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PYRETHRUM INVESTIGATIONS IN COLORADO

By C. B. GNADINGER, L. E. EVANS and C. S. CORL

I. PRELIMINARY REPORT ON FACTORS AFFECTING PYRETHRIN CONTENT

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PYRETHRUM INVESTIGATIONS IN COLORADO

I. PRELIMINARY REPORT ON FACTORS AFFECTING PYRETHRIN CONTENT.

BY C. B. GNADINGER, L. E. EVANS AND C. S. CORL*

The production of pyrethrum flowers for the manufacture of insecticides is carried on principally in Japan and Yugoslavia. At the present time Japan supplies about 90 percent of the pyrethrum used in the United States, the remainder coming from Yugoslavia. The government of Yugoslavia has recently undertaken a complete reorganization of the pyrethrum industry in an attempt to increase that country's share of the business.

The United States is the world's largest consumer of pyrethrum, hence the advantages of developing a source of supply within this country are too obvious to require discussion. The idea of cultivating pyrethrum in the United States is not a new one, having been first proposed about 1859. So far, however, attempts to grow pyrethrum in this country on a large scale have proved unsatisfactory.

The isolation and identification of the active principles of pyrethrum by Staudinger and Ruzicka (4) in 1924 and the development of quantitative method for determining the pyrethrins, by Tattersfield (6) and by Gnadinger and Corl (1) in 1929, made possible for the first time the scientific study of the effect of different cultural methods and climatic conditions on the pyrethrin content of the flowers.

The possibilities of pyrethum as a commercial crop for Colorado were first recognized by Dr. E. P. Sandsten, Director of the Colorado Experiment Station, to whose initiative the present investigation is primarily due.

The climatic and soil conditions of Colorado are suitable for the production of pyrethrum flowers. The normally dry air conditions and the use of irrigation water to supplement rainfall in growing the crop are especially favorable. The fact that irrigation can be given at any time to produce a vigorous growth is also favorable to satisfactory production.

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The climatic conditions in the producing areas of Japan and Yugoslavia are comparable with those in the higher altitude sections of Colorado. The agricultural districts of this state range in elevation from 3400 to 9000 feet, with a growing season varying from 90 days to 170 days in length.

Chrysanthemum cinerariaefolium has been grown in the experimental plots at Fort Collins, Colorado, since 1929. The plants have withstood low temperatures without winter protection and very little loss has resulted. These plants were exposed to a sub-zero temperature period of 10 days in which a minimum of -39°C. was recorded. The average length of the growing season at Fort Collins is 120 days. The elevation is 5000 feet above sea level. It is generally observed in this district that

Fig 1.—Section of experimental plots at Fort Collins, Colorado.

winter injury is due to a drying out of the plant rather than to extremely low temperatures. The results of these plantings indicate the possibility of growing the crop on a commercial basis. More extensive plantings are under way to furnish definite information on costs and yields under general field conditions. This is necessary before pyrethrum can be brought into commercial production. The loss from crown and root rots has not been high enough to be seriously considered as a factor in production.

Plans have been made on a conservative basis in order to permit the selection of a higher-yielding commercial strain, and at the same time to obtain more complete and extensive information on growing and handling the crop on a commercial basis.

The chemical methods for assaying small samples for pyrethrin content make it possible for the plant breeder to select and develop pure-line strains of higher-pyrethrin-yielding plants. This is accomplished by the analysis of flowers picked from individual plants, and makes possible the elimination of low pyrethrin yielders and the selection of high yielders for seed production. By careful breeding methods it may be possible to develop a strain of pyrethrum that will yield double the percentage of pyrethrins found in present commercial strains. There has been no plant character that could be used as an index to indicate a high or low pyrethrin content. This has prevented any noticeable improvement in the pyrethrin content of seed stocks over a period of years, as can be shown by a comparison of the pyrethrin content of flowers produced during 1928 with those produced in 1932.

This paper is a presentation of results of preliminary investigations of factors affecting the pyrethrin content of *C. cinerariaefolium,* which have a direct bearing on methods of experimentally and commercially growing the crop. In order to proceed as quickly as possible and with a minimum of unnecessary and unproductive work, various projects were outlined and conducted during 1931 and 1932. The first problem was to develop methods of handling the experimental samples so that there was as little loss as possible in the pyrethrin content between the date samples were collected and the time they were chemically analyzed.

