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INHERITANCE OF CERTAIN CHARACTERS OF GRAPES.

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INHERITANCE OF CERTAIN CHARACTERS OF GRAPES.*

U. P. HEDRICK AND R. D. ANTHONY.

SUMMARY.

In the last 25 years, during which time nearly 10,000 seedlings have been grown, various changes in the methods used at the Geneva Experiment Station have been made as the knowledge of breeding laws has been extended.

Results have compelled the belief that improved varieties of grapes will not be produced to any extent until the fundamental laws of heredity are understood. The present aim is to discover these laws.

The work is now progressing mainly along two lines: (1) The determination of the breeding possibilities of varieties of grapes and (2) the study and interpretation of breeding phenomena.

Nearly 200 varieties of grapes have been used in the breeding work.

Much of the value of the early work was lost by growing too few seedlings of each cross.

Recently ***Vitis vinifera*** has been used to a considerable extent in hybridization.

The usual method of emasculation has been ineffective in a few cases and may be open to criticism.

One of the surprises in the study of grape varieties was the failure of many commercial sorts to transmit desirable qualities.

In order to study grape varieties, nearly 3,000 selfed, or pure, seedlings have been grown. These are uniformly lacking in vigor.

The inheritance of those grape characters which have sufficient data available has been discussed in this paper.

Of the two types of stamens, reflexed and upright, the first is correlated with complete, or nearly complete, self-sterility, the second with self-fertility.

Self-sterility is probably caused by impotent pollen. It exists in varying degrees and depends to some extent upon the condition of the vine and environmental factors.

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Self-sterile varieties of grapes being undesirable from a horticultural standpoint, can we eliminate those with reflexed stamens? The following crosses have given upright and reflexed stamens in the indicated ratios:

$$U \times U = 4.3\ U{:}1R$$
$$R \times R = 1.2\ U{:}1R$$
$$R \times U = 1U{:}1R$$
$$U \times R = ?$$

Breeding from the upright varieties only will decrease but not eliminate the seedlings with reflexed stamens.

The following seem to be the results secured in the study of sex inheritance:

Hermaphrodite female × hermaphrodite male = all hermaphrodites.

Hermaphrodite female × pure male = ½ hermaphrodites + ½ males.

Two general laws have been formulated with regard to color of the skin: (1) White is a pure color; and (2) it is recessive to both black and red.

No black variety has proved pure for blackness. Some contain white, others white and red. Red varieties are equally diverse.

The colors of pure seedlings of certain varieties show wide variation, even when derived from varieties of similar color.

In the inheritance of quality the most noticeable thing is the low percentage of seedlings whose quality is good or above good. This is probably due to the leveling influence of the wild ancestors from which the seedlings are but a step removed.

Most grapes of high quality possess some ***V. vinifera*** blood. This predominance of high quality is probably due to the intense selection to which the species has been subjected for centuries.

The pure seedlings on the New York Station grounds have been lower in quality than crossed seedlings.

In the inheritance of size of berry there is no indication of dominance of any one size, though there is a tendency for a variety to produce seedlings approaching its own size.

The oval form of many ***V. vinifera*** hybrids is probably an intermediate between round and a more pronounced oval. Oblate may be a pure form recessive to round.

The season of ripening of the parent influences to a considerable extent the season of the offspring.

A vineyard of 1,500 seedlings bred from 1898 to 1903 has dwindled through selection to less than 75. Of these, 5 have already proved promising enough to be named.

INTRODUCTION.

