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Hunt Institute was dedicated in 1961 as the Rachel McMasters Miller Hunt Botanical Library, an international center for bibliographical research and service in the interests of botany and horticulture, as well as a center for the study of all aspects of the history of the plant sciences. By 1971 the Library's activities had so diversified that the name was changed to Hunt Institute for Botanical Documentation. Growth in collections and research projects led to the establishment of four programmatic departments: Archives, Art, Bibliography and the Library.

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UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF PLANT INDUSTRY
WASHINGTON

GMD/KB
HORTICULTURAL INVESTIGATIONS

April 27, 1925.

Mr. Wilson Popenoe,

Foreign Seed and Plant Introduction.

Dear Wilson:

This is a copy of the manuscript which I am preparing for the Journal of Heredity. By going over this you will get something of the viewpoint which I have in regard to the problems in the strawberry.

Very truly yours,

Geo. M. Darrow

Geo. M. Darrow,
Associate Pomologist.



THE IMPORTANCE OF SEX TYPES IN THE STRAWBERRY.
by Geo. H. Darrow.

Based on their sex expression two forms of strawberry flowers are commonly recognized, pistillate and hermaphrodite. Pistillate flowers contain pistils but lack stamens. Hermaphrodite flowers contain both pistils and stamens.

All varieties whose flowers lack stamens are called pistillate; all others are called hermaphrodite or perfect-flowered sorts. In the field growers do not commonly consider it necessary to mix hermaphrodite varieties to insure cross pollination but set large acreages to single sorts. If pistillate varieties are grown they usually alternate two rows of a pistillate sort with one of the hermaphrodite type to furnish pollen.

The classification of sex types in the strawberry and the disposal of problems arising from differences in flower types is not as simple as the above statements seem to indicate. Sex expression in the strawberry is and always has been one of the most important problems in raising strawberries, for the form of sex shown by any variety in a field determines to a large extent the possible crop.

Pistillate varieties as commonly thought of do actually constitute at present a fairly definite group. Their flowers are practically always lacking in pollen and nearly always set fruit when pollinated.

Hermaphrodite varieties are most distinctly not a uniform group. Though all varieties which appear to have morphologically perfect stamens and pistils are placed in this class, every breeder and every close observer of wild strawberries knows that there is the greatest possible variation in this group. Some often bear a large proportion of pistillate flowers; others bear flowers

in which the pollen is nearly all abortive and are thus practically pistillate sorts. Most common and of much the greatest importance are hermaphrodite varieties in which the pistils of a greater or less proportion of the flowers are sterile. All or nearly all cultivated hermaphrodite varieties show this sterility. Under some conditions not one in fifty of the flowers of some varieties set. This is not due to frost, nor to cold, nor to rain, nor even to lack of pollen but to sterility of the pistils. Proof of this statement is easily secured by examining the setting of the flowers of pistillate varieties and comparing them with adjacent hermaphrodite varieties.

Seventy-five to ninety-five years ago it was quite well known that there were differences in the sex of the so-called hermaphrodite varieties - far better known than it is today. This was due to the studies of Nicholas Longworth and his associates.

Studies of Longworth and Associates.

The attention of Longworth was first directed to the sex differences in strawberries by the success of a market gardener, Mr. Arbigust of Philadelphia, who later moved to Cincinnati. This gardener had discovered that some varieties were pistillate, that others had flowers containing both pistils and stamens, and that by planting pistillate varieties with some plants of the perfect-flowered sorts nearby the largest crops were produced. Longworth recognized the importance of this and by his addresses and writings between 1835 and 1860 made it common knowledge throughout America.

Longworth was aided in his studies and in his publicity work by the Cincinnati Horticultural Society. Various committees of this society made

reports on their studies of the sex of the strawberry during which millions of flowers were examined. Since the time these reports were made many of their findings have been forgotten. Yet some of their findings are of greatest importance to breeders and physiologists today.

Among their conclusions are the following:

1. That the different varieties have characteristic inflorescences.
2. That the differences in their inflorescence consist in the greater or less development of the stamens and pistils.
3. That while in some varieties the flowers are apparently perfect, the pistils are really to a greater or less extent defective.
4. That in pistillate varieties stamens are in most instances wholly abortive and such sorts will not bear a perfect fruit if kept apart from staminate varieties.
5. That no varieties with flowers containing stamens could be depended upon as heavy bearers, "though from some unknown causes, the pistils may be so well developed as to be followed by a good crop, some years and in some locations".
6. That there is no known perfect-flowered variety in which the blossoms will all be followed by perfect fruit every year. (One report, however, mentions three varieties that always have both stamens and pistils fully developed in all flowers. These were the La Grange (a variety of *F. elatior*), the White Pine and the Monthly Alpine (*F. vesca semperflorens*)⁽¹⁾. La Grange was at another time reported as being from 7 to 90 percent of its flowers sterile.)
7. That the only certain method of producing large crops was to set pistillate varieties with only as many perfect-flowered sorts as might be necessary for pollinating.

At one time four classes were reported: Pistillate, staminate, hermaphrodite and a rare fourth class which bore both pistillate and hermaphrodite flowers on the same plant.

(1) Report on the Cultivation of the Strawberry. Report of transactions of the Cincinnati Horticultural Society. 1846 pp. 59-61.

One report stated that not more than 30 percent and on the average not more than one in twelve of the flowers of hermaphrodite varieties ever set. They even left a record of the percentage of flowers that set in various hermaphrodite sorts. The following is a record of some of the varieties they examined:

Keens Seedling - about 15 percent of the flowers develop perfect fruit.
British Queen - no flowers develop perfect fruit.
Grove End Scarlet - 10 percent develop perfect fruit.
Ross Phoenix - 10 percent develop perfect fruit.
Swainstone - 15 percent develop perfect fruit.
Eberleins Seedling - 43 percent develop perfect fruit.
Baists Prize - 4 percent develop perfect fruit.
Baynes Seedling - 2 percent develop perfect fruit.
Duke of Kent - 23 percent develop perfect fruit.
La Grange (var. of *F. elatior*) - 10 to 95 percent with an average of about 52 percent develop perfect fruit.

The average setting of the flowers of all the above varieties is 17 percent. Longworth reported that in growing seedlings fully one-half of them were hermaphrodite and that not one in fifty of these hermaphrodites bore even a single berry. He further stated that all the white varieties and the Alpines have good stamens and pistils in all flowers, but that of only one other variety was this true. In all other hermaphrodites some at least of the flowers were sterile.

In the eighty years since these reports were made a great change has taken place in the sex type of commercial varieties. During the time of Longworth pistillate varieties were recommended as being much more productive than hermaphrodite sorts. The best varieties of the latter type according to the only record available set only 17 percent of their flowers. Today, however, pistillate varieties constitute but a small percentage of the total acreage of strawberries. Some at least of the hermaphrodite varieties are as productive as pistillate sorts and in general they set a much greater proportion

of their crop than did the hermaphrodite varieties of eighty years ago.

Studies of Vallean.

