

UNIVERSITY OF MISSOURI      COLLEGE OF AGRICULTURE  
AGRICULTURAL EXPERIMENT STATION  
RESEARCH BULLETIN 39

# BUD SELECTION WITH SPECIAL REFERENCE TO THE APPLE AND STRAWBERRY

(Publication Authorized January 31, 1920.)



COLUMBIA, MISSOURI  
AUGUST, 1920

UNIVERSITY OF MISSOURI

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# Agricultural Experiment Station

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<sup>1</sup>In service of U. S. Department of Agriculture.

# Bud Selection With Special Reference to the Apple and Strawberry

V. R. GARDNER

The history of horticulture might well be written from the viewpoint of the changes and improvements that gradually have taken place in horticultural plants, so important have those changes been and so closely associated with the development and progress of the industry from its beginnings to the present time. At times, perhaps, horticultural advancement has been most closely associated with the perfection of some new cultural practice or the invention and introduction of some new appliance, but when a broader perspective is taken evidence in support of the first statement is abundant. During more recent years few subjects in the field of horticulture have received more, if as much, attention than that of plant improvement. When all horticultural plants are considered it is obvious that the greater portion of the improvement that has taken place has been because of, or at least incident to, seed selection and hybridization, for the great majority of horticultural plants have been propagated seminally. On the other hand vegetative or asexual propagation has been practiced since before authentic records of agriculture are available and so there should be a considerable body of evidence on the improvement of plants thru bud selection, if improvement actually may be effected that way. The small number of recorded cases of improvement thru bud variation and bud selection previous to, say 1850, suggests that either such variations are comparatively rare or that they are comparatively unimportant. However, the very fact that distinct varieties have originated by bud variation should lead us to examine carefully the facts surrounding their origin with the hope of gaining information as to how future improvement may be effected. Recently a considerable amount of attention has been devoted to the whole question of bud variation and the improvement of plants thru bud selection and a considerable body of literature has appeared dealing with it. Because there is expressed

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ACKNOWLEDGMENT.—In 1895, there was begun at the Missouri Agricultural Experiment Station an investigation dealing with the question of bud selection in apples and strawberries. This was carried on for a period of twenty-three years under the direction of Dr. J. C. Whitten. In 1913 a similar investigation was begun at the Oregon Agricultural College Experiment Station. It was continued for a period of five years under the direction of Mr. V. R. Gardner. Because of changes in the personnel of the Departments of Horticulture of the two Stations it has seemed practicable to combine the data and issue a joint report upon the two independent investigations. It is made possible as a Bulletin of the Missouri Station thru the courtesy of the Director of the Oregon Station.

in this literature such a diversity of opinion—a diversity of opinion that is almost as apt to confuse as to enlighten—it may be well to examine somewhat carefully some of the more important contributions that have been made to it. No attempt is made to give a complete review of all the literature in this field, but rather to present such a resume as will acquaint the reader with the diversity of opinions held and with the general nature of the evidence upon which these opinions are based.

### REVIEW OF LITERATURE

Thomas Andrew Knight<sup>8</sup> was one of the first to call attention to the changes that gradually may take place in a variety when it is bud propagated. As early as 1795 he read a paper in which he presented evidence to show that as varieties of bud-propagated plants become older the tree or plants become weaker and more subject to disease, undergoing a kind of senile degeneration. It was also Knight's opinion that variety deterioration could be delayed or postponed by using for cions vigorous watersprouts or suckers rather than slower growing shoots from the fruiting portions of the tree, for in the paper he says: "I took cuttings from the extremities of the bearing branches of some old ungrafted pear-trees, and others from cions which sprung out of the trunks near the ground, and inserted some of each on the same stocks. The former grew without thorns, as in the cultivated varieties, and produced blossoms the second year; whilst the latter assumed the appearance of stocks just raised from seeds, were covered with thorns, and have not yet produced any blossoms." It will be noted that according to Knight's conception the entire variety gradually deteriorates; the deterioration taking the form of a steady loss of vigor and an increase in susceptibility to disease; tho theoretically if some should propagate the variety by means of cions cut from the old slow-growing wood (old in the sense of being in the immediate vicinity of the bearing wood) and others should propagate it by means of cions cut from watersprouts or young nursery stock two strains might exist at one time. One would be a young, fairly vigorous strain and the other well along the road to deterioration and decay.

