

day, for air-mass ranges 1.3 to 4; 4 to 12; and 1.3 to 20 air-masses, respectively. All six solar constant values thus found fall between 1.90 and 1.95 calories. The smallest air masses, as it happens, yield slightly the highest values. We conclude that our previous results have not been made too small by neglecting to observe during the time when the sun is within 15° of the horizon.

On July 11, 1914, in coöperation with the United States Weather Bureau, a recording pyrheliometer attached to sounding balloons was sent up to the altitude of about 24 km., where the barometric pressure was 3 cm. of mercury, which is only one twenty-fifth of that which prevails at sea level.

Good records of solar radiation were obtained over a period of more than an hour, and including the period when the instrument reached highest elevation. The mean value of the best three records made at highest altitudes, as reduced to mean solar distance, comes out 1.84 calories per cm.^2 per minute. We believe about 2% should be added to represent radiation scattered and absorbed in the atmosphere above the level reached, making for the probable value of the solar constant, from this day's work, 1.88 calories. This value falls decidedly within the range of solar constant values we have observed. We state in connection with it the following results which are the highest reliable direct observations of solar radiation at the various altitudes, as reduced to mean solar distance and vertical sun:

| Station | Washington | Mount Wilson | Mount Whitney | Manned Balloon | Free Balloon |
|----------------|------------|-----------------|------------------|-------------------|-----------------|
| Altitude..... | 127 m. | 1730 m. | 4420 m. | 7500 m. | 24000 m. |
| Barometer..... | 75 cm. | 62 cm. | 45 cm. | 30 cm. | 3 cm. |
| Radiation..... | 1.58 | 1.64 | 1.72 | 1.755 | 1.84 cal. |
| Observer..... | Kimball | Abbot | Abbot | A. Peppler | (Smithsonian) |

VARIATION OF FLOWER SIZE IN NICOTIANA

By T. H. Goodspeed and R. E. Clausen

DEPARTMENT OF BOTANY, UNIVERSITY OF CALIFORNIA

Presented to the Academy, April 28, 1915

During the past five years considerable attention has been given to the study of the inheritance of flower-size in *Nicotiana* at the University of California Botanical Gardens. In the course of these investigations it has been found that flower size varies markedly under different conditions attending development. This report is concerned with an analysis of some of these conditions, and the bearing of such variations on the study of flower-size inheritance in *Nicotiana*.

The conclusions drawn in this paper are based on some 25,000 measurements taken on the following pure lines and hybrids of *Nicotiana*:

1. *N. Tabacum* var. *macrophylla*¹ in the growing season 1913. This *N. Tabacum* variety has been grown at the University of California Botanical Gardens for six years in the pure line, under the garden number 22/07.

2. The F₁ hybrid, *N. Tabacum* var. *macrophylla* × *N. sylvestris*,² which will be referred to as F₁H₃₈. Flowers of this hybrid were measured on plants from the first sowing of the hybrid seed in 1912, on the same plants cut back and coming up from the roots in 1913, and on a second sowing of the same hybrid seed in 1913.

3. F₁H₁₃₇, the reciprocal of the above cross, flowers of which were measured in 1913.

4. The F₁ hybrid produced by crossing the F₁ of the hybrid *N. Tabacum* var. Maryland × *N. Tabacum* var. Cavala with *N. sylvestris*, the garden number of which is H₄₄. As with H₃₈, flowers of this hybrid were first measured in 1912, and again on the same plants cut back and coming up from the roots in 1913. In addition cuttings of these plants were made and measurements taken on them.

