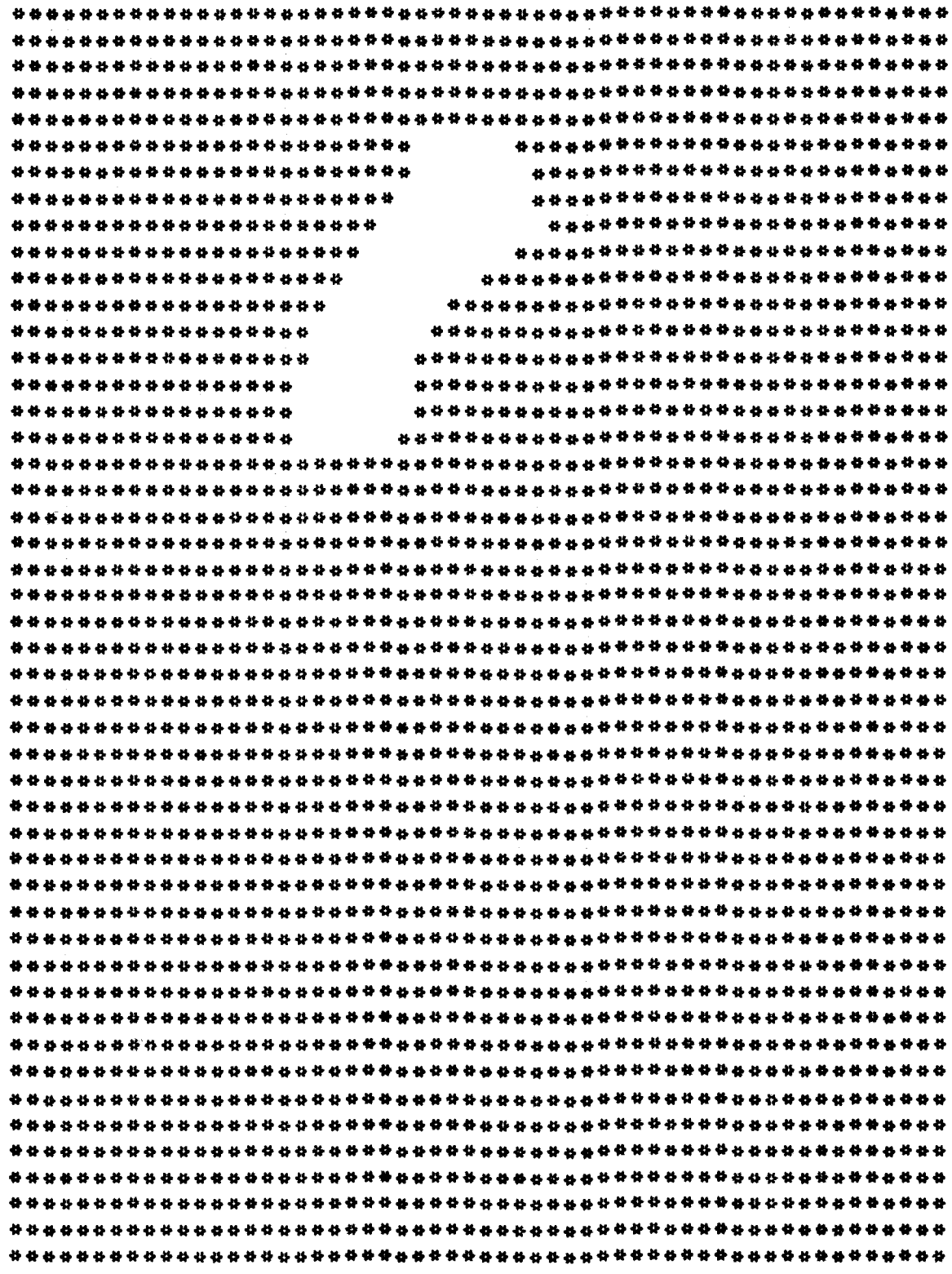
Figure 6

CHRY SOPA EGGS JUNE 4

* =VALUES ABOVE 1.00 UNITS. (Eggs/Plant)

• INDICATES LIMITS OF INTERPOLATION REGION.

EACH SYMBOL REPRESENTS 0.010 ACRES



SYMBOL COUNT = 2600

Figure 7

CHRY SOPA EGGS JUNE 4
* =VALUES ABOVE 2.00 UNITS. (Eggs/Plant)
. INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS 0.010 ACRES

SYMBOL COUNT = 2250

Figure 8

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   CHRY SOPA EGGS JUNE 4
 * =VALUES ABOVE     7.00 UNITS.        (Eggs/Plant)
 .  INDICATES LIMITS OF INTERPOLATION REGION.
   EACH SYMBOL REPRESENTS  0.010   ACRES

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SYMBOL COUNT =  139
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Figure 9

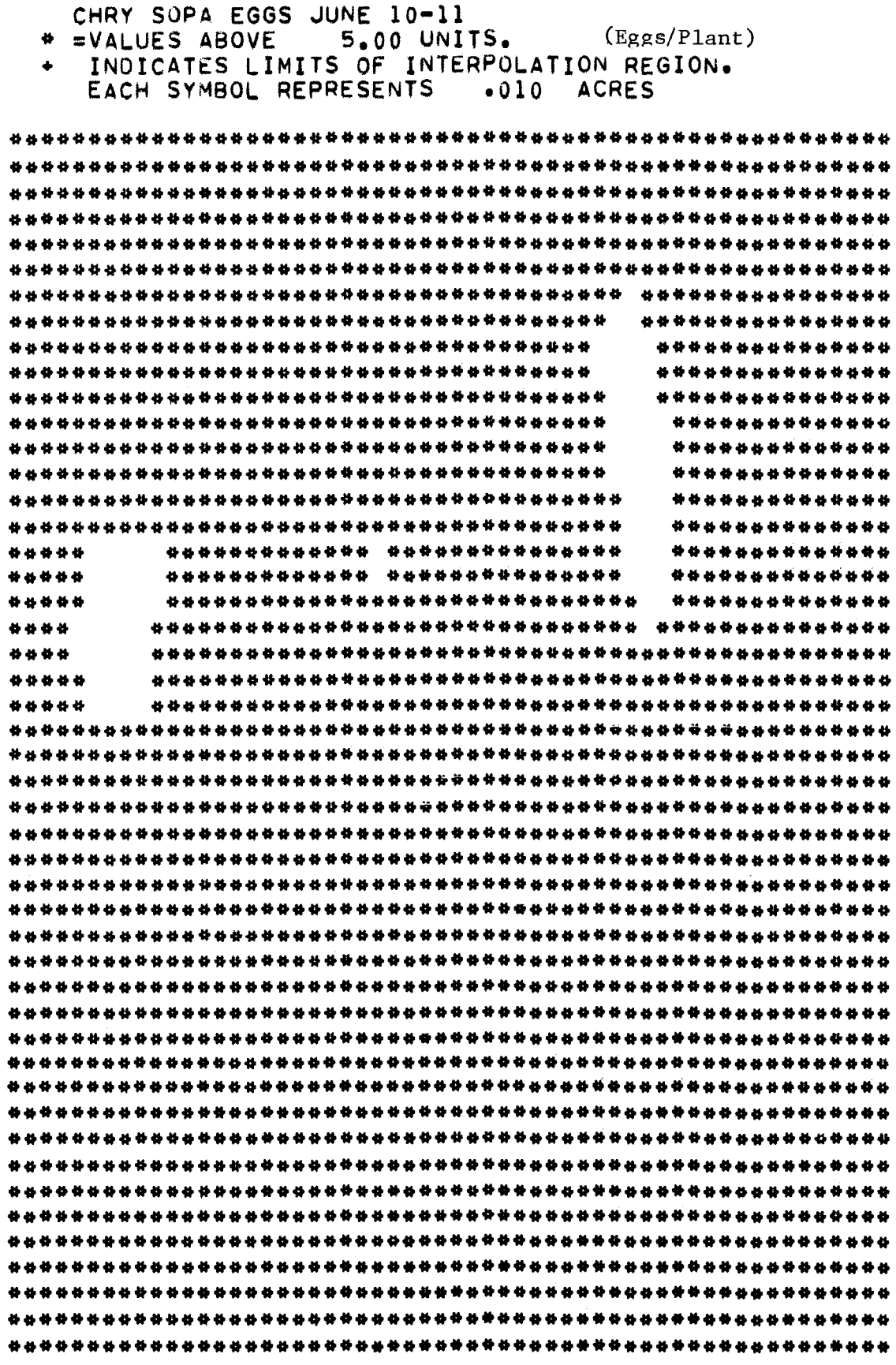

CHRY SOPA EGGS JUNE 10-11
* =VALUES ABOVE 5.00 UNITS. (Eggs/Plant)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES
SYMBOL COUNT = 2612

Figure 10


CHRY SOPA EGGS JUNE 10-11
* =VALUES ABOVE 10.00 UNITS. (Eggs/Plant)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES
SYMBOL COUNT = 1380

Figure 11


CHRY SOPA EGGS JUNE 10-11
* =VALUES ABOVE 15.00 UNITS. (Eggs/Plant)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES
SYMBOL COUNT = 410

Figure 12

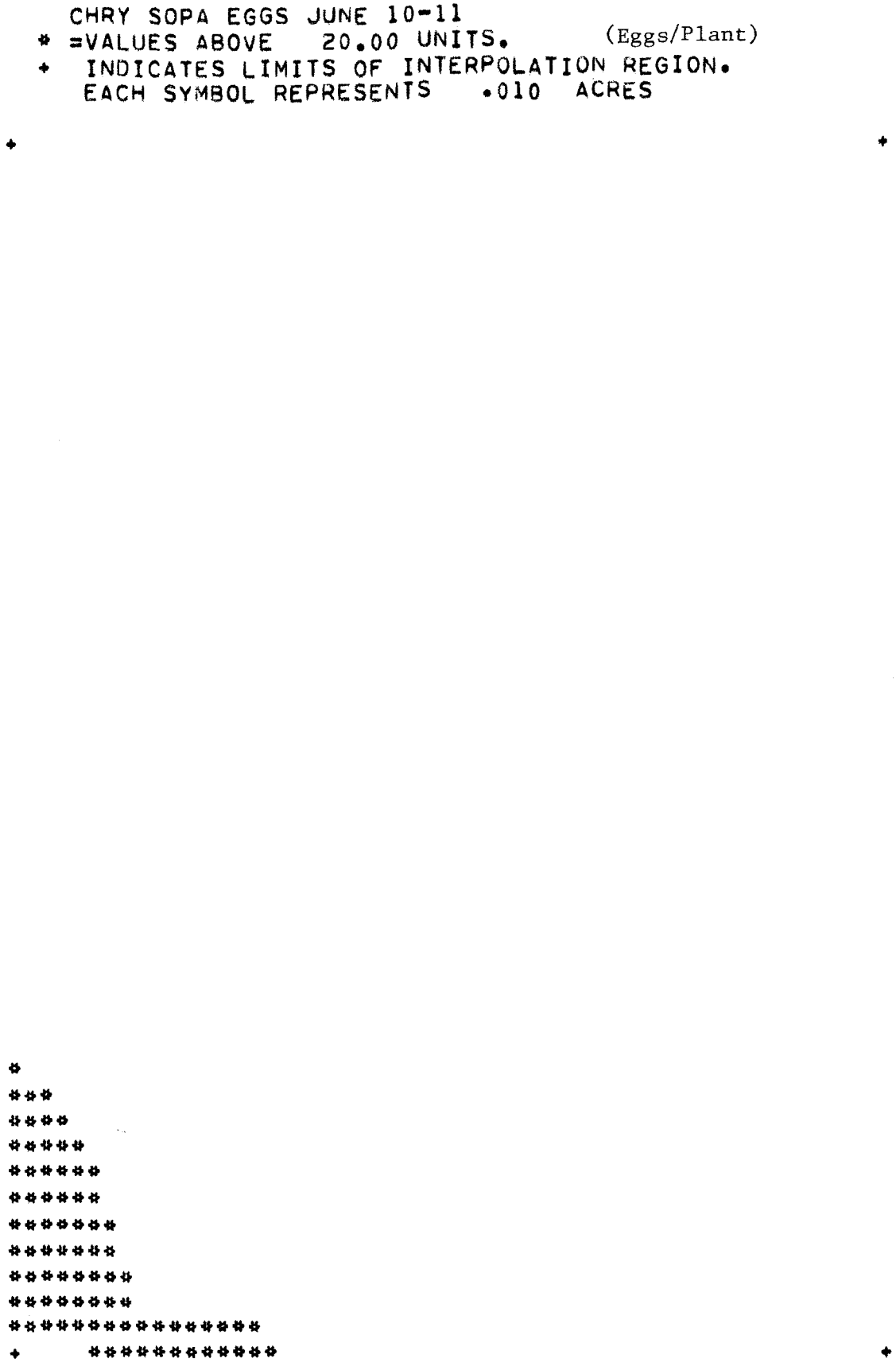

CHRY SOPA EGGS JUNE 10-11
* =VALUES ABOVE 20.00 UNITS. (Eggs/Plant)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES
SYMBOL COUNT = 83

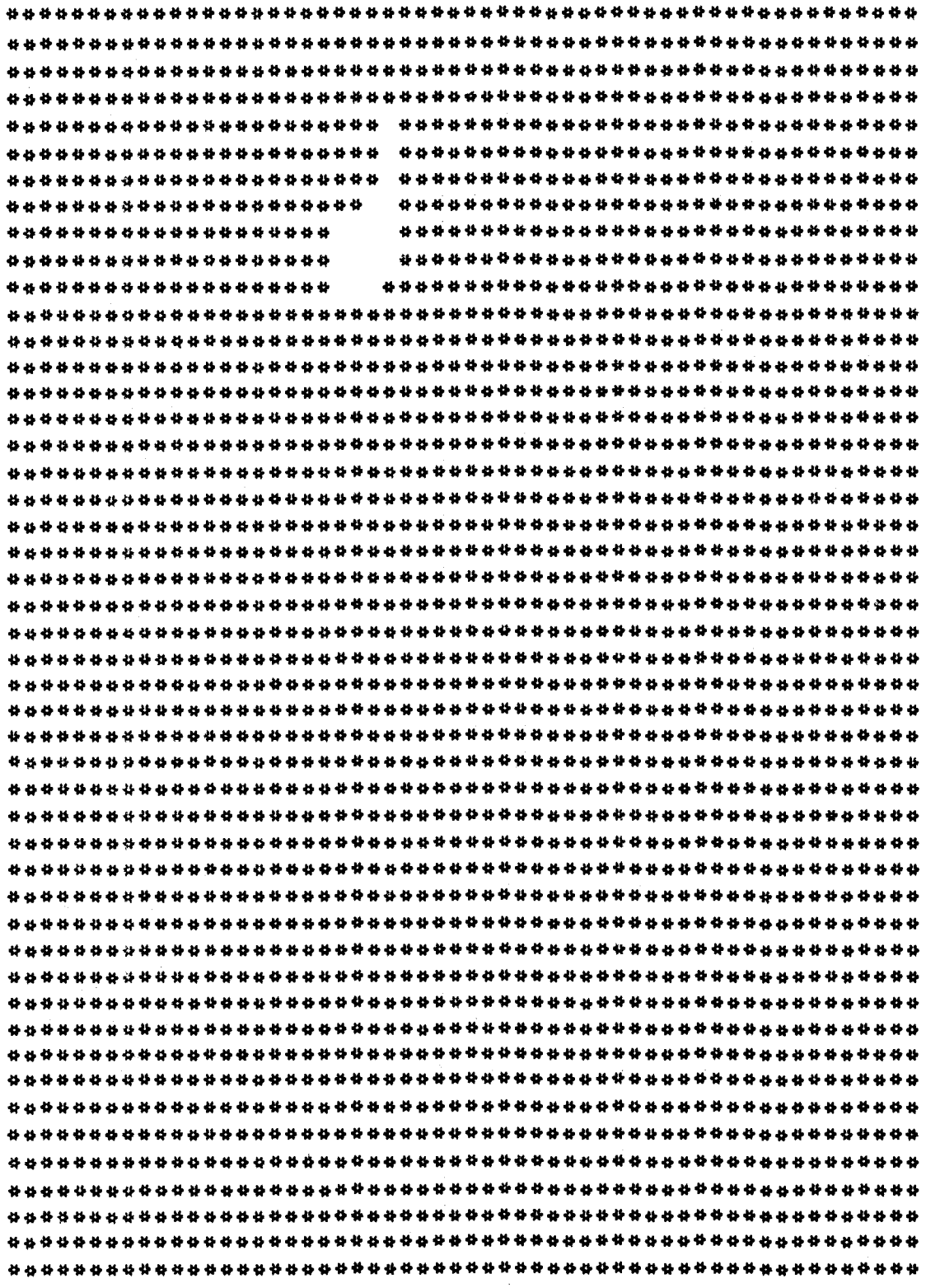
Figure 13

CHRY SOPA EGGS JUNE 19
* =VALUES ABOVE 1.00 UNITS. (Eggs/Plant)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES

SYMBOL COUNT = 595

Figure 14

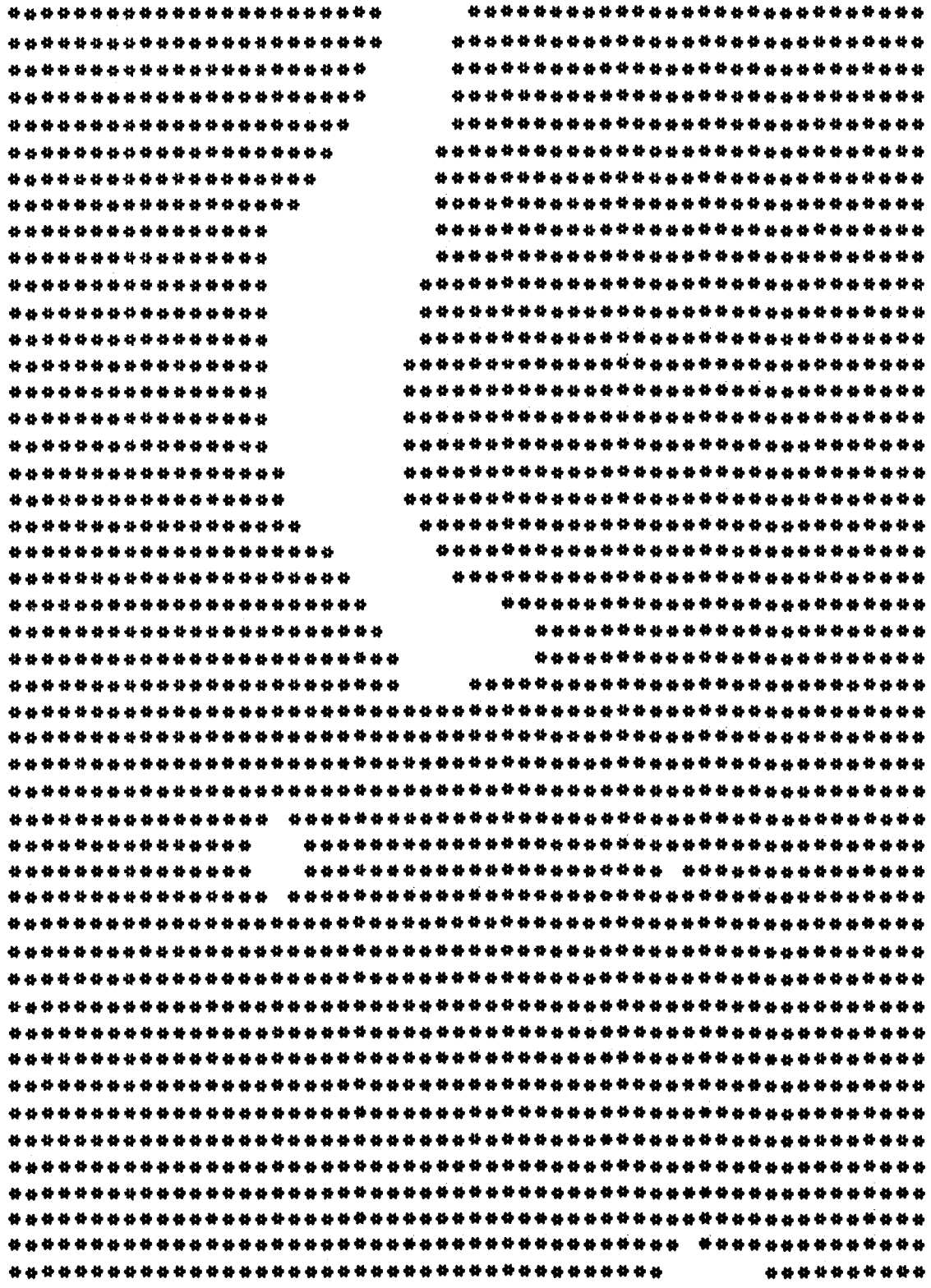
SQUARES JUNE 19
* =VALUES ABOVE 10.00 UNITS. (Squares/Plant)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES



SYMBOL COUNT = 2672

Figure 15

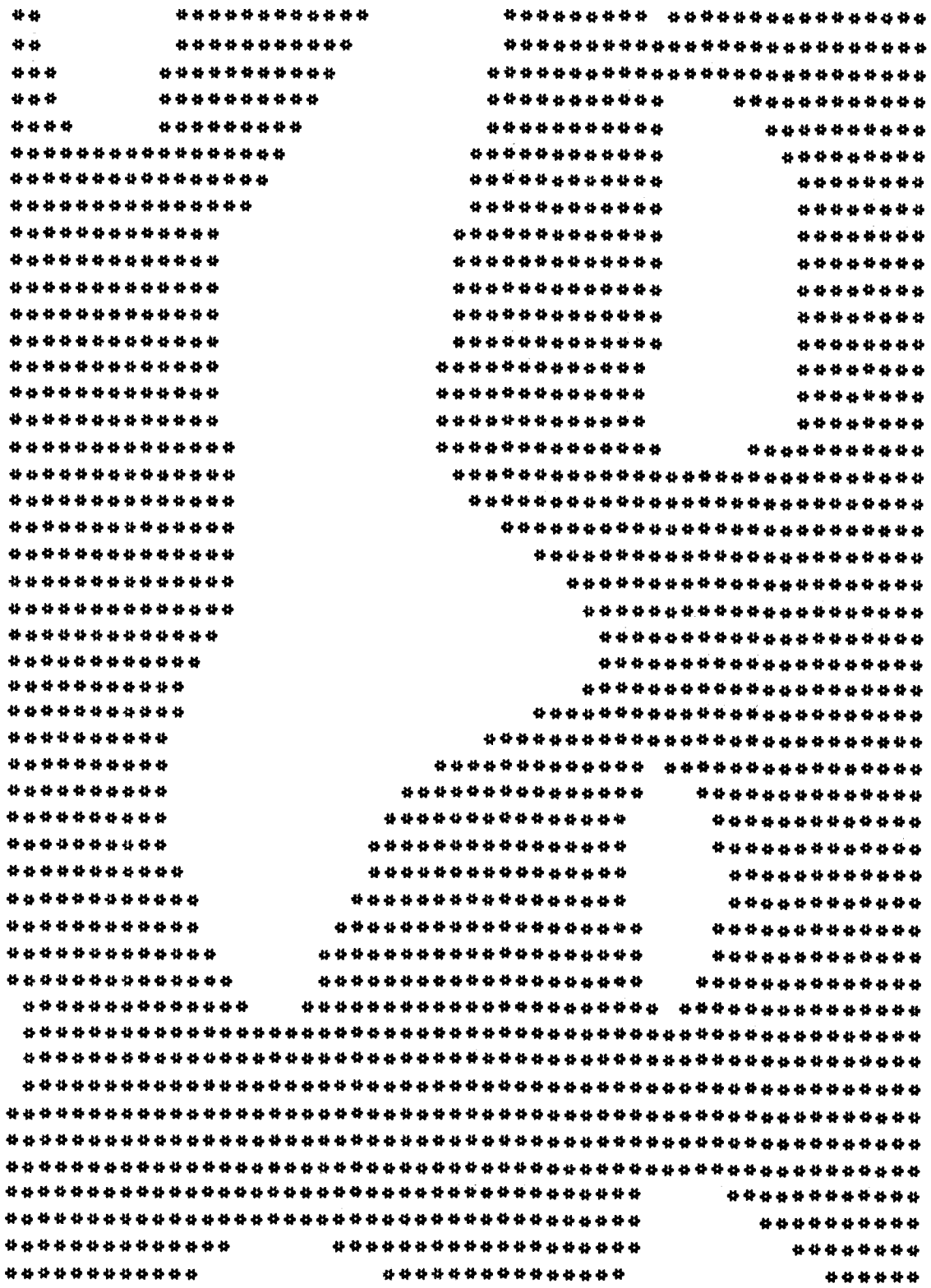
SQUARES JUNE 19
* =VALUES ABOVE 15.00 UNITS. (Squares/Plant)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES



SYMBOL COUNT = 2485

Figure 16

SQUARES JUNE 19
* =VALUES ABOVE 20.00 UNITS. (Squares/Plant)
• INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES



SYMBOL COUNT = 1943

Figure 17


SQUARES JUNE 19
* =VALUES ABOVE 25.00 UNITS. (Squares/Plant)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES
SYMBOL COUNT = 1020

Figure 18

BLOOMS JUNE 19
* =VALUES ABOVE 1.00 UNITS. (Blooms/Plant)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES

SYMBOL COUNT = 233

Figure 19

```
  BOLLWOWM L JUNE 19    (Bollworm larvae)
* =VALUES ABOVE     1.00 UNITS. (Larvae/Plant)
+  INDICATES LIMITS OF INTERPOLATION REGION.
   EACH SYMBOL REPRESENTS    .010  ACRES

+                                                                +

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                                *
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+                                                                +

SYMBOL COUNT =     6
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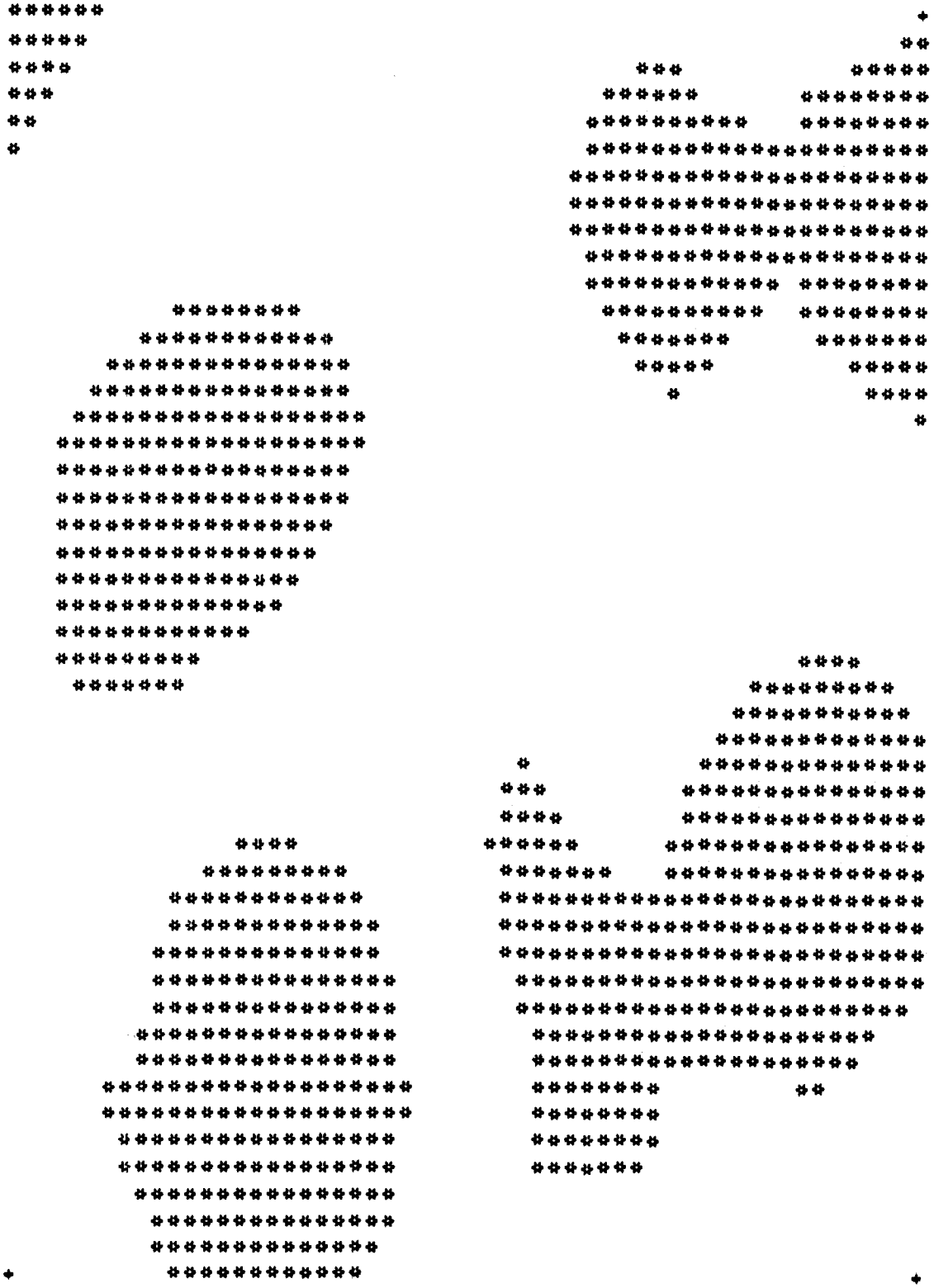
Figure 20

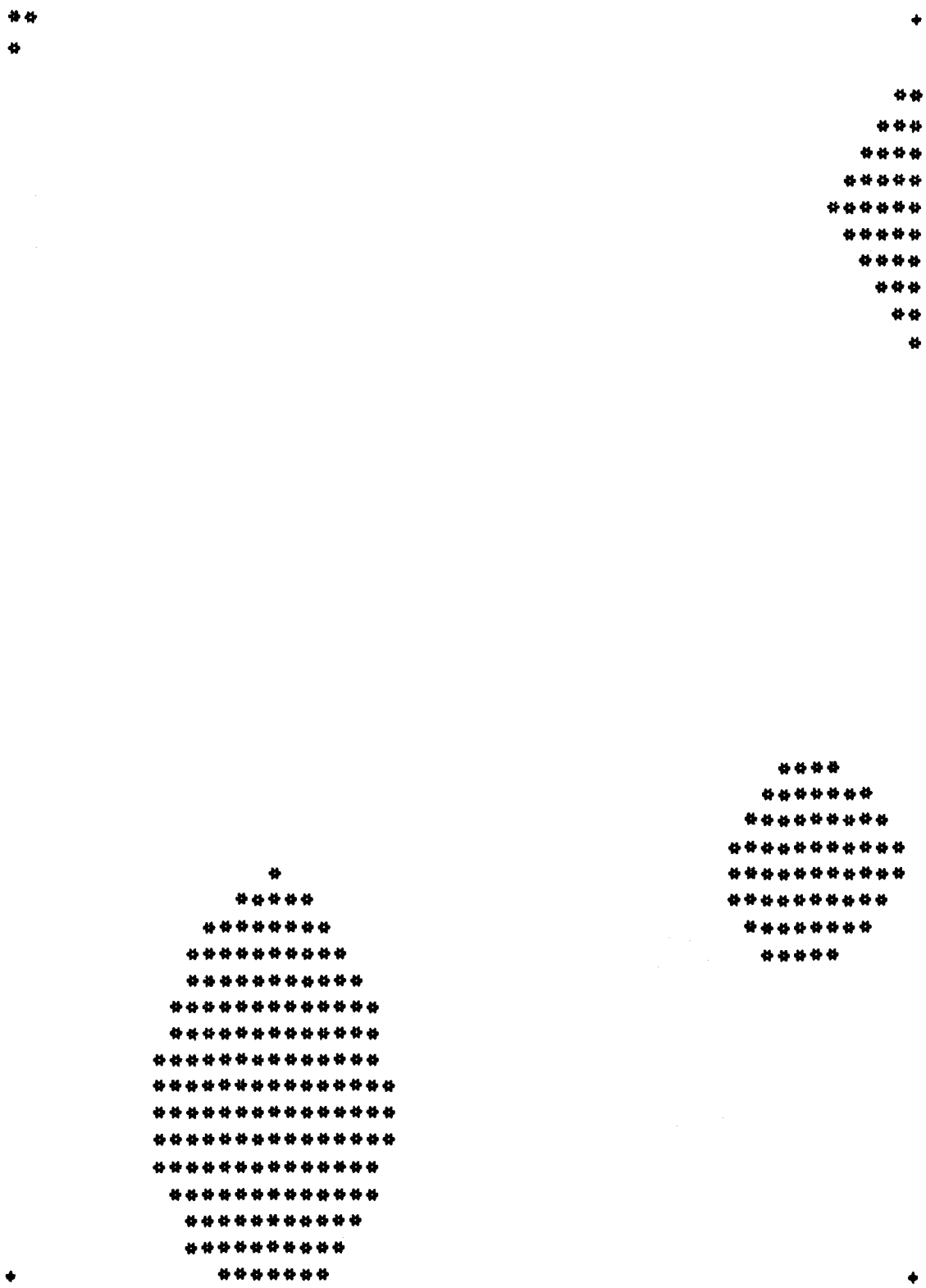
BOLLWORM DQS JUNE 19 (Damaged Squares)
* =VALUES ABOVE 1.00 UNITS. (Damaged Squares/Plant)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES



SYMBOL COUNT = 1031

Figure 21

BOLLWORM DQS JUNE 19 (Damaged Squares)
* =VALUES ABOVE 3.00 UNITS. (Damaged Squares/Plant)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES



SYMBOL COUNT = 278

Figure 22

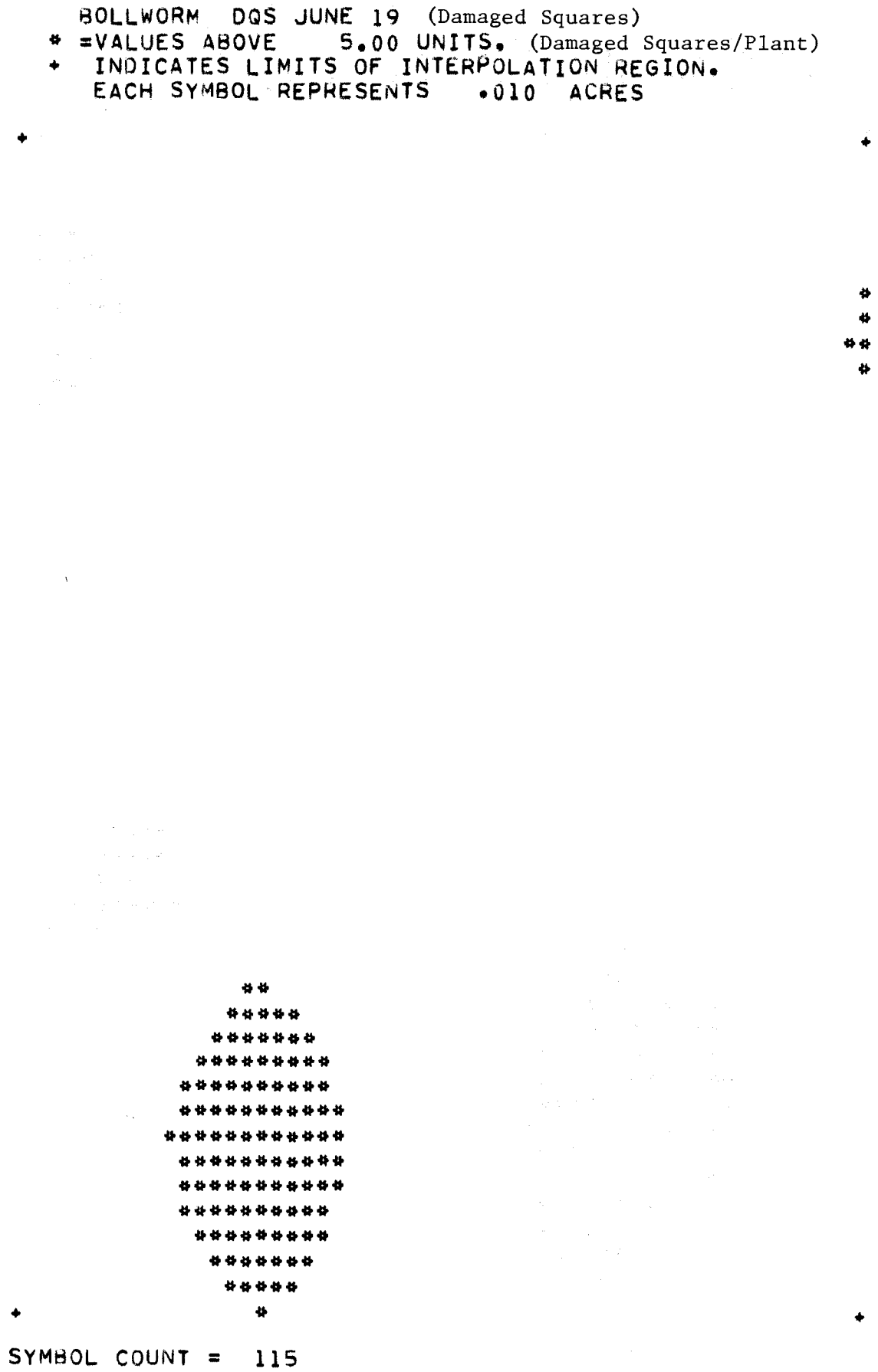

BOLLWORM DQS JUNE 19 (Damaged Squares)
* =VALUES ABOVE 5.00 UNITS. (Damaged Squares/Plant)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES
SYMBOL COUNT = 115

Figure 23


COLLOPS JUNE 19
* =VALUES ABOVE 1.00 UNITS. (Individuals/Plant)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES
SYMBOL COUNT = 312

Figure 24

DISTANCE BETWEEN PLANTS SEPT. 12,1968
  * =VALUES ABOVE 15.00 UNITS. (Centimeters)
  + INDICATES LIMITS OF INTERPOLATION REGION.