Recently Vallean⁽¹⁾ made a detailed study of sterility in the strawberry. On the basis of their sex expression, he grouped varieties into three classes, pistillate, staminate and perfect-flowered. He found that the flowers of all pistillate varieties bore "staminodia" (abortive stamens) showing varying degrees of development but which never produced pollen. staminate varieties had pistils which appeared normal but which did not set fruit. Staminate sorts were found in which the first flowers to open were pistillate and bore only staminodia in place of the normal stamens. Cases were even found where only a few of the later flowers produced stamens, all the rest being pistillate. The pistils of such flowers were fertile and produced fruit. Sometimes one or more of the later flowers of staminate varieties were pistillate while the first was staminate. Cases in which one part of a flower was staminate and the other part pistillate were found. In addition a full series of types between the two forms was reported and illustrated. Vallean further stated that all degrees of stamen development might be found on a single cultivated perfect-flowered variety. Varieties such as Lovett, Glen Mary and an unnamed seedling were listed which produced some pistillate flowers early in the season but which later produced all hermaphrodite flowers with good stamens.

Vallean examined the pollen of about 120 varieties of strawberries and found it nearly all perfect in some sorts and nearly all imperfect in others. For example, in the Glen Mary 46.7 to 100 percent of the pollen was imperfect while in the Aroma only 1.5 to 22.4 percent of abortive pollen was found. On the

(1) Vallean, W. D., 1916. Sterility in the Strawberry. Jour. Agr. Res. Vol. XII, No. 10 pp 613-670.

average, however, a little over one-third of the pollen was abortive. In general, the later flowers on an inflorescence contained more good pollen than did the earlier flowers.

Though Vallesau reports such widespread pollen abortion in the strawberry, under field conditions growers have little trouble from lack of good pollen. It is probable that where the flowers of a variety contain even as low as 5 percent of good pollen a full set of fruit loss will result. Glen Mary and Progressive are probably the two widely planted hermaphrodite sorts which most often need another variety set with them.

Vallesau also observed another form of sex expression in hermaphrodite varieties - pistil sterility. He does not appear to have realized the economic importance of this condition as fully as did Longworth, partly perhaps because of an actual change in the amount of pistil sterility in the seventy-five or more years intervening. Vallesau pointed out that pistil sterility occurs in the wild species Fragaria virginiana and F. chilcensis from which our cultivated sorts come and also that F. elatior of Europe, F. cuneifolia from Vancouver Island and Washington State and F. platyphala all show more or less pistil sterility. Where pistil sterility occurs he showed that the first flowers to open tend to set while a very great progressive increase in sterility from the first flowers to the last occurs.

In fifteen hermaphrodite varieties under field conditions he found 10.6 percent of the primary flowers in the clusters failing to set or setting imperfectly, 20.9 percent in the secondary, 36.7 percent in the tertiary and 60.6 percent in the quaternary, or an average of 53 percent failing to set or setting imperfectly and 67 percent setting fruit. In a test using 86 hermaphrodite varieties and 39 unmated seedlings where the flower clusters were bagged the percentage of setting was much lower. Of primary flowers 73.2 percent

failed to set or formed nubbins as did 75.1 percent of secondary flowers, 76.5 percent of tertiary flowers and 88.2 percent of quaternary flowers.

Valleau cites instances of changes in the sex type of varieties. He states that it is a matter of common observation that a bed of berries, if allowed to fruit more than one year, will produce an increasing number of small berries and nubbins. A variety, Glenville, only occasionally set fruit in the greenhouse in winter while the same plants the following summer when potted produced over 50 percent of flowers setting fruit. At the same time in the field the Glenville produced less than two percent of flowers which set. He notes that the tendency toward the production of staminodia is much greater in early spring than later on hermaphrodite varieties.

Observations in Maryland on Flower Sterility

Some records secured in 1924 furnish additional data on the extent and importance of sex expression in different varieties. These records were taken at three places in Maryland, - at Salisbury on a coarse sandy soil, at Glenn Dale on a fine but variable sandy loam and at College Park on a clay loam. Tables I, II and III present the data.

TABLE I. Number of Flowers per inflorescence and percentage of flowers failing to set of strawberry varieties at Salisbury, Maryland, 1924. (Except as noted 30 clusters were used in getting averages)

Variety	Avg. No. Flowers to stalk	% flowers failing to set	Remarks
1. Joe	10.85	23	51 clusters avg'd. Fine foliage
2. Marshall-	9.57	74	Foliage small, leaf spot bad
3. Brandywine	9.44	22	Fair to good foliage, some leaf spot.
4. Sun (Sun Special)	8.73	62	Little leaf spot
5. Excelsior	8.70	44	Good foliage
6. Big Wonder	8.47	89	Much leaf spot
7. Parsons	8.20	56	Poor foliage, some leaf spot
8. Gold Mine	7.93	16	Fine foliage
9. Belt (Wm. Belt)	7.77	25	Much leaf spot
10. Fremont Williams	7.73	38	Some leaf spot
11. Marvel	7.67	19	Good foliage, some leaf spot
12. Progressive	7.30	14	Fine foliage
13. Chesapeake	6.90	16	Fine foliage, some leaf spot
14. Delicious	6.87	34	Leaf scorch- not much spot
15. Lea	6.83	31	Sparse, small foliage, some leaf spot.
16. Michels' Early	6.77	49	Leaf spot bad
17. Ozark (Early Ozark)	6.77	11	Some leaf spot, much calyx injury
18. Judith	6.53	33	Leaf spot bad
19. McAlpin	6.16	59	Leaf spot very bad
20. Eaton	5.67	29	Small foliage, some leaf spot
21. Corneille (Lady Corneille)	5.53	28	Much leaf spot
22. Lupton	5.07	2	Healthy foliage
23. Klondike	4.17	14	20 clusters average
Avg. perfect-flowered	7.35	34 percent	

Pistillate Varieties:

24. Big Late	10.60	8	Good foliage, much leaf spot
25. Warfield	8.82	27	Avg. 28 clusters, poor leaf growth.
26. Paul Jones	6.44	11	Avg. 27 clusters - slight leaf spot.
27. Fendall	<u>6.13</u>	<u>3</u>	Little leaf spot.
Avg. pistillate-flowered	8.00	12 percent.	

TABLE II. Number of flowers per inflorescence and percentage of flowers failing to set, of strawberry varieties at the Bell Horticultural Field Station, Glenn Dale, Maryland, 1924.

<u>Variety</u>	<u>Avg. No. flowers per stalk</u>	<u>Percent flowers failing to set</u>	<u>Remarks</u>
1. Belt	15.9	21	8 clusters
2. F. virginiana #13	13.4	38	26 "
3. Joe	13.4	17	10 "
4. Parsons (Gibson)	13.4	44	20 "
5. Marshall	9.6	26	10 "
6. DanLap	7.7	32	14 "
7. Klondike	7.0	17	10 "
8. Judith	<u>5.2</u>	<u>45</u>	30 "
Avg. perfect-flowered -	10.7	28	
<u>Imperfect flowered sorts:</u>			
9. Sample	11.8	12	10 "
10. F. virginiana #9	10.3	3	19 "
11. F. virginiana #15	7.1	2	29 "
12. Howard 25	<u>6.2</u>	<u>6</u>	10 "
Avg. pistillate flowered -	8.9	6	

TABLE III. Number of flowers per inflorescence and percentage of flowers failing to set, of strawberry varieties, College Park, Maryland. - 1924.