From the data on these and other populations it has been found possible to determine a number of factors which influence flower size in *Nicotiana*. For convenience these are treated under various rather arbitrarily selected headings. Under the 'age of plant' heading are included not only a consideration of the difference in the size of flowers borne early in the season as compared with those borne late in the season on the same plants, but also a consideration of the difference in the size of flowers the first blooming season of the plant compared with the size of the flowers produced the second year on the same plants cut back and coming up from the roots. Under the 'age of flower' heading are included first, a consideration of the difference in the size of flowers borne on the terminal inflorescences just going out of flower and those borne at the same time on laterals and second, the influence of age on the individual flower; i.e., comparisons of measurements of flower fully opened, before and after shedding pollen. Other factors such as the influence of the removal of flowers and developing seed capsules, the behavior of cuttings under various conditions, and the influence of soil fertility have likewise furnished data upon this variability of flower size under conditions attending development.

When plants first come into flower the spread and length of corolla are greater than the spread and length of flowers produced on the same plants later in the growing season. Thus the mean spread of corolla

of 75 plants of *N. Tabacum* var. *macrophylla* at the beginning of the blooming period was 28.49 ± 0.09 mm. and the length 45.60 ± 0.07 mm. Measurements of flowers taken on an average one month later gave a mean corolla spread for the same plants of 24.19 ± 0.22 mm. and for length 42.25 ± 0.15 mm. For the same plants means derived by grouping together the measurements of 25 of these plants early in the season, 25 in the middle of the period, and the remaining 25 toward the end of the period of measurement gave for spread 26.69 ± 0.20 mm. and for length 43.96 ± 0.18 mm., which figures lie very close to the means for all the plants for the entire season which are 26.83 ± 0.09 mm. and 44.27 ± 0.07 mm. respectively.

The latter arrangement brings up a practical matter of considerable importance in connection with genetic investigations of flower size in *Nicotiana*. In this case although the means were practically identical for the two arrangements, the coefficient of variability where each third of the plants was measured at a different time was $9.77 \pm 0.54\%$, whereas that based on the distribution of means for all the plants for the entire season was less than half as great, $4.45 \pm 0.24\%$. For length the corresponding coefficients of variability, $5.18 \pm 0.29\%$ and $2.13 \pm 0.12\%$ respectively, show a closely proportionate correspondence in this respect. This higher variability is exactly what would be obtained if a large F_2 population were measured progressively, that is beginning at one end of the field and working through until the last plant had been measured. Such a method of measurement used in comparing large F_2 populations with relatively small parent and F_1 populations might very easily lead to erroneous conclusions on the critical point of the experiment, namely the extent of increase of variability in F_2 .

In the case of the semi-sterile hybrids of *N. Tabacum* varieties with *N. sylvestris* another factor enters in, namely the lack of seed production and the consequent prolonged blooming period. There is, therefore, not so sudden a decrease in corolla size as in the case of *N. Tabacum* var. *macrophylla*; but nevertheless a marked decrease occurs rather later in the blooming season. In the case of spread of flowers of F_1H_{137} there was a decrease during the period from August 9 to September 19 from 38.33 ± 0.11 mm. to 31.67 ± 0.26 mm. For length the decrease was less striking, from 56.22 ± 0.09 mm. to 53.44 ± 0.28 mm. Similarly in 13 (11) F_1H_{38} there was a decrease in corolla spread from August 4 to November 7 from 39.10 ± 0.31 mm. to 33.10 ± 0.22 mm., and in length from 57.10 ± 0.22 mm. to 52.60 ± 0.29 mm. Flowers of $13F_1H_{38}$, genetically the same but a different population blooming the second

year on their own roots, were measured at the beginning of the flowering season during the period from May 21 to June 20. During this time the flower size did not decrease as is shown by comparing the mean spread on the first dates of 38.81 ± 0.31 mm. with 40.05 ± 0.35 mm., the mean spread for the last dates, and in the case of length of corolla, 55.19 ± 0.15 mm. and 53.81 ± 0.24 mm., a slight decrease. On Plant 6, however, flowers were measured again on July 31. It was found that a mean spread of 43.41 mm. based on measurements of all the flowers on June 16 had decreased to 37.38 mm. based on measurements of all the flowers on July 31. H_{44} , which was measured during this same period, similarly shows only a slight decrease in flower size, but in every case where flowers were measured on the later date a striking decrease in size was obtained. We have taken the results of similar determinations and condensed them in the following table in which not only the means and their probable errors are given, but also the differences between measurements of different dates and the probable errors of these differences. These differences are to be regarded as significant in case they exceed two and a half or three times the corresponding probable error. In each case the constant for spread is given on the first line, that for length on the second.

