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A PRELIMINARY STUDY OF
BARRENNESS OF GOOSEBERRIES
IN MICHIGAN

Thesis for the Degree of M. S.
Glenn H. Cowles
1937

THESIS

0075

Gooseberries

Horticulture - Fruit-culture

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Michigan State College

A Preliminary Study of Barrenness
of Gooseberries in Michigan

A Dissertation Submitted to
The Faculty of The Division of Horticulture
in Candidacy for the Degree of
Master of Science

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East Lansing, Michigan

June 1937

Approved June 5, 1937

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THESIS

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INTRODUCTION

Owners of gooseberry plantations in various sections of Michigan have from time to time made inquiry concerning a barren condition of individual bushes characterized by excessive vigor. The more painstaking and prudent growers have attempted to remedy this condition by roguing out these unprofitable plants or by special fertilizer applications, but barrenness has continued to be a problem. Nevertheless in spite of this and other difficulties, Michigan canners packed 5600 tons of gooseberries in 1934, a year of great drought. At present (1937) there is much renewed interest in this fruit as the growers report a good price the past season. Thus, any light that may be cast upon the subject of gooseberry barrenness would seem timely.

HISTORICAL BACKGROUND

All of the important commercial varieties of gooseberries which have become popular in the United States originated directly from North American species. Of the dozen or more varieties to gain prominence, only three are extensively planted at the present time, namely: Downing, most widely grown in the United States; Oregon (Oregon Champion), in Rocky Mountain and Pacific Coast States; and Poorman, the newest of the three, now

on trial in various parts of the United States. Even Downing, the old reliable, is but 80 years old, having been introduced by Charles Downing in 1855 (8). It is recognized of course, that the gooseberry attained its greatest development in England during the latter portion of the twentieth century. This, however was with European varieties seldom found in the United States.

REVIEW OF LITERATURE

A great dearth of material is noted by all who attempt to locate any reference on the subject of gooseberry barrenness. This is due partly to the fact that gooseberries and currants have generally been treated together, and partly because both of these fruits are minor and often neglected. A careful review of the literature since 1900 showed only two references on either gooseberries or currants that could be construed as having any bearing on the subject. The first is a report by P. Thayer (9) describing a variation in the Downing gooseberry, which is probably identical to the barren type under consideration in this paper. A second is an investigation on the American out-lawed species, black currants, by J. Amos (1) at the East Malling Research Station and might possibly be in the nature of a parallel for that species. He reports these "rogue" varieties as having no

commercial value. "Rogue" bushes were inarched with normals, others were connected directly by an arrangement of tubes, and in all, 103 successful transmissions were made. The normal plants, however, did not show rogue characteristics until the second season. Further, this "unprofitable rogue" has many characteristics quite different from the barrenness under consideration in this paper.

DEFINITION OF TYPES

Barrenness of one sort or another has vexed the fruit grower since early times. It has been reported in all fruits but as here used deals only with an unfruitful condition of the Downing gooseberry.

Early in this investigation it was found that grower reports as to the behavior and appearance of these so-called "Bull" or barren type bushes varied considerably. Thus, it became imperative to delineate the type or types under consideration. Field surveys were accordingly initiated in four plantations totaling 29 acres. These varying reports were soon found to be due to intermediate or possibly transitional stages. See Figure 4. Often it was difficult if not impossible to differentiate barrenness of the intermediate "Bull" type from barrenness due to various common and well-

known causes. These barren types were found to be scattered throughout each patch in a hit and miss manner. It is also quite common to find a rather typical barren plant which will have one or more of its branches producing a normal crop, and with few and small berries throughout the remainder of the bush. However, the typical "Bull" or barren type is easily recognized even at a distance by its large size and extremely vegetative condition. The comparative size of a "Bull" bush and a normal plant of the same age is clearly shown in Figure 1.



Fig. 1.--The "Barren" type bush on the left produced four pounds in 1936 while the "Normal" on the right produced over seven pounds.

These two plants are the same age, apparently the

same variety, and only eight feet apart. Figures 2 and 3 are also photographs made in the same field and show foliage differences as seen at a few feet.



Fig. 2.--Normal fruitful bush with a fair crop of berries and wide flat leaves.



Fig. 3.--"Bull" bush with scattered fruits and narrow puckered leaves.

Figure 4 was taken against the sky to show the large size and sparse foliage of the so-called "intermediate" type which so confused the early reports.



Fig. 4.--Barren type bush with long shoot growth but scant foliage. (Intermediate type).

The contrast between typical "Bull" bushes and representative normals with the size of a picking lug is shown in Figures 5 and 6.



Fig. 5.--Normal, yielding a good crop of 13 pounds in 1936.



Fig. 6.--"Bull" bush nearly four times as large as the normal in Fig. 5 but yields only 8½ pounds.