<u>Variety</u>	<u>Avg. No. flowers per stalk</u>	<u>Percent failing to set</u>
1. Wyona	10.10	43
2. Joe	9.87	28
3. Late Stevens	9.13	48
4. Tennessee	8.77	23
5. Burrill	8.17	75
6. Charles I	7.40	35
7. Klondike	6.47	12
8. Lupton	<u>5.67</u>	<u>25</u>
Avg. perfect flowered -	8.20	36 percent
<u>Imperfect flowered sorts:</u>		
9. Sample	9.87	21
10. Bubach	<u>7.60</u>	<u>14</u>
Avg. pistillate flowered -	8.74	18 percent

The most striking thing shown by these data is the great difference between the percentage of failure to set of the hermaphrodite and the pistillate varieties at each place. At Salisbury the average failure to set of the two types was 34 percent and 12 percent respectively, at Glenn Dale 28 percent and 6 percent and at College Park 36 percent and 18 percent. Additional records of several pistillate seedlings in 1924 at Glenn Dale show a much lower percentage of flowers failing to set on pistillate varieties. These seedlings showed respectively 0, 0, 0, 0, 2, 2, 4, 4, 5 and 5 percent of flowers failing to set. Observations in former years have indicated that all flowers of many pistillate

varieties set under favorable conditions. Fungi, drought, mechanical injuries and other causes commonly prevent the setting of some flowers. Though such causes may explain the failure to set, shown in the tables, it seems probable that pistillate varieties do occur which show some sterility of the later flowers under certain conditions but more records are needed on this point.

A second striking fact shown by these data is the great variation in the sterility of hermaphrodite varieties. At Salisbury the percentage of failure to set varied from 89 percent in the Big Wonder to 2 percent in Lupton. At Glenn Dale, Judith showed 45 percent not setting while Joe and Klondike each showed 17 percent. At College Park, Burrill showed 75 percent not setting and Klondike only 12 percent. Observations in different parts of the United States indicate that corresponding degrees of failure to set exist in most, if not all, regions. The decrease in size of fruit from the beginning to the end of the season varies with the variety, being much greater with some varieties than with others. Because the first berries on a cluster to ripen are the largest and the last ones to ripen are the smallest the actual loss in yield and in value of the crop is less than the percentage failing to set would indicate. For this reason, where not more than 10 percent of the later flowers are sterile the economic loss is probably small. That part of the potential crop that does set and mature is likely to be of better grade than if the later flowers which would naturally produce small berries were fertile. In those varieties where the size of the later berries does not decrease materially the economic loss, when even 10 percent of the flowers are sterile, is considerable.

The average failure to set of hermaphrodite varieties at the three places in Maryland in 1924 agrees quite closely with that reported by Valleson. Strawberries at these points show 29, 34 and 36 percent of flowers failing to set

while Vallean found about 33 percent in Minnesota. Individual varieties show considerable variation at different places. Vallean reported 41 percent failing to set in the Parsons. At Salisbury in 1924 it showed 56 percent and at Glenn Dale 44 percent sterility. Dunlap showed 56 percent not setting in Minnesota and 32 percent at Glenn Dale, Maryland. Joe showed 23 percent at Salisbury, 17 percent at Glenn Dale and 28 percent at College Park, while Klondike showed 14, 17 and 12 percent respectively. Small variations in failure to set like those in the Klondike at the different places might be expected but a difference such as that shown by the Dunlap with 56 percent and 32 percent indicates that conditions have affected the fertility of its flowers.

Pistillate Flowers on Perfect-flowered Varieties.

In a report of a committee of the Cincinnati Horticultural Society referred to above a rare fourth class was reported consisting of hermaphrodite varieties that produced some pistillate flowers. Vallean mentioned this but does not seem to appreciate the extent of its occurrence. It is more common and has much more influence on the crop than does the development of a very low percent of good pollen. The first flowers of Dunlap often lack well developed stamens. During cool weather of early spring this condition seems the most common. As a result the earlier flowers may not be pollinated and as the first flowers bear the largest fruit the economic loss may be considerable. Under greenhouse conditions during the short days of winter many varieties develop neither stamens nor petals. It is probable that the lack of stamens under the short days of winter determines to a considerable extent the yield which can be grown in Florida and other southern sections.

Some records of the flower type of Howard 17 taken in the ge

April 7, 1925, about a week after the first flowers appeared, illustrate the extent of the lack of stamens. On 137 plants there were 702 flowers, of which 669 were pistillate and 33 or less than 5 percent were hermaphrodite. A distinct flower type was also noted on these plants - a flower where both stamens and petals were undeveloped, and of the 669 pistillate flowers 144 had no well developed petals. Where they could be seen the petals were green and rarely as long as the sepals.

A few varieties were examined in the field, May 3, 1924, at Glenn Dale, Maryland when the first flowers were appearing. Of these the Maryland variety had 6 normal flowers and 32 with abortive stamens, Progressive had 4 normal and 13 abortive, Campbell had 6 normal and 25 abortive and Missionary had 4 normal and 9 abortive.

More extensive records were taken at Salisbury, Maryland, on May 10, 1924, which are given in Table IV. In it are listed 15 varieties having some flowers with abortive stamens and 21 varieties in which all flowers had good stamens.

TABLE IV. Number of hermaphrodite flowers and (flowers lacking well developed stamens) in strawberry varieties at Salisbury, Maryland, May 10, 1924.

V Variety	No. of hermaphrodite flowers.	No. of flowers lacking well developed stamens.
1. Marvel	3	47
2. Progressive	6	44
3. Shropshire	10	30
4. Delicious	43	37
5. Tennessee	25	25
6. KeAlpine	25	26
7. Judith	12	8
8. Late Stevens	3	2
9. Klondike	14	6
10. New York	42	13
11. Gold Mine	30	9
12. May	45	4
13. Howard 17	41	1

14. Lupton	49	1
15. Gandy	50	1

The following varieties showed no flowers which did not contain some well developed stamens:

1. Abington
2. Big Wonder
3. Belt
4. Brandywine
5. Sun (Sun Special)
6. Burrill
7. Cornelle
8. Campbells
9. Dunlap
10. Early Jersey
11. Osark
12. Eaton
13. Parsons (Gibson)
14. Joe
15. Klondike
16. King Wealthy
17. Lea
18. Marshall
19. Missionary
20. Michels Early
21. Nick Chmer

Discussion

The studies of Longworth and Vallean and the observations in Maryland recorded above give some idea of sex types in the strawberry. Cultivated varieties may still be grouped into two primary classes, pistillate and hermaphrodite or perfect-flowered forms. Pistillate varieties are apparently distinct from the perfect ones though it has been reported that certain pistillate varieties become hermaphrodite in England.