This report gives the results secured to date in a study of the effect on pyrethrin content of drying methods, seasonal variation, of shading, handling of flowers, and storage treatment of dried flowers. The results of a comparative study are also presented, showing the variation that occurs in botanical characters and the yield of pyrethrins by individual plants. The work on pyrethrum flowers in Colorado is being planned to extend over a period of years and progress reports will be released from time to time on the results secured in various phases of the investigation.

Standardized Methods and Materials for All Projects

Thruout these investigations, 250 4-year-old plants of *C. cinerariaefolium* were used. They were grown from the same

seed source and the same seed stock. Cultural practices were uniformly the same.

The stage at which the pyrethrum flowers were picked was the same in all phases of the various projects reported hereafter. This stage was standardized on the basis of the results secured by the investigations of Gnadinger and Corl (2) in 1930. Their work showed that pyrethrum flowers picked in the fully open stage contained 18 to 61 percent more of the active principles than those picked at an earlier stage. Tattersfield (5) in 1931, also reported results indicating a quantitative development of the active principles from the bud stage to full maturity of the flowers.

A thermostatically controlled cabinet was used to dry all of the samples collected, except when comparative drying methods were being investigated. In drying samples by this method, the heat was furnished by a 60-watt, 120-volt electric bulb which held the temperature at 37°C. to 40°C. The preliminary test for dryness consisted of lightly crushing the bloom and if the floral parts could be readily separated the sample was considered dry. After a sufficient number of samples was artificially dried, the time necessary to dry a sample was set at 55 hours, which was the time required to dry to constant weight. Samples preparatory to analysis were stored and shipped in air-tight, screw top, metal containers.

Comparison of Different Drying Methods and Their Effect on Pyrethrin Content

Seven drying methods were used in this study:

1. Full sunlight exposure for 27 hours and remainder of drying period under outdoor shade.
2. Sixty-two hours in outdoor, full shade and remainder of drying period under full outdoor sunlight.
3. Full outdoor sunlight.
4. Dried completely in outdoor full shade.
5. Dried in thermostatically controlled drying cabinet at 37°C. to 40°C. temperature.
6. Dried at 35°C. to 40°C. temperature with forced circulating air currents.
7. Dried in vacuum oven at a temperature of 35°C. to 40°C. and 100 mm. pressure.

The first method consisted of drying on a wire screen tray for 2 days, during which time 27 hours were full sunlight. The screen permitted a natural circulation of air currents around the

sample. After the first 48 hours of outdoor exposure, the samples were placed in full shade, accomplished by the use of a specially constructed cabinet, which did not permit sunlight to fall on the samples under test. This cabinet was set upon supports 2 feet from the ground and wire screen trays were so arranged that air could circulate thru the samples.

The second method used was to dry in full shade for 62 hours in the above-mentioned full-shade cabinet. After this period the samples were placed on a wire tray for exposure to full sunlight until completely dry. Drying in full sunlight was the third method. The samples were placed on unshaded wire trays outdoors until completely dry.

The drying of samples in method 4 was accomplished by the use of the full-shade cabinet described in method 1. The mean temperature on the inside of the cabinet was 26°C.

For the fifth method of drying, a wooden asbestos-insulated cabinet 46x92x46 cm. was used. The top and bottom were perforated with holes 5 mm. in diameter to permit natural air circulation. The temperature was regulated by a thermostat which was calibrated to hold the temperature between 37°C. and 40°C. The thermostat controlled a 60-watt, 120-volt electric bulb placed at the bottom of the cabinet and partitioned from the drying chamber by perforated asbestos. The samples were suspended in cheese-cloth bags on hooks placed at intervals of 8 cm.

Drying by the sixth method was accomplished in a cabinet constructed as just described, except that a heating unit and electric fan were placed under the bottom of the cabinet. This forced a continual circulation of warm air around the samples. The flowers were placed in cheese-cloth bags and arranged in the cabinet as described in the fifth method.

The seventh method consisted of drying samples in a vacuum oven in which the temperature was regulated from 35°C. to 40°C. by electrical heating units. A pressure of 100 millimeters was maintained in the oven by a motor-driven vacuum pump with water condenser attached.