Representative branches of the two types were cut and

photographed, as shown in Figures 7 and 8.



Fig. 7.--Representative branch from "Bull" bush.

Fig. 8.--Representative branch from a "Normal" bush with a fair crop of berries.

Upon close observation it is found that the barren bushes have more deeply cleft leaves which are held in a more upright position and have a more pointed appearance than do the average normal plants. This difference is more clearly shown if the leaves are removed and spread out on a flat surface. This was done in Figure 9,

which shows all of the leaves from a barren branch on the one hand contrasted with the leaves of a representative normal limb on the other.



Fig. 9.--Contrasting normal wide leaves on the one hand with narrow deeply cleft "Bull" bush leaves on the other.

These differences are further contrasted in Table I. At harvest time the difference is most apparent as the "Bulls" yield a maximum estimated at 70 per cent of a crop and from this on down to a practically barren condition of three to five small berries on one very large limb.

TABLE I

CONTRASTING NORMAL AND BARREN CHARACTERISTICS

TABLE I

CONTRASTING NORMAL AND BARREN CHARACTERISTICS

Points of Comparison	Normal	"Bull"
Leaf Characteristics:		
Petiole size	Medium	Thinner than normal
Angle of petiole	Normal for Grossularia	Less than normal
Blade size	"	" " "
Upper surface	Apparently	very similiar
Lower surface	"	" "
Length of lobes	Terminal equal to lateral	Terminal longer
Length of sinuses	Slightly cleft	Deeply cleft
Blade shape	Reniform to deltoid	Ovate to lanceolate
Blade apex	Obtuse to acute	Acute to acuminate
Blade base	Truncate to obtuse	Obtuse to acute
Blade margins	Crenate	Serrate or incised
Blade segment-ations	Indistinctly palmately lobed	Distinctly lobed

MATERIALS AND METHODS OF PROCEDURE

(a)

OCEANA COUNTY AN IDEAL LOCATION FOR WORK

As some of the largest commercial gooseberry plantations of the state are located in the Oceana

county fruit district, it is an ideal place to pursue an investigation with this fruit, though general observations throughout this district disclosed many plantations in such a state of general neglect as to be quite useless. Nevertheless, four were selected as representative, two in Hart Township and two in Shelby Township.

(b)

FIELD SURVEYS

A nine-year old plantation of ten acres was first selected for this field survey work. Two plots of ten rows each with from 76 to 79 bushes in each row were laid out. In addition to these, when frost injury became evident in 1934, two new plantations were selected. These were located on lighter soil but on such a high elevation as to be nearly free from injurious frosts. In all of these plots field surveys were made and the condition of each plant was recorded for 1934, 1935, and 1936. Also, yield records, to be used as corroborative evidence, were secured whenever possible. However, because of severe droughts, early spring frosts, uncontrolled cutworm infestations, and severe attacks of mildew dependable data could be secured for only two plots, one containing 759 bushes and the other 233. In these plots accurate tabulations were secured for each bush for the

three successive years. From these it is possible to ascertain which are "Bull" bushes, which are normal, and which should be classified as small or inferior. Also, it is possible to determine if there were any changes toward or away from the "Bull" or barren type. Notes on flower, leaf, and other plant characteristics were taken from these plants at the proper time of the season.

(c)

ATTEMPT TO TRANSMIT "BULL" CONDITION

Early in the spring of 1934 dormant wood was cut and stored. "Bull" scions were later set on normal bushes and normal scions on "Bull" bushes. Several scions were placed on each plant. The test plants selected were as typical as possible and scattered throughout Plots I and II. These scions failed to take and Plot I was lost after the drought. Nevertheless, 17 plants remained and these were watched very carefully. If it were a virus that caused this barren condition, then these grafts might have transmitted the disease as the cambium layers were brought together. This would seem more probable as four or more scions were set on each bush.

(d)

(d)

BLOSSOM COUNTS WERE MADE

As this study was initiated it was thought possible that the barren bushes failed to differentiate sufficient fruit buds. This was soon disproven the following season by a field inspection of the two types of plants during full bloom.

In order to secure a numerical sample of this condition blossom counts were taken in Plot I (discontinued after drought of 1934) and in Plot II, only in 1935 these were ruined by spring frosts. This was repeated in 1936 when counts were made and percentage of fruit-set determined ahead of a late spring frost which did considerable damage in the low areas.

As more light was thrown on the blossom-set problem the need of investigating the flower mechanism became more and more evident.

(e)

COLLECTION AND PREPARATION OF HISTOLOGICAL
MATERIAL

A preliminary sampling of flowers had been taken in 1934. These were subsequently sectioned and stained to show pollen-tube development. The regular paraffin

method was followed except that n-butyl alcohol was substituted for xylol (at the suggestion of Dr. De Zeeuw) as it speeds up the work by combining the dehydrating and clearing processes and also does not harden bud scales. The sections were cut at twelve microns and stained with Safranin "O" on the advice of G. F. Gray who had had exceptionally clear differentiation of pollen tubes when working with *Vaccinium*.