Hermaphrodite varieties show a great range of flower types from those bearing pistillate primary flowers and which may even bear many pistillate secondary and tertiary flowers to those whose flowers all have good stamens. Moreover, this latter group grades from hermaphrodite varieties whose flowers

all to those where none set. In a single cross between a pistillate or a hermaphrodite variety a complete series of intergrades or intersexes from nearly perfect-flowered to staminate seedlings may be secured.

Actual records indicate that a change in the setting of hermaphrodite varieties from the time of Longworth to Vallesu from 17 percent to 66 percent of the flowers setting perfect fruit has occurred. Instead of almost exclusively pistillate varieties hermaphrodite sorts are now grown almost entirely. Unconscious selection of the most productive hermaphrodite varieties during the seventy-five years has evidently brought about this change in the fertility of hermaphrodite varieties.

While Longworth appreciated the importance of sex types and recognized the principal forms, Vallesu studied the exact manner of sex expression in each type and has made it possible for growers and breeders to judge varieties by a new and much more exact measure; that is, their sex type and the sterility of the flowers according to their position on an inflorescence.

The problems relating to sex in the strawberry are genetical and physiological. By breeding and selection a great increase in the setting of flowers has been secured. A further increase in their fertility is most important. Under some conditions a much greater percentage of the flowers set than under other conditions and an understanding of the causes of such changes is also important.



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illustrations for Strawberry Article]

The Journal of HEREDITY

*A monthly publication devoted to Plant Breeding
Animal Breeding and Eugenics*



TWO TYPES OF STRAWBERRY FLOWERS
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A Review

JUNE, 1925

VOL. 16 No. 6

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THE DARROWS
OLALLIE FARM
GLENN DALE, MARYLAND 20769

Aug 13 '67

Dear Wilson -

Yours of Aug 5 came yesterday. It is nice to know that you still are kicking and that your mind works just right yet.

If you have followed the work of Bringhamst & Voth you will appreciate that they are getting (1) the right variety (2) getting growers to use certified disease-free stock to plant (3) planting at the right time (4) #3 means holding plants in cold storage until just the right time to plant and (5) holding the plantings for one year - rather one crop only and (6) plant only in fumigated soil.

I would think you still should test carefully Florida variety and Tioga. Both seem to be doing well in Mexico and Tioga is being

tried in Florida

Day before yesterday I rode with Drs Scott & D. A. Fisher of the U.S.D.A. at Beltsville to New Jersey to see the newest selections and the seedlings in the blueberry-breeding work. The work is advancing nicely and both are able and hard workers. They had lots of things to show; the grower on whose place the work is located (about 50 miles from Atlantic City) has just about 500 acres planted to blueberries now.

But on the 150-mile trip up we had a chance to talk over Scott's recent trip to the West to review the work at the various research stations. Scott got the impression that Triega was quickly replacing other varieties except for Shasta at

THE DARROWS

OLALLIE FARM

GLENN DALE, MARYLAND 20769

Salinas and some Fresno near
 Fresno and near Los Angeles. Also
 that ever bearing crosses ^{in production and flavor} were
 showing up well (this from Dr Thomas)
 also Binghamst was going to Chile
 for a year to work at Santiago
 Brno.

When you think of the size of
 Parramos, remember that Florida 90
 is usually a tiny berry here, yet one
 of the largest known as grown in
 Florida. It is far less firm than
 Tiooga but gets to market with far
 finer flavor - probably the best of any
 variety. When I saw Parramos it was
 not large but missionary was not
 either. I saw missionary by Lake
 Attlan.

Dr. Brooks in Fla. did some work
on putting local Fla. plants in
cold storage. Could you get a
report of his work and adapt it
to Guatemalan conditions? For
a home refrigerator bundles of
100 plants would not take too much
room and could give surprising
results. Also soil fumigation
can give surprising results - use
a home garden kit. I have red raspberries
and day lilies in my garden where I
fumigated last Dec. and they are
remarkable in vigor. The Harrow Bros
fumigate all their 20 acres and can
replant at once.

All well here - hope you are. A
recent card from John said that he
visited you - was it John Bigger?

Are you growing blackberries? Going
to Gamesville soon?

as ever
George

Dear Wilson - It's our earliest season here - 2 weeks earlier than last year - we have irrigated for frost protection 4 times this year and have half grown berries. We have about 17+ acres to harvest this year - all pick your own. The day later than are picking now. *Look lush with your book. Hope to get to Gainesville next week - George*

Box 13603 University Station
Gainesville Florida 32601
21 April 1968

Dear George:

At long last I have prepared some notes on strawberries for the book "Fruit Growing in Tropical America" which we simply must finish this year. These notes may seem very brief but we must hold this book down to a size which will not put the price out of reach - my pals down in tropical America are not in the market for \$15 books.

Will you go over these notes and punch them full of holes. Don't think you can hurt my feelings and I would like to say in the preface to the book that you have reviewed the section on strawberries if you will give me permission to do so, after you have made any corrections or additions you think necessary. I would of course say that you are not responsible for anything which is printed.

I have used some of your notes from that article in Ceiba, and some items from your letter of 13 August 1967. Some of the material is based on my own observations. I probably need some fresh notes from the huge Irapuato plantings; you doubtless know what has gone on there and I don't. I wonder what variety they are using? Seems to me they have gone over to Florida 90. *in part - in part Cal varieties* If so I believe I should mention it. *yes for fresh market*

I have been here in Gainesville since the first of the year. I will have to go back to Guatemala before long. Yes, it was John Bregger who was with us last year. You probably saw I mentioned him in my paper in the April issue of Fruit Varieties and Hort Digest of the Am Pom Soc. I was a long time getting ready to publish that article; but I really believe we have got the Guatemalan situation straightened out and are prepared to go ahead. Best regards to all of you,

Wilson

I cannot find the Mexican total last year but
it was 60 to 70 million pounds frozen and 10 to 15
million shipped fresh. * or you it has 2,644,747 lbs. frozen to US
for 1947-48
about 731,100 lbs. with Canada.

STRAWBERRIES

Fifty years ago it was rare to find strawberries on the markets of tropical American countries. There were a few exceptions. In the vicinity of Irapuato, Mexico, strawberries have been grown for a long time to supply, on a small scale, the markets of Mexico City. Recently this industry has developed tremendously. ^{Thousands} Hundreds of acres are in production; the fruit is frozen and shipped to the United States to be used in the manufacture of ice cream, jams, and other products. In Central America there are small plantings in several countries which supply local markets with small quantities of fruit. At Guachi, near Ambato, Ecuador, strawberries have been grown on the high plateau (9400 feet) for more than three hundred years, having been introduced from Chile, presumably via Peru. The situation at Guachi is horticulturally unique, and has attracted much attention from foreign specialists.