    EACH SYMBOL REPRESENTS .010 ACRES

SYMBOL COUNT = 1808

Figure 25

DISTANCE BETWEEN PLANTS SEPT. 12,1968
* =VALUES ABOVE 20.00 UNITS. (Centimeters)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES

SYMBOL COUNT = 1047

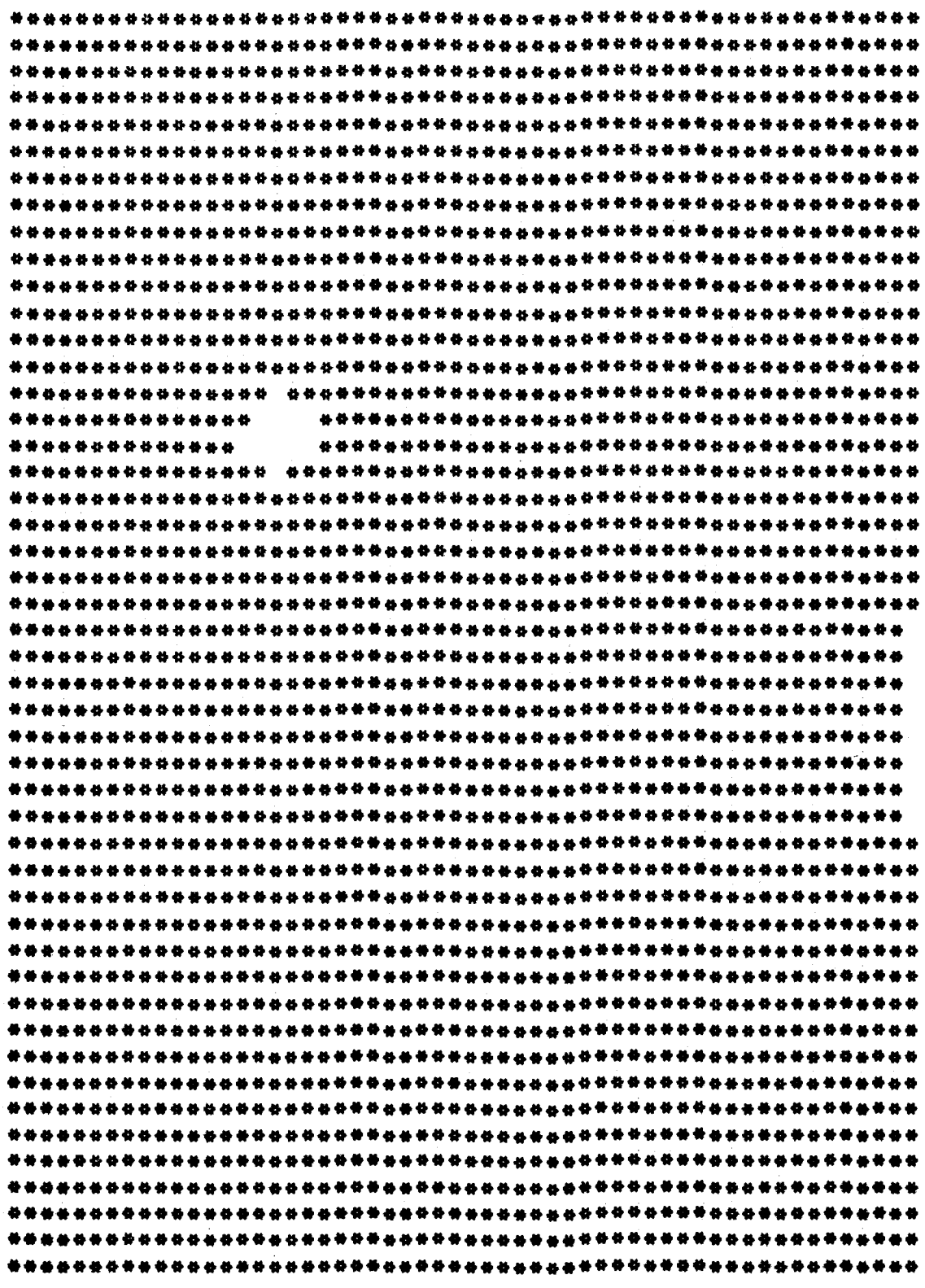
Figure 26

DISTANCE BETWEEN PLANTS SEPT. 12,1968
* =VALUES ABOVE 25.00 UNITS. (Centimeters)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES

SYMBOL COUNT = 469

Figure 27

PLANT HEIGHT CM SEPT. 12,1968
* =VALUES ABOVE 120.00 UNITS. (Centimeters)
• INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS 0.010 ACRES



SYMBOL COUNT = 2669

Figure 28

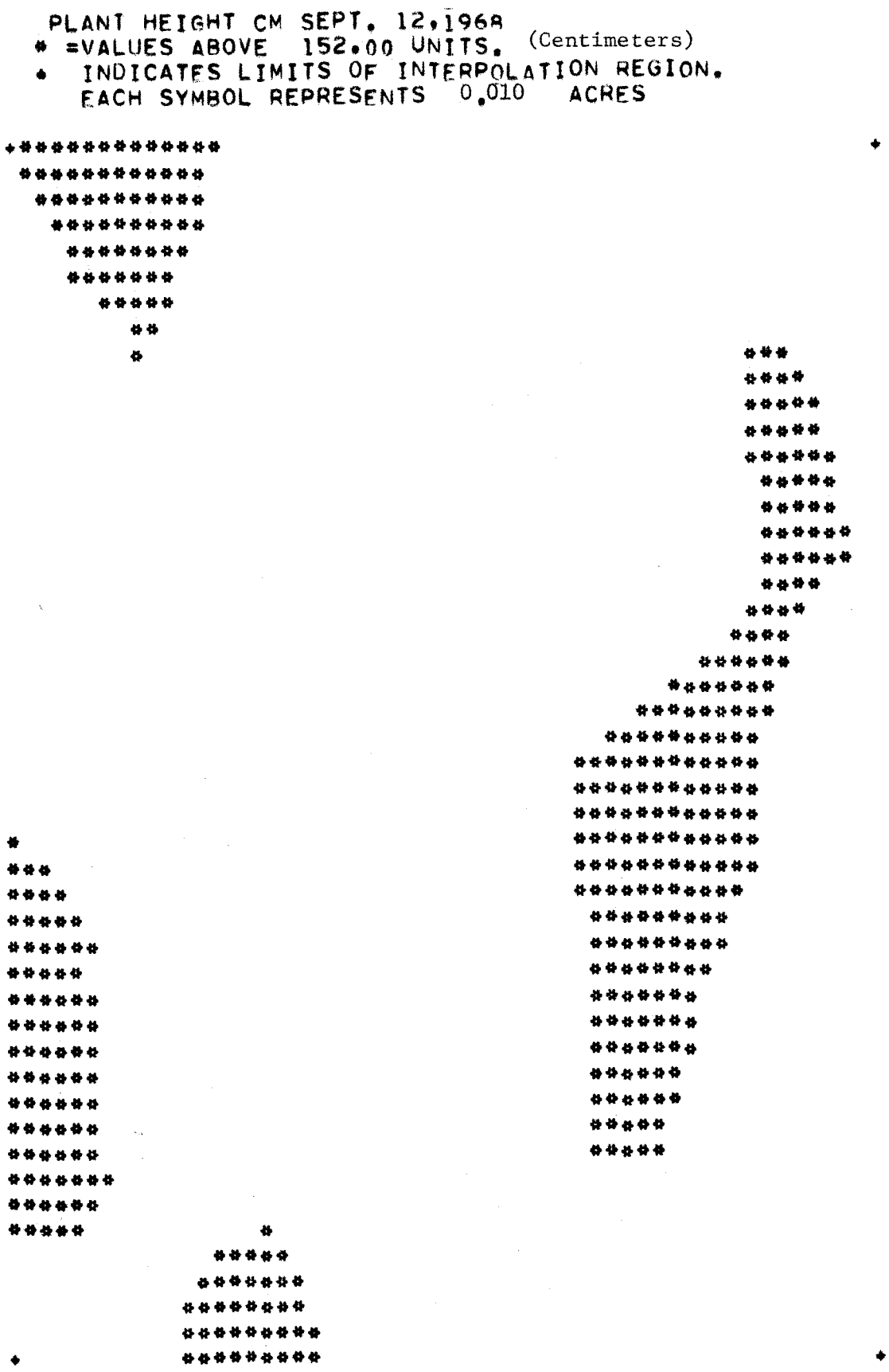

PLANT HEIGHT CM SEPT. 12,1968
* =VALUES ABOVE 152.00 UNITS. (Centimeters)
• INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS 0.010 ACRES
SYMBOL COUNT = 421

Figure 29

PLANT DIAMETER SEPT 12
* =VALUES ABOVE 51.00 UNITS. (Centimeters)
• INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS 0.010 ACRES

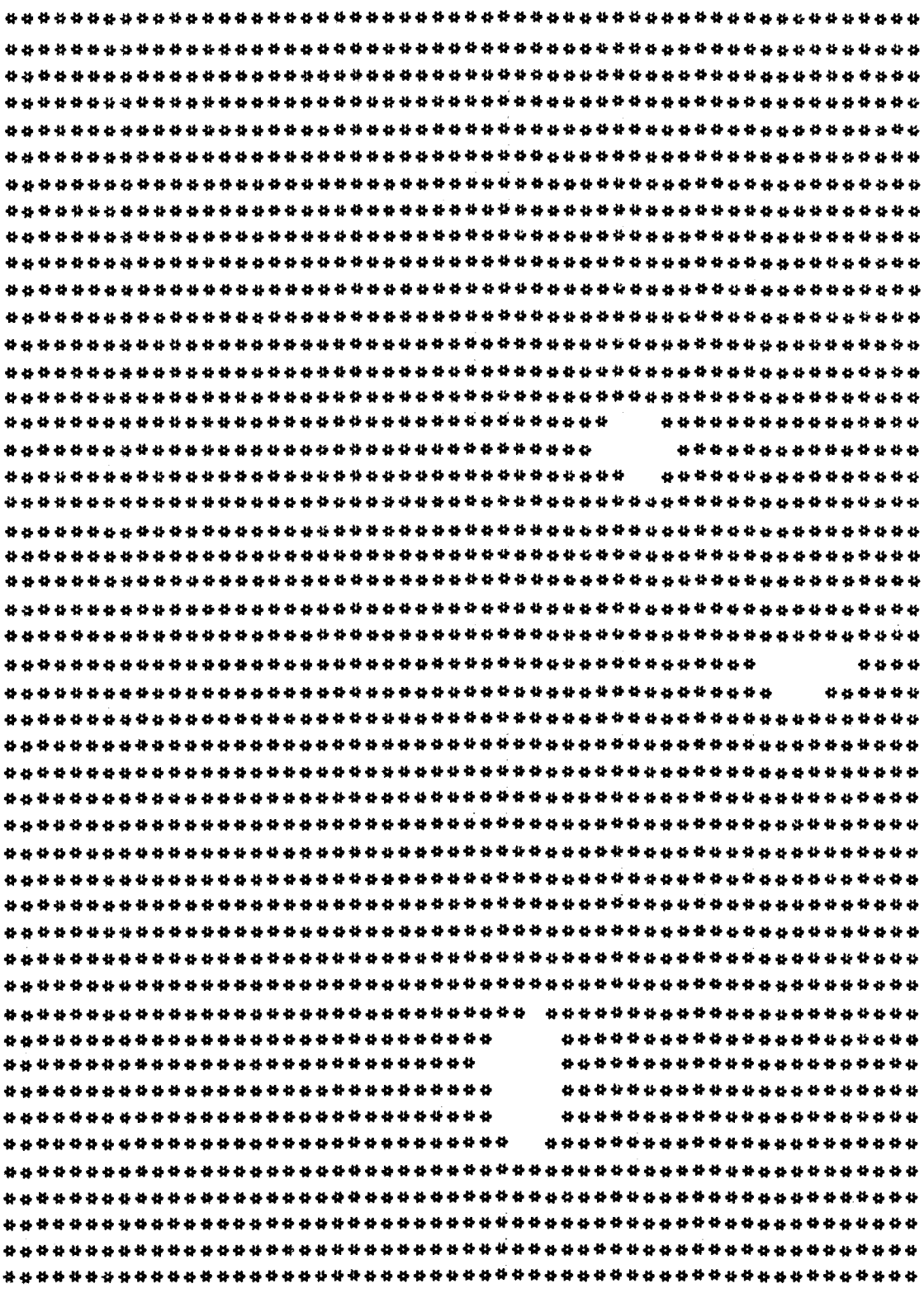
SYMBOL COUNT = 1408

Figure 30


PLANT DIAMETER SEPT 12
* =VALUES ABOVE 83.00 UNITS. (Centimeters)
• INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS 0.010 ACRES
SYMBOL COUNT = 22

Figure 31

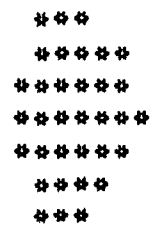
SOIL MOISTURE PER CENT OF DRY WEIGHT SEPT.12
* =VALUES ABOVE 6.00 UNITS. (Percent)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES



SYMBOL COUNT = 2649

Figure 32

SOIL MOISTURE PER CENT OF DRY WEIGHT SEPT.12
* =VALUES ABOVE 12.00 UNITS. (Percent)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES



SYMBOL COUNT = 34

Figure 33

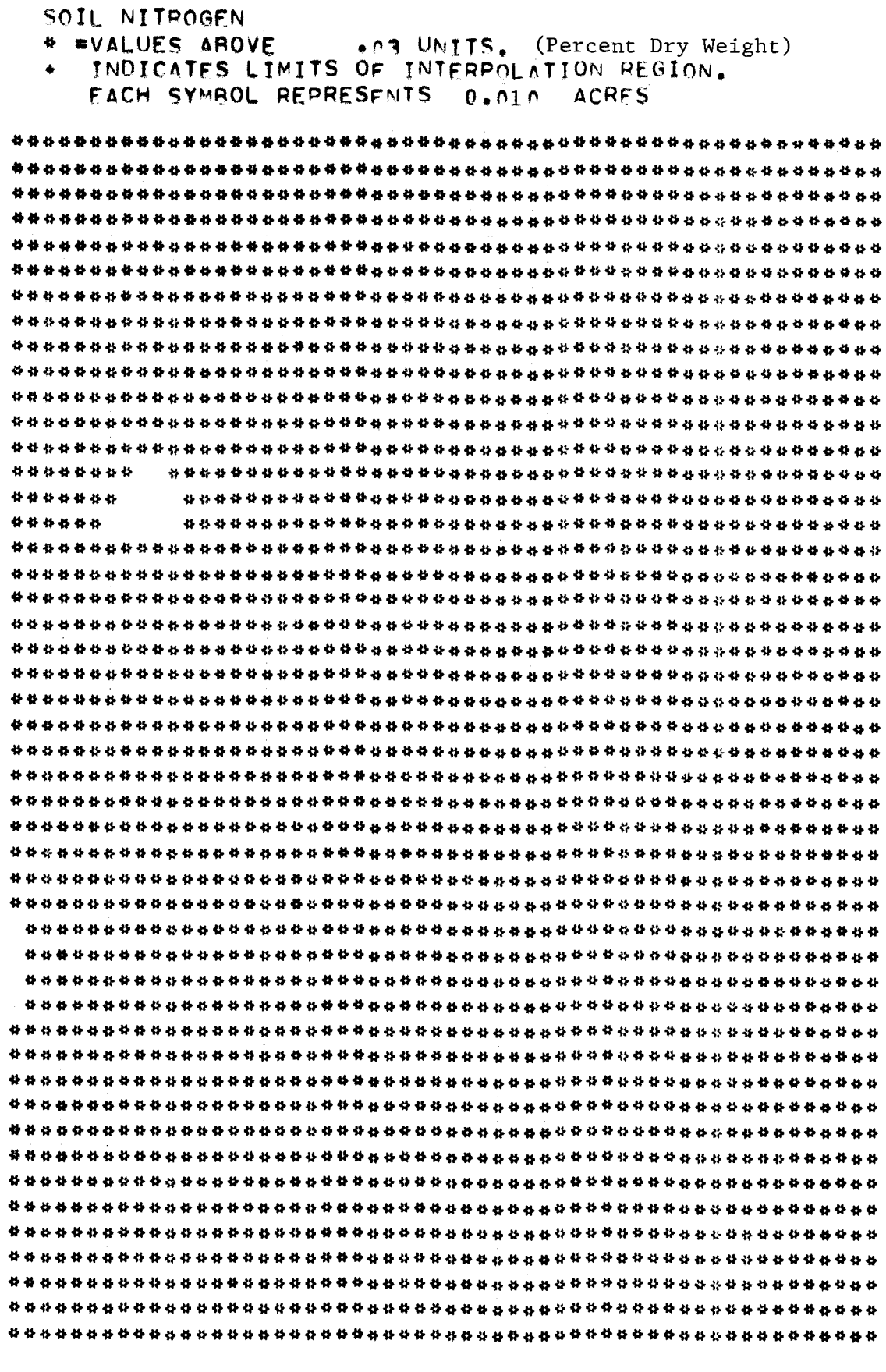

SOIL NITROGEN
* =VALUES ABOVE .03 UNITS. (Percent Dry Weight)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS 0.010 ACRES
SYMBOL COUNT = 2673

Figure 34

SOIL NITROGEN

* = VALUES ABOVE .05 UNITS. (Percent Dry Weight)

◆ INDICATES LIMITS OF INTERPOLATION REGION.

EACH SYMBOL REPRESENTS 0.010 ACRES

SYMBOL COUNT = 64

Figure 35


SQUARES SEPT 12
* =VALUES ABOVE 10.00 UNITS. (Squares/Plant)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES
SYMBOL COUNT = 1163

Figure 36

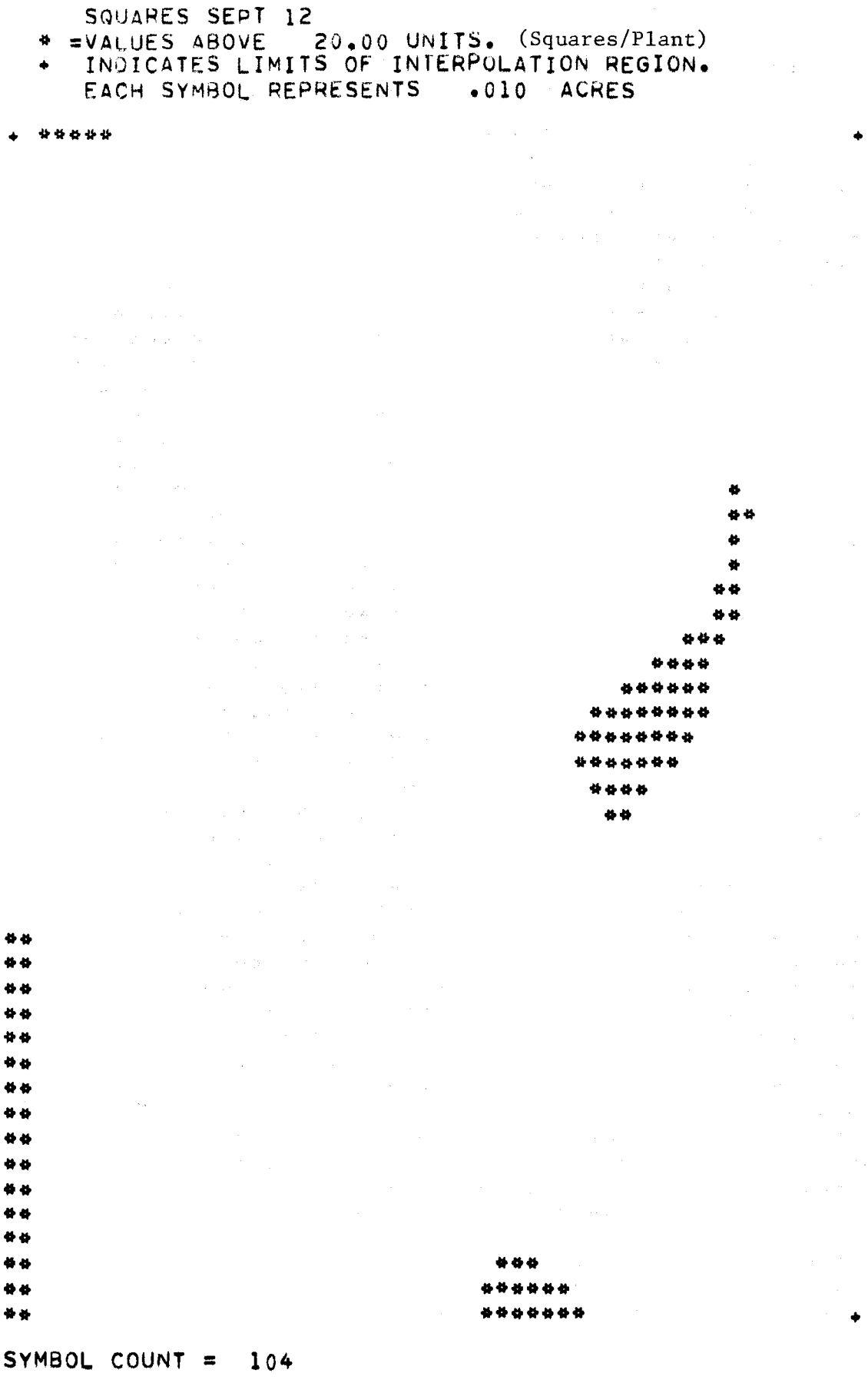

SQUARES SEPT 12
* =VALUES ABOVE 20.00 UNITS. (Squares/Plant)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES
SYMBOL COUNT = 104

Figure 37

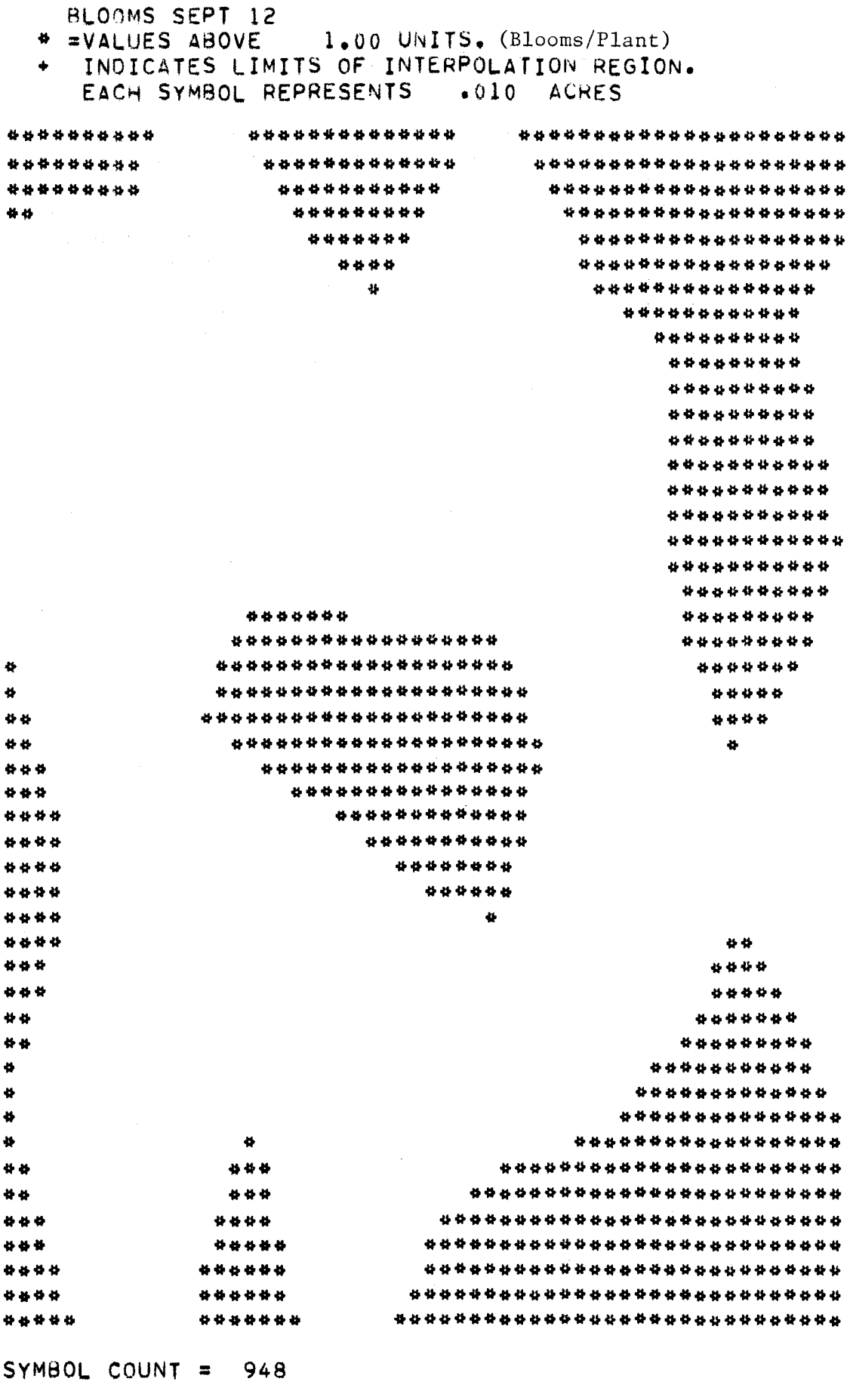

BLOOMS SEPT 12
* =VALUES ABOVE 1.00 UNITS. (Blooms/Plant)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES
SYMBOL COUNT = 948

Figure 38

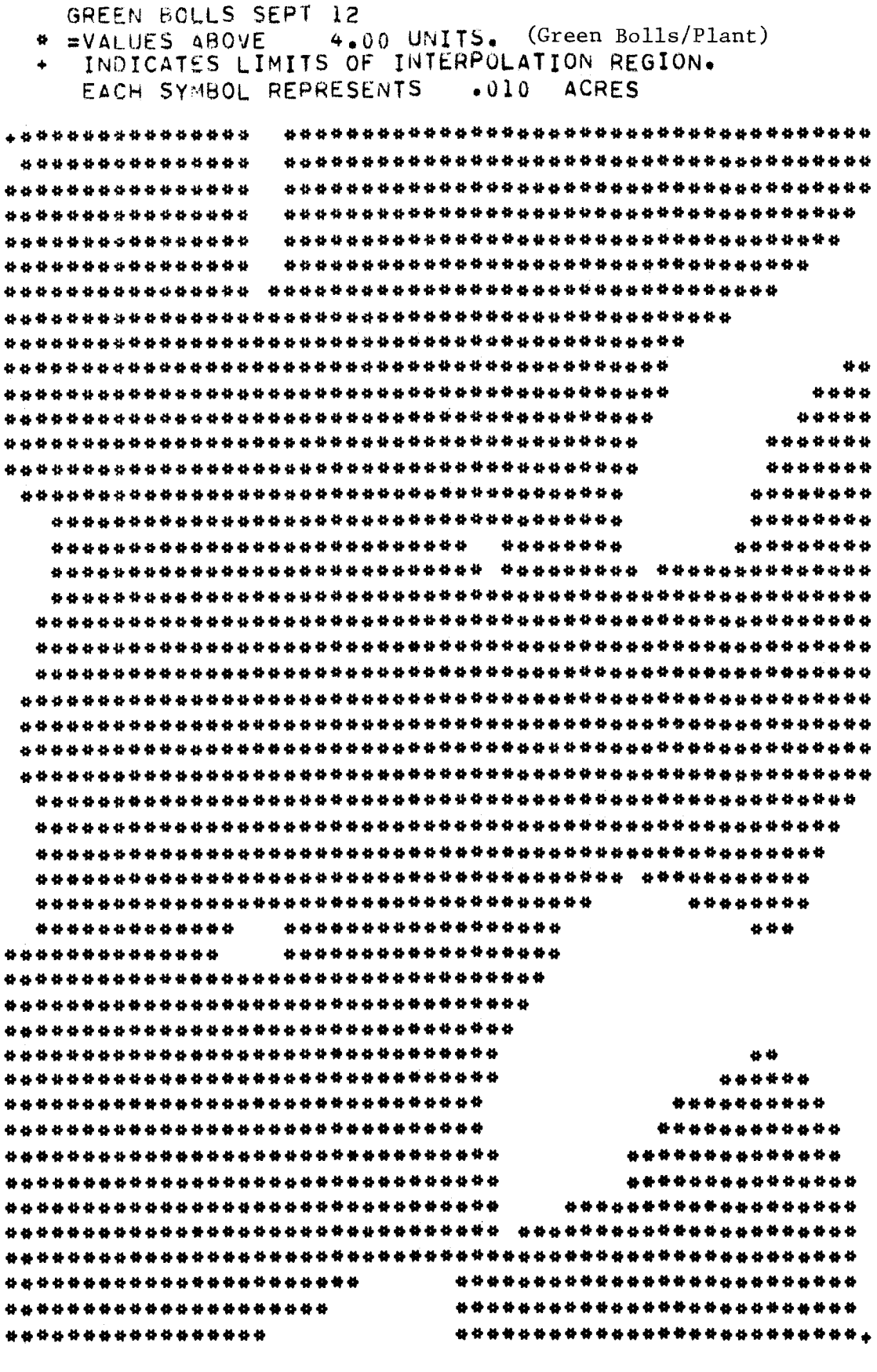

GREEN BOLLS SEPT 12
* =VALUES ABOVE 4.00 UNITS. (Green Bolls/Plant)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES
SYMBOL COUNT = 2277

Figure 39

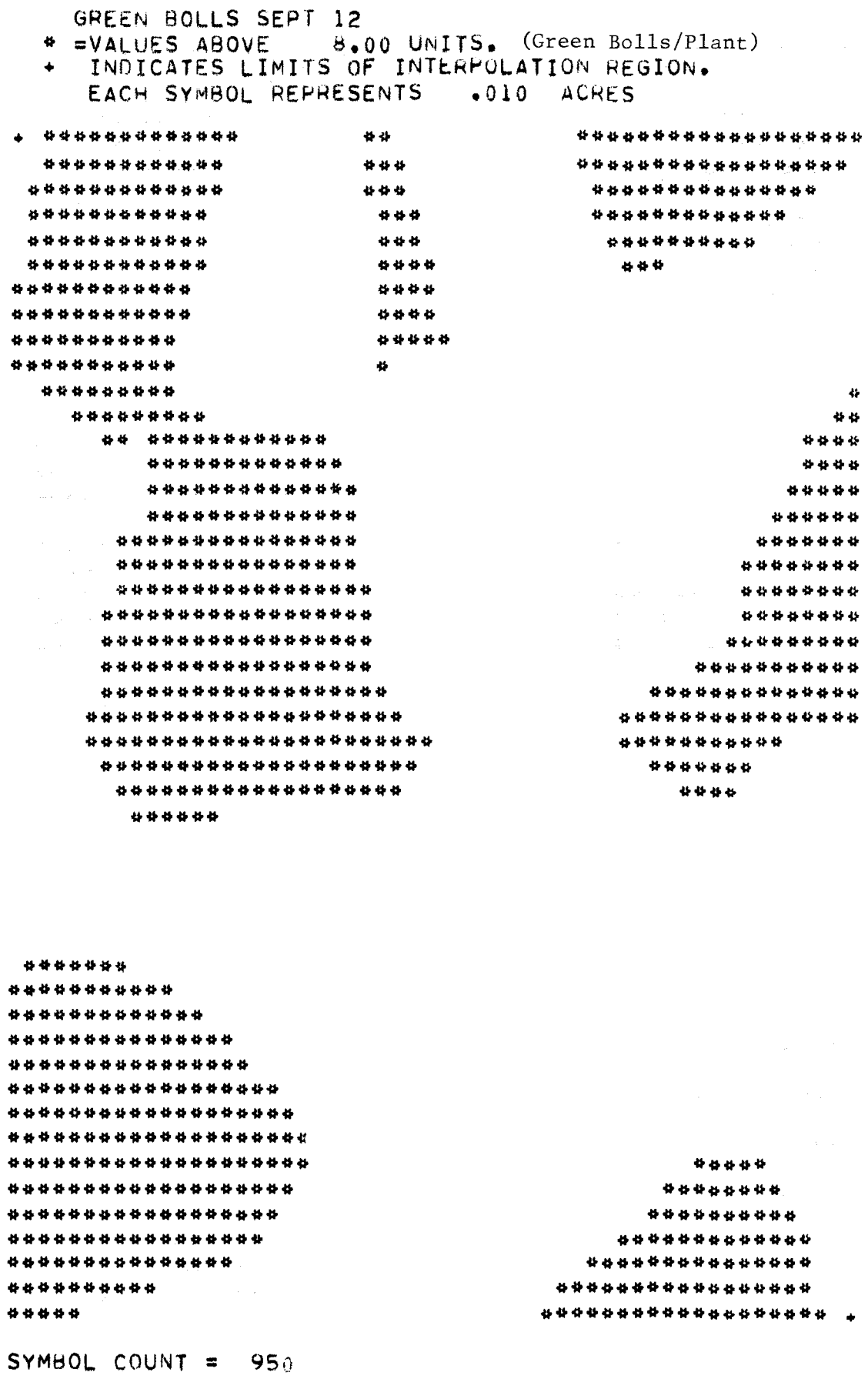

GREEN BOLLS SEPT 12
* =VALUES ABOVE 8.00 UNITS. (Green Bolls/Plant)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES
SYMBOL COUNT = 950

Figure 40

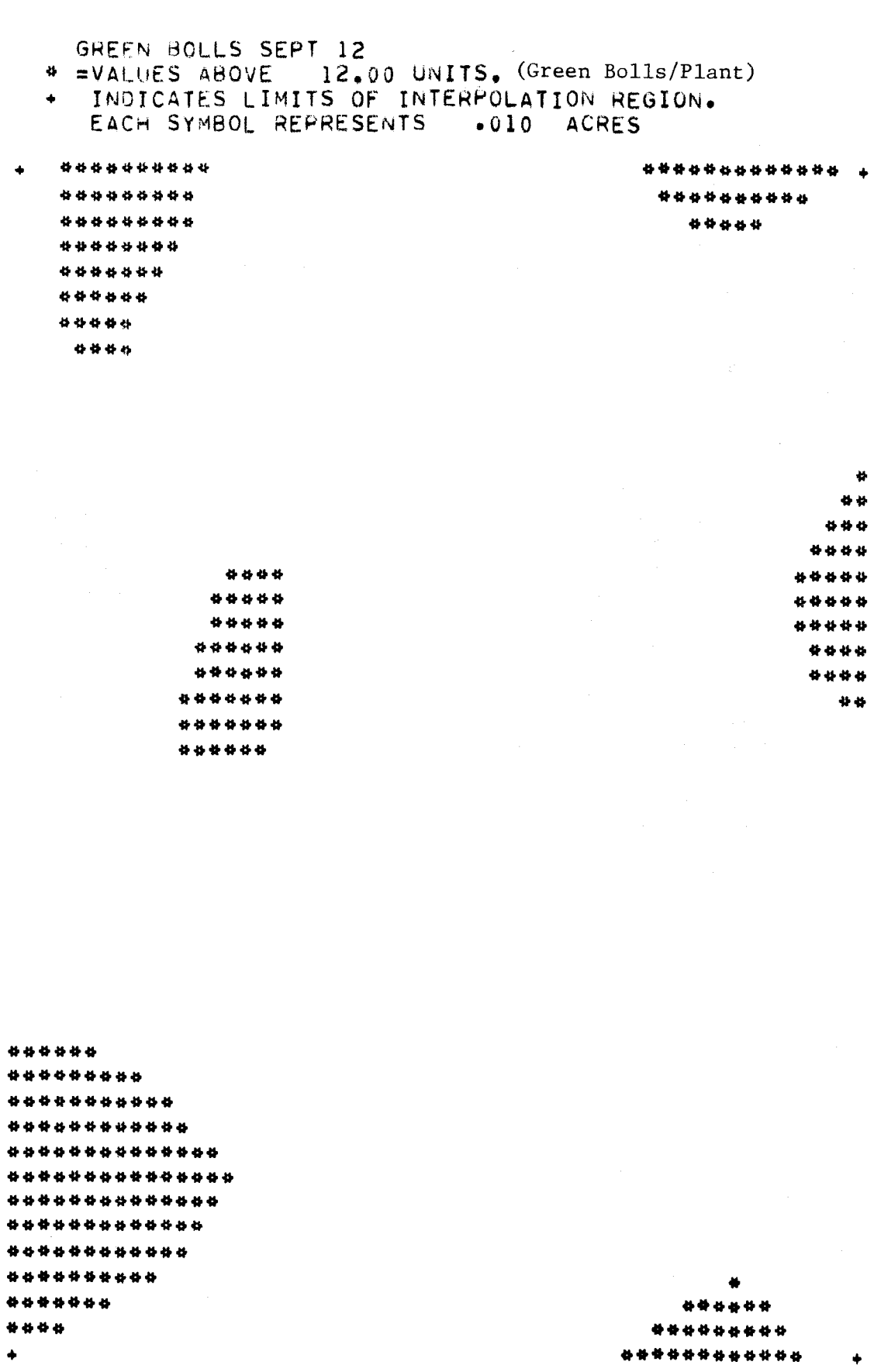

GREEN BOLLS SEPT 12
* =VALUES ABOVE 12.00 UNITS. (Green Bolls/Plant)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES
SYMBOL COUNT = 322

Figure 41


GREEN BOLLS SEPT 12
* =VALUES ABOVE 16.00 UNITS. (Green Bolls/Plant)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES
SYMBOL COUNT = 108

Figure 42

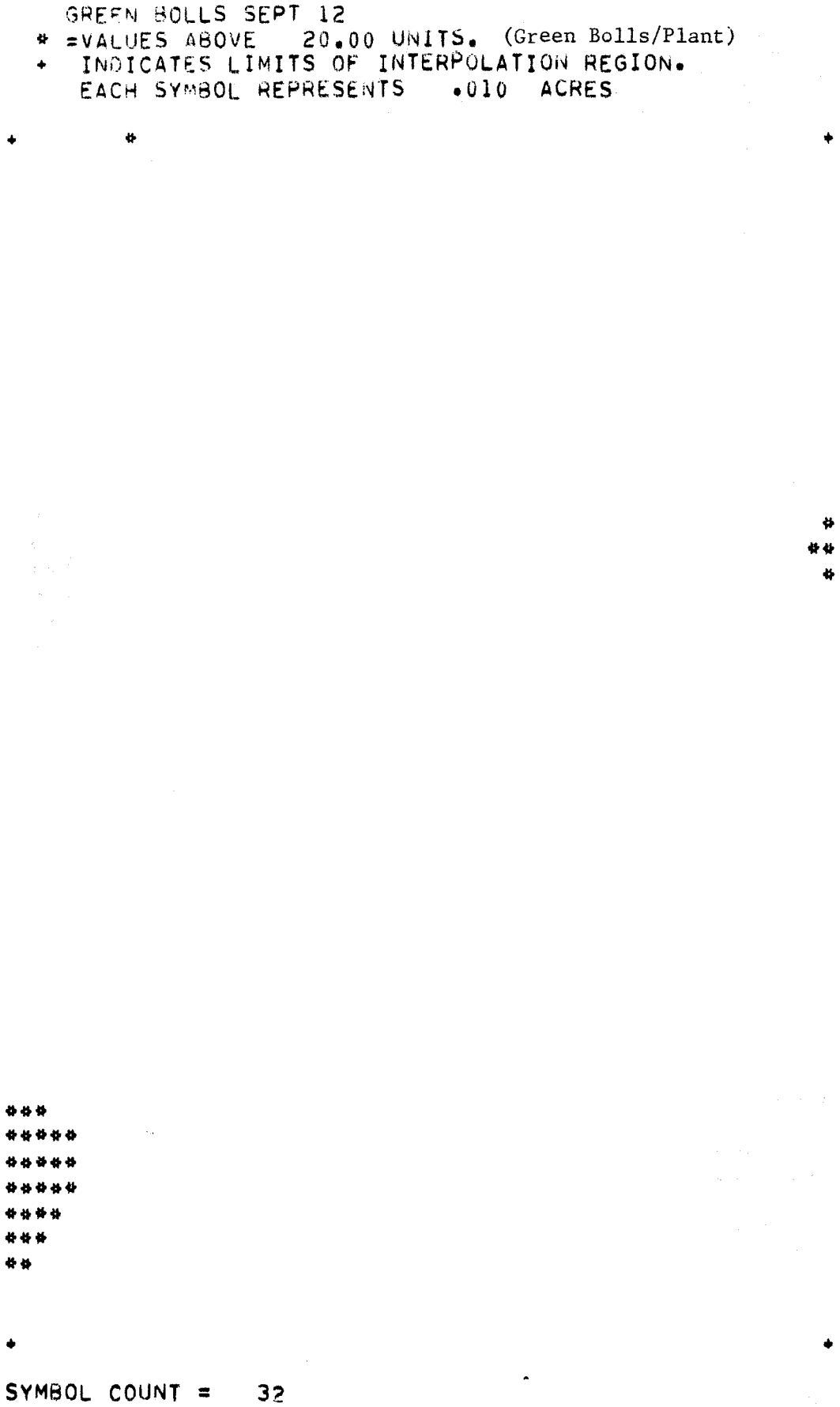
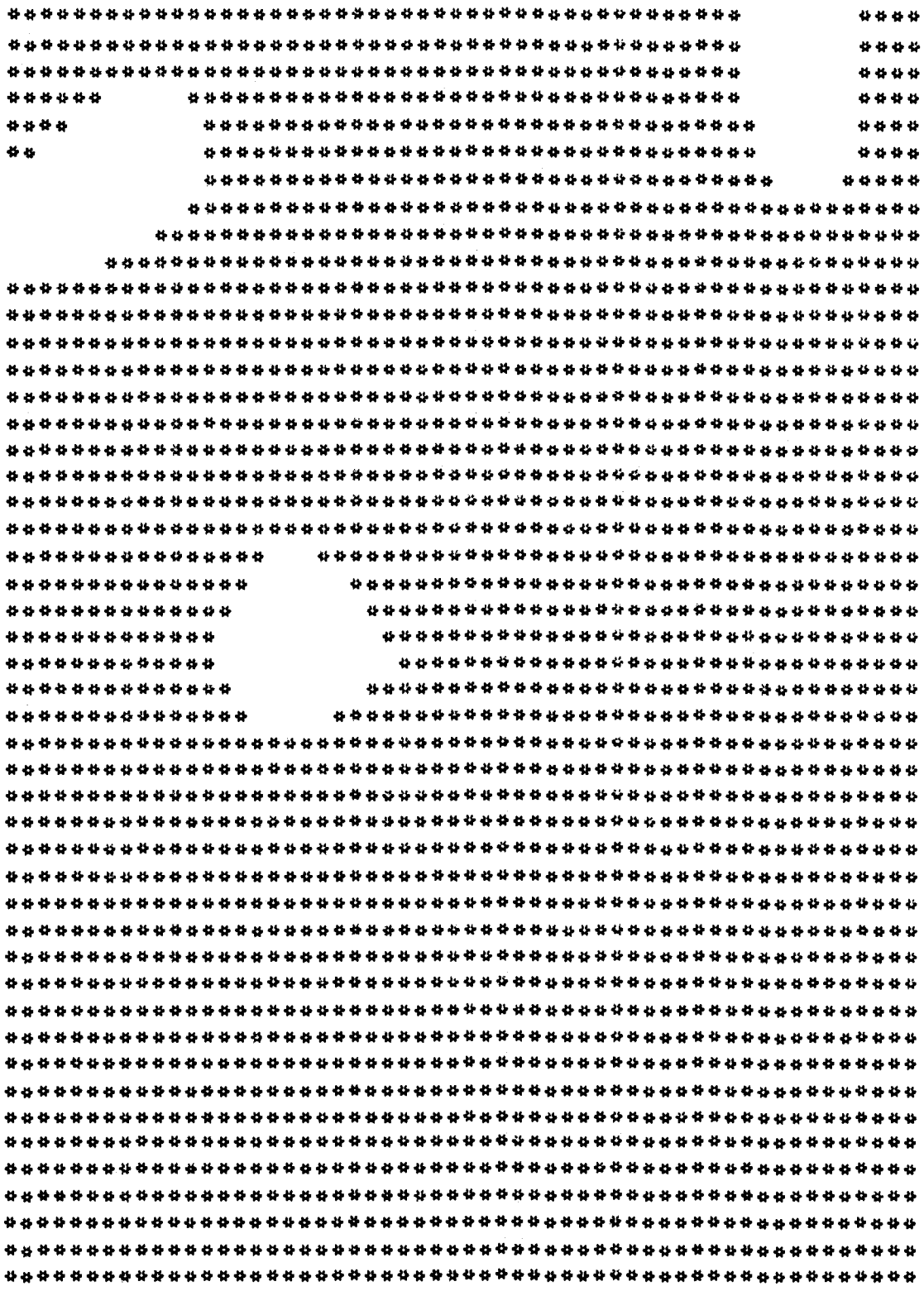

GREEN BOLLS SEPT 12
* =VALUES ABOVE 20.00 UNITS. (Green Bolls/Plant)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES
SYMBOL COUNT = 32

Figure 43

DRY BOLLS SEPT 12
* =VALUES ABOVE 4.00 UNITS. (Dry Bolls/Plant)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES



SYMBOL COUNT = 2532

Figure 44

DRY BOLLS SEPT 12
* =VALUES ABOVE 8.00 UNITS. (Dry Bolls/Plant)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES

SYMBOL COUNT = 1681

Figure 45

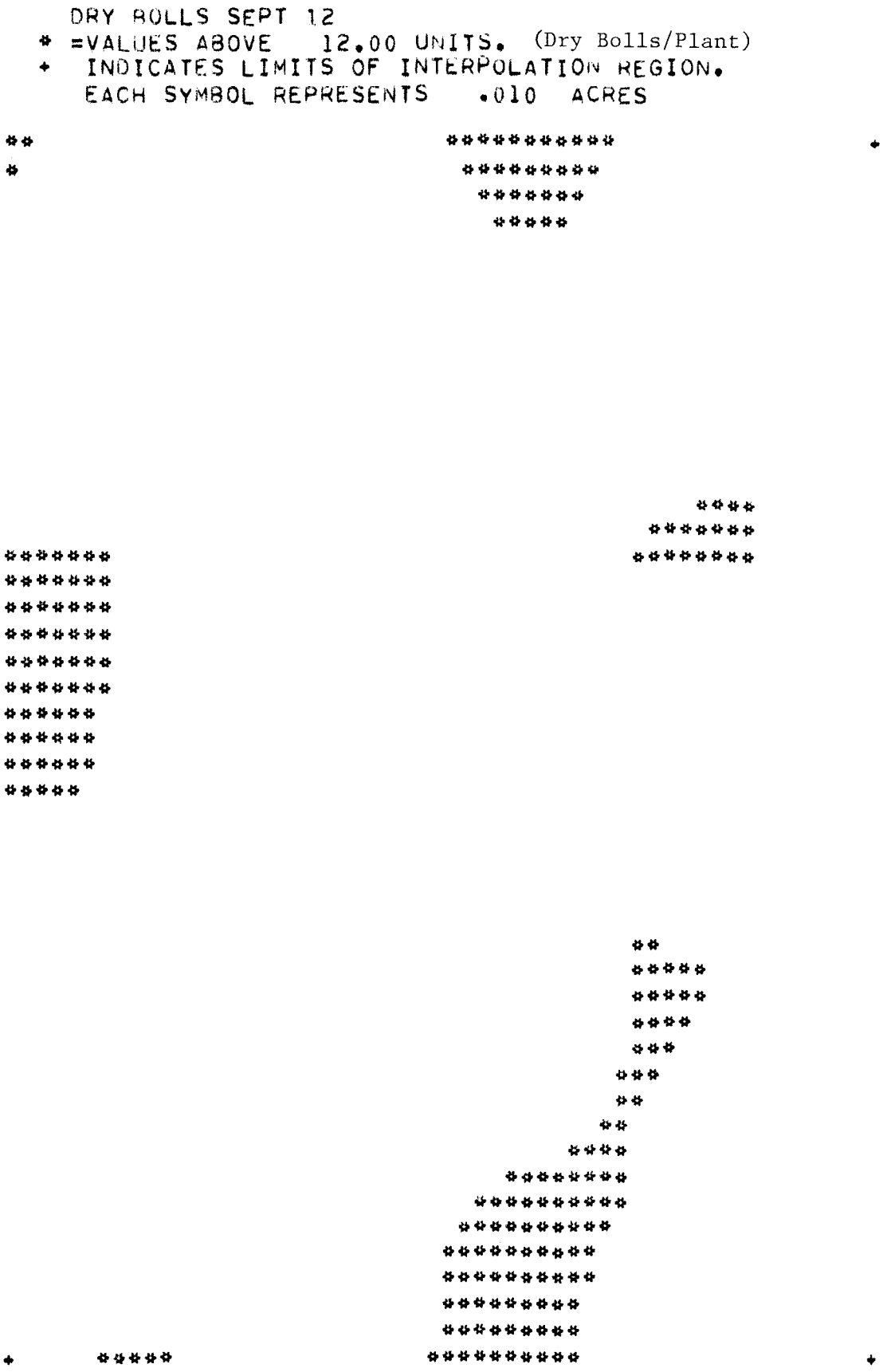
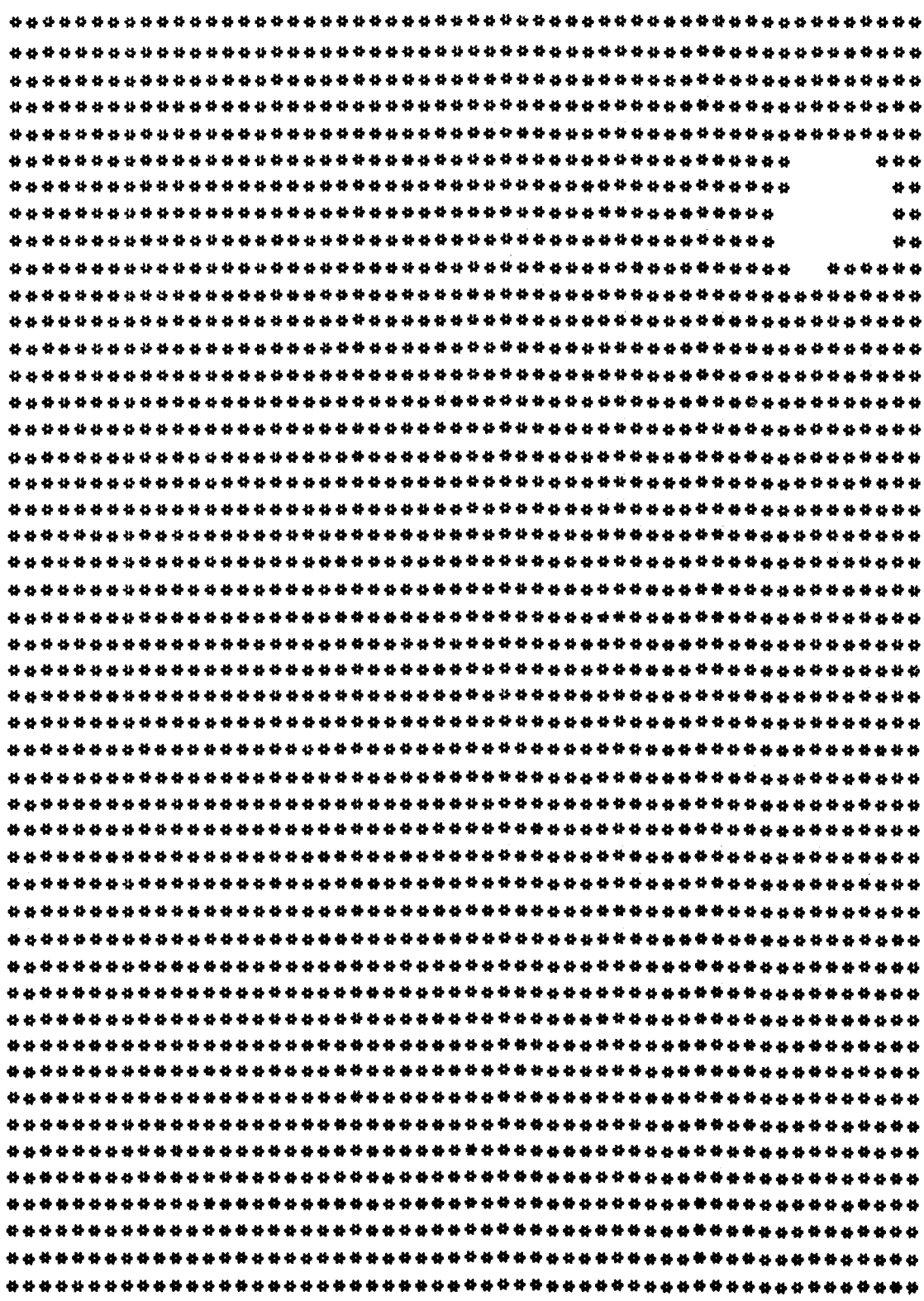

DRY BOLLS SEPT 12
* =VALUES ABOVE 12.00 UNITS. (Dry Bolls/Plant)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES
SYMBOL COUNT = 230

Figure 46

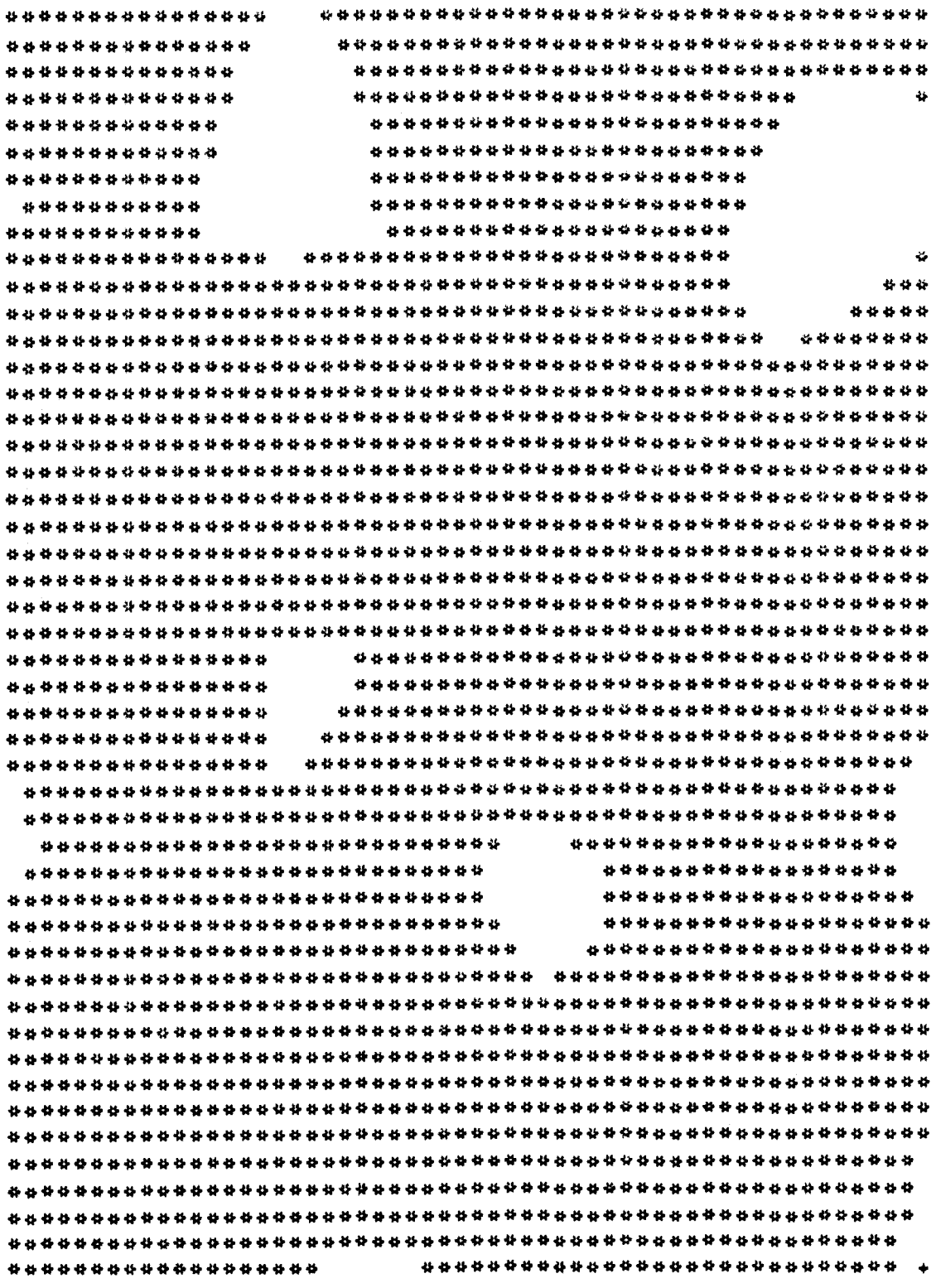
TOTAL BOLLS SEPT 12
* =VALUES ABOVE 8.00 UNITS. (Total Bolls/Plants)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES



SYMBOL COUNT = 2661

Figure 47

TOTAL BOLLS SEPT 12
* =VALUES ABOVE 12.00 UNITS. (Total Bolls/Plant)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES



SYMBOL COUNT = 2450

Figure 48


TOTAL BOLLS SEPT 12
* =VALUES ABOVE 16.00 UNITS. (Total Bolls/Plant)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES
SYMBOL COUNT = 1205

Figure 49

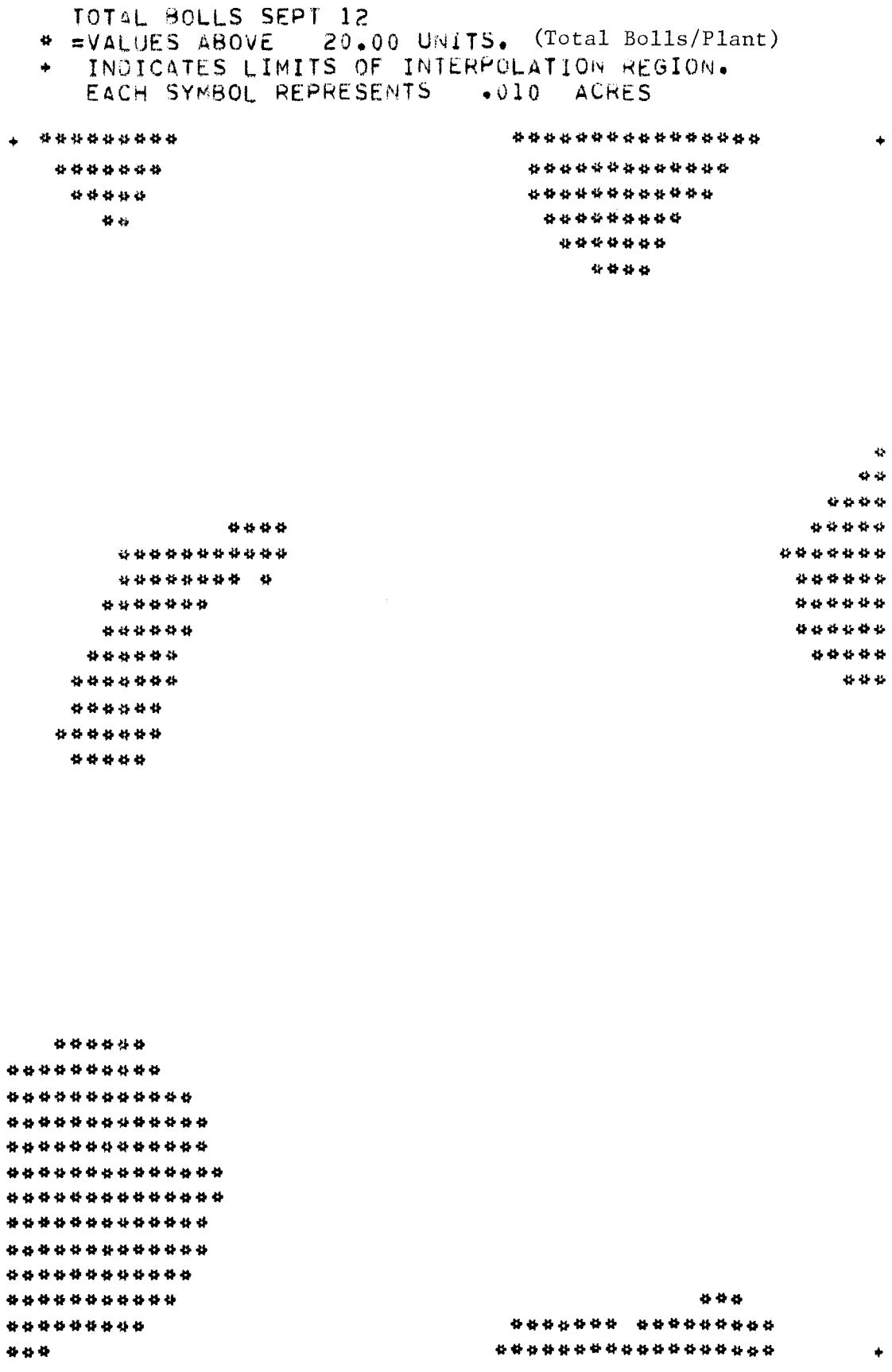