Two series of samples were run by each of the drying methods. In the first series, 70 grams of flowers were used in each test, and in the second series 50 grams. Samples were made up of composite pickings from 30 plants. All the flowers in a series were picked on the same date and in the same stage of development, accurately weighed before and after drying, and the percentage of moisture loss computed. At no time during the tests was there any cloudy or partially cloudy weather.

The data, as presented in Table I, give the results of the two complete series of tests and include all essential figures. The first series was started on July 21 and the last series on July 30, 1932. The drying of all samples in a series was begun simultaneously.

Table I.—Effect of Different Drying Methods on Pyrethrin Content. (Average of Duplicate Tests)

Treatment	Fresh weight g.	Dry weight g.	Moisture loss on drying—percentage	Hours required to dry	Moisture in dried flowers—percentage	Pyrethrin content moisture-free basis—percentage
(1) Full sunlight 27 hrs. Remainder shade	60	17.842	70.26	310	7.1	1.25
(2) Shade 62 hrs. Remainder in sunlight	60	18.080	69.86	199	5.9	1.24
(3) Full sunlight	60	17.019	71.63	123	5.8	1.18
(4) Full shade	60	17.306	71.16	355	7.9	1.28
(5) Temp. regulated cabinet. 37°C. to 40°C.	60	17.397	71.00	53	6.0	1.20
(6) Circulated air current cabinet 35°C. to 40°C.	60	17.448	70.92	89	9.1	1.18
(7) Vacuum oven 35°C. to 40°C.	60	16.584	72.36	19	5.6	1.21

Inspection of the data in Table I does not show any great difference in the pyrethrin content of the samples dried by the different treatments. The lowest average pyrethrin content was secured on flowers dried by methods 3 and 6. In each case this amounted to 1.18 percent. The highest average yield of pyrethrins, 1.28 percent, was secured by method 4. The difference between the highest and lowest average pyrethrin content was 0.10 percent.

The Seasonal Variation in Pyrethrin Content During the Blooming Period

The object of this study was to determine whether there is a time during the blooming period in which there is a maximum amount of pyrethrins produced. In this study two individual plants were selected and a daily record of the number of flowers picked, fresh weight, dry weight, and percentage of moisture

loss was tabulated. Samples for analyses were made up of the bloom that opened during the first 5 days, the second 3 days, and the third 2-day period. All flowers were picked at the same stage of maturity.

The results, given in Table II, were procured upon each plant for each of the three periods and show that there is apparently some relationship between the pyrethrin content and the development of flowers during the blooming period. The flowers picked during the first 5 days of the blooming period of each plant had a pyrethrin content of 1.15 percent and 1.18 percent, respectively. The flowers picked on the sixth, seventh and eighth days yielded the highest percentage of pyrethrins, which amounted to 1.25 percent and 1.24 percent, respectively. Flowers picked on the ninth and tenth days had a slightly lower pyrethrin content than those picked on the sixth to eighth days. There was not sufficient bloom from the eleventh to the fourteenth day to permit an analysis. From this it appears that the highest yield of pyrethrins can be secured in the flowers picked between the fifth and ninth days. It is also noted from Table II that the total number of bloom was highest during the period in which the pyrethrin content reached a maximum. These results however cannot be considered as conclusive because of the small number of plants used. Moreover, in a series of experiments on response to fertilizer treatment, a definitely higher pyrethrin content was found in the flowers picked toward the

Table II.—Variation in Pyrethrin Content During Blooming Period.

Plant No.	Picking period	No. of flowers picked	Fresh weight g.	Dry weight g.	Moisture loss on drying—percentage	Moisture in dried flowers—percentage	Pyrethrin content on moisture-free basis—percentage
149	6/16 to 6/20	130	76.604	16.723	78.03	4.9	1.15
	6/21 to 6/23	146	69.689	18.152	73.95	8.0	1.25
	6/24 to 6/25	108	55.766	13.200	76.34	10.9	1.23
150	6/16 to 6/20	139	86.099	17.606	79.55	6.8	1.18
	6/21 to 6/23	205	96.324	25.930	73.08	6.9	1.24
	6/24 to 6/25	162	83.289	18.745	77.49	9.1	1.17

end of the blooming period, all flowers being picked at the same stage of maturity.