The eminent authority, George M. Darrow of the U.S. Department of Agriculture, has pointed out that most of the cultivated varieties of ^{the} today are hybrids of Fragaria chiloensis, which occurs in a wild state along the Pacific coast of North America and again in southern Chile, and F. virginiana, the delicious, aromatic wild strawberry of ^{the} ^{eastern} ^{part of} ^{the} United States. The Chilean strawberry was taken to Europe in the ^{late} ^{1700s} ⁽¹⁷¹⁴⁾ ^{the Chilean} 1700s. Through hybridization ^{it} has given our present varieties size and firmness, while F. virginiana ^{has} added the flavor which was lacking in chiloensis. It might be mentioned that the wood strawberry of Europe, Fragaria vesca, small but tasty, has become naturalised in the Andes. Its fruit often appears in the markets of Bogotá.

Horticultural Varieties

George Darrow considers the strawberry formerly grown at Irapuato to be a selection of Fragaria chiloensis. The one grown at Guachi in Ecuador is a pure form of this species. Most of the others seen in tropical America have varying amounts of chiloensis and virginiana "blood".

Strawberry varieties preferred by growers vary from region to region, and they change from time to time. The prospective planter in tropical America should keep these facts in mind. He must consider his climate and soil, ^{and} he must take into account the ~~bb~~ objectives of his program.

The principal varieties which have received attention in tropical America are ^{discussed below} ~~the following~~; forms of pure chiloensis blood are not included for two reasons: their relatively poor dessert quality and their unsatisfactory behavior in several regions where they have been planted experimentally.

MISSIONARY. This is the old stand-by, a truly good berry which for a long time was the principal commercial variety in the southern United States. It has been planted more widely in tropical America than any other. In recent years it has been superseded in southern Florida, where strawberries are extensively grown and climatic conditions are similar to those of tropical America, by a hybrid known as Florida 90, of which Missionary was one parent. This variety is more productive than Missionary and its fruits are large (in that climate, not when it is taken farther north) ^(excellent quality in cool weather) and of good quality. Florida 90 has not yet been tested in tropical America for a sufficient number of years to have found its place in this part of the world. ^{It is however extensively} ~~grown in the Tropics~~ ^{grown in the Tropics are of Mexico and sent by truck + plane to} ~~markets of United States.~~

KLONDIKE is a relatively old variety which has made a good record in several tropical strawberry-growing regions. It is a large berry, ^{and of excellent quality frozen} of attractive form, ^{and good quality.} It is not being planted extensive-

3.

highly

ly at the present time as it is not highly productive.

BLAKEMORE has done well in Guatemala at 5000 feet; it is said to need cooler weather than Missionary. LASSEN (Lassen Mammoth), a large soft berry but ~~not~~ ^{poor} of the ~~best~~ quality, has done well on rather dry soils in El Salvador; TIOGA, a new variety ^{of California former and better flavored}, has been recommended for trial. Several others might be mentioned. It can safely be said that every five years or so new and promising varieties which will merit testing will appear upon the tropical scene. Because the strawberry is such an excellent fruit (there is an old saying, "assuredly God might have made a better berry, but assuredly God never did"), and because hybrids ^{can be produced} in such a short time, compared with the tree fruits, this field has been a favorite with the plant breeders.

Climate and Soil

Strawberries are grown successfully in tropical America at elevations from 2000 to 7000 or 8000 feet (10,000 near the Equator). They can be grown below 2000 feet, with a limited degree of success if an appropriate variety is chosen. ^{But 4500 to 8000' is best} After his visit to tropical America in 1952, George Darrow wrote that fruit of the best flavor was produced at 5000 or 6000 feet. This is an effect of the cool climate.

Another point: The strawberry is one of those plants which shows a definite reaction to ~~the~~ length of day. In those regions which are ~~not too~~ near the Equator where hours of daylight are about the same at all times of the year. ^{only a few varieties are adapted} In Honduras at 2500 feet Missionary yields fruit abundantly from January to June, but produces no runners; from June to December it produces runners but very little fruit.

While not exacting as regards soil, a good loam rich in organic matter is ideal. Heavier soils may require shallow tillage to keep them in good condition. The soils which have given real trouble in Central America are the volcanic sands and sandy loams, which ^{do} not retain moisture

to the extent required by strawberry plants. There have been some distressing failures in Guatemala on coarse volcanic sands, even when they were given what was thought to be sufficient irrigation. The prospective planter will be wise to avoid such soils.

Planting and Care

Here it seems appropriate to present a program based upon experience in tropical America - plus a few details suggested by experts in the United States, one or two of which the small grower in a remote region may not be able to carry out.

1. If planting is to be done on a commercial scale, use only varieties which have stood the test of time in your particular region. Plant ~~the~~ others experimentally and see what happens.

2. Plant at the right time of the year. This will vary from place to place; obviously it will not be the same at 15 degrees north as it will at 15 degrees south of the Equator.

3. Maintain the planting for one year only. Take off one crop, then replant. Commercially this system has worked better than continuing a planting in production for two or three years. More and larger fruit is obtained.

4. If possible, hold the plants in cold storage for ^{one to two weeks} ~~a time~~ before planting. George Darrow says 100 plants wrapped in a bundle would not ~~take too~~ much space in the refrigerator and ^{might} ~~could~~ give surprising results.

5. Plant only in fumigated soil. This again is George Darrow's recommendation and may not be so important in tropical America if new land is used. It is also suggested that certified disease-free stock should be used. Growers in Mexico sometimes import such stock from the United States. Not every small grower in tropical America will be able to afford it.

to 3 1/2 4"

Plants should have the roots trimmed before being put in the field. They may be set in rows two to three feet apart, with the plants a foot apart in the row. The roots should be spread out as they were when taken out of the ground for planting, and great care must be taken not to cover with soil the bud or growing point. Many plants are lost in tropical America by failure to observe this point. Watch the plants to make sure rain or irrigation does not bury the growing point; strawberries simply cannot stand it.

Little is known about the requirements of strawberry plants regarding fertilizers, simply because this information can only be acquired through experience. The use of stable manure would ^{is} be ideal, and good ^{It also brings in weed seed.} all soils, but unfortunately it is rarely available in quantity. ^(as 16N-6P-4K) Side dressing with chemical manures, especially those high in nitrogen, will undoubtedly produce good results in most cases, yet they have not ~~yet~~ been used on strawberry plants in most parts of tropical America. It will pay the planter to experiment with them, keeping careful records of results, including comparative figures from check plots.

Little information is available regarding diseases and pests in tropical America. George Darrow reported in 1952 that the "Missionary variety was entirely free of leaf diseases wherever seen. In contrast, the Parramos variety (of European origin, and little known out of one small area in Guatemala) was heavily infested with both leaf spot and leaf scorch. In Ecuador, the Guachi strawberry was severely infected with leaf scorch.... Aphids were common on strawberries in Guatemala, Honduras and Ecuador." If strawberry growing follows the trend of other crop plants we will see more pests when larger areas are in cultivation.