The breeding of grapes (*Vitis* spp.) was begun in the Horticultural Department of the New York Agricultural Experiment Station about 25 years ago and has been continued throughout this time as a horticultural problem. Nearly 10,000 seedlings have been grown, and of these about 6,000 have fruited. This work was begun about 1885 by Prof. E. S. Goff, who at first grew seedlings and plants from seeds open to cross-pollination. Later he crossed a number of varieties. In 1891 Prof. S. A. Beach became the Station horticulturist, and besides seeking to obtain new varieties he made studies of self-sterile varieties, studied the correlation between the size of seeds and vigor of plants, and did considerable hybridizing. In 1905 the senior author took charge of the work in horticulture at the Station. Mendel's work had just been discovered, and plant breeding was undergoing a stimulus from it. The work with grapes was therefore replanned and extensively added to with a view to studying problems of inheritance. This work has been continued and increased from year to year. Several assistants and associates have spent much of their time working with grapes at this Station. Mr. N. O. Booth worked with grapes from 1901 to 1908; Mr. M. J. Dorsey from 1907 to 1910; Mr. Richard Wellington from 1906 to 1913; Mr. R. D. Anthony, the junior author, began work at this Station in the summer of 1913, and has devoted most of his time to the grape work since then. Upon him has fallen the task of presenting the data in this paper. It is the purpose of this paper to discuss certain results of this work.

AIMS, METHODS, AND MATERIALS.

During this quarter of a century, experience and a better understanding of the principles of breeding have modified many of the methods and changed considerably the nature of the data which are now taken.

The ultimate aim in this work is, of course, the production of improved horticultural varieties. Through the early days, when breeding laws and methods were less understood than now, there was a tendency to make this the immediate as well as the ultimate aim. The fact that the first twenty years of grape breeding produced but one variety worthy a name served to confirm the conviction that this goal would be reached quicker by forgetting it for the time being and bending every effort to the discovery of how grape characters are transmitted.

The work is now proceeding mainly along two lines: (1) The determination of the breeding potentialities of a considerable number of varieties of grapes, especially with the view of finding unit characters; and (2) a review of all the New York Experiment Station breeding data on this fruit, to study and interpret breeding phenomena, accompanying this review with the making of the crosses necessary to throw further light upon doubtful points.

The results secured in testing the breeding possibilities of grape varieties, which will be discussed later, have made it seem desirable to extend this study to all the varieties which show any promise. For this reason nearly 200 different kinds have been used as pollen parents and nearly 100 as maternal parents in this work.

Frequently during the early days of the work seedlings which seemed to lack vigor in the nursery were discarded, instead of being planted in the test vineyards. Though this undoubtedly removed many unpromising seedlings, it seriously decreased the number which fruited, and made the interpretation of results difficult and uncertain. At best the number of seedlings that lived of each cross was smaller than could be desired, and, when this number was still further decreased by selection in the nursery or by untoward circumstances, much of the value of the work from a breeding standpoint was lost.

Another change of method which bids fair to be exceedingly important has been the use of varieties of *Vitis vinifera* in breeding. Every indication points to the desirability of the addition of some of the blood of the European grape to our native sorts. Although we are working primarily to determine breeding laws, there is usually a wide choice of varieties which answer our purpose, and with the growing of nearly 100 varieties of this species on the New York Station grounds we have been able to use several as parents. There are now several hundred hybrids containing *V. vinifera* blood growing on the Station grounds, and these will be increased by many hundreds during the following years.

The methods used in the actual work of crossing are similar to those of most breeders. The female blossoms are emasculated before the calyx cap splits off and are then bagged; the male blossoms are also bagged before the calyx splits. When the pollen is ripe, the bagged male cluster is usually cut from the vine and all or part of it brushed over the emasculated female. Usually some of the male cluster is inclosed in the bag, which is again put over the female after pollination. In a few cases, where the periods of blossoming of two varieties are too widely separated, it has been necessary to save pollen in clean glass jars. It is customary to dip the forceps used in pollination into alcohol with each new variety.

Certain results secured in the summer of 1914 seem to indicate that this method is perhaps open to criticism. While emasculating clusters of the Janesville variety it was found that, although the cap had not split, the pollen in the anthers seemed to be mature, and, as the anthers were ruptured during the emasculation, there was a possibility of self-fertilization taking place. Several clusters were emasculated and bagged without being pollinated. These set nearly the full quota of berries with seeds that have every appearance of

being viable. With two other varieties, clusters emasculated and not pollinated matured a few plump seeds, though the clusters were much below normal. A somewhat similar instance is reported by Beach (1),[1] the variety being the Mills. This point deserves careful study, for if it is found that serious danger of self-pollination exists before the calyx cap splits it will be necessary to change the method — at least to the extent of emasculating the clusters several days before the cap is ready to come off.