This first material indicated the need of much more intensive sampling of both types of blossoms (i.e., "Bull" and normal). These were taken at the same time in the hope that a variation could be found in the two types which results in the premature dropping of "Bull" blossoms and in the retention of sufficient flowers by normal plants to insure a full crop of fruit. These samples were later collected and handled as before. The slides from this material not only shed some light upon the problem of blossom fall, but further pointed the way for more specific investigations of pollen-tube formation. Little of a concrete nature could be learned from these samples as we find blossoms of varying ages on a given bush and thus pistils, stigmatic surfaces, and pollen tubes in varying stages of development.

This clearly indicated the further need of hand-

pollination of both types of pistils so that pollen-tube development could be followed and that pre-fertilization and post-fertilization stages could be determined at stated intervals. Accordingly, unopened buds were emasculated and covered with manilla bags. Two days later each pistil that appeared normal and healthy was pollinated by touching the stigmatic surfaces with a dehiscent anther from the same plant. A mature anther is readily distinguishable with the unaided eye after its appearance has been verified by the hand lens. Samples were then to be taken every 24, 48, 72, and 124 hours. The five-day sample was injured by an unseasonable frost. However, the early samples were made and placed in killing solution in the field to be sure of instant termination of all life processes.

These samples were in due time cleared, sectioned, and stained as before. Several different stains were tried but Safranin "O" seemed superior for pollen-tube differentiation for *Ribes* as well as *Vaccinium*.

PRESENTATION OF RESULTS

(a)

ECONOMIC ASPECTS

The field survey material was so plotted for

each individual plant that its growth and fruition for 1934, 1935, and 1936 could be read at a glance. From these plottings the bushes were classified as follows: normal, i.e., normal in 1934, normal in 1935, and normal in 1936, or N-N-N; barren or "Bull" as indicated by B-B-B, for the three years as above; X---B, i.e., changing to the "Bull" type; B---X, a barren bush changing to something else, during the three years under consideration; and five other groups of lesser importance in this study. These in turn were summarized (with production totals and averages for each type) as shown in Tables II and III.

TABLE II

THE TOTAL AND AVERAGE YIELDS FOR THE PLANT TYPES
IN PLOT III

Type of bush*	No. in Plot	% of Total	Total Lbs. Berries			Av. per 3 Year Plant Average			
			1934	1935	1936	'34	'35	'36	
N-N-N	80	34	353	491	370	4	6	5	5
B-B-B	12	5	9	58	67	1	5	6	4
X---B	4	2	10	20	16	3	5	4	4
B---X	6	3	11	35	34	2	6	6	5
X-B-X	8	4	34	67	52	4	8	7	6
L's-N's	26	11	177	320	199	7	2	8	9

TABLE II (continued)

THE TOTAL AND AVERAGE YIELDS FOR THE PLANT

TYPES IN PLOT III

Type of Bush*	No. in Plot	% of Total	Total Lbs. Berries			Av. per Plant			3 Year Average
			1934	1935	1936	'34	'35	'36	
S---N	49	21	99	174	111	2	4	2	3
Misc.	48	21	65	95	33	1	2	1	1

*For bush types see key.

Key For Tables II and III

N--Normal

Illustrations

B--"Bull"

N-N-N--Normal '34, '35, and '36.

X--Some other type

B-B-B--"Bull" '34, '35, and '36.

L--Large

X-B-X--"Bull" in 1935.

S--Small

Misc.--Miscellaneous.

TABLE III

THE TOTAL AND AVERAGE YIELDS FOR THE PLANT

TYPES IN PLOT II

Type of Bush*	No. Plants	% of Plot	Total Lbs.	Av. Yield
N-N-N	259	34	406.8	1.6
B-B-B	72	9.5	32.4	.45
X---B	31	4.1		
B---X	87	11.4		
B-X-B	14	2.0		

TABLE III (continued)

Type of Bush*	No. Plants	% of Plot	Total Lbs.	Av. Yield
S-N	98	12.9		
Misc.	199	26.0		

By reference to Tables II and III, it will be found that Plot III contained only five per cent typical "Bulls", whereas, Plot II contained nine and one-half per cent three-year consecutively barren bushes. This variance is probably explained by the fact that Plot III was in a plantation which had previously been regularly rogued of its typical "Bull" and suspicious plants for some years. At any convenient time following the picking season the bushes were marked and later removed. Plot II on the other hand had not received such treatment and thus contained nearly twice as many barren types. An interesting side light on Plot II is found in the fact that of the 19 "Bull" plants, out of a total of 72, which bore over one-half pound of berries each, 16 were partially dead at picking time. This may be explained by the fact that many woody plants will bear many seeds when they are in such a low state of vigor as to have some or all of their limbs die at the end of the season.