One of the first comprehensive accounts of the part that bud variation and bud selection has played in plant improvement from a horticultural viewpoint is presented by Darwin<sup>5</sup> in his *Animals and Plants Under Domestication*. Here he lists and describes a large number of varieties of fruits, vegetables and ornamental plants that have originated as bud variations, classifying them according to the part affected and pointing out some of their more significant charac-

teristics. He calls attention to the fact that some of these bud varieties or bud sports have been known to occur repeatedly, as the nectarine sporting from the peach; others are comparatively rare, perhaps having been known to appear only once. Some of these bud varieties are comparatively unstable, reverting freely to the parental form; others are extremely stable, seldom or never reverting, and even breeding true when propagated by means of seeds. Some of these bud variations affect a single branch or limb, others only a single flower cluster on a limb, or a single flower in a flower cluster, or only a part of a single flower. Cases are cited in which a limb or even an entire plant has been producing a certain type, color or form of fruit or flower for a number of years and then has sported suddenly, the limb or plant in question producing fruit or flowers of another type, color or form only. Attention is called to the fact that certain variegated plants which have originated as bud sports propagate true only when portions of the plant above ground are used for cuttings or cions, the variegation disappearing when root cuttings or suckers are employed. A particularly interesting case cited is that of a variety of the common Barberry whose fruit is seedless. If propagated by means of ordinary stem cuttings it comes true but if propagated by root cuttings or suckers seed-bearing fruit is produced. Bud variation of a somewhat different type—different in that, presumably, the successive variations presented cannot be propagated by vegetative means—are those in which a plant may produce one type of flower early in the season, a second type in midseason, and a third type late in the season. At least one instance of this latter kind cited by Darwin is associated with a change in the environment of the plant; that is the successive bud variations appeared in plants transplanted to a new location. Darwin calls attention to the fact that certain bud variations apparently are associated with a hybrid condition of the plant; they take the form of re-expressing the characters exhibited by one or another of the parental forms.

Within the last two or three decades considerable attention has been directed to the subject of bud selection by writers who, knowing something of the improvement that has been effected thru the agency of selection in domesticated animals and in plants that are propagated regularly by means of seeds, have assumed that a similar improvement can be effected in bud-propagated varieties thru the agency of bud selection. From their statements it is evident that they have had in mind variety or strain improvement, corresponding to variety and strain improvement in seed-propagated plants, rather than the origina-

tion of new varieties by bud sports such as those listed and discussed by Darwin in his *Animals and Plants Under Domestication*. These writers apparently have regarded any (and hence every) markedly superior plant of a given variety as a suitable starting point for bud selection for variety improvement. It has been their idea that the continued selection of buds (cions) from superior plants would lead to a steady improvement of the variety and the gradual development of a superior strain. They have assumed a cumulative influence from such bud selection. The stock resulting from such methods of propagation is referred to in the literature as "improved," "selected" or "pedigreed" strains. For the most part this discussion of the improvement of plants by bud selection has been based upon theoretical considerations, reasoning from the supposed analogy between propagating plants seminally and vegetatively and from the supposed analogy between evolutionary tendencies in the animal kingdom and in bud-propagated plants. Little of the discussion has been based upon careful and extended observation or painstaking experimentation. It is not necessary at this time to give citations to the literature here referred to. Statements of the type mentioned have been frequent in the horticultural press, the reports of various horticultural society meetings, the advertisements and catalogs of nurserymen and other plant growers, and in popular bulletins and books by many authors.