All data regarding size and shape have been recorded in comparative terms, instead of the actual measurements being taken. With a limited number of observers and thousands of seedlings of the various fruits to be studied each year, it was a physical impossibility to take measurements and would not have increased the value of the records to any extent from a horticultural point of view, though it would, of course, have furnished interesting material for a statistical study. The value of data reported in comparative terms depends upon the accuracy of the recorder. The work with the grape has always been done by members of the scientific staff, and the observations have usually been checked during several seasons.

GENERAL RESULTS OF THE STUDY OF VARIETIES OF GRAPES.

One of the surprises in the study of varieties of grapes was the failure of many of our commercial sorts to transmit desirable qualities to their progeny. Seedlings of Concord, Niagara, Worden, Delaware, and Catawba grapes have so far proved only disappointments. The best results have been secured from such little-grown varieties as the Ross, Collier, Mills, Jefferson, Diamond, and Winchell. This has made it seem desirable to test all varieties that show any promise. The first step, then, was to secure as many varieties as possible which were of any value and which could be grown in northeastern United States. More than 400 such varieties have fruited in the Station's vineyards and have been described. About 200 of these have been used to a greater or less extent in the breeding work.

As an aid in studying the breeding possibilities of grape varieties the Station has grown nearly 3,000 selfed, or pure, seedlings, using as parents most of those varieties which have entered into the crosses that have been made. These seedlings have thrown much light upon the inheritance of various factors, but they have been so uniformly lacking in vigor as to lead to the belief that only through crossbreeding can we hope to produce improved varieties.

[1] Reference is made by number to "Literature cited," p. 19.

INHERITANCE OF CHARACTERS.

The grape characters discussed in the following pages are those for which sufficient data are available to make such a discussion of value.

SELF-STERILITY.

On the basis of flower type, grapes may be divided into three classes: (1) True hermaphrodites; (2) hermaphrodites functioning as females, owing to completely or partially abortive pollen; and (3) pure males with the pistil absent or rudimentary. Among these classes there are two types of stamens: Those with upright filaments and those in which the filaments bend backward and downward soon after the calyx cap falls off. According to Dorsey (5), this is due to the cells of the outer surface of the reflexed stamens being smaller and having thinner walls.

So far as observed at the New York Station, all pure males have upright stamens. Among the two classes of females Beach (1) found that only those varieties with upright stamens were capable of producing marketable clusters of fruit when self-fertilized. At the same time he reported nine varieties with upright stamens to be self-sterile. Since Beach published his report further work at this Station with three of these nine varieties has proved them self-fertile, and it is probably safe to say that all varieties with upright stamens are self-fertile, though in varying degrees. Reflexed stamens are always correlated with complete or nearly complete self-sterility. Reimer and Detjen (6) found this last conclusion to hold also with *Vitis rotundifolia*, a species not studied at this Station.

The cause of self-sterility in varieties with reflexed stamens seems to be a lack of viability in all or a larger part of the pollen of such varieties. Booth (2) found that such pollen was quite irregular in form and would not germinate in sugar solutions. Reimer and Detjen (6) state " the pollen of all the present cultivated [female] varieties [of *V. rotundifolia*] is worthless." Recently Dorsey (4) has ascribed the cause of this self-sterility to a degeneration in the generative nucleus. While this impotency may be absolute in many of the varieties, in some at least it is only relative. Frequently viable pollen will be found mixed with the usual misshapen, abortive pollen of the self-sterile varieties, and nearly a hundred pure seedlings of the varieties which Beach (1) reported as totally self-sterile have been grown in the Geneva Station vineyard. The degree of sterility seems to depend to some extent upon the condition of the vine due to environmental factors.