In Table IV the loss due to the presence of

"Bull" bushes in the plantation is calculated for both plots.

TABLE IV

MONETARY LOSS IN PLOTS II AND III

Plot	No. of Plts.	Pltng. Dist.	Plts. per A.	"Bulls" per A.	Av. per	Lbs.			
						Plt.	Loss		
					"N"	"B"	Lbs. "B"	Lbs. A.	¢ .04
II	760	5'x 8'	1089	103	1.6	.45	1.15	118	\$4.72
III	233	6'x 8'	907	45	8.9	3.70	5.20	234	\$9.36
Max.	Loss		1089	103	8.9	3.70	5.20	536	\$21.42

In Plot III, where five per cent were "Bulls" and there were 907 plants per acre, there would, therefore, be 45 "Bull" plants each of which lost its owner an average of 5.2 pounds per plant, or a monetary loss of \$9.36 per acre. This loss was calculated at the rate of four cents per pound which is less than many growers received in 1936. Similarly, in Plot II with an increased number of "Bulls" (9.5 per cent or 103 barren types per acre, as there are 1089 plants per acre in this field) but with very materially decreased yield (due to late weeding and successive early frosts) the loss becomes \$4.72 per acre. This, however, is only part of the story as Plot II has been rogued in prev-

ious years and Plot II is in a very unthrifty condition. Thus, if we were to compute the loss on the basis of the rogued patch (i.e., 9.5 per cent "Bulls") and take as the yield the production of the well-cared-for plot, we find that the value of that loss to be \$21.42.

As previously stated, of the 72 "Bull" plants in Plot II, 16 partially dead plants produced most of the fruit for this group. In fact, 21 of the 32 pounds were produced by the 16 dying plants. This leaves only 11 pounds for the remaining 56 "Bulls" or two-tenths pounds per plant. This low yield is of course important to the grower as it costs him as much to fertilize and cultivate the "Bull" types as it does for a productive bush and even more to prune and spray it because of its comparative large size. The picking cost need not be considered, as this is always specified as a per cent of the pounds picked and is therefore levied against the crop irrespective of variable yields per plant.

All this points directly to the value of rogueing as a remedy for the "Bull" bush variety in gooseberry plantations as the loss was reduced from a possible \$21.42 to an actual \$9.36 or \$4.72. Even in this illustration rogueing had been discontinued for recent years under new management.

In Tables III and IV are found several groups of apparently transition types of partial barrenness all of which showed one or two years barren out of three under survey. An analysis of these 193 plants, all located in Plot II (760 plants), is shown in Tables V, VI, and VII.

TABLE V

AN ANALYSIS OF THE THIRTY-TWO PLANTS IN
PLOT II CHANGING OVER TO "BULL" TYPE

Survey Types			No. of Plants	Totals
1934	1935	1936		
Nor.	Bull	Bull (Dying)	7	
"	Weak	" "	2	9
"	Bull	Bull	6	
Miscellaneous			2	8
Nor.	Nor.	Bull	7	
Small	"	"	3	
Miscellaneous			5	15
4.2 % Total				32

Table V shows that 4.2 per cent of the total bushes changed over to barren types during the period under consideration, i.e., 1934, 1935, and 1936. While this per cent is low, nevertheless a continuous change

of this sort during two or three decades in the life of a plantation would accumulate a greatly lessened yield although an almost imperceptible annual change. Also, it has been a question whether or not "Bull" bushes become weaker and later died. And it was found that nine of 31 had portions dead in 1936. No other trend is noticeable except the fact that 20 plants changed abruptly from one type to another.

TABLE VI

REGROUPING THE BUSHES WHICH CAME OUT

OF THE "BULL" CONDITION

Types as Recorded in Field Work			Number of Plants	Totals
1934	1935	1936		
Bull	Bull	Nor.	25	
"	Wk. "	"	8	
"	" "	Weak	6	
Miscellaneous			4	43
Bull	Nor.	Nor.	32	
Miscellaneous			12	44
11.4 % Total				87

In Table VI are classified the "Bulls" located in 1934 which had changed over to some other type by 1936. From this it will be seen that 11 per cent of the

total plants in Plot II had been cured or partially cured by normal handling of a large commercial plantation, even though no rogueing had been practiced. It is further shown that 57 of the 87 bushes made this transition in one season and with no intermediate stage or stages.

It is also shown in Table VI that 11 per cent came out of the "Bull" stage while in Table V only four per cent entered. This would indicate that this barren condition would be eliminated at the rate of about seven per cent per year. However, field observations show that there are more "Bulls" in an old patch than in a young one, which, in turn would indicate that many of those plants apparently cured in 1936 will again revert to a "Bull" form. This also agrees with growers' opinions.