On the other hand the idea that varieties may be improved by the cumulative effect of selecting favorable bud variations year after year, has been frequently challenged. Sometimes the challenge has been based upon observations or experience that would tend to discredit the claims of those advocating the exclusive use of so-called "pedigreed" stock; sometimes it has been based upon a limited amount of experimental work that has given negative results from bud selection; and sometimes it has come mainly from questioning the validity of the analogical reasoning of those who would regard any bud selection as necessarily accompanied by improvement. As a fair example of some of the criticism directed against the general practice of selecting bud variations and using so-called pedigreed stock the following statements by Hedrick<sup>7</sup> may be cited: "At the very outset it must be pointed out that the seeming analogy between plants propagated from buds and cions and those grown from seeds has given a false simplicity to the facts and has led many astray. Analogy is the most treacherous kind of reasoning. We have here a case in which the similarity of properties is suggestive but the two things are wholly different upon close analysis. In the case of seeds there is a combination of definite char-

acters in the offspring from two parents. Since the combinations of characters handed down from parents to children are never the same, individual seedlings from the same two plants may vary greatly. On the other hand a bud or a graft is literally a 'chip of the old block,' and while plants grown from buds may vary because of environment they do not often vary thru heredity. . . . The Geneva Station has an experiment which gives precise evidences on this question of pedigree stock. Sixteen years ago a fertilizer experiment was started with sixty Rome trees propagated from buds taken from one branch of a Rome tree. Quite as much variation can be found in these trees from selected buds as could be found in an orchard of Romes propagated indiscriminately and growing under similar conditions. Data showing the variations in diameter of tree and in productiveness can be found in Bulletin No. 339 of this station, and will go far to convince anyone that uniformity of behavior as regards vigor and productiveness of tree and size and color of fruit cannot be perpetuated." Nevertheless, Hedrick admits that: "There are, probably, more than one strain of some varieties of fruits, as of the Baldwin for example. But these strains are few, not more than two or three for any variety and but one in the great majority of fruits. . . . The fact of these occasional strains does not alter the statement that the great majority of the infinitude of variations in every orchard are not transmissible."

Bailey<sup>1</sup> calls attention to the fact that, theoretically at least, there are several different kinds of "running out" among bud-propagated varieties; or at least that that term is applied by different individuals to several different processes or phenomena. One of these forms of running out might be designated more accurately by the term "dropping out." This refers to the disappearance of a variety from cultivation, simply because people do not care to grow it and not because the variety has changed in any way. This is not a case of "running out" in the strict sense of the term tho it is the phenomenon that actually has taken place in most cases of so-called "running out." Another type of running out involves a decline or weakening of the variety due to senility and its final disappearance from this cause. This is the "running out" referred to by Knight. Bailey holds that while perhaps theoretically bud-propagated horticultural varieties may "run out" from this cause, historical evidence that they have or that they do is extremely limited. (He leaves one to draw the inference that from a practical viewpoint variety deterioration of this type is negligible.) A third type of "running out" refers to a change in the variety, a change that involves a loss of identity, tho not necessarily any break

in the line of descent. This change might be gradual and result in a single form different from the original but directly descended from it, or it might result in the development of a number of diverse forms, a kind of breaking up of the original type. Bailey holds that undoubtedly varieties of bud-propagated plants that are propagated by means of abnormal buds, like the potato, occasionally do "run out" in this sense, or in this way. On the other hand varieties of orchard fruits, which are propagated by buds, very rarely "run out." The inference is that the fruit grower and nurseryman has little occasion to practice bud selection as a means of variety improvement or of keeping his variety up to standard. In the absence of bud selection on the one hand and in its presence on the other the variety may be expected permanently to retain its identity and remain stationary.

Most of the discussion relative to the deterioration of varieties thru bud propagation has been in connection with the potato. East<sup>6</sup> presents a very complete resume of the literature dealing with this particular phase of the subject and appearing previous to 1907. East's own conclusions, after weighing all the evidence, is that while varieties of potatoes deteriorate, their deterioration is due to unfavorable environmental conditions and not to variety old age nor to intra-variety variation. He says: "The fact of degeneration in potatoes seems to have been explained as variety senility due to bud propagation, as a convenient prop to various hypotheses as to the function of sex; and this conclusion on theoretical grounds is decidedly unproved. . . . Relying for our conclusions on the philosophical grounds and the practical work of the German and French investigators, it seems tenable that there is no variety senility. . . . The more serious practical question, is the manner in which outside pernicious influences are to be avoided. There is a wide-spread belief both in this country and in England that northern grown seed is the superior, and should be obtained every two years or so because of degeneration. It is interesting to note that in experiments at six stations (Illinois, Vermont, Maryland, Georgia, Louisiana and Missouri) in the early nineties, all show results slightly in favor of home-grown varieties. It is probable that in these experiments more care was paid to seed, fertilizers and cultivation than is usual to growers, resulting well for home grown seed; nevertheless had the results been different it would only have shown, either that the northern grown were better adapted to such climate or the soils there found, or that coming from growers who made a commercial business of supplying seed tubers, they had been given better care in regard to selection and environmental conditions."