From a practical standpoint it is undesirable to grow self-sterile varieties. They will not succeed in the large blocks of the commercial plantation, nor are they always properly fertilized in the small home vineyard. Can we, then, in our grape breeding eliminate

self-sterility? Letting U stand for upright stamens and R for reflex, the following table gives the results of our crosses:

U × U* = 180U + 47R	R × R = 16U + 16R	R × U = 207U + 206R
U selfed = 691U + 152R	R selfed = 94U + 73R	Ratio.........1U:1R
Total....871U + 199R	Total....110U + 89R	U × R = ?
Ratio.........4.3U:1R	Ratio.....1.2U:1R	

Of the varieties whose pure seedlings have entered into the ratio of 4.3 U to 1R, only two, involving 18 seedlings, have given simply upright stamens; consequently it may safely be said that no variety has proved pure for upright stamens. In the remaining crosses of this class the ratios have ranged from 1U to 2R up to 10U to 1R, with the greatest frequency at 2U to 1R. The results with the crossed seedlings are practically the same. Over a thousand seedlings from crosses of one type would be expected to give some rather definite results; yet these results are anything but definite, and apparently no conclusions can be drawn from them except that the varieties are not homozygous for uprightness of stamens.

The ratio of practically 1 to 1 in crosses of varieties with reflexed stamens is perhaps best accounted for by the supposition that the gametic composition of pollen and ovules is not alike. The ratio of 1 to 1 in crosses of reflexed by upright stamens may be covered by the same assumption. It should be noted that the pollen of the upright varieties produces the same ratio as that of the reflexed varieties when both are used on ovules of the reflexed kinds.

Upright varieties have been crossed many times with reflexed sorts and several hundred seedlings should have resulted from these, yet only one plant has survived the vicissitudes of the seed bed and nursery to be planted in the test vineyards. In the last five years 50 crosses have yielded 600 seeds; yet from these there are now in the nurseries but 25 living seedlings. Many of the pollen parents used in these crosses were the same as those used in the cross R × R. In the two crosses R × R and R × U, the pollen from upright and reflexed varieties produced the same results; but comparing this last case, U × R, with the first one, U × U, we see that the pollen of the upright and reflexed varieties has produced quite different results when used on upright sorts. Why this should be is not apparent.

At present there does not seem to be any way of eliminating reflexed stamens, but we can at least decrease the proportion by using for breeding only varieties with upright stamens.

INHERITANCE OF SEX.

Among more than 6,000 seedlings which have flowered in the New York Experiment Station vineyards, less than 100 pure male vines

*The pollen parent is always placed last.

have been found. Of these there are complete breeding records for 62 vines, 51 of which came from crosses in which the pollen parent was a pure male, leaving 11 males recorded as produced by pollen from hermaphrodite plants. Of these, 5 were pure seedlings from one parent, the other 6 from 5 crosses. These 6 were probably hermaphrodites erroneously recorded as males, an error very easy to make when the pistil has a short style and one which has been made several times and corrected by subsequent observations. The parent yielding the 5 males was discarded shortly after being used in breeding, and our records are meager. It was probably an intermediate recorded as a hermaphrodite. Such an intermediate, having both male and hermaphrodite blossoms, is under observation in one of the Station vineyards, and its pollen seems to behave as the pollen of a pure male; in other words, it is reasonable to assume that, excluding these intermediate forms, pollen from hermaphrodite plants will not produce pure males.