TABLE VII

REMAINING GROUPS IN PLOT II WHERE THE "BULL"
TYPES APPEARED

Survey Types			No. Bushes	Totals
1934	1935	1936		
Nor.	Bull	Nor.	30	
"	Wk. "	"	22	
Miscellaneous			7	59

TABLE VII (continued)

REMAINING GROUPS IN PLOT II WHERE THE "BULL"
TYPES APPEARED

Survey Types			No. Bushes	Totals
1934	1935	1936		
Bull	Nor.	Bull Dying	6	
"	"	Bull	4	
Miscellaneous			4	14
7.9 % Total				73

In Table VII are shown these remaining bushes which exhibited the barren type but did not fall in any of the previous classifications. This represented nearly 10 per cent of the plot, and of the 73 plants concerned, 14 or two per cent changed from "Bull" in 1934 to another type in 1935 and back again to a "Bull" in 1936. (It is possible that this two per cent indicates a portion of those plants that might be in a state of biennial bearing found in tree fruits).

From Tables VI, VII, and VIII it may be calculated that 165 plants change to, or away from, the "Bull" type from one season to the next. These sudden switches would indicate a definite need to test the food relationships of these bushes, and such work is to go on in 1937.

ANALYSIS OF GROWERS OBSERVATIONS

Plantation owners have various theories concerning the occurrence of the "Bull" bushes in their gooseberry patches. Most of them had observed the condition and some had practiced a system of rogueing. Some even insist that they can spot those bushes which are about to become barren, and others believe that a plant may be barren one year, productive the next, and so on, according to favorable or unfavorable environment.

Various causes for this condition have been suggested by growers, field men, and others. Some of these causes are: (1) mixture of varieties, (2) development and propagation of unfruitful (but excessively vegetative) bud-sports; parenthetically, it should be noted that this vigorous type would be the one selected for propagation before the "Bull" type became so well-known, (3) a disease of one sort or another (4) favorable or unfavorable moisture relationship, and (5) variations in nutritional relations.

Undesirable varieties or unproductive bud-sports are entirely improbable in this case as several of the plantations have been subjected to systematic rogueing, which, if continued long enough would eliminate these sorts. Also, an inferior variety or a bud-sport

would not account for the fact that "Bull" bushes often have one or more branches which bear normal crops when the remainder of the bush is nearly, if not entirely, barren.

The third point, disease, was to have been tested by grafting the "Bull" type on normal and visa-versa. However, this point is not fully clear as the great drought of 1934 so nearly killed many of the plants in Plot I as to render them useless and also caused the desiccation and resultant death of the scions set on the test bushes of Plot II. This was again attempted in 1935, but again with little success, partly because the genus *Ribes* seems very difficult to graft and possibly because the scions, although stored under refrigeration, were injured by too heavy a coating of very hot wax. There is a good possibility, however, that since the cambium layers touched together, there may have been a transfer of any possible disease or virus. This would seem probable as many grafts were set on each of the 17 plants shown in Table VIII.