Stuart,<sup>14</sup> in 1913, reporting upon a series of tests with potatoes grown from "seed" obtained from different localities summarizes the results of his investigations as follows: "Northern-grown seed is superior to that grown in the South. . . . The effect of one year's removal of the potato from northern influence is generally noticeable, and after this period the decline in yield is quite rapid. After a six years' removal from northern influence the southern seed almost, if not quite, equalled that from the North when tested under similar environment." This is equivalent to saying that in a new environment a potato variety may deteriorate or degenerate; or, in the case of southern grown stock, return to normal from a degenerate condition. That is, the variety gradually changes thru bud variation. It is a change, however, which, it is to be assumed, applies to, or involves, the entire stock of the variety in the new location. Reporting in 1915 upon a series of "tuber-unit" and "hill-selection" studies the same investigator<sup>15</sup> states that from a practical point of view much may be gained by growing the crop from such hill-selected stock as compared with unselected stock. However, he attributes this mainly to the fact that the selection eliminates diseased or disease-weakened seed and results in growing a more disease-free crop rather than to the isolation of true intra-variety strains. Here again one type or kind of degeneration or running out of the variety is recognized as a fact, but it is believed to be due to disease. This is exactly opposite to the view held by Knight<sup>8</sup> that degeneracy comes first from internally-controlled causes thus rendering the individual or the variety more susceptible to disease.

However, Knight's views are upheld by Benedict,<sup>9</sup> who recently has made a study of senile changes occurring in the leaves of certain horticultural species. His investigations show that as the individual plant ages there is a gradual encroachment of the vascular tissue of the leaf upon food-manufacturing inter-vein areas, the effect being gradually to lessen the plant's photosynthetic ability and thereby to weaken it.

In an article published in 1916, Stewart<sup>13</sup> describes several distinct but closely-related forms of degeneration in the potato and gives a detailed account of their occurrence and behavior. About these degenerate forms the following statements are made: "Degeneration may occur quite suddenly. . . . What its cause may be we do not know. However, it may be confidently stated that it is not an organism of any kind. The writer has seen no evidence that any one of the three forms of degeneration is communicable from one plant to another except thru the seed tuber. Neither can the cause be ascribed

to any weather or soil condition of the current season. Normal and affected plants may grow side by side in the same soil under the same weather conditions. Their hereditary character and the fact that normal and affected plants may come from different buds of the same tuber suggest that all three forms of degeneration have their origin in bud variation. On the other hand, the fact that plants may be affected with leaf-roll and mosaic in widely different degrees is opposed to this view. Usually, bud varieties are more constant in their characters. Also, it is very unusual for the same sort of bud-varieties to occur so frequently as do these three kinds of degenerate potato plants. . . . It is often stated that potatoes will not 'run out' if rigorous seed selection is practiced. The writer's experience with the degenerate strains herein described lead him to question the accuracy of this statement." One instance is mentioned in which the use of seed from degenerate plants of the Ionia variety gave rise to plants, all degenerate except for a single individual which was normal. This return to normal from a degenerate condition is particularly significant.

Perhaps no one during recent years has done more to call attention to the possibilities of breeding thru bud selection than Shamel<sup>9, 10, 11, 12</sup> and some of his associates. The following quotations from their recent reports will serve briefly to summarize and indicate the general tenor of their findings: "The term 'strain' as here used designates a group of individuals of a horticultural variety differing from all the other individuals of the variety in one or more constant and recognizable characteristics and capable of perpetuation thru vegetative propagation."<sup>9</sup> "Thirteen important strains (of Washington navel orange) have been found in the investigational performance-record plots."<sup>9</sup> "Twelve important strains of the Valencia variety have been found and described during these investigations."<sup>10</sup> "The lowest percentage of off-type trees, i. e., marked variations from the best or Washington strain, found in commercial orchards, has been about ten per cent, and the highest about seventy-five per cent, of the total number of trees in the orchard."<sup>9</sup> "Tree-census observations in navel-orange orchards in California show a general average of about twenty-five per cent of trees of diverse strains, most of which are inferior to the Washington as regards both the amount and the commercial quality of the fruit."<sup>9</sup> "Occasional limbs have been found in such trees (Washington strain) producing typical Golden Nugget fruits consistently from year to year during the entire period of observation."<sup>9</sup> "Fruits of this strain (Long strain) are found frequently as individual fruit or limb sports in Washington and Thompson