Influence of Age of Plant on Flower Size. Measures in Millimeters

| GARDEN NUMBER | MEANS FOR DATES | | | DIFFERENCES BETWEEN DATES | | |
|--------------------------------------|-----------------|--------------|--------------|---------------------------|--------------|----------------|
| | First | Mid | Last | First and Mid | Mid and Last | First and Last |
| 13F ₁ H ₄₄ | 38.53 ± 0.38 | 40.16 ± 0.44 | 39.32 ± 0.64 | -1.63 ± 0.58 | 0.84 ± 0.77 | -0.79 ± 0.74 |
| | 54.05 ± 0.26 | 54.53 ± 0.28 | 52.84 ± 0.49 | -0.48 ± 0.39 | 1.69 ± 0.57 | 1.21 ± 0.56 |
| 13F ₁ H ₃₈ | 38.81 ± 0.31 | 39.05 ± 0.40 | 40.05 ± 0.35 | -0.24 ± 0.51 | -1.00 ± 0.53 | -1.24 ± 0.47 |
| | 55.19 ± 0.15 | 55.43 ± 0.15 | 53.81 ± 0.24 | -0.24 ± 0.21 | 1.62 ± 0.28 | 1.38 ± 0.28 |
| 13(11)F ₁ H ₃₈ | 39.10 ± 0.31 | 36.10 ± 0.43 | 33.10 ± 0.22 | 3.00 ± 0.53 | 3.00 ± 0.49 | 6.00 ± 0.38 |
| | 57.10 ± 0.22 | 54.10 ± 0.29 | 52.60 ± 0.29 | 3.00 ± 0.37 | 1.50 ± 0.41 | 4.50 ± 0.37 |
| 13F ₁ H ₁₃₇ | 38.83 ± 0.11 | 36.67 ± 0.44 | 31.67 ± 0.26 | 1.66 ± 0.45 | 5.00 ± 0.51 | 6.66 ± 0.28 |
| | 56.22 ± 0.09 | 55.00 ± 0.18 | 53.44 ± 0.28 | 1.22 ± 0.21 | 1.56 ± 0.34 | 2.78 ± 0.30 |
| 13 22/07 | 28.48 ± 0.09 | | 24.19 ± 0.22 | | | 4.29 ± 0.24 |
| | 45.60 ± 0.07 | | 42.25 ± 0.15 | | | 3.35 ± 0.17 |

With respect to the influence of removal of flowers on corolla size, the measurements show a striking correspondence between the size of corolla and the presence of developing seed capsules on the plant. By removing all flowers from the plant as fast as they go by it is possible to keep up the flower size to nearly that of the first flowers produced, and in some cases to double the life of the plant. A case in point is that of two plants of the *N. Tabacum* var. *macrophylla* series. On Plant 14 only the flowers measured were removed, while on Plant 15 all flowers

too old to be measured and all developing seed capsules were removed twice a week. In a month the spread of corolla for Plant 14 decreased 5.78 mm. and for Plant 15 only 0.75 mm. At the end of two months the decrease amounted to 5.40 mm. for Plant 14 and 2.29 mm. for Plant 15. The length behaved similarly in this case, in Plant 14 there was a decrease of 4.55 mm. and in Plant 15 of 0.25 mm.; and at the end of two months, a decrease of 4.00 mm. in Plant 14 and 0.79 mm. in Plant 15.