TABLE VIII

APPEARANCE AND YIELDS OF GRAFTED PLANTS

IN PLOT II

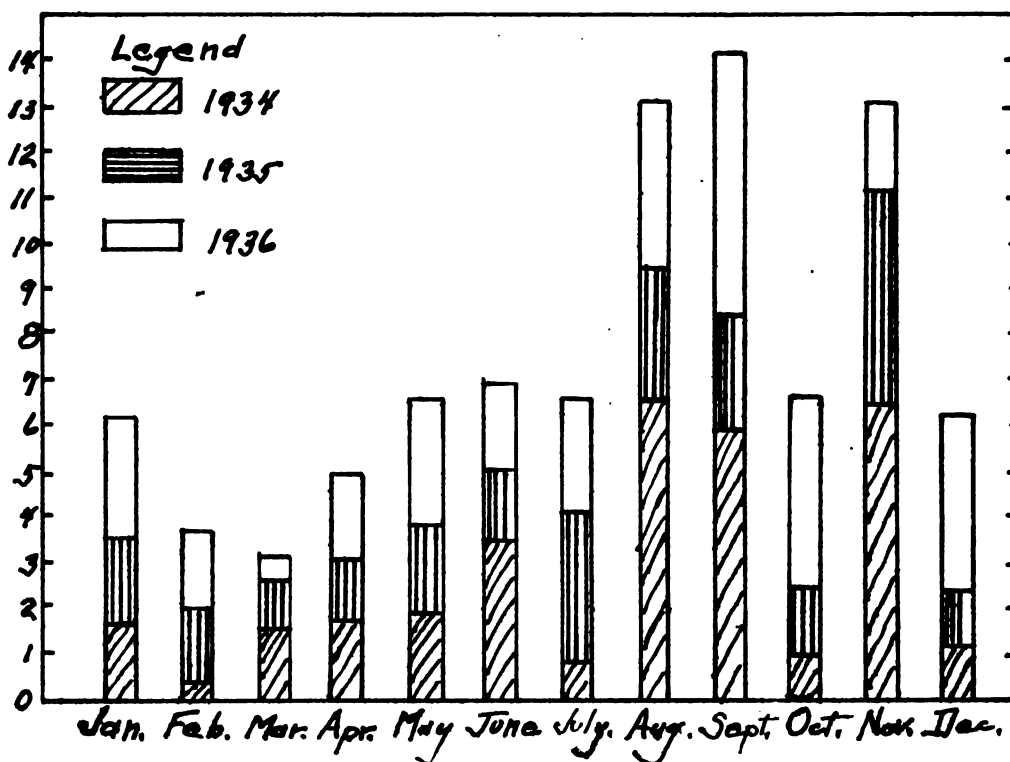
Plant No.	Grafted With	Appearance			Yields in
		1934	1935	1936	'36 in Lbs.
75-2(N)	74-39(B)	Nor.	Nor.	Nor.	3.5
75-3	74-39	"	Bull	"	5.5
75-5	74-39	"	Nor.	"	.75
78-44(N)	76-40(B)	"	Bull	Bull Dying	Trace
78-44(N)	76-40(B)	"	Nor.	Nor.	.75
78-15(N)	73-7(B)	"	"	"	1.50
76-3(B)	75-13(N)	Bull	Bull	Nor.	4.5
76-4(B)	75-13	"	Wk.	"	3.75
76-5(B)	75-13	"	Nor.	Bull	.25
73-7(B)	72-17(N)	"	Bull	Bull Dying	1.00
76-10(B)	72-17	"	Wk. "	" "	1.25
73-35(B)	71-3(N)	"	" "	Bull	Trace
71-12(B)	71-3	"	Bull	"	.5
71.20(B)	71-3	"	"	"	.5
76-40(B)	78-44(N)	"	"	Nor.	6.0
76-28(B)	78-31(N)	"	Wk."	Bull Dying	.5
73-7(B)	78-15(N)	"	Bull	" "	1.0

TABLE VIII (continued)

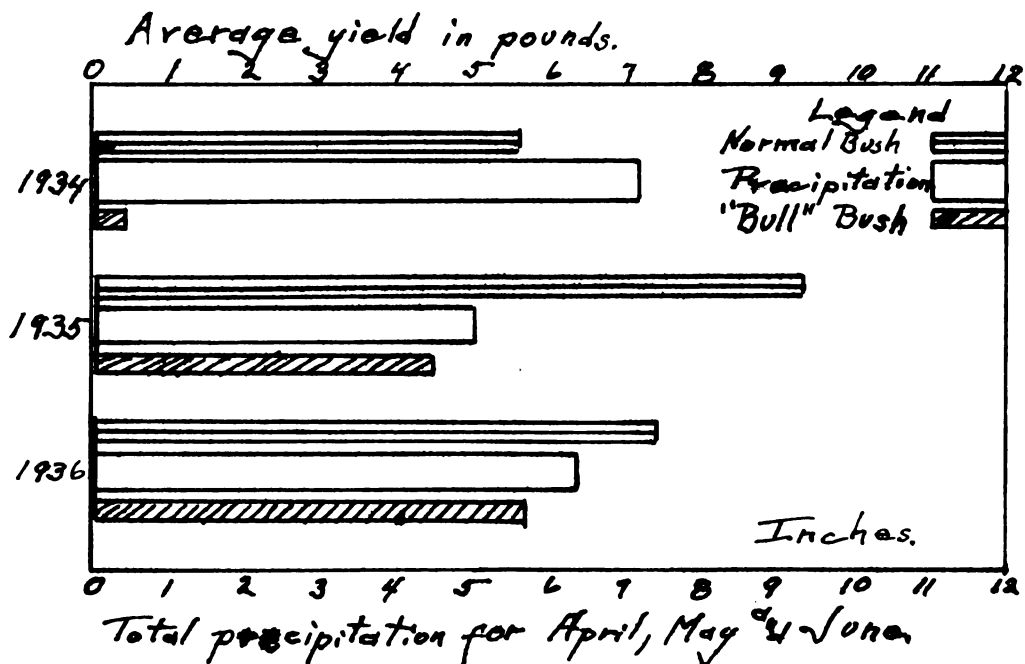
Plot II Average normal yield	1.6
" Bull "	.45

This of course, is a small number of test bushes from which to draw conclusions but the table is interesting if nothing more. Of the six normal plants on which "Bull" scions were set one has definitely and clearly changed over to the barren type and two others have such low yields as compared to the average normal and to the yields of neighboring bushes as to be indicative of a definite trend away from the normal. On the other hand, three of the 11 "Bull" bushes produced a normal yield in 1936 and also were normal in appearance. This is in line with a previous finding in which barren plants became normal and produced normal yields.