trees.”<sup>9</sup> “The variation in the amount of annual crops produced by a given series of individual Washington navel-orange trees is relatively uniform thruout the series each year; that is, the highest producing trees in any one year are in general the highest producing ones each year, and the lowest ones remain at the bottom of the list continually. Individual trees are relatively very stable over a series of years in the character and the amount of their fruit production.”<sup>9</sup> “The trees of the Valencia strain vary considerably in regularity of production and as a whole may be divided into three general classes: (1) regular producers, (2) alternate-season producers, and (3) irregular producers, bearing full crops only at infrequent intervals. This condition indicates that the Valencia strain as here considered is probably made up of several minor strains, which upon further investigation may be classed among the major strains.”<sup>10</sup> “The tree listed in rank 45 is representative of a small class which shows a gradual decrease in production each year.” “The tree listed in rank 51 is representative of the most desirable group of any commercially valuable strain, namely, that one in which the crop production is gradually increased from year to year.”<sup>10</sup> “Suckers, or unusually vigorous non-bearing branches, have been used almost universally for this purpose. This practice has led to the propagation of a continually increasing proportion of trees of those strains producing the largest amount of sucker growth. Inasmuch as such trees are usually light bearers and produce inferior fruits, this practice has been unfortunate and is the direct cause of the presence of the large proportion of unproductive trees found in many orchards.”<sup>9</sup> “Experiments with fruit-bearing bud wood proved that the buds from such wood grew equally well and in most cases better than the buds cut from nonfruit-bearing wood.”<sup>9</sup> “Fruit-bearing bud wood has been selected from limb variations occurring in trees of the Washington or other strains, and in several hundred cases where the growth from these buds has fruited every selection has come true.”<sup>9</sup> “So far, not a single failure has been observed in transmitting the characteristics of the parent trees by means of the selected buds. The large amount of positive evidence as to the possibility of improving undesirable trees by top-working them with selected buds has resulted in the almost universal adoption of this practice by California citrus growers.”<sup>9</sup> “Enough evidence has been secured in these investigations to warrant the assertion that all of the twelve strains described in this bulletin can be isolated thru bud selection. It seems probable that other strains also can be isolated in the same manner. This conclusion does not include the idea that bud variation within

these strains can be entirely eliminated. On the contrary the investigations have shown that variation will probably continue as long as the strains are propagated." <sup>10</sup>

These quotations and many others that might be included together with the evidence submitted indicate clearly that much improvement may be realized thru the agency of bud selection. However, it is worth while noting the exact kind of improvement that can be or has been effected in this way. Nearly all the bud sports described are classed as "off-type" and may be regarded as more or less degenerate forms, forms distinctly inferior in one or more respects to the original varieties from which they sprung. Thus the *improvement* actually effected thru bud selection has been to restore the variety to its original or normal condition thru the elimination of degenerate forms. In the strictest sense of the term this is not *variety improvement* but rather *crop improvement* thru a utilization of the best that the variety contains. From a practical standpoint the results may be much the same, but from a biological viewpoint quite different principles are involved.

On the other hand certain of these bud strains may represent a real advance—at least horticulturally, if not biologically, speaking—over the original variety. An example of this would be the Navelencia orange about which the following statements are made: "This strain occurs occasionally as individual fruit and limb sports in trees of the Valencia strain. It has been isolated in commercial propagation and is grown to a limited extent under the name of Navelencia orange. This strain is especially interesting from the fact that there is a possibility of isolating from it by bud selection a seedless strain of the Valencia variety." <sup>10</sup> Similarly, "occasional limbs bearing absolutely seedless fruits (of the March grapefruit) have been observed in the performance-record trees." <sup>11</sup> Tho undoubtedly such seedless strains would be regarded as improvements from a horticultural point of view, they might be regarded as degenerate biologically, because they are less fitted than the forms from which they sprung to perpetuate themselves in the struggle for existence. However, if seedless forms are to be classed as degenerates biologically, strains that show a great increase in seediness, such as have been isolated from the March grapefruit, must be looked upon as representing a corresponding advance. Thus it cannot be said that bud variation in the citrus group invariably represents a step toward degeneracy.