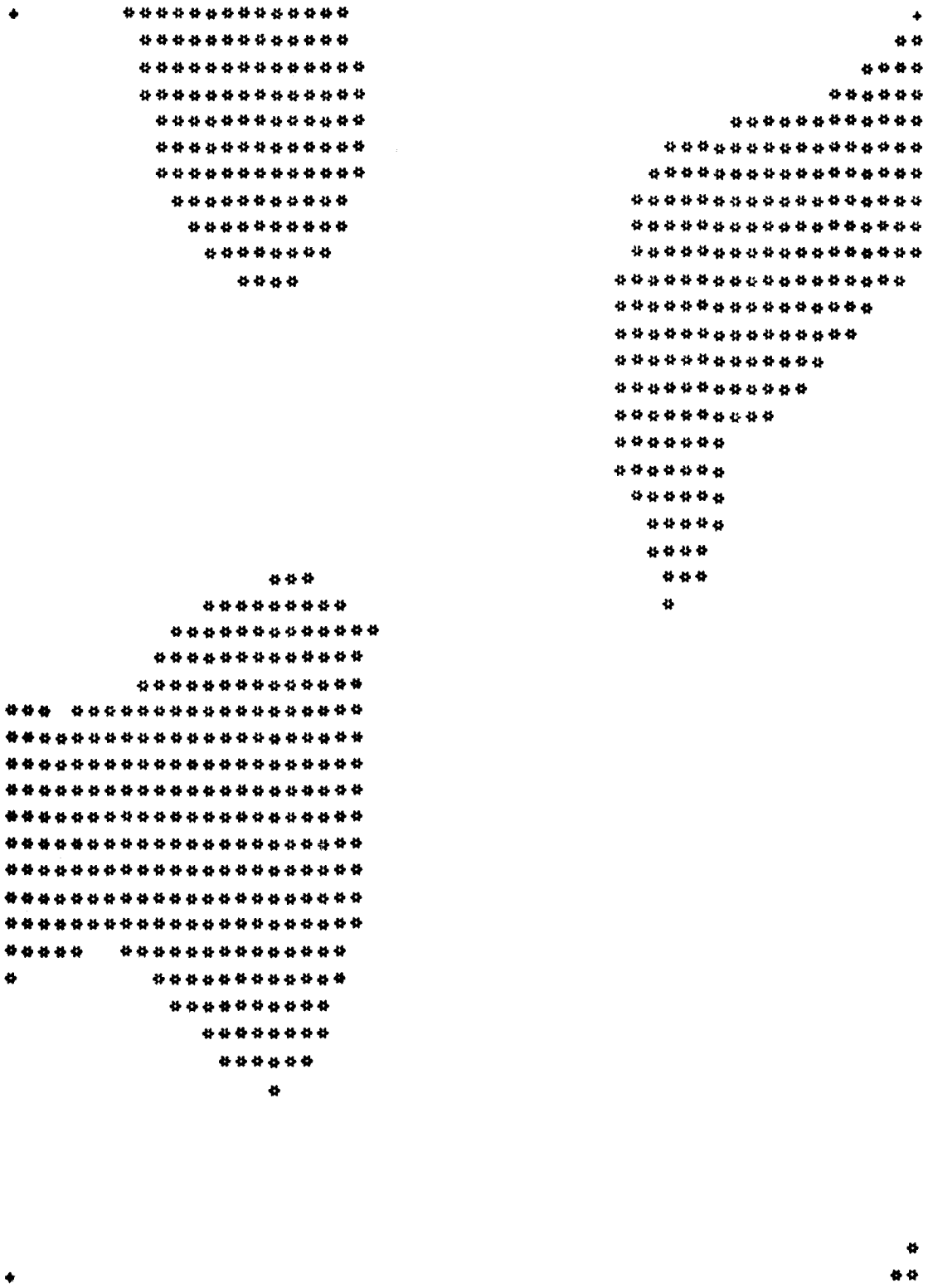

TOTAL BOLLS SEPT 12
* =VALUES ABOVE 20.00 UNITS. (Total Bolls/Plant)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES
SYMBOL COUNT = 377

Figure 50

(Total Bolls/Plant)

Figure 51

ROOTS (Nitrogen)
* =VALUES ABOVE .48 UNITS. (Percent Dry Weight)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS 0.010 ACRES



SYMBOL COUNT = 664

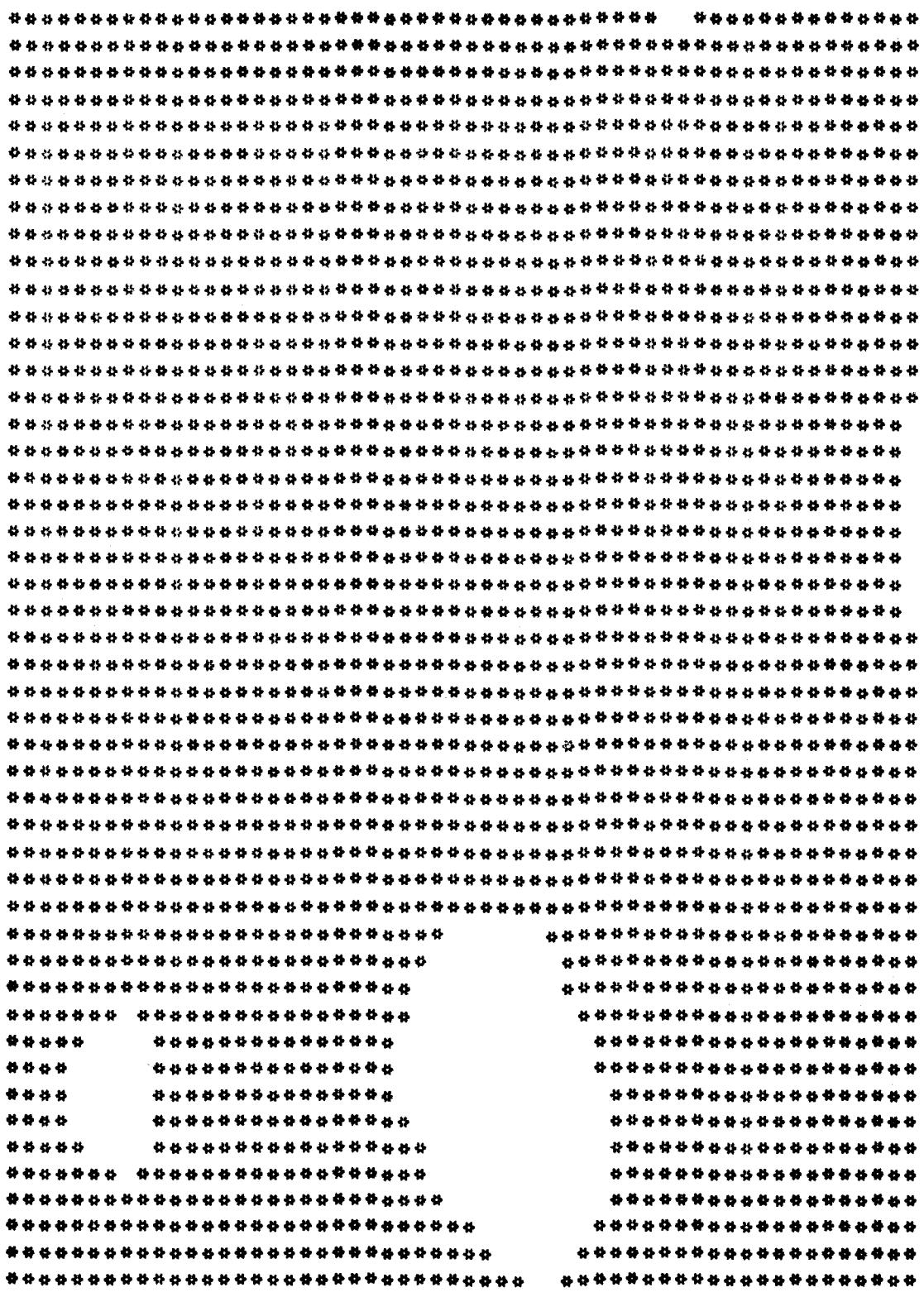
Figure 52

STEMS (Nitrogen)

* =VALUES ABOVE .55 UNITS. (Percent Dry Weight)

\+ INDICATES LIMITS OF INTERPOLATION REGION.

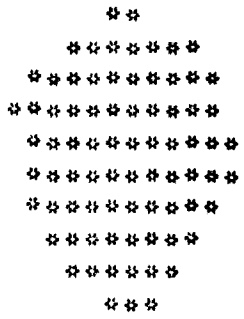
EACH SYMBOL REPRESENTS 0.010 ACRES

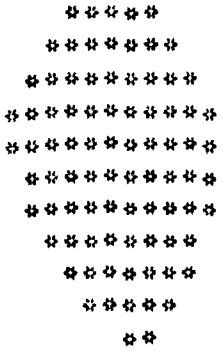


SYMBOL COUNT = 2525

Figure 53

STEMS (Nitrogen)
* = VALUES ABOVE .85 UNITS. (Percent Dry Weight)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS 0.010 ACRES

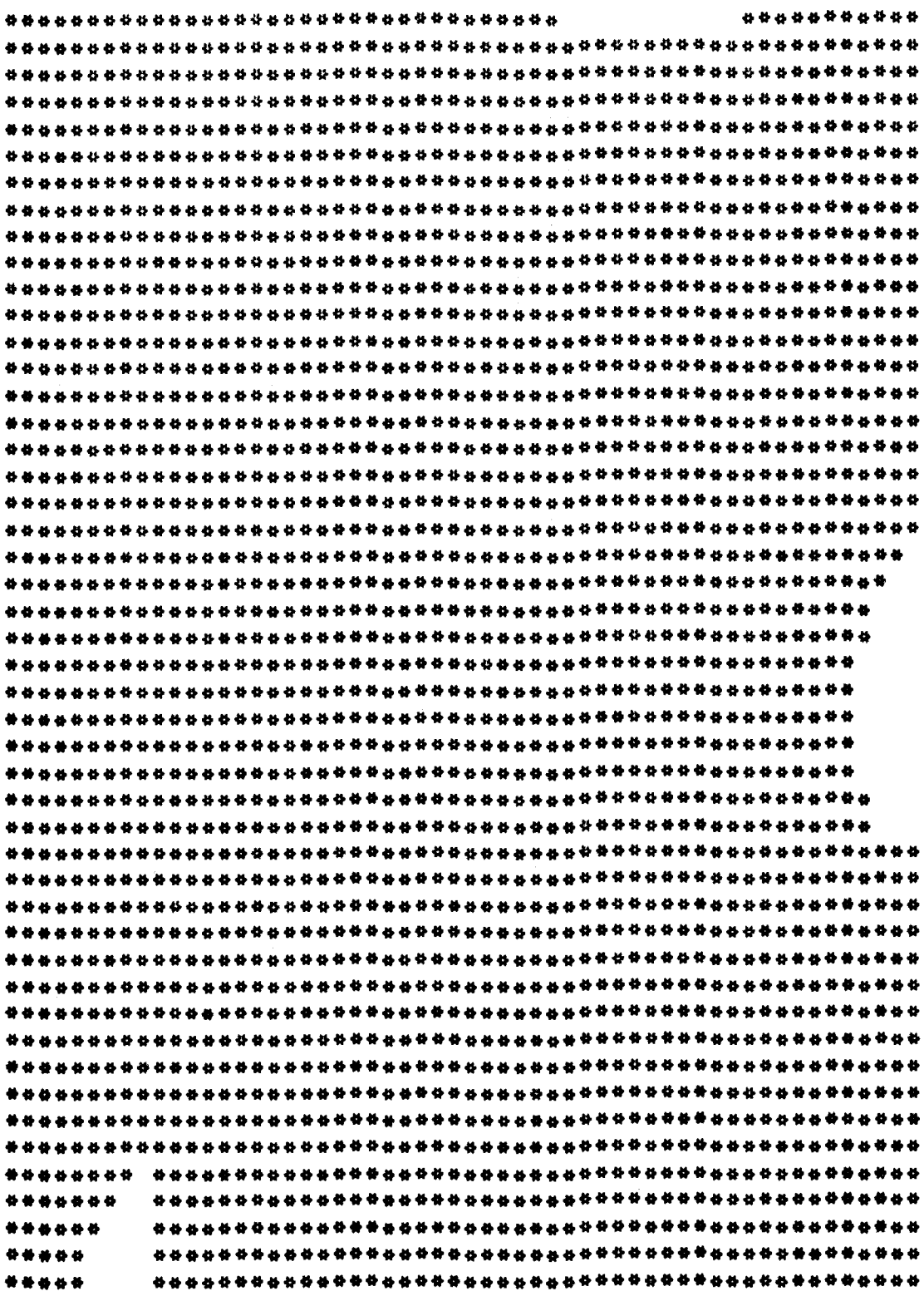




SYMBOL COUNT = 165

Figure 54

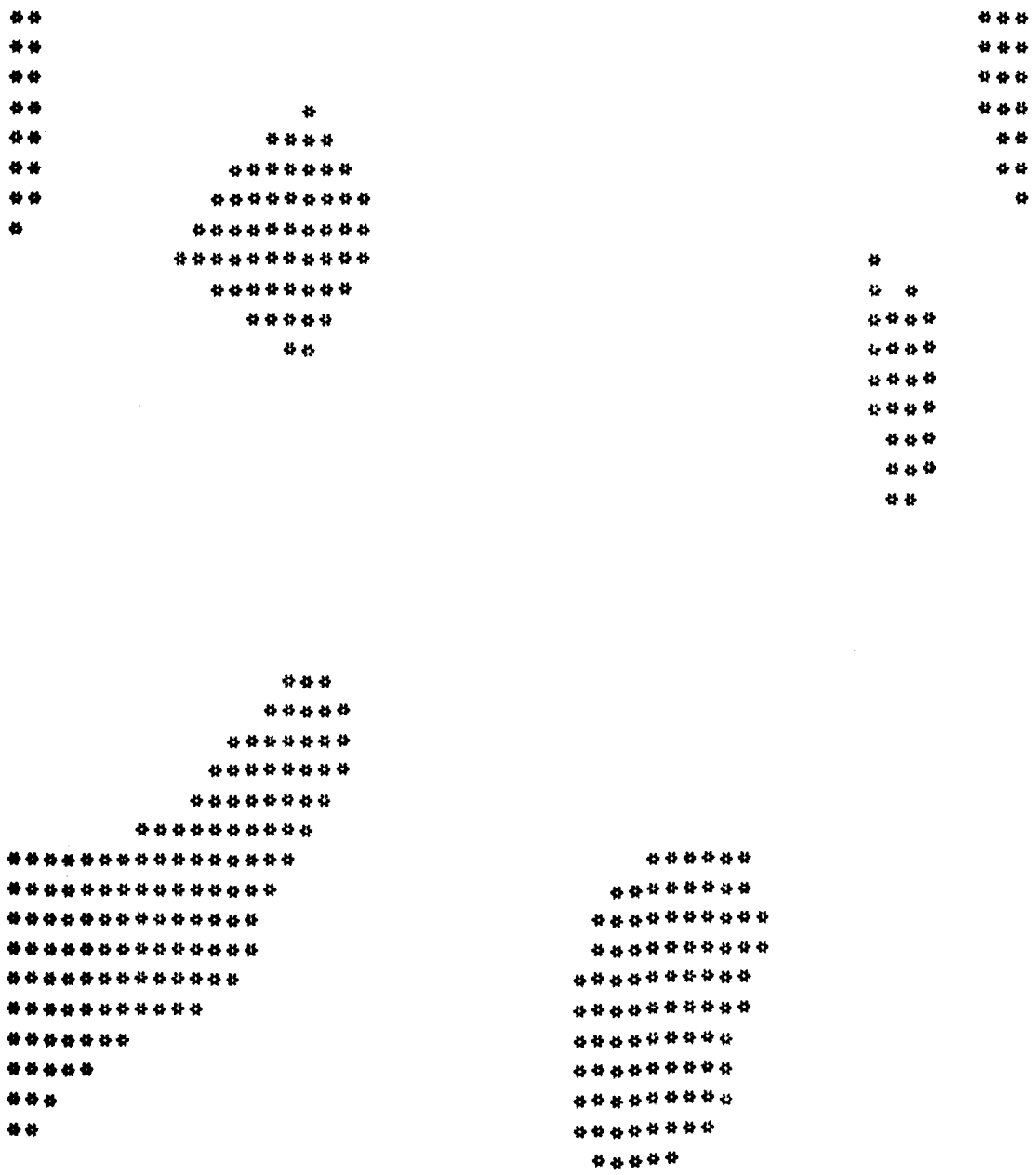
LEAVES (Nitrogen)
* =VALUES ABOVE 2.40 UNITS. (Percent Dry Weight)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS 0.010 ACRES



SYMBOL COUNT = 2628

Figure 55

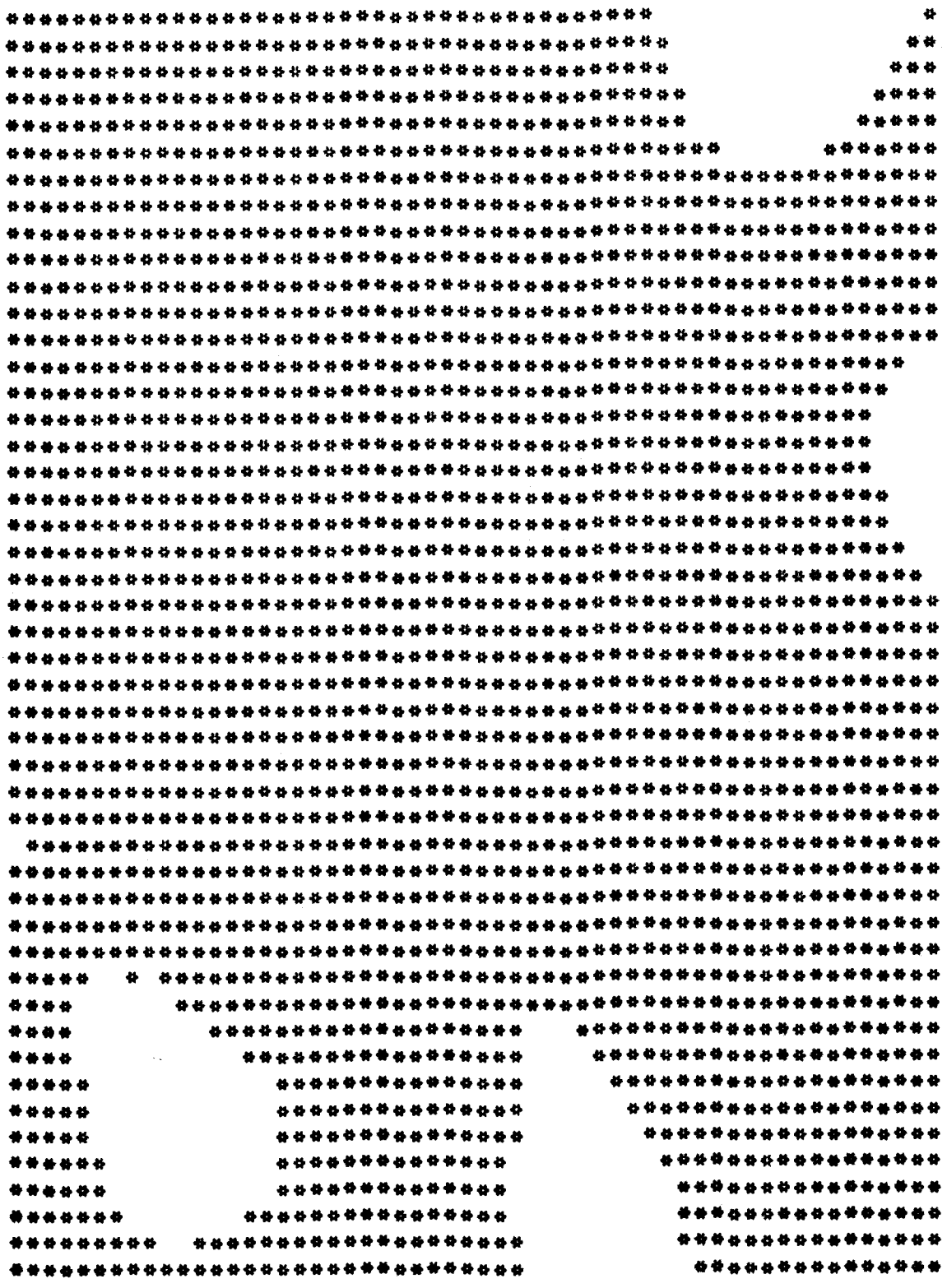
LEAVES (Nitrogen)
* =VALUES ABOVE 3.00 UNITS. (Percent Dry Weight)
• INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS 0.010 ACRES



SYMBOL COUNT = 353

Figure 56

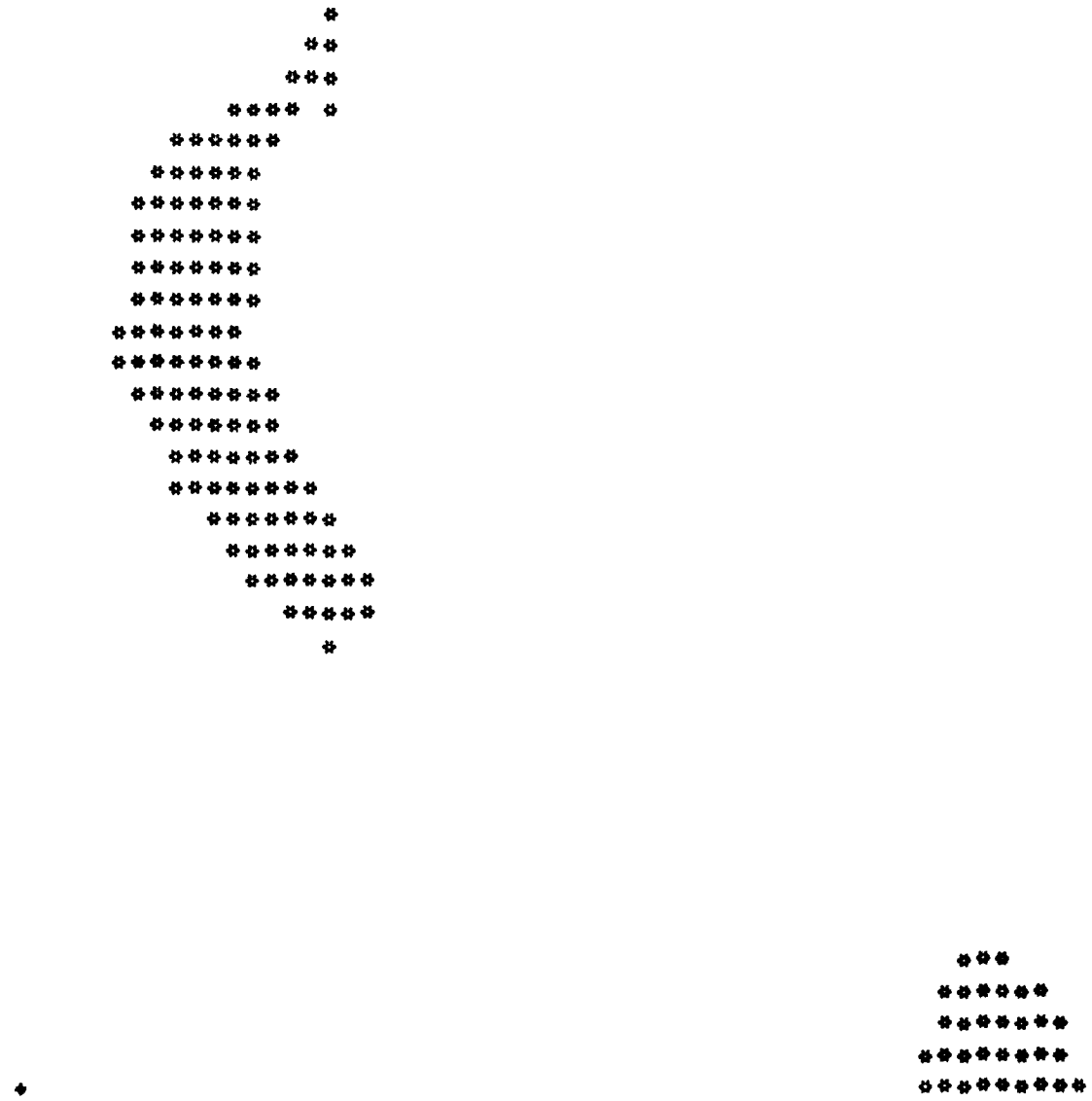
SQUARES (Nitrogen)
* =VALUES ABOVE 2.50 UNITS. (Percent Dry Weight)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS 0.010 ACRES



SYMBOL COUNT = 2429