As to moisture relationships, the records of the Hart Weather Bureau sub-station were consulted and are shown in Graphs I and II.



Graph 1. Showing precipitation in Oceana county during 1934, 1935, and 1936.



Graph 2. Showing the relation of "Bull" and normal yields to early summer precipitation.

This shows the monthly precipitation for three years. The bar graph shows the total rainfall for the three-month period of April, May, and June. It also shows the average yields of "Bulls" compared with normals for Plot III. The precipitation reached extreme lows in February and July of 1934. The first low probably greatly reduced the current season's yield (to five and .61 pounds for normal average plants) and reduced the yields of the "Bulls" to almost nothing (.78 pounds). The second low probably had a very pronounced effect upon the fruit-bud differentiation as growth was entirely stopped in Plot II. Many fruit buds must have been formed at that time as we find the 1935 yields at over nine pounds for normals and about four and one-half pounds for "Bulls". Also, this yield was produced in spite of the comparatively low April, May, and June rainfall of that year. To continue this study into 1936 shows that the normal yields are only 1.6 pounds more than the "Bulls". This would indicate that environmental factors have a pronounced effect upon the yield of "Bull" types. This result is based upon 12 "Bulls", 106 normals, and 233 total bushes in Plot III.

Something as to the nutritional variation between the four plots is known but nothing as to the variation between individual bushes. Plot II, located

upon heavy clay soil, is usually cultivated from five to seven times per season, sprayed two or three times, and usually receives no fertilizer of any kind. On the other hand, Plot III is on a good strong sandy silt loam. An average year's schedule for this would include about the following: plowed twice in early spring, heavily fertilized with barnyard manure, sprayed once if necessary, and cultivated three to six times. The effect of these treatments is clearly shown by comparing the average yield of normal plants in Plot II and III, which are 1.06 pounds and 5.06 pounds respectively in 1936.

In addition to the external conditions suggested by growers, Gardner⁴ mentions the following as being associated with unfruitfulness: (a) pruning, (b) grafting, (c) locality, (d) season, (e) temperature, (f) light, (g) rain at blossom time, (h) wind, (i) spraying at blossom time, (j) age of plants. Inasmuch as the barren plants are scattered throughout each patch and since both "Bull" and normal are equally subject to and affected by all of the above conditions excepting the last (which is taken up under the problem of blossom-set) it seems reasonable to pass over these factors as being extremely unlikely causes of gooseberry barrenness. Thus completing the study of external factors, we shall look further to the internal factors as affecting un-

fruitfulness which are considered under a later heading.

THE BLOSSOM-SET PROBLEM

Field inspection of gooseberries in blossom soon established the fact that "Bulls" blossom about as full as normals or at least bear far more blossoms than would be needed for a heavy crop. There seemed to be little difference in the appearance of the blossoms as they first open, possibly the "Bull" blossoms are slightly more pale than the normals. In a few days there is no question about this pallor and the blossoms shower from the bushes whenever a branch is touched. The blossoms continue to fall until less than one-fourth of the crop remains. Sometimes only a handful of berries will be matured on a branch or even on an entire bush standing from four feet high and spreading over an area of six or seven feet each way,

TABLE IX

BLOSSOM COUNTS

(Two Ten-year Old Plants)

Plant No.	Blossoms	Set	%
76-6(B)	7,944	38	.5
76-8(N)	9,783	1100	11

TABLE IX(continued)
(Two Five-year Old Plants)

Plant No.	Blossoms	Set	%
Large 32-5(B)	6,011	617	12.6
Small 28-5(N)	4,097	989	24.1

Table X shows that although only four plants were counted they bore nearly 28,000 blossoms with only .5 per cent blossom-set in a ten-year old "Bull" up to 24 per cent in a six-year old normal. Further, it will be noted that the blossom-set was very much greater in the young plants than in the older plants. Inasmuch as these plants are on similiar exposures (northern slopes), and also have similiar elevations, some importance may be attached to these findings and also, as these plants were seemingly fairly representative and only further confirm field observations.

INTERNAL FACTORS

This leads us directly to a consideration of those internal factors that are associated with un-⁵fruitfulness which Gardner lists as follows: imperfect flowers, dichogamy, degenerating or abortive pistil or ovules, and impotence of pollen. By an inspection of the blossoms, perfect flowers with equal

pistils and stamens are found in both "Bull" and normal plants. See Plate I. Also, it is well to note that the bushes from which the sample flowers were secured have been typical for the type for three successive years. The second point, dichogamy, could be of little importance in this case as so many bees were present at the time of blooming as to insure wide distribution of pollen throughout the patch. Further, there is great variation in the maturing of the blossoms on various parts of the bush and bushes in various locations on the plantation. It is possible of course, to find degenerating pistils on both normal and barren bushes, but the great majority in both cases are apparently normal in every way. Lastly, the pollen seemed normal as many of the pollen grains had grown pollen tubes as shown by cross and longitudinal sections of the stigmatic surfaces and longitudinal sections of styles from both types of flowers.