A recent report dealing with a somewhat different phase of bud variation, but nevertheless a phase that should be considered in this connection, is one by Crandall\* on apple-bud selection. This report

presents the results of an extended series of experiments in which buds of various sizes, from various parts of the tree, and representing extremes of stored food materials were selected for propagation. Crandall's results may be summarized by the following quotations from his report: "At no time during the eight years of this experiment did there appear any striking differences between the groups of trees from large buds and those from small buds. There were and still are marked differences between individuals in the same group, but the summation of growth records for the different groups shows that they closely approximated thruout. . . . Central terminal buds exhibited no advantages over extreme lateral buds, or over buds from interior branches, or even over buds from watersprouts, and the same results prevailed with reference to location on the shoot. Buds from near the base, from central, and from terminal locations gave equally good trees. . . . There is no tangible basis upon which to establish the assumption that robust cions are superior to cions of small diameter for purposes of propagation. . . . Fluctuations in growth of individuals within particular groups are decided, often extreme."

#### HISTORY OF THIS INVESTIGATION.

The investigation upon which this is a report was begun at the Missouri Agriculture Experiment Station in 1895, a time when there was much discussion as to the advantages that might accrue from bud selection in orchard fruits but when little exact information upon the subject was available. At that time there was located upon the College Farm an orchard of over 200 Ben Davis trees which had already reached full bearing. The behavior of the individual trees had been observed for years and the lowest as well as the highest yielding tree had been noted. Subsequent behavior of these two trees shows conclusively that the most productive tree uniformly out-yielded other trees in the orchard and that the fruit from this tree was unusually large and fine quality. Conversely, the unproductive tree not only continued to produce poor crops of fruit, but the fruit was small, never well colored, and showed a large amount of russetting. Some years later this Ben Davis orchard was taken out and the soil and subsoil where these two trees stood was carefully examined. This examination revealed no evidence that the difference in performance of the two trees was in any way due to difference in their surroundings. Thus it would seem that these two trees would furnish exceptionally good material for starting a bud-selection experiment to test the transmissibility of individual variations in

productiveness. Consequently scions were cut from these two trees in 1895, grafted upon ordinary seedling roots and the grafts were lined out in the nursery row. At two years of age the nursery trees were set in the Experiment Station orchard, trees from the poor parent alternating with trees from the good parent. Thruout the period covered by this investigation the trees have been accorded uniform cultural, spraying and pruning treatment. As the trees approached bearing age observations were made from time to time to detect if possible any difference in the growth; and when the trees began to bear, notes were taken upon productiveness and grades of fruit produced. The crops of 1912-1918, inclusive, were measured accurately at the time of harvest and these records furnish exact data upon the effect of bud selection in this investigation.

Very shortly after the inauguration of the bud selection work with apples a similar experiment was begun with strawberries by the Missouri Agricultural Experiment Station. Notes were made upon the productiveness of individual plants of a single variety in one of the Station's plantings. Runners were then taken from the most productive six and from the least productive six individuals and new plots were started. When these daughter plants came into bearing proper records were made and selection again made from the most productive and least productive individuals. This work was continued until ten successive generations had been grown and fruited, the plants at the close of the experiment representing the product of ten successive selections of most productive individuals from most productive parents and of least productive individuals from least productive parents.

In 1913, a similar investigation was begun by the Oregon Agricultural Experiment Station. Very marked intra-variety variation had been noted in the case of several varieties of strawberries, and even tho results obtained at other experiment stations from bud selection with the strawberry were known it was thought worth while to make a series of selections and watch results. Eight plants, two each of four varieties, were marked shortly before the maturing season of the fruit and the individual plant yields obtained. One of each pair of plants promised to be very productive, the other promised to be very unproductive. Later other plants of other varieties were marked as starting points for bud selection studies. As in the Missouri experiments runners were obtained,

set in new plots and suitable records made as the plants came into bearing.