Effect of Shading the Plant on Pyrethrin Content

The purpose of this study was to determine the relationship of the pyrethrin content of flowers produced in full sunlight, partial sunlight, and in absence of sunlight. The partial shade was accomplished by covering the plant with a muslin frame. Absence of sunlight was obtained by the use of a canvas-covered frame which did not admit sunlight. Three plants of similar foliage characters, size and number of flower buds were selected and treated as mentioned above. The yield of flowers and pyrethrin content was determined upon each plant.

The results presented in Table III include a summary of data secured on each individual studied. The pyrethrin content of flowers produced in absence of sunlight was 0.42 percent, which is 0.57 percent less than for flowers produced in full sunlight. The absence of sunlight affected the normal appearance of the plant, and the flowers were malformed and very small. The difference in the pyrethrin content of flowers produced in full sunlight and in partial sunlight may possibly be due to differences in individuals, or to a modification of the photoperiodic response of chrysanthemums to a shortened day.

Table III.—Effect of Shading on Pyrethrin Content.

Plant number and treatment	No. of flowers picked	Fresh weight g.	Dry weight g.	Moisture in dried flowers—percentage	Pyrethrin content moisture-free basis—percentage
No. 206 Full sunlight	325	169.44	39.89	9.1	0.99
No. 178 Partial sunlight	250	119.90	24.85	7.9	1.22
No. 216 Absence of sunlight	93	Not determined	7.69	9.0	0.42

Effect of Storage on Newly Harvested Pyrethrum

There is a marked decrease in the pyrethrin content of whole or ground flowers during prolonged storage (3). Heretofore it was not known whether there is a pronounced loss during the period immediately after harvesting. Since sharp changes in pyrethrin content in this period would interfere with the interpretation of the results obtained in the various experi-

ments, it became necessary to investigate the question. Two lots of flowers were harvested, dried and assayed as promptly as possible, so that the analyses were completed within 10 days of picking. At the time of assaying, each sample was ground and mixed and divided into several equal portions, which were placed in air-tight screw-top metal containers. These cans were stored under different temperature conditions and the flowers were assayed at intervals, as indicated in Table IV.

Table IV.—Effect of Storage Time and Temperature on Newly Harvested Pyrethrum. (Average of Two Experiments.)

Time stored days	Temperature of storage °C.	Pyrethrin content dry-basis—percentage	Loss of pyrethrins—percentage
0	—	1.13	—
32	20 to 35	1.05	7.0
180	20 to 35	0.95	15.9
180	-2 to -5	1.15	none

The loss of 7 percent on samples in storage, from the tenth to the forty-second day after harvesting, was not greater than normal. The effect of storing the flower below 0°C. was extremely interesting, the decomposition of the pyrethrins being entirely prevented during 6 months of storage. It is believed that decomposition in storage will not affect the results of investigations, when analyses are made within 10 days after picking.

Effect on Pyrethrin Content of Treatment Given Flowers Previous to Drying

In some sections of Japan the flowers with stalks are suspended on a frame during the drying period. The object of this study was to note the effect on pyrethrin content of holding flowers, with 7-inch stems, in water 48 hours before drying; also, drying flowers with 7-inch stems as compared to flowers dried without stems. A composite lot of flowers with 7-inch stems was gathered from 30 plants, thoroly mixed, and divided into three samples. Sample 1 was placed in water immediately after picking for a period of 48 hours in the laboratory. At the end of this period the sample was placed in the thermostatically controlled drying cabinet. Sample 2, with stems, and sample 3, in which the flower heads were removed from the stems, were immediately placed in the thermostatically controlled cabinet. The stems were, of course, removed from samples 1 and 2 before assaying.

The results, shown in Table V, are the averages of two complete tests. From the data it is noted that there is only 0.02 percent difference in the pyrethrin content of flowers dried with stems and without stems. The difference in the pyrethrin content between sample 1 and sample 3 was 0.08 percent.

Table V.—Effect of Treatment Given Flowers Previous to Drying on the Pyrethrin Content. (Average for Two Tests).

