THE FLOWERING BEHAVIOR OF THE HOLLYHOCK (*ALTHEA ROSEA* CAV.)

ROBERT STRATTON
Oklahoma A. and M. College

For many years, I have kept a record of the date of first flowering of many species of local plants. For a few species, I have observed the number of days a flower remains open. It was such a study regarding the Hollyhock that led to the data presented in this paper.

Two different plants were observed until one was broken off by a windstorm. These plants developed from volunteer seed that happened to be scattered in my back yard. Both plants were located about ten feet west by south from a white maple tree. Plant *X* was shaded by a house until nine or ten a. m. Plant *Y* located about two feet farther from the tree received a little more light each day. This plant was broken off by a storm when it had completed about one-third of its total flowering period.

When this study was begun, May 24, 1938, plant *X* had already opened its first flower. Following this, observations for the two plants were made and results recorded about 8 o'clock a. m. each day throughout their flowering period. It will be observed from the photograph and the chart that the lower nodes of the Hollyhock plants have three flowers each (sometimes four) varying to one for the top nodes. Also it will be noted that the flowers open in an ascending order, one flower opening (rarely two) at a node on the same day. About one week later, the second flower of that node will open, followed by the third flower a week or more later. This produces a series of open flowers one following another.

After a flower remains open for a time, the corolla closes over the monadelphous stamens by a spiral twist (convolute) and finally falls carrying the enclosed stamens with it. Flowers with corollas which are partly eaten by grasshoppers fail to close in this manner and fall off. They simply shrivel up on the plant.

When the fruit of the plant began to mature as evidenced by the browning of the calyx, new flower-buds failed to form and growth in length of stem ceased. Later the one-seeded carpels turned brown, spread apart, and fell away separately. The conservation of the available food for seed maturation was evidenced by the failure of some flower-buds on the branches to open. They aborted and fell off. The eighth flowering node had a branch on which nodes 1, 2, and 7 produced flower-buds that opened while those of 3, 4, 5, and 6 aborted. Only one flower-bud of this branch matured fruit. The table shows the observations made in reference to the maturing of the fruit. The figures under the heading "Node Rank" refer to the number of the node to which the browning of the calyx, etc. has proceeded up the stem.

Plant *X* varied in height from 6 feet 9 inches on May 27, 1938 just following the opening of the first flower to 8 feet 10 inches on June 30. The last flower bud (No. 50) had already formed and growth in height had ceased. Plant *Y* was about 6.5 feet high on June 27 and almost 9 feet high when broken off by a storm during the night of June 9-10.

On July 11, an estimate of the number of seed produced by Plant *X* was made. The lower fruits on branches produced 35 or 36 seed per

Table Showing the Order of Maturing of the Three Fruits at each Node

	No. of Fruit	Node Rank (See text)												
First Browning of Calyx	1	1	13		25	36	21							
	2				5	14	7							
	3													
First Mature Seed	1			1		32		35	37	39	39	40	41	45
	2					4	15	21	24	24	26	29	29	34
	3						5	7	7	8	10	12	13	21
Carpels Separating	1			1		26								
Date of Observation		June 18	20	23	24	30	July 1	2	3	4	5	6	7	11

fruit; the upper 43. Those of the main stem 42 for the lower fruits; 41 or 42 for the upper, making an average of 40 seed per fruit. There were 92 fruits on the branches, 116 on the main stem making a total of 208 fruits with 40 seed each or 8320 seed for the plant.

Honey bees were the chief pollinating agents.

Discussion:

According to Garner (1) plants may be of the long-day type, or of the short-day type or a combination of the two types. He states that the long-day type has a preflowering vegetative period limited chiefly to a leaf-rosette stage succeeded by a rapid elongation of the axis followed by flowering. Exposure to a day-length below that which he calls the critical tends to limit growth to a leaf-rosette stage; while that in excess of the critical results in the elongation of the axis, followed promptly by flowering.

In what he calls the short-day type, elongation is a prominent feature of the early stages of growth and under some conditions the axis may continue to elongate for a prolonged period without flowering. Exposure to a day-length in excess of the critical gives elongation without flowering while that below the critical quickly initiates the reproductive activity.