Included under genetic factors (6) are hybridity and incompatibility. One of the well-established characteristics of the unfruitful type is its ability to change from time to time and that would hardly be true of a hybrid. Unfortunately, in this investigation no artificial pollen germination was attempted but as pointed out many pollen tubes enter the stigma and start downward through styler tissue. A comparison of

the ovules of each type disclosed a normal embryo sac and associated tissues in the younger blossoms. Then, since the ovules are not fertilized in time to set fruit, a clear case of incompatibility is indicated.

Those causes of unfruitfulness due to physiological influences include, according to Gardner, et al., (7) slow growth of pollen tube, premature or delayed pollination, and variations in the nutritive conditions within the plant.

The continuous growth of the pollen tubes was not determined but the early growth in hand-pollinated blossoms is readily compared in the longitudinal sections, and little difference is noted between normals and "Bulls". That pollination was complete and immediate was evinced by the presence of many pollinizers in the plantation at the time of full bloom, (which occurred during several days of clear warm weather). Further, the "Bulls" are scattered throughout the patch and would have neither better nor poorer opportunities for pollination than normal neighbors in adjoining rows. It is a well-known fact that nutritive conditions of the plant greatly affect the growth of the pollen tube through the stylar tissue. The rate of growth may be greatly retarded if the plant fails to have a certain balance between various nutritive substances in its system. We are, therefore, forced again

to the conclusion that nutritive conditions are in some way tied up with barrenness of these so-called "Bull" bushes.

SUMMARY

1. Unproductive types are known to occur in the Downing gooseberry.
2. Field surveys show that five per cent to nine and one-half per cent are of this type.
3. Rogueing of the barren types may reduce a possible loss of \$21.42 to an actual \$4.72.
4. Four and one-half per cent of the bushes changed over to barren types during 1934, 1935, and 1936.
5. "Bulls" do not get weaker or die out as supposed by some.
6. Abrupt changes toward or away from the barren types were noted in one year.
7. Eleven per cent of the bushes changed back to normal by 1936.
8. Environmental factors may have a pronounced effect upon both normal and "Bull" yields.
9. External factors could not be direct causes of barrenness as both types of plants are equally affected.
10. Blossoms occur in about-equal numbers on both

types of plants.

11. Blossoms on "Bull" bushes turn pale and fall leaving as little as five per cent set in some cases.

12. Barren plants apparently have perfect flowers.

13. Pollen tubes penetrate the stigmatic surfaces.

14. Incompatibility seems to be the cause of the small fruit-set.

15. Incompatibility seems to be related in some way with the nutritional conditions within the plant itself.

ACKNOWLEDGEMENTS

The writer wishes to express his appreciation of the services rendered him in his work:

To V. R. Gardner for his assistance and many constructive suggestions; to F. C. Bradford for translating of French and German literature and a kindly interest in the progress of the work, and to G.F. Gray for his suggestions and criticisms of the procedure in the histological studies.

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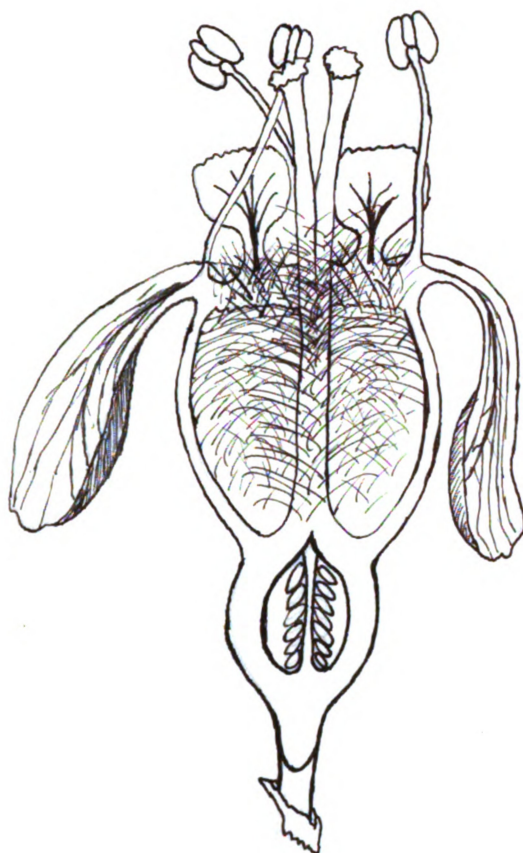


Plate 1.--Showing Cross-section of
the Flower of Downing Gooseberry Rep-
resenting Both Normal and "Bull"
Types.

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