The results obtained from pure males as pollen parents are:

Hermaphrodite female × pure male = 56 hermaphrodites + 51 pure males

Following the assumptions usual to such cases, the hermaphrodite would be considered a sex heterozygote and the male a sex homozygote. Yet selfed hermaphrodites yield only hermaphrodites. These results are similar to those obtained at this Station from selfed hermaphrodite strawberries, but differ from Shull's results (7) with species of Lychnis, where the hermaphrodite gave both females and hermaphrodites. This condition might be covered by the assumption that the hermaphrodite is a female in which the addition of a single dose of maleness has caused the production of male organs, the ovules keeping the composition ♀ ♀ and the pollen becoming ♂ ♀:

Hermaphrodite × hermaphrodite = ♀ ♀ × ♂ ♀ = 2 ♂ ♀ + 2 ♀ ♀

Since we have no pure females, we must assume that some condition prevents the formation of individuals with the composition ♀ ♀; therefore, the above cross gives only hermaphrodites. Of course, if we do not attempt to assume the method of origin of the hermaphrodite, the case may be covered by considering the hermaphrodites pure for this character, while the males would be heterozygous:

☿ ☿ × ☿ ☿ = ☿ ☿
☿ ☿ × ☿ ♂ = ☿ ☿ + ☿ ♂

COLOR OF SKIN.

Colors of grapes are not sharply differentiated, grading from white through many shades of red and purple to black. Because of this wide range, the problem of finding varieties which are pure for certain colors has been greatly complicated, yet until we are able to find such pure colors and to study their various combinations our knowledge of the color composition of many varieties will probably be only conjectural.

The thousands of seedlings which have been fruited have made possible the formulation of but two general laws: (1) White is a pure color; and (2) white is recessive to both black and red. White, yellow, green, and amber are all considered under the one term and are regarded as being the absence of red and black.

No black variety that has been tested to an extent sufficient to make the results at all conclusive has proved pure for blackness. Some have a factor for red; others seem to contain only black and its absence, white, while still others have both white and red progeny.

In order to simplify the study of red varieties, it has seemed best to divide the seedlings into two shades, the light or medium reds and those ranging from dark red to purple. Those in the second classification are probably red plus either an intensifying factor or various amounts of black. Such a division is somewhat arbitrary and some colors are difficult to place, but, in general, it is a helpful arrangement. Table I gives the result of combining similar colors and shows that results obtained from crosses of red varieties are as diverse as those from crosses of blacks. The table includes mainly pure seedlings.

TABLE I.— RESULTS OF CROSSING GRAPES OF SIMILAR COLORS.

COLORS OF PARENTAL TYPES.	COLORS OF SEEDLINGS.			
	Black.	Purple to dark red.	Medium to light red.	White.
White × white	....	....	....	166
Light red × light red	8	6	13	8
Dark red × dark red	38	43	45	42
Black × black	407	49	13	54

Table II illustrates the variation in color composition among most of the varieties given above in the cross black × black and shows the number of varieties which fall in similar groups. From this table it will be seen that 15 black varieties have given only black seedlings, but the number of seedlings is not large enough to be conclusive.

TABLE II.— COLOR GROUPS OF PURE SEEDLINGS OF BLACK VARIETIES OF GRAPES.

Number of parental varieties.	Colors of seedlings.		
	Black.	Red.	White.
6	52	16	29
6	128	31	...
10	71	...	25
15	132	...	...

It is interesting to note that the parents with only black and white seedlings produce these colors in the ratio of 3 to 1 and that the seedlings of the varieties yielding only black and red are reasonably close to this same ratio.

The results when different colors are combined are given in Table III. The range of color in the seedlings again emphasizes the necessity of knowing more of the color composition of a variety than can be determined from its appearance.

TABLE III.— RESULTS OF CROSSING GRAPES OF DIFFERENT COLORS.

Color combinations of parents.*	Colors of seedlings.			
	Black.	Purple to dark red.	Medium to light red.	White.
White × dark red †	5	44	14	50
White × black	41	3	3	12
Black × dark red	100	52	40	32

* Light-red varieties were not used to an extent sufficient to make the results of value.

† The reciprocal cross is included in each case.

It would take up altogether too much space to report upon the color of the progeny of all the varieties studied, but a few of the more common ones are given in Table IV, in order to show the wide variation in different varieties of similar color.

TABLE IV.—VARIATION IN COLOR OF PURE SEEDLINGS OF CERTAIN VARIETIES OF GRAPES.

