INFLUENCE OF BIOMETEOROLOGICAL FACTORS IN TOMATO TRANSPLANT PRODUCTION[1]

V. J. VALLI AND C. A. JAWORSKI[2]

INTRODUCTION

South Georgia and North Florida provide the major source of tomato transplants for the Northern U. S. and Southeastern Canada. Prediction of growth rates of tomato transplants are necessary in order to have plants of certified size (5) available at a time when weather conditions in the transplanting areas are favorable; transplants may be of certification size when cold weather still prevails in the areas or, conversely, too small when Northern growers are ready for transplanting.

The objective of this study was to determine which biometeorological measurement or combination of measurements might be the best predictor or predictors of the time intervals between seeding and first emergence, seeding and first harvest, and first emergence and first harvest.

REVIEW OF LITERATURE

The use of biometeorological measurements as predictors of morphological development (silking, flowering, fruiting, etc.) and growth rates (accumulation of dry matter) is more than 200 years old. The heat unit approach (in terms of accumulated daily mean temperatures above certain threshold values) has been used for studying plant growth. For example, it has been established that the threshold temperature for most English peas is 40° F. (4). Therefore, 40 is subtracted from the daily mean temperature each day and the differences are accumulated. Thus a day with a mean temperature of 52 minus the 40 threshold value would give 12 heat units or growing degree days. A mean temperature of 40° F. or less would give 0 growing degree days. In theory, once the requirements for optimum maturity of a given variety of peas has been established, it is only necessary to accumulate growing degree days above the threshold value to predict the harvest time. Such a heat unit system is utilized by the canning industry to schedule seeding dates for an orderly flow of crops to canneries during harvest season. These seeding dates are established from climatic normals from which accumulated heat unit normals have been derived. Additional uses have been made of heat unit accumulations for scheduling applications of hormone sprays at critical times in fruit trees, and also for application of various chemicals for control of plant pests. From their earliest use by Réamur (9) in 1735 through the work of Boswell with peas (4); and more recently by Baker and Brooks (2) with fruit; Barnard (3), Jaworski and Valli (6) with tomatoes; Lana and Haber (7) with sweet corn; and Mills (8) and Valli (10) with peanuts; units based on biometeorological measurements have been useful in predicting plant growth and development.

Mills (8) proposed a heat unit system, called effective heat units (EHU), based on the assumption that no perceptible growth takes place below a certain lower cardinal temperature; therefore, values below this temperature should be subtracted from the daily mean temperature. Since temperatures above certain optimum cardinal temperatures cause plant growth to stop, these values were also subtracted from the daily mean temperature.

Although the heat unit system is in widespread use throughout the world, certain recognized weaknesses exist in the system. Arnold (1) has shown that some researchers have used threshold temperatures which are too high. It is known that growth rates are not usually linear over large temperature ranges and, in addition, heat or energy requirements are not constant through the growth cycle. For instance, Went (12) reported that tomato plant growth occurs mostly at night and that optimum temperatures for young tomato plants were above 77° F. while with older plants it was below 68° F. Wang (11) in his critique of the heat unit approach summarized the disadvantages of the heat unit system by pointing out the chang-

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[2] Advisory Agricultural Meteorologist, Environmental Science Service Administration, Weather Bureau and Research Soil Scientist, Crops Research Division, Agricultural Research Service, U.S. Department of Agriculture, Tifton, Georgia.

ing plant response to the same temperatures during the life cycle of the plant.

MATERIALS AND METHODS

Biometeorological data were collected from 22 tomato transplant production fields of the Joseph Campbell Company Farms, Climax, Georgia, in 1964. Seeding dates ranged from February 13, 1964 to April 4, 1964. First harvest dates ranged from April 29, 1964, to May 22, 1964. From these data, computations were made of degree days with bases of 45, 50, 55, and 60° F.; and effective heat units (EHU) with lower cardinal temperatures of 45, 50, and 55° F.; and optimum cardinal temperatures of 75, 80, and 85° F. (6, 8, 10). Total incoming radiation in langleys (cal/cm^2) was also calculated, as well as the cross products of total radiation, degree days and EHU's. Accumulations of the various measurements were made from seeding to first emergence, from seeding to first harvest, and from first emergence to first harvest, to estimate total accumulations necessary to produce a marketable tomato transplant. Means, standard deviations and coefficients of variations were computed for each of the variables.

RESULTS AND DISCUSSION

For the period from seeding to first emergence, the coefficients of variation are quite large and none are satisfactory (Table 1). The lowest were for degree days with a threshold temperature of 45° F. and for this measurement times the daily langleys. The langley unit alone also had a coefficient of variation comparable to degree days with a threshold temperature of 45° F. The coefficient of variation increased for degree days as the threshold temperature values in-

Table 1. Accumulation of biometeorological factors for tomato transplants from seeding to first emergence.