Treatment	Weight before drying g.	Dry weight of flowers without stems g.	Moisture loss on drying—percentage	Moisture in dried flowers—percentage	Pyrethrin content moisture-free basis—percentage
Sample No. 1 7-inch stems placed in water 48 hrs. previous to drying	89.52	13.05	77.16*	7.7	1.22
Sample No. 2 Dried with 7-inch stems	77.20	13.07	72.21*	7.0	1.16
Sample No. 3 Control; dried without stems	45.79	12.90	71.82	7.9	1.14

*Computed on basis of flowers with stems.

VARIATION IN *C. cinerariaefolium*

Two hundred fifty 4-year-old plants were available for securing information on the botanical characters and pyrethrin content of *C. cinerariaefolium*. Thirty-nine plants were selected to secure information on the variation in yield of pyrethrins in individual plants. The following botanical characters were studied upon each individual plant in 1932 to furnish information on the possible association of such characters as an index to low or high pyrethrin content.

A. Foliage characters
   1. Growth habit
   2. Type of foliage
   3. Shape
   4. Amount of leaf bloom
   5. Color
   6. Leaf size

B. Flower-stalk characters
   1. Relative strength of flower stalk
   2. Pubescence
   3. Color
   4. Length

C. Flower-head characters
   1. Bracts
      a. Relative length and width
      b. Pubescence
      c. Imbrication
      d. Scariousness
   2. Ray flowers
      a. Entire or toothed
      b. Color
      c. Length
   3. Receptacle
      a. Flat or convex
   4. Disk
      a. Width of disk
      b. Shape of achene
      c. Color of achene
      d. Length of achene

Each individual plant was carefully studied and the average for each particular characteristic was computed from a large number of observations. Measurements of flower heads from individual plants were made upon a large number of flowers picked at the same stage of maturity, that is, when the first three rows of disk florets were open. Achene measurements were made on the outside row of open disk florets.

The daily yield of flowers from individual plants was carefully recorded. Any deterioration in the pyrethrin content that may have taken place in the first-picked flowers was held to a minimum by storing in an air-tight, screw top, metal container. Further, the 10-gram sample for analysis was made up from the composite yield of all flowers picked from each plant. This procedure was followed so that any variation in yield of pyrethrins would be due entirely to differences in individual plants.

Non-variable Botanical Characters

From the detailed study of individuals, it was found that certain botanical characters remained constant last season. The pubescence, imbrication, scariousness and the relative length and width of the bracts were not variable. The ray flower was found to be creamy white and toothed for all individuals. The slightly convex receptacle and light yellow-green, ribbed achenes were uniformly present in all plants.

Variable Botanical Characters

Growth Habit.—A comparison of the growth habits of individual plants revealed striking differences ranging from prostrate and spreading to erect and bushy.

Foliage.—There was considerable difference in foliage, ranging from a light feathery to a coarse and heavy type. The variable appearance of the plant was due to a decided difference in the size and shape of the leaves. In the feathery-foliage type the leaves were deeply pinnatifid with small lobes, while in the heavy-foliage type the lobes were larger and not as deeply pinnatifid.

Some of the plants were glaucous or covered with a whitish bloom, which varied in intensity in individual plants from a light to a heavy covering, giving the plant a silvery appearance. In other plants the whitish bloom was entirely absent, in which case the foliage color varied from a pale yellow-green to deep, dark green.

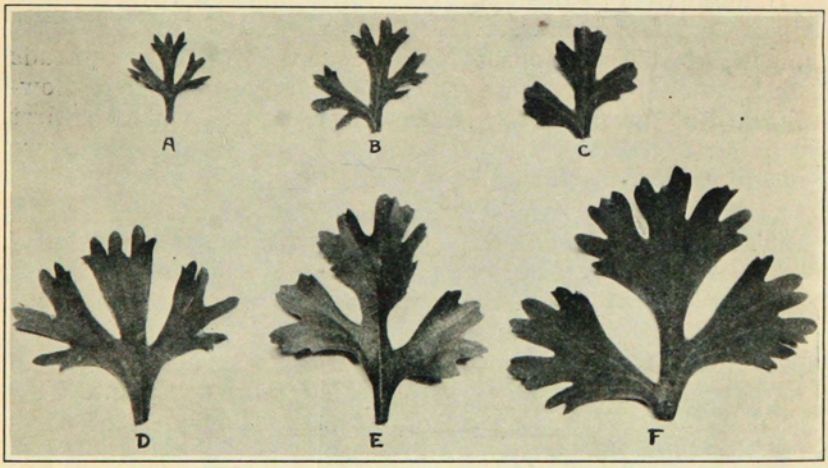

Fig. 2—Showing the variation in the size of leaves as found in individual plants.