During the period which elapses from the time a flower is fully opened to the time at which pollen is shed, there is a considerable increase in corolla spread and associated with it little or no increase in corolla length. On ten plants of F_1H_{188} , the increase in spread amounted on an average to 4.53 ± 0.23 mm. and for length there was an increase of 1.62 ± 0.22 mm. Similarly the spread of corolla for F_1H_{187} averaged 3.18 ± 0.17 mm. greater for flowers after shedding pollen, but in this case the length was 0.47 ± 0.11 mm. smaller, a slight discrepancy undoubtedly due to the indirect method of comparison made, which still further emphasizes the increase in spread of corolla during this period. This increase in spread has, also, been repeatedly confirmed on individual marked flowers.

That there is a differential distribution of flowers on tobacco plants according to size at any given time is shown by the comparative measurements of flowers borne among developing seed capsules on the terminal inflorescence of a plant and those borne on laterals of the same plants. In the case of plants of *N. Tabacum* var. *macrophylla* the flowers borne on laterals were found to have an average spread greater by 2.56 ± 0.16 mm. than those of the terminal inflorescence, and in the case of length, 1.24 ± 0.11 mm. greater. In the hybrids studied the difference is rather more marked, so much so that there is a distinctly noticeable difference in size between these two classes of flowers.

Similarly we have found that numerous other factors have a like influence on flower size, some relatively great and others less marked. For instance cuttings of F_1H_{44} growing in the greenhouse produced flowers 3.95 mm. smaller in spread and 1.42 mm. greater in length than those on the field plants from which the cuttings were taken. Pure line populations of *N. sylvestris* grown in a shaded situation on rich moist garden soil produced distinctly larger flowers than plants growing on higher unfertilized soil and not shaded, and pot experiments likewise showed that flower size could be distinctly influenced by applications of sodium nitrate, and in a direction parallel to that of the influence on vegetative characters.

The conclusion seems irresistible that flower-size in *Nicotiana* is not

so constant as it has been assumed to be, but that it is affected by a number of conditions, and that at least some of these may not affect length and spread in the same manner. Attention has been called to these facts because they have not been given adequate consideration in genetic research on the behavior of flower size in *Nicotiana* and other genera.

The experiments reported upon above have, in part, been made possible by an allotment from that portion of the Adams Fund of the United States Department of Agriculture granted to the Agricultural Experiment Station of the University of California.

¹ Setchell, Studies in *Nicotiana*, I, Univ. of Cal. Pub. Bot., 5, 8, 1912.

² Ibid., p. 29.

RETENTION IN THE CIRCULATION OF DEXTROSE IN NORMAL AND DEPANCREATIZED ANIMALS, AND THE EFFECT OF AN INTRAVENOUS INJECTION OF AN EMULSION OF PANCREAS UPON THIS RETENTION

By I. S. Kleiner and S. J. Meltzer

DEPARTMENT OF PHYSIOLOGY AND PHARMACOLOGY, ROCKEFELLER INSTITUTE
FOR MEDICAL RESEARCH

Read before the Academy, April 19, 1915. Received, April 29, 1915

The content of dextrose in the circulating blood of normal animals is almost constant, it amounts to about 0.1 percent. The carbohydrates of the foodstuffs form the main source of dextrose in the body. On their way from the digestive tract the carbohydrates are transformed into various forms of saccharides; but all are finally converted largely into glycogen, which is stored up mostly in the liver. The blood obtains its supply of dextrose from the glycogen of the liver, and distributes it among the tissues of the body according to their demand for it. In the normal animal none of the dextrose escapes through the kidneys. Accordingly the constancy of the amount of dextrose in the blood is regulated by a mechanism which controls either of the two factors; the *supply* of or the *demand* for it.

In diabetes the dextrose content of the blood is higher than normal, is variable in amount, and, when it is sufficiently high, dextrose escapes through the kidneys. The cause of the increase of the blood dextrose, or hyperglycaemia, may be found either in a decrease in the demand of the tissues for dextrose, that is, the tissues burn dextrose less readily than in normal conditions; or in an increase in the supply, that is, the liver supplies the blood with more dextrose than in normal conditions.