Parent.		Pure seedlings.			
Name of variety.	Color.	Black.	Purple to dark red.	Medium to light red.	White.
Agawam	Purple red	1	2	...	2
Brighton	Dark red	6	5	9	7
Catawba	Purple red	2	4	3	4
Champion	Black	13	1	1	2
Clinton	Black	15	...	...	7
Concord	Black	40	6	...	12
Essex	Purple black to black	4	2	3	...
Hartford	Black	4	...	1	3
Hercules	Black	3	1	1	10
Isabella	Black	8	...	...	1
Merrimac	Black	9	3	6	...
Nectar	Black	4	5	2	...
Ozark	Black	16	...	...	...
Pearl	White	...	...	...	15
Regal	Dark red	...	...	15	5
Worden	Black	4	3	...	1
Wyoming	Dark red	1	4	2	3

In the ultimate solution of the problems of color inheritance we shall probably be aided in no small degree by those who are studying the subject from the standpoint of the chemistry of the various colors; thus, Wheldale (8) has isolated two anthocyanins from species of Antirrhinum which produce different shades of red and three flavones for ivory, yellow, and white. Some work has already been done along this line with the grape. Dezani (3) has found two chromogenic substances in white grapes, and several have reported work on the coloring matter of red grapes, but apparently the results are as yet too indefinite to be of much value to the breeder.

INHERITANCE OF QUALITY.

At first thought it would seem useless to attempt a study of such an elusive and composite character as quality the interpretation of which depends so much upon the tastes of the observers; yet in the final analysis it is this character which very largely determines whether a seedling is worth saving or must go to the brush pile, and any addition to our knowledge of its inheritance is worth the effort.

Table V shows the rating of the progeny of various parental combinations which run the gamut of quality. Most noticeable is the very low percentage of seedlings whose quality is good or above good even when parents of the highest quality were used. When we consider the ancestral history of these seedlings, these results are not surprising or discouraging. Our American grapes, except for the *V. vinifera* hybrids, are but a step removed from the wild, only a few possessing sufficient quality to make them stand out from the many thousands too poor to be eaten with relish. In breeding from these we are breeding from the topmost point of the species and the effect of the several hundred poor kinds in the immediate ancestry is to pull the seedlings down toward the "level of mediocrity."

TABLE V.— INHERITANCE OF QUALITY IN GRAPES.

Parental Types.	Types of Progeny.											
	Best.	Very good to best.	Very good.	Good to very good.	Good.	Total good to best.	Fair to good.	Fair.	Medium.	Poor.	Total, poor to best.	**Percentage of good or better.**
Very good to best × very good				2	9	11	4	7		1	23	**48**
Very good × very good		1	7	5	22	35	8	24	3	14	84	**41**
Very good × good to very good			2	8	30	40	9	30	2	20	101	**40**
Very good × good				3	6	9	3	43	7	23	85	**10**
Good to very good × good to very good			1	6	43	50	20	48	6	36	160	**31**
Good to very good × good			1		2	3	8	38	2	15	66	**4**
Good × good		1	5	3	31	40	18	59	15	31	163	**24**
Good × fair				1	3	4	1	6	1	4	16	**25**
Fair to good × poor					2	2	5	9	1	23	40	**5**
Medium × medium			1	3	18	22	14	54	20	103	213	**10**
Poor × poor				1	1	2		7	2	40	51	**4**
Total number of progeny		2	17	32	167	218	90	325	59	310	1,002	**21**

The tendency for the proportion of seedlings of good quality to decrease as we use parents of poorer quality shows clearly the importance of breeding from varieties of only the highest excellence, and even then we must be reconciled to a relatively small percentage of seedlings of good quality.

Practically every grape in the vineyards of the New York Station which ranks high in quality possesses some blood of *V. vinifera*. A moment's consideration of the history of the species shows us the reason for this predominance. European grapes are centuries removed from the wild and have been subjected to a more intense selection than any other fruit; the "level of mediocrity" has been raised to such a point that the species has become a powerful factor in transmitting high quality.