Flower Stalks.—The relative strength of flower stalks ranged from prostrate to erect. This characteristic of flower stalks is very important from the standpoint of picking the flowers and quality of the dried flowers. Those plants with prostrate flower stalks made harvesting difficult. The soil adhering to the floral parts materially reduced the quality of the product.

The color and pubescence of stem varied in the same manner as the leaves.

The average height of flower stalks for individual plants varied from 37.08 cm. to 67.05 cm.

Fig. 3.—Two plants illustrating the variation in foliage and stem.

FLOWER HEAD.—The ray flower varied in length from 12.1 mm. to 46.8 mm. The width of disk varied from 6.95 mm. to 14.1 mm., with achenes ranging in length from 1.75 mm. to 2.45 mm.

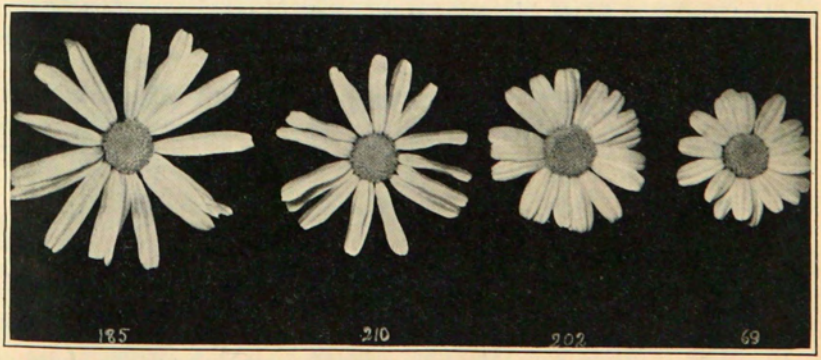

Fig. 4.—Illustrating the variation that occurred in the width of disk and length of ray flowers.

VARIATION IN YIELD OF FLOWERS AND PYRETHRINS

Table VI shows the extreme variation in the yield of flowers from the 39 individuals under trial. The difference in the yield of dried flowers by individual plants varied from 70 flowers

Table VI.—Variation in Yield of Flowers from Individual Plants.

Plant number	Total number bloom picked	Fresh weight g.	Dry weight g.	Moisture lost—percentage
A9-81	70	42.20	9.24	78.10
A9-53	72	44.97	9.71	78.41
A9-153	82	42.68	9.86	76.89
A9-175	97	39.31	9.88	74.87
A9-199	77	40.28	10.15	74.80
A9-90	77	46.48	10.42	77.58
A9-237	85	47.91	10.81	77.43
A9-225	152	88.58	11.08	87.49
A9-187	84	53.21	11.63	78.14
A9-240	98	60.30	12.02	80.06
A9-208	99	41.72	12.28	70.56
A9-233	105	61.59	12.68	79.41
A9-140	100	44.38	13.26	70.12
A9-212	104	52.31	13.33	74.51
A9-86	96	60.60	13.70	77.39
A9-14	121	66.48	15.24	77.07
A9-190	102	66.63	15.53	76.69
A9-162	171	69.40	16.34	76.45
A9-241	125	70.50	16.64	76.39
A9-115	132	66.95	16.96	74.66
A9-75	122	57.21	17.11	70.09
A9-236	131	75.79	17.56	76.83
A9-69	144	71.51	18.99	73.44
A9-77	164	77.28	19.12	75.25
A9-197	152	93.25	19.27	79.33
A9-59	189	81.19	19.55	75.92
A9-18	221	71.04	20.43	71.24
A9-61	187	82.14	21.04	74.38
A9-161	181	101.50	21.69	78.63
A9-210	186	84.50	22.19	73.73
A9-5	127	76.70	22.19	71.06
A9-228	162	100.63	25.35	74.81
A9-239	209	116.76	26.59	77.23
A9-73	215	105.48	27.82	73.62
A9-200	182	111.83	30.30	72.90
A9-202	284	143.61	35.93	74.98
A9-151	283	159.78	38.51	75.89
A9-149	422	219.49	51.95	76.33
A9-150	543	286.76	66.15	76.93

weighing 9.24 grams, to 543 flowers weighing 66.15 grams. It is also noted from Table VI that the percentage of moisture lost on drying is quite constant with one exception, in which the flowers from plant 225 lost 87.49 percent. All others varied from 70 to 80 percent.