Biometeorological factor	Mean	Standard deviation	Coefficient of variation
DD_{45}	154	64	41.3%
DD_{50}	101	50	49.8%
DD_{55}	57	38	66.0%
DD_{60}	24	23	95.3%
Langleys	4,907	2,331	47.5%
DD_{45} X Langleys	62,292	25,647	41.2%
DD_{50} X Langleys	40,113	20,547	51.22%
DD_{55} X Langleys	21,682	15,525	71.60%
DD_{60} X Langleys	8,275	9,309	112.5%

Table 2. Accumulation of biometeorological factors for tomato transplants from seeding to first harvest.

Biometeorological factor	Mean	Standard deviation	Coefficient of variation
1. Langleys	24,970	4,669	18.7%
2. DD_{45}	1,038	150	14.4%
3. DD_{50}	777	109	14.0%
4. DD_{55}	531	77	14.5%
5. DD_{60}	311	52	16.8%
6. EHU_{45-75}	908	149	16.4%
7. EHU_{45-80}	994	151	15.2%
8. EHU_{45-85}	1,038	154	14.8%
9. EHU_{50-75}	671	110	16.4%
10. EHU_{50-80}	779	112	14.4%
11. EHU_{50-85}	823	116	14.1%
12. EHU_{55-75}	449	75	16.8%
13. EHU_{55-80}	562	83	14.7%
14. EHU_{55-85}	606	87	14.3%
15. Langleys X Mean temperature	1,586,000	264,000	16.7%
16. Langleys X DD_{45}	464,800	73,000	15.7%
17. Langleys X DD_{50}	347,200	58,600	16.9%
18. Langleys X DD_{55}	238,400	47,700	19.2%
19. Langleys X EHU_{45-80}	443,400	66,800	15.1%
20. Langleys X EHU_{50-80}	349,900	51,200	14.6%
21. Langleys X EHU_{55-80}	253,200	37,600	14.8%

Table 3. Accumulation of biometeorological factors for tomato transplants from emergence to first harvest.

Biometeorological factor	Mean	Standard deviation	Coefficient of variation
1. Langleys	20,580	3,890	18.9%
2. DD_{45}	888	138	15.5%
3. DD_{50}	673	101	14.9%
4. DD_{55}	468	70	15.0%
5. DD_{60}	280	47	16.7%
6. EHU_{45-75}	756	133	17.6%
7. EHU_{45-80}	839	136	16.2%
8. EHU_{45-85}	883	139	15.7%
9. EHU_{50-75}	558	100	17.9%
10. EHU_{50-80}	661	105	15.8%
11. EHU_{50-85}	705	107	15.2%
12. EHU_{55-75}	370	69	18.6%
13. EHU_{55-80}	474	76	16.1%
14. EHU_{55-85}	518	79	15.3%
15. Langleys X Daily Mean temperature	1,335,000	231,000	17.3%
16. Langleys X DD_{45}	409,800	67,500	16.5%
17. Langleys X DD_{50}	310,800	53,500	17.2%
18. Langleys X DD_{55}	217,300	41,400	19.0%
19. Langleys X EHU_{45-80}	384,900	61,600	16.0%
20. Langleys X EHU_{50-80}	305,400	47,500	15.6%
21. Langleys X EHU_{55-80}	220,300	34,500	15.7%

creased. This could be due to the increase in the number of zeros as the base temperature increased so that the inferences are based on fewer observations. The original data indicate that emergence occurred quicker during the last half of March than with earlier seeding under colder temperatures, or with later seeding under higher temperatures. These data suggest that factors other than temperature are exercising considerable control over germination time.

The period of seeding through first harvest degree days with a threshold temperature of 50° F. had the lowest coefficient of variation, 14.0%, although all of the accumulated temperatures or langleys had coefficients which were acceptable (Table 2). On the basis of coefficients of variation there is little reason to select one variable over the others as the best indicator of the time interval between seeding and first harvest. The data indicate a reduction from 82 to 39 days from the early to late seedings for this period. Using a threshold value of 50° F., an accumulation of 777 degree days were necessary from seeding to first harvest to produce a marketable transplant.

The coeffiicients of variation probably could be reduced by using a prescribed transplant height in lieu of first harvest. A marketable tomato transplant may range between 5 and 10 inches high and therefore first harvest could include transplants within this range (5).

For the period from first emergence to first harvest, all of the accumulated temperatures or langleys had acceptable coefficients of variation (Table 3). With a threshold of 50° F., an accumulation of 673 degree days were necessary from first emergence to first harvest to produce a marketable transplant.

SUMMARY AND CONCLUSIONS

Biometeorological data were collected from 22 tomato transplant fields during the 1964 season, to determine which measurement of accumulated heat units or langleys was the best predictor of the time intervals from seeding to first emergence, from seeding to first harvest, and from first emergence to first harvest. None of the accumulated temperatures or energy units had acceptable coefficients of variation from seeding to first emergence. The data suggest that factors other than temperature exercise considerable control over germination time of tomato seeds. For the periods from seeding through first harvest, and from first emergence to first harvest, all measures of accumulated temperatures and langleys had acceptable coefficients of variation. There is little reason to select one measurement over another as a predictor of the time intervals. Ease of computation and availability of data would, however, point toward degree days with a threshold temperature of 50° F. With this value, accumulations of 777 degree days would be necessary to produce a marketable tomato transplant from seeding to first harvest.

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