In this connection it is well to speak again of the future that lies ahead of the breeder who will search out and use those varieties of this potent species which blend best with our hardy native kinds. The ages of selection and breeding in Europe have developed varieties of this one species adapted to nearly as wide a range of climate as is covered by all our native species taken together. The proper selection of parents among these should enable us greatly to extend and enrich our viticulture.

A considerable proportion of the seedlings the results of whose crossing are given in Table V are pure seedlings. These have been separated and tabulated in Table VI. Comparing the percentage of those pure seedlings which are good or above good in quality with the percentage of the remaining similar cross-bred seedlings shows an interesting condition. The pure seedlings are uniformly poorer in quality than the crossed seedlings. Is this due to the decrease in vigor which seems to follow selfing, or is there some weightier reason?

TABLE VI.— QUALITY OF PURE SEEDLINGS OF GRAPES.

Parental Types.	Types of Progeny.				
	Good or above good.	Below good.	Total.	Percentage good or above.	Percentage of crossed seedlings good or above.
Very good × very good	14	25	39	36	47
Good to very good × good to very good	6	26	32	19	34
Good × good	33	102	135	24	25
Medium × medium	17	147	164	10	17
Poor × poor	0	31	31	0	10
Total	70	331	401	17	31

SIZE OF BERRY.

In order to economize space it was necessary to plant the seedlings so close together in the test vineyards that the clusters frequently did not reach full and characteristic size. For this reason the size of cluster can not be discussed, although it is an important factor. The size of the berry, on the other hand, is one of the size factors least influenced by environment and season. The data from these vines should be of value and are presented in Table VII.

TABLE VII.— INHERITANCE OF THE SIZE OF THE GRAPE BERRY.

Parental Types.	Classes of Seedlings.						
	Very small.	Small.	Below medium.	Medium.	Above medium.	Large.	Very large.
Large × large	1	2	3	*28	*28	19	8
Large† × medium to large‡	1	6	7	56	34	*67	6
Large × medium	......	1	......	*4	2	2	......
Medium to large × medium to large	5	34	35	*103	59	20	4
Medium to large × medium	......	20	35	*57	37	3	2
Medium × medium	4	49	39	*83	38	11	......
Medium to large × small	......	*13	11	12	12	3	......
Medium to small × medium to small	26	*35	12	23	7	......	......
Small × small	5	*16	4	5	3	......	......

* Numbers in the bold-face type represent the mode.
† The reciprocal is included in each cross.
‡ The use of the two terms shows that the berries varied from medium to large in the same variety.

A study of the various crosses which have entered into Table VII has failed to show any indication of purity for size among the varieties studied. Lacking exact measurements for the various sizes, it is not possible to compute an accurate mean, but the relative position of the mean with respect to the mode can be determined by a short study of the table. The wide variation about the mean, even in crosses where both parents were of the same size, prevents the only cross made between extremes of size, medium to large × small, from showing any clear tendency for the F_1 progeny to be intermediate. The steady decrease in the mean and mode as the parental types grow smaller shows clearly the strong tendency for a variety to produce progeny centering around its own size.

FORM OF BERRY.

The ovalness of many varieties of *V. vinifera* is so pronounced that some have given this as a species characteristic and have assumed that ovalness in our American grapes was an indication of the presence of blood of this species, an assumption hardly warranted by the facts. The large number of markedly oval varieties among table varieties of *V. vinifera*, together with the complete or nearly complete loss of this extreme form in hybrids with our American grapes, would lead us to suppose that this pronounced ovalness is perhaps a nearly pure form and that it is either recessive to roundness or else unites with roundness to produce a less pronounced oval. It is this latter type of oval that is referred to in Table VIII showing the inheritance of berry form. The appearance of so many seedlings with round berries in crosses of such oval varieties would tend to strengthen the idea that this is an intermediate form.