UNITED STATES DEPARTMENT OF AGRICULTURE
 AGRICULTURAL RESEARCH SERVICE
 CROPS RESEARCH DIVISION
 BELTSVILLE, MARYLAND 20705

at office Apr 30 '67

Dear Wilson -

Found the strawberry import record. Fresh strawberry imports from Mexico in 1967 over 18000 000 lbs. ($1\frac{1}{2}$ lbs to qt), nearly double the previous year. 1964 - 1965 - 1966 - 1967
 carload equivalent 292 - 412 - 839 - 1464

1967 Imports of fresh by months (carload equivalent)
 Jan Feb Mar Apr May June July Aug Sept Oct Nov Dec
 195 259 339 208 53 - - - - 2 70 358 = 1464

Frozen strawberries to U.S.

	lbs,		lbs
1954	8,985,000	1962	32,281,000
1955	11,662,000	1963	34,530,000
1956	11,350,000	1964	39,720,000
1957	13,709,000	1965	51,746,000
1958	14,367,000	1966	82,826,000
1959	14,063,000	1967	72,694,000
1960	25,817,000		
1961	29,517,000		

Imports of fresh strawberries from Mexico by season (Nov-May)

1958-9	51,000
1959-60	540,000
1960-1	387,000
1961-2	966,000
1962-3	2,149,000
1963-4	3,194,000
1964-5	5,183,000
1965-6	9,778,000
1966-7	18,736,000

Shipments to Canada are quite heavy but I have not seen recent figures.

As ever

George Darrow

STRAWBERRIES

Fifty years ago it was a rare thing to find strawberries on sale in the markets of many tropical American countries. There were exceptions, however. In the vicinity of Irapuato, Mexico, strawberries have been grown for a long time to supply, on a small scale, the markets of Mexico City. Recently this industry has developed tremendously; hundreds of acres are now in production; the fruit is frozen and shipped to ~~North American~~ the United States to be used in the manufacture of ice creams, jams and other products. In Central America there are now small plantings in Guatemala, El Salvador and perhaps elsewhere to supply local markets. ~~In Ecuador~~ At Guachi, near Ambato, Ecuador, strawberries have been grown on the high plateau (about 9500 feet) for more than three hundred years, having been introduced from Chile, probably via Peru. The situation at Guachi is well-nigh unique, and has attracted much attention from professional horticulturists.

The eminent authority George M. Darrow of the U.S. Department of Agriculture has pointed out that most of the cultivated varieties of today are hybrids of Fragaria chiloensis, the frutilla of Ecuador, which occurs in a wild state along the Pacific coast of North America, and again in southern Chile; and F. virginiana, the delicious ^{aromatic} little wild strawberry of the ~~North~~ United States. The Chilean strawberry, which was taken to Europe in the late 1700s, has given our present-day varieties size and firmness, the American ~~variety~~ species ~~most~~ has given most of the flavor. It might be mentioned that the wild strawberry of Europe, Fragaria vesca, small but ~~aromatic~~ aromatic (less so than F. virginiana) has become naturalised in the vicinity of Bogotá, Colombia, where the fruit is often ^{appears} sold in the market.

Horticultural Varieties

George
 Dr Darrow considers the ^{one} ~~one~~ ^{strawberry} formerly grown at Irapuato to be a selection of F. chiloensis. The ^{one} grown at Guachi also is a pure form of this species. Most of the others ^{seen} ~~grown~~ in tropical America have varying amounts of chiloensis and virginiana "blood".

Strawberry varieties preferred by commercial growers vary from region to region, and from time to time, ~~in marked contrast with varieties of tree fruits such as the apple, of which numerous commercial varieties of today originated fifty to a hundred years ago.~~ The prospective planter in tropical America should bear these facts in mind; he must consider his climate and soil, and the objectives of his program.

Some of the principal varieties which ~~have~~ received attention in tropical America ~~today~~ are described briefly below; forms of the pure chiloensis species are not included here for two reasons: their relatively poor dessert quality and their unsatisfactory behavior in several parts ^{regions} of tropical America where they have been planted experimentally.

Missionary. This is the old stand-by, a good berry which for a long time was the ^{principally commercial variety} ~~standard~~ in the southern United States, and which has been grown more widely in tropical America than any other. In recent years it has been superseded in southern Florida, where strawberries are extensively grown by a hybrid known as Florida 90, of which one of the parents was Missionary. This variety ~~is more productive and of excellent quality,~~ is more productive, its fruits are large and of excellent quality, but it has not yet been tested for a sufficient ~~length~~ number of years and in a sufficient number of tropical ^{America} countries to have found ~~its place~~ ^{in this part of the world.}

Klondike is relatively an old variety, which has made a good record in several strawberry-growing regions. It is a large berry, of good

form and ~~firmness~~ quality. It is not being planted extensively at the present time. Blakemore has done well in Guatemala, at 5000 feet. Lassen (Lassen Mammoth) has ^{been planted} ~~done well~~ in Guatemala and El Salvador as good as but it is not well-known as yet. It is not ~~up to~~ ^{as good as} Missionary and ~~other~~ ~~varieties~~ several others in flavor. Tioga has recently been recommended for trial, and it can safely be assumed that every five years or so, new and promising varieties will come upon the scene, which will merit testing, in many tropical regions. Because ~~of its excellent taste and~~ she strawberry is such ~~an excellent fruit~~ an excellent fruit (there is an old saying, "assuredly God might have made a ~~better~~ better berry, but assuredly God never did), and because hybrids can be produced in such a short time, compared with tree fruits, this field has been a favorite one with the plant breeders.

Climate and Soil

Strawberries are grown successfully in tropical America from elevations of 2000 feet (and even lower in special cases) up to 7500 in Central America, 10,000 near the Equator. ~~They are definitely~~ ~~length of day~~. After his visit to tropical America in 1952, ~~Dr~~ Darrow wrote that ~~the~~ fruit of the best ~~quality~~ ~~flavor~~ flavor was produced at elevations of 5000 or 6000 feet; this is an effect of cold weather, of course. ^{Another point:} The strawberry is one of those plants which shows a definite reaction to length of day, depending upon distance from the Equator; ^{and perhaps altitude} in Honduras, the Missionary variety ^{at 2500 feet} ~~produces~~ yields fruit abundantly from January to June, but makes ^{no} ~~any~~ runners during that period. From June to December there are abundant runners but little fruit. Differences in altitude, however, seem to have an effect on this sequence.

While not exacting as regards soil, a good loam rich in organic matter is ideal. Heavier soils may require some tillage to maintain them in favorable condition. The soils which have given real trouble in tropical America, ^{in those instances} where horticultural varieties, not pure chiloensis are concerned, are the volcanic sands and very sandy loams, ~~in~~ which ~~is~~ ~~are~~ ~~difficult~~ ~~to~~ ~~supply~~ ~~sufficient~~ are difficult to keep sufficiently moist. These soils should probably be avoided.

~~Cultural-practice~~

Planting and Care

Right here it seems appropriate to present a program ~~which is based~~ ~~on the results of~~ ~~the~~ ~~experience~~ ~~of~~ ~~the~~ ~~past~~ ~~years~~ ~~of~~ ~~experience~~ ~~in~~ ~~the~~ ~~tropics~~ ~~of~~ ~~Central~~ ~~and~~ ~~South~~ ~~America~~ based upon recent experience in tropical America:

1. If planting is to be done on a commercial scale, use only varieties which ~~are~~ ~~have~~ stood the test of time. Plant new varieties experimentally.
2. Plant at the right time of the year. *This varies from region to region*
3. Maintain the plantings for one year, then replant. *Water* This is of course common practice, in home gardens especially, to maintain plants for two or even three years, but commercial growers have found it more profitable to take off one crop only, then replant if possible with ~~young~~ strong young plants which have been kept in cold storage for some time.