The results of the pyrethrin-content determinations of the 39 individual plants are given in Table VII. The difference in yield of pyrethrins by individual plants varied from 0.90 percent to 2.07 percent. The average pyrethrin content for the 39 individuals is 1.27 percent, which is 0.08 percent less than the pyrethrin content secured from a composite sample gathered from this planting in 1931.

No definite plant character has been found that could be used as an index to high or low pyrethrin content. The results indicate the possibility that variation in the yield of flowers and pyrethrins is due to genetic inheritance. This should make it possible to select plants with desirable characters and to produce from such plants, pure lines which are superior in the yield of flowers and pyrethrins.

The extent to which environmental conditions may have affected the results secured in the investigations of individual plants is very small, as cultural practices and methods of handling bloom are uniformly the same in this study.

Several plantings have been made in different sections of Colorado to secure information on the influence of environmental factors such as temperature, rainfall and soil conditions on the pyrethrin content. These plantings cover districts where the rainfall varies from 12 to 25 inches, under irrigated and non-irrigated conditions, and at elevations of 4,000 to 10,000 feet above sea level.

Further, in 1932, a complete fertilizer experiment was started to determine the effect of nitrogen, phosphorus and potassium on the pyrethrin content.

The investigations also include a study of various spacing distances and their effect on the pyrethrin content.

In 1932, experimental plantings were extended to include approximately 5,000 individuals in order that further study can be made of the factors affecting the yield of flowers and pyrethrins.

Table VII.—Variation in Pyrethrin Content of Individual Plants.

Plant number	Moisture in dried flowers—percentage	Pyrethrin content on moisture-free basis—percentage
A9-115	7.8	0.90
A9-175	6.8	0.92
A9-161	8.0	0.99
A9-162	7.2	1.00
A9-153	7.9	1.02
A9-59	8.6	1.04
A9-86	7.0	1.08
A9-190	5.4	1.09
A9-73	7.2	1.09
A9-212	6.7	1.11
A9-197	8.2	1.11
A9-81	10.1	1.14
A9-69	7.4	1.14
A9-202	7.4	1.16
A9-225	6.6	1.17
A9-150	7.6	1.19
A9-187	5.6	1.20
A9-149	7.9	1.21
A9-18	7.1	1.22
A9-239	7.5	1.24
A9-199	7.6	1.24
A9-210	10.3	1.24
A9-208	5.9	1.25
A9-53	7.1	1.26
A9-151	10.3	1.26
A9-61	7.6	1.27
A9-76	6.4	1.26
A9-200	8.1	1.29
A9-240	7.7	1.34
A9-228	8.7	1.43
A9-90	9.8	1.43
A9-5	8.2	1.53
A9-233	5.8	1.53
A9-14	8.1	1.54
A9-241	6.5	1.56
A9-236	7.0	1.63
A9-140	9.2	1.66
A9-77	9.3	1.95
A9-237	5.4	2.07

SUMMARY

From experiments with seven widely different drying methods, it was found that the method of drying did not appreciably affect the pyrethrin content. The pyrethrin content of flowers from individual plants, picked at the same stage of maturity,

fluctuates during the blooming period. The causes of this seasonal variation have not been determined.

Complete shading of the plant during the picking season greatly lowered the pyrethrin content.

Ground flowers, assayed within 10 days of picking, showed no more than normal loss of pyrethrins when stored in an airtight container at room temperature. Decomposition of pyrethrins in similar samples was entirely prevented during 6 months storage by keeping the temperature at -2° to -5° C.

Drying the flowers with stalks or without stalks did not influence the pyrethrin content of the flower heads.

There was a wide range in the yield of flowers and pyrethrins from individual plants. The yield of dried flowers varied from 9.24 grams to 66.15 grams per individual plant. The pyrethrins varied from 0.90 to 2.07 percent with an average of 1.27 percent for all plants in the study.

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