Any study of oblateness is made uncertain by the small number of varieties that possess this form. One of the most pronounced is the Goff, a seedling originated at this Station. The behavior of pure seedlings of the Goff grape would seem to indicate that, in this variety at least, oblateness is a pure form and its disappearance when combined with round, as is shown in Table VIII, would seem to show it as recessive to round.

TABLE VIII.— INHERITANCE OF FORM OF THE GRAPE BERRY.

Parental Types.	Types of Progeny.						
	Oblate.	Slightly oblate.	Oblate to round.	Round.	Round to oval.	Slightly oval.	Oval.
Oval × oval	......	1	1	*15	7	2	11
Oval × round to oval	......	......	......	*56	10	15	10
Round to oval × round to oval	3	3	10	*129	30	25	56
Round × oval	......	......	......	*15	1	6	3
Round × round to oval	......	1	2	*100	9	14	1
Round × round	10	17	22	*333	34	24	17
Round to oval × round to oblate	3	......	1	*17	2	2	1
Round × round to oblate	......	4	2	*42	5	2	1
Round to oblate × round to oblate	3	......	1	*24	2	1	8
Round × oblate	......	......	......	7	......	......	......
Oblate × oblate	*15	......	......	1	......	......	......

* Numbers in bold-face type represent the mode.

From a study of Table VIII it is seen that the mean would be more nearly coincident with the mode in each cross than was the case in Table VII. This shows clearly the strong tendency for roundness to obscure both oval and oblate.

SEASON OF RIPENING.

The period of ripening of a variety depends so much upon the vigor of the vine, the season, cultural methods, and environmental conditions that no very accurate data can be presented. In one year all varieties may be 10 days earlier than normally, while in another year early varieties may be unusually early; but a cold, wet period late in September and early in October may cause the late varieties to be unusually late. These variations are minimized when the records extend over a number of years. The ripening dates of the seedlings are usually taken for at least three years — not long enough, but much better than if taken for a single year.

In Table IX the ripening season extends approximately through the months of September and October. The first two periods cover about 15 days each, the next two about 10 days each, while the length of the last period is usually fixed by the first killing frosts.

TABLE IX.— EFFECT OF HEREDITY ON SEASON OF RIPENING OF GRAPES.

Parental Types With Reference to Ripening Season.	Ripening Periods of Progeny.					
	Approximate mean.	Very early.	Early.	Early mid-season.	Mid-season.	Late.
Early × early	Sept. 23	8	***30**	20	......	.....
Early × early to midseason †	Sept. 22	13	***46**	18	......	.....
Early to midseason × early to midseason	Sept. 27	7	***46**	42	7	1
Early × midseason	Sept. 28	......	20	***22**	......	.....
Early to midseason × midseason	Sept. 26	21	***126**	100	8	.....
Midseason × midseason	Oct. 1	11	165	***244**	49	.....
Early × late	Oct. 1	......	8	8	......	.....
Early to midseason × late	Sept. 27	2	***9**	2	......	3
Midseason × late	Oct. 4	3	20	***27**	18	6
Late × late	Oct. 7	......	10	***104**	19	14

* Numbers in boldface type represent the mode.
† Each cross includes also the reciprocal.

As would be expected, Table IX fails to show purity or dominance for any one season, but it does show, both in the mode and in the approximate mean, the extent to which the season of the parent influences the offspring. A study of the varieties which enter into the table has failed to show results at all different from those of the group in which they fall.

NEW VARIETIES FROM EARLIER CROSSES.

The results of the first 20 years of work were anything but encouraging. Now, however, there is tangible evidence that progress is being made. A vineyard of 1,500 seedlings bred from 1898 to 1903 has by a process of vigorous selection decreased to less than 75 vines, but among this number are several that seem very promising. Five of these have already proved so desirable both at Geneva and in a test vineyard at the Station's Vineyard Laboratory at Fredonia, N. Y., that in the fall of 1914 it was decided to give them names and place them in the hands of the nurserymen.

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