This last point has been emphasized by ^{George} Dr. Darrow, who also suggests that certified disease-free stock only should be used. He also ~~men-~~ ^{will not be} tions the desirability of planting only in fumigated soil. It is ~~is~~ ~~not~~ easy for small commercial growers in tropical America to carry out this part of the program. Growers in Mexico sometimes ~~are~~ ^{certified} import ~~an~~ new stock annually from the United States, where the plants have gone through a cold season; it has been suggested that locally-grown plants

might be kept in a refrigerator (not too cold) for some time before going out in the field.

Plants may be set about a foot apart in rows, the spacing between which depends somewhat upon the fertility of the soil and how much tillage will be required. The use of organic manures is excellent practice, but these are not easily obtainable in tropical America in large quantities. ~~Little experience has been had~~ Chemical fertilizers will doubtless come into more general use when commercial strawberry cultivation is more extensively ^{and} practiced in tropical America generally; it is ^{impossible} inadvisable to make recommendations which are applicable to a wide range of soils, and other conditions. Each grower will have to depend upon the experience of his neighbors or work it out for himself on the basis of carefully conducted trials.

Not much information is available regarding diseases and insect pests in the more tropical regions. Darrow reported in 1952 that the "Missionary variety was entirely free of leaf diseases wherever seen. In contrast, the Parramos ^(a) variety of European origin, and not well known outside a limited area in Guatemala) was heavily infested with both leaf-spot and leaf scorch, both of which were damaging the plants. In Ecuador, the Ambato (Guachi) strawberry was severely infested with leaf scorch. It was also badly ^{attacked} infested with leaf spot..... Aphids were common on the strawberries in Guatemala, Honduras and Ecuador". If strawberry ^{growing} culture follows the trend of other crop plants, we can expect to see pests become more serious as areas in cultivation become more extensive.

STRAWBERRIES IN MEXICO, CENTRAL AMERICA, COLOMBIA, AND ECUADOR

George M. Darrow¹

FROM JANUARY 19 TO MARCH 19, 1952, while making a survey of temperate fruits in the highlands from Mexico to Ecuador, I observed strawberries in most of these countries. Though a minor fruit in Costa Rica, El Salvador, Honduras and Colombia, they were seen in most of the larger city markets in each country. In Mexico and Ecuador, however, strawberries are an important fruit even though bananas, avocados, pineapples, and citrus are abundant and relatively cheap. They are used in many ways in Mexico, possibly in even more ways than in the United States — fresh and in preserves, fruit salads, shortcakes, sauce, fruit drinks, and so forth. In Ecuador, besides being used fresh, they were served as preserves and probably in many other ways. In the other countries there seems to be no reason for their not becoming an equally successful and important crop. At elevations of 2,500 to 3,000 feet the flavor was only fair, but at elevations of 5,000 to 9,500 feet the quality was excellent. In all sections the plants produced the year through and the yields compared well with those in the United States. At no time, so far as could be determined, were the plants without buds, flowers, or fruit.

In the Irapuato area of Mexico, about 200 miles northwest of Mexico City, some 1,000 to 1,500 acres of strawberries are grown on a high, level irrigated plateau. The industry there probably started over 100 years ago to supply Mexico City with strawberries. Now modern freezing and storage plants freeze several million pounds annually for export. Planting is done in the fall and the fields are kept for 3 to 4 years. The plants are set in double rows about 12 inches apart, about 30,000 per acre.

In the semiarid Ambato section of Ecuador the strawberries (*frutillas*) are grown in a few immense fields on a

¹ Principal horticulturist, Bureau of Plant Industry, Soils, and Agri-

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plateau and on hillsides, without irrigation. So far as could be learned, the original fields have not been replanted in the 200 to 400 years since they were first started. There are no rows; the plants are about one per square foot of ground and they cover the entire acreage. The berries are picked about once a week throughout the year (1), carried by man or burros in boxes holding up to a bushel each from Guachi to Ambato, about 6 miles, and then shipped to Quito and other markets. Because of the dry climate and their slow development, they are firm enough to arrive in Quito in excellent condition. They are commonly sold retail by the hundred berries, not by the pound. Short days and cool temperatures make strawberries everbearing.

In all this area from Mexico to Ecuador ordinary varieties of strawberries are everbearing, for the daylight periods the year through are short enough and the temperature low enough to initiate fruit-bud formation. At the equator the day length (sunrise to sunset) is relatively constant the year through; at 20° North latitude it increases gradually from approximately 11 in December to 13-1/3 in June; and at 30° North latitude from 10-1/4 to approximately 14 hours. The daily effective light period for plant growth is slightly longer, however. At 5,000 feet, or above, the temperatures are never high, rarely above 80° F., while the nights are always cool. Frosts occur where strawberries are grown at 5,200 feet at Irapuato in Mexico, at 7,000 feet in Guatemala, and at about 9,000 feet in Colombia and Ecuador. The humidity and intensity of light vary with the local conditions. Rainfall is, of course, extremely variable, ranging from that of a desert to that of a rainforest, even within short distances.

Though all varieties seen at 5,000 feet, or over, produce throughout the year, the time of the heaviest production varies with local conditions. Thus, at Irapuato, Mexico, at about 5,200 feet elevation and 21° North latitude, the heaviest production usually is from February to May, cropping being affected by heavier fruit-bud formation under (1) the somewhat short days of October to December, (2) the lower temperatures of November to January, and (3) the rainy season, June to September. In Guatemala at 14° to 15° North latitude the seasonal change in day length is somewhat less than in the

Irapuato section, but where fields were observed at about 5,600 feet the temperatures are nearly as low. There the peak of the harvest season is December, the period when production is least in the United States. The reason for this production peak was not evident but may be the reaction of a locally grown variety. At about 9,500 feet, near Ambato, Ecuador, at 1° South latitude, cropping was also the year through, but the crops were somewhat larger at recurring periods in February, August, and December (1). At Turrialba, Costa Rica, at an elevation of just over 2,000 feet, in a tropical climate, only one of three identified varieties seemed to be everbearing. At all elevations and in all countries the strawberries seen were making runners and runner plants. Near Cali, Colombia, runners were being produced freely in March.