Figure 57

SQUARES (Nitrogen)
* =VALUES ABOVE 3.10 UNITS. (Percent Dry Weight)
. INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS 0.010 ACRES



SYMBOL COUNT = 156

Figure 58

BOLLWORM DSQ +LL SEPT 12 (Damaged Squares & Bolls)
* =VALUES ABOVE 1.00 UNITS.(Damaged Squares & Bolls/Plant)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES

SYMBOL COUNT = 99

Figure 59

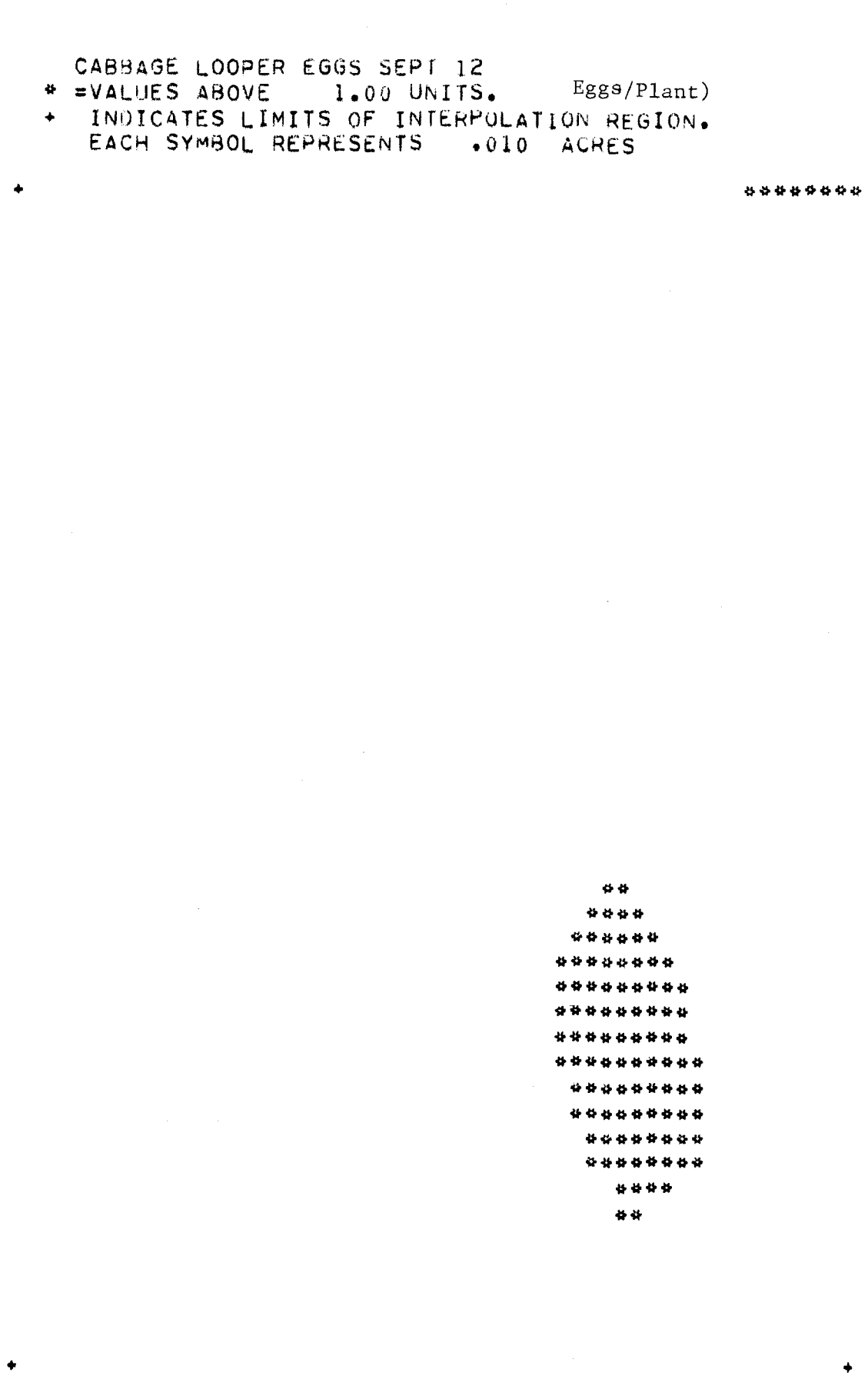
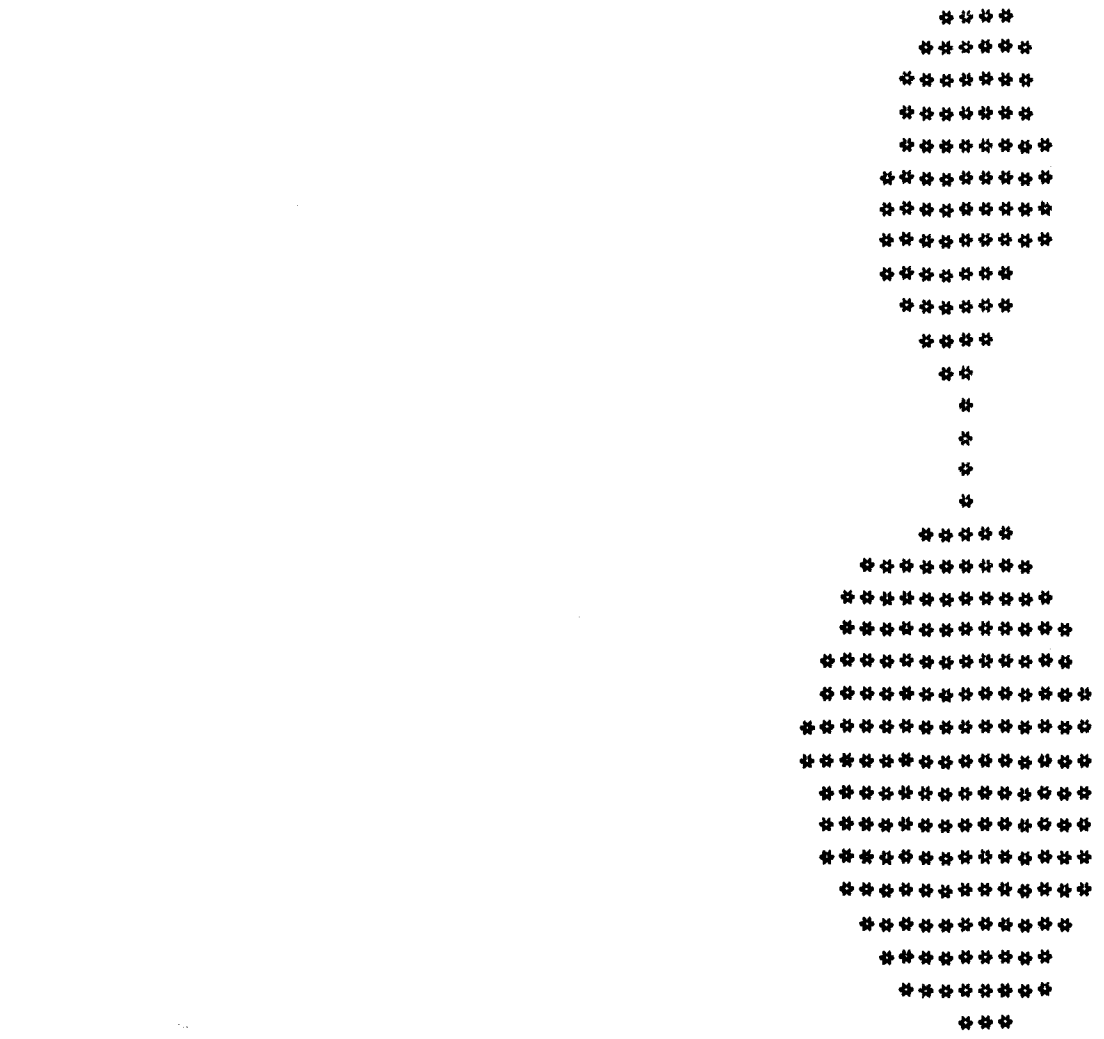

CABBAGE LOOPER EGGS SEPT 12
* =VALUES ABOVE 1.00 UNITS. Eggs/Plant)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES
SYMBOL COUNT = 105

Figure 60

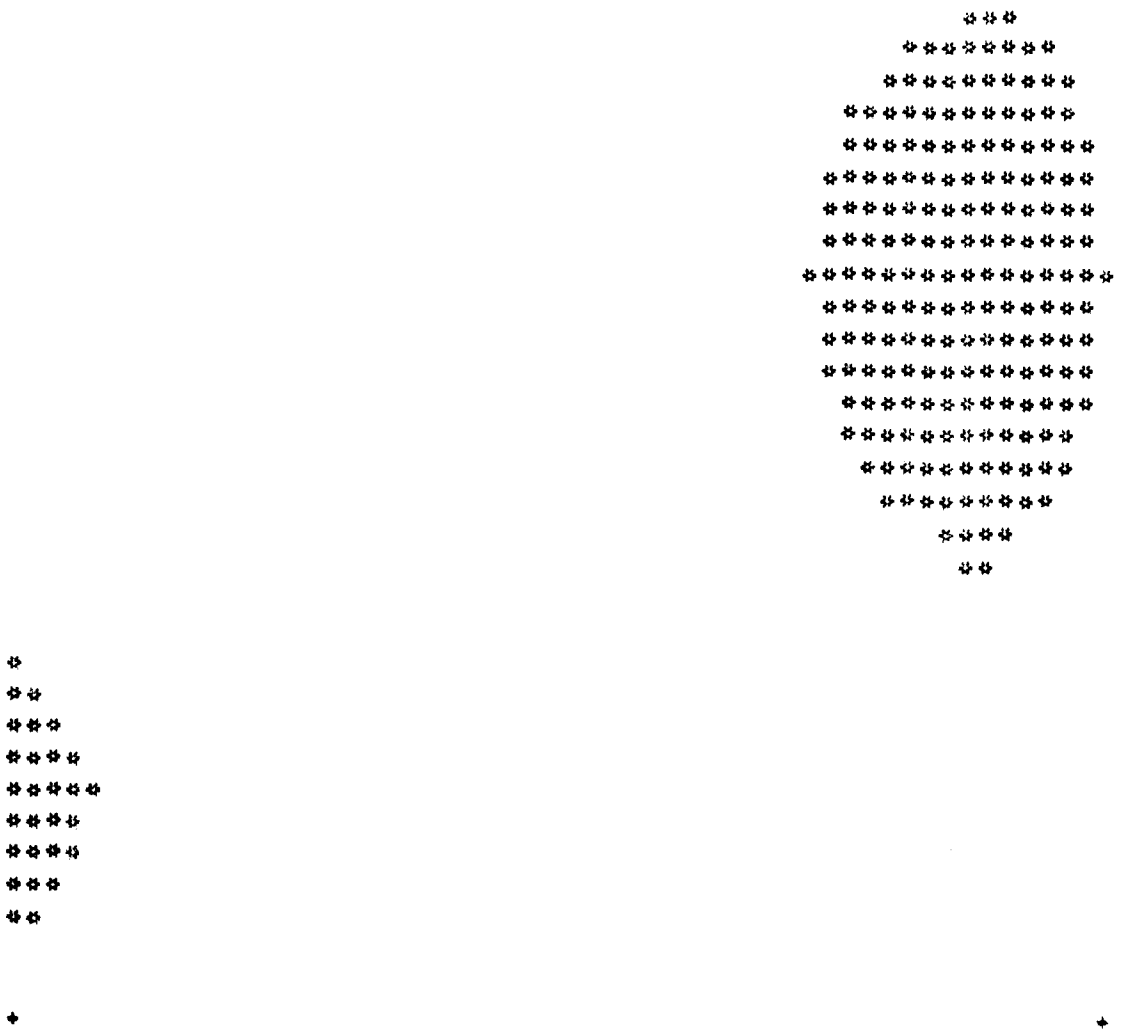
CABBAGE LOOPER LARVE SEPT 12
* =VALUES ABOVE 1.00 UNITS. (Larvae/Plants)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES



SYMBOL COUNT = 262

Figure 61

BA- LARVE SEPT 12 (Beet Army Worm)
* =VALUES ABOVE 1.00 UNITS. (Number/Plant)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES



SYMBOL COUNT = 225

Figure 62

CHRYSOPA EGGS SEPT 12

* =VALUES ABOVE 1.00 UNITS. (Eggs/Plant)

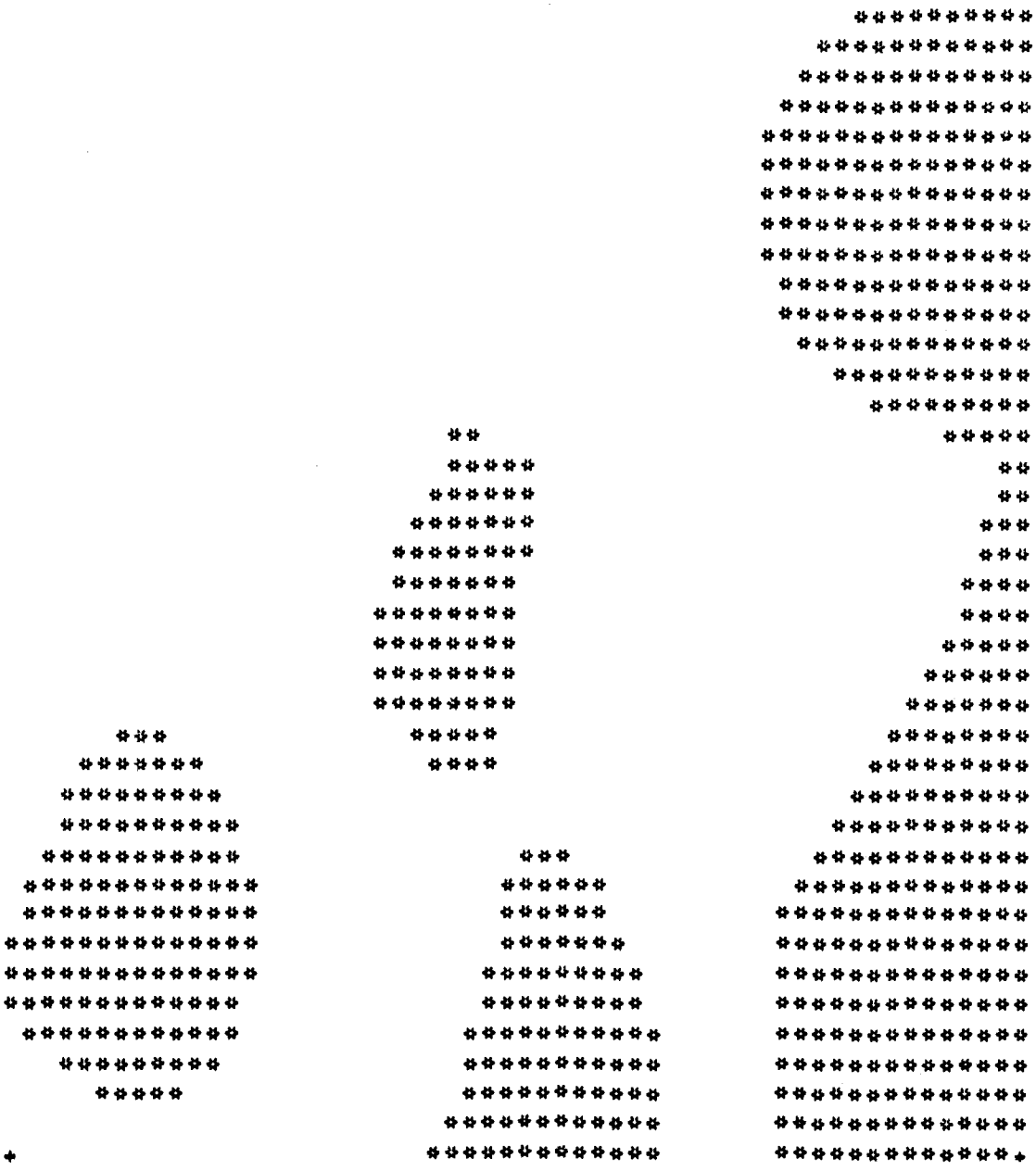
\+ INDICATES LIMITS OF INTERPOLATION REGION.

EACH SYMBOL REPRESENTS .010 ACRES

SYMBOL COUNT = 2416

Figure 63

CHRYSOPA EGGS SEPT 12
* =VALUES ABOVE 4.00 UNITS. (Eggs/Plant)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES



SYMBOL COUNT = 721

Figure 64


CHRYSOPA EGGS SEPT 12
*=VALUES ABOVE 8.00 UNITS. (Eggs/Plant)
+ INDICATES LIMITS OF INTERPOLATION REGION.
EACH SYMBOL REPRESENTS .010 ACRES
SYMBOL COUNT = 251

Figure 65