Plants showing a combination of the two would have two critical periods. With day-lengths below the lower critical period they would have the leaf-rosette form; between critical periods they would bear flowers; and with day-length in excess of upper critical period, they would show stem elongation without flowers. From this, the Hollyhock must belong to the long-day type, since it has a leaf-rosette stage through the winter followed by stem elongation and later the flowering stage. Garner also states that since the length-of-day factor is essentially constant from year to year while the seasonal temperature varies, under ordinary circumstances temperature may be regarded as more commonly responsible for variations in plant growth and development from year to year, particularly with respect to time of flowering.

According to Maclagan, climatic factors operate by influencing the metabolic functions of the plant. Any factor stimulating growth, retards flowering. Hence, the date of first flowering is the first marked indication of the onset of the reproductive phase. He believes that temperature exerts its maximum effect at the moment of gamete formation. Using the

term "weather belt" for the weather obtaining over a period of time from one to three months, he recognises three main significant weather belts; namely, the Distal belt, occurring in autumn after that year's flowers have fallen; the Proximal belt, occurring in the spring or early summer, nearer in time to date of flowering; and the Immediate belt just at or about flowering time. He believes low temperatures during one or more of these weather-belt periods retard flowering, while higher temperatures at these periods expedite earlier flowering. My experience leads me to believe that favorable or unfavorable moisture supply at the above periods also expedites or retards respectively the first flowering time.

The length of light-day increased from 14 hr. and 16 min. May 24 to 14 hr. and 39 min. June 20 and 21, and decreased to 14 hr. 29 min. July 10. From June 15 to 19 the light-day was 14 hr. 38 min. which was within one minute of the longest light-day. Since the first browning of the calyx was observed June 18, followed by mature seed June 23, it might be inferred by some that the length of light-day caused the quick maturations of seed.

The minimum temperature varied from 49°F to 76°; maximum from 73° to 100°. Both plants began flowering when the minimum temperature was near 60° and the maximum above 70° F. If temperature may have brought about the maturing of the fruit, then it would appear that a minimum above 70° and a maximum above 90°F. would be required for this.

Conclusions:

Since these observations are based upon a single experiment, it would be presumptuous for me to draw definite conclusions. However, the following observations and suggestions may prove to be of some value.

1. After the calyx began to open and thus expose the purple corolla, the corolla opened within less than a day to two days depending upon the degree of cloudiness. The flowers opened more slowly in cloudy weather. Likewise the shedding of the corolla was delayed by cloudy weather.
2. Generally more flowers opened on a bright day following a cloudy one.
3. The flowers remained open longer in clear weather than in cloudy or rainy weather; hence, it appears that time of pollination may have had little to do with the closing of the flower. Being pollinated largely by bees, pollination would be less likely in rainy weather.
4. Flowers with corollas which were partly eaten by grasshoppers failed to close and fall off—simply withering upon the plant.
5. Some nodes flowered earlier than the node immediately below them. This earlier flowering was usually more pronounced for flowers two and three from such nodes. This may have been due to the accumulation of growth substances at these nodes in larger amounts than at the other lower node.
6. Since the Hollyhock did not begin flowering until the light-day was over 14 hours long, it may be regarded as a long-day plant.
7. Since growth continued until the first fruit began to mature, the food factor rather than temperature, or length of light-day may have been the limiting factor in growth of the Hollyhock.

Explanation of Chart:

The day of the month is shown along the horizintal line. The flowering nodes are indicated along the lower part of the perpendicular line, and the temperature along its upper portion. So far as could be determined for plant X, the first flowering node was the 25th node of the plant. Six branches arose below the twenty-fifth node, but no record was kept of their flowering dates.

The weather conditions are shown by squares at the top. The position of the marking in the squares indicates whether the weather condition occurred in the forenoon or the afternoon. The solid horizontal lines on the curves indicate open flowers. The broken lines on the left indicate that the purple petals were visible while the broken lines to the right indicate a closed corolla before it fell off. A plus sign indicates flowers which were plucked off by some person. Other conditions shown are explained on chart.

Literature Cited:

Garner, W. W., Photoperiodic responses. Plant Physiol. 8:347-356. 1933.

Maclagan, J. F. A. Date of flowering as affected by climatic temperature. Plant Physiol. 8:395-423. 1933.