VARIETIES GROWN

In the Irapuato, Mexico section the chief varieties being grown (Blakemore, Klondike, and Klommore) were introduced from the United States. They are replacing the "Criollo", a selection of apparently pure *Fragaria chiloensis*, long grown in this area. In Guatemala, though the Missionary variety was seen growing well at 6,000 feet, a variety grown at Parramos and here referred to as the "Parramos" berry, with more *F. chiloensis* in its parentage than Missionary, was producing very well and was perhaps better than the latter. In Honduras, Missionary was growing well at 2,600 and 6,000 feet but was more vigorous and better flavored at the higher elevation. In the section around Cali, Colombia, at 3,000 feet the Missionary, grown for preserving, produced very well. At the lower elevations, 2,600 to 3,000 feet, the fruit of the Missionary was more like that of the same variety in North Carolina or Maryland; but at the higher elevations, 5,000 to 6,000 feet, where climate is cooler it was nearer that grown in Florida in midwinter though better flavored. In Ecuador most of the strawberries were grown on the loose, fine, sandy soil near Ambato. All of the several hundred acres there are planted with an ancient perfect-flowered selection of pure *Fragaria chiloensis* which, according to Popenoe (1) was introduced

from Chile to Peru in 1557 and probably taken to Ecuador about the same time. This selection growing near Ambato may well be the original one selected by the Indians in prehistoric times. It is referred to as the "Ambato" strawberry and in this paper the variety is called by that name. The fruit is long blunt-conic, with the calyx covering the stem end of the berry as it does in the wild *F. chiloensis*. The berries average medium in size but vary from large to small, are pale red on the surface, with white flesh. The flavor is good, but not equal to the flavors of the "Parramos" and Missionary varieties at elevations of 6,000 to 8,000 feet. The Ambato variety has less color and flavor than Missionary and other United States varieties and, like most *F. chiloensis* when put under cultivation, is very subject to leaf scorch.

No native strawberry was found in any of the countries visited. However, *Fragaria vesca*, the wood strawberry of Europe, had been introduced and naturalized on mountains at about 10,000 feet in Ecuador and Colombia. At San Rafael (6,800 feet) near Guatemala City a strawberry suggesting *F. moschata* in appearance has become naturalized.

VARIETIES RECOMMENDED

The varieties grown in each area are probably the best available for the conditions under which they are grown. Thus, for all countries from Guatemala to Ecuador the Missionary is probably the best variety for elevations of 2,500 to 6,000 feet. It is the most vigorous variety under most conditions. From 6,000 to 9,500 feet the "Parramos" variety may be the best where it can be irrigated, but it may be too subject to leaf scorch and leaf spot to grow in humid areas unless these diseases are controlled. In the Ambato, Ecuador, section probably no variety other than the Ambato, the *Fragaria chiloensis* selection, can be grown unless irrigation is used, for the annual rainfall is said to average less than 25 inches, possibly less

than 20 (1)

BREEDING

It would seem fairly easy to obtain selections much better adapted than the present varieties. Suggested crosses are *Missionary* × *Parramos* (for Central America); and *Missionary* × *Ambato* (for Ecuador). At first lots of perhaps 1,000 seedlings of each cross should be grown in each location for selecting the best for local use. If crosses were made in the winter of 1952-3, seeds could be available by April 1, 1953. Seedlings could be large enough for field planting 2 to 3 months later. Seedling populations of the crosses recommended may suggest other crosses that might be tried.

DISEASES

The Missionary variety was entirely free of leaf diseases wherever seen. In Mexico the Blakemore, Klondike, and Klommore were remarkably free from leaf diseases, only three single spots on leaves being noted in all fields seen. In contrast, the "Parramos" variety was very heavily infected with both leaf spot and leaf scorch in Guatemala and both were damaging the plants. In Ecuador also, the Ambato strawberry was severely infected with leaf scorch: perhaps 80 percent of the leaves were destroyed by this disease. It was also badly infected with leaf spot along the living fences of *Furcraea cabuya*, an agave relative and along an irrigation ditch that ran through one field, but it was infected in the main part of the fields. It would seem as though the "Parramos" and Ambato varieties could be rapidly cleaned up. Because there are no native strawberries in these areas, the varieties could be propagated in an isolated place; all leaves showing any disease could be destroyed and all new planting could be isolated from old infected fields.

INSECTS

Aphids were common on the strawberries in Guatemala, Honduras, and Ecuador. Those in the first two countries were species of *Capitophora*, which could transmit viruses if they

were present in the fields. The aphids in the Ambato, Ecuador, fields were of other genera, and it is not known whether they could transmit viruses. Every plant examined there was infested with aphids.

In the Cartago area of Costa Rica, at about 4,000 feet elevation, white grubs were reported to have destroyed the strawberry fields. These rarely cause serious losses in the United States where they are usually controlled by planting strawberries after cultivated crops have been grown. Chlordane mixed with the soil at a rate of ten pounds of dust per acre should control the grubs. No root lice and no bud weevil (clipper) were seen or reported. Slugs were occasionally seen and reported in the more humid regions.

SOIL FERTILITY

In Mexico there seemed to be little use of fertilizers, even though strawberries had been grown in the area for perhaps 100 years. Tests for the need of fertilizers, especially of nitrogen, seemed to be indicated.

In the fields at Parramos, Guatemala, heavy applications of complete fertilizers were said to be used and the plants were vigorous and very productive. In the Ambato fields apparently no fertilizer was used; nor had any ever been used, so far as we could learn. Tests for the need of fertilizer could well be made.

SUMMARY AND RECOMMENDATIONS

The Missionary variety is suggested as the only variety for testing for all locations at 2,500 to 6,000 feet. It is probably at its best at 4,500 to 6,000 feet. It should probably be tested in comparison with the "Parramos" in Central America at 6,000 to 9,500 feet. Both "Parramos" and Missionary should be tested at 6,000 to 9,500 feet in Colombia and Ecuador under irrigation except where the rainfall is adequate. Though the Ambato strawberry as grown in Ecuador is remarkably firm and drought-resistant, it is very subject to leaf scorch, is

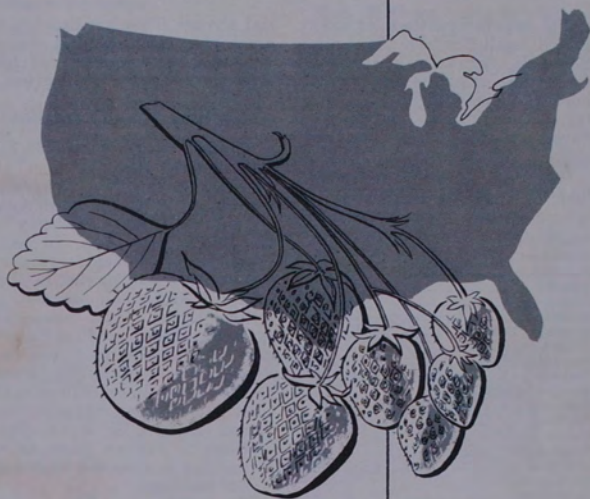
white-fleshed, and is not very attractive or highly flavored. Breeding work, using the Missionary, "Parramos" and Ambato varieties, seems warranted and should result in better varieties for each country. By sanitary means, pinching off all diseased leaves and propagating in an isolated place, far better planting stocks of the "Parramos" and Ambato varieties should be made available. Aphids should be eliminated from present fields by the use of modern insecticides, preferably those that break down quickly, because of the continuous production of the fruit. Trials of fertilizers, especially nitrogen, are needed in both Mexico and Ecuador. Probably double-hill rows with plants spaced 12 inches each way in the row and the double rows 36 inches from center to center should be used in most areas.

LITERATURE CITED

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STRAWBERRY VARIETIES

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