The results of the Missouri experiments have been summarized and progress reports made from time to time. Consequently it does not seem necessary to present all of the detailed records of that work. Only such data will be included as seem necessary to indicate the general tenor of the results. On the other hand no statement has appeared regarding the work of the Oregon Station and consequently a somewhat more detailed report of that work will be given.

### THE MISSOURI EXPERIMENTS WITH APPLES AND STRAWBERRIES.

As stated before, detailed records of fruit production were made only during the seasons 1912-1918. The first three years of that period the fruit was graded at the time of picking and the amount of each grade produced by each tree properly recorded. It soon became evident, however, that the trees grown from cions from the "poor" parent were producing fruit indistinguishable in grade from that produced by the trees from the "good" parent, and since 1914 no records were taken of the percentage of the different grades produced by the individual trees. Table 1 shows the average yields per tree of the two lots of trees.

TABLE 1.—PRODUCTION RECORDS OF APPLE TREES PROPAGATED FROM HIGH-YIELDING AND FROM LOW-YIELDING PARENTS

	Average yield from "Good" parent, bu.	Average yield from "Poor" parent, bu.
1912.....	6.1.....	5.4
1913.....	7.0.....	11.3
1914.....	10.2.....	6.3
1915.....	7.1.....	10.3
1916.....	4.7.....	8.1
1917.....	11.4.....	6.6
1918.....	4.2.....	11.8
Avg. ....	7.2.....	8.5

Inspection of Table 1. brings out two interesting facts: First, that the trees propagated from the unproductive parent have been as productive (as a matter of fact a little more productive) as those propagated from the superior parent; second, that the two lots of trees have alternated with each other in light and heavy production. That is, the heavy crop year of one lot has been the light crop year of the other lot, the alternate bearing habit being quite firmly established in both groups. That this is purely accidental, however, is evidenced by the fact that individual trees

within each group showed even more marked alternation in bearing habit. Each season presented a large amount of variation within each group, a variation greater than that appearing between the two groups. Evidently nothing was gained, or lost, by bud selection in this instance. The two parent trees represented simply two extremes in fruit production and fruit development, extremes that were of interest and importance in themselves but which were of no significance when it came to the propagation of the variety or the origination of a new strain. They are to be regarded simply as fluctuating variations tho for some reason or other stable for the lifetime of the individual plants.

The same statements that are used to summarize the results of the single selection of apple cions may be used to summarize those following the ten successive selections of high and low-producing strawberry plants. There was as much variation within the strains (if they may be called strains) resulting from the selection of productive plants or unproductive plants as there was within the entire stock of the variety at the beginning of the investigation; and the average yield of the plants of the one selection was practically the same as that from the other selection. Nothing was gained, or lost, by the work of selection.

## **THE OREGON AGRICULTURAL EXPERIMENT STATION WORK WITH STRAWBERRIES DESCRIPTION OF MATERIALS**

During the summer of 1913, there were growing on the grounds of the Oregon Agricultural Experiment Station at Corvallis, small plots of a number of strawberry varieties, together with small plots of several of the Station's seedlings that had been considered promising or interesting enough for further trial. It was noticed in connection with these variety trials that while the plants of certain varieties or selections were uniformly vigorous and productive or uniformly weak and unproductive, as the case might be, the plants of certain other varieties or selections showed extreme ranges in vigor, runner production, productiveness and other qualities. It was known that the results attending bud selection with orchard fruits reported upon up to that time indicated that little is to be gained by it; but the plants in question seemed to offer such wide extremes in their development and behavior that it was decided to make some selections of them. Accordingly in that summer several individual plants were marked at flowering time as



giving promise of being extremely productive or unproductive or as being of special interest in some other way. Records were then kept of the yield, both of runners and of berries, of these individual plants. In the spring of 1914, another series of plants were marked for individual record taking and a second season's records were obtained of the mother-plants marked the year before.

Following are brief descriptive notes upon the individual plants selected.

CLARK A.—A medium sized, healthy plant; good foliage; promised to be productive.

CLARK B.—Plant medium to below in size; healthy; good foliage; promised to be very light yielder.

CLARK C.—A very large, vigorous, healthy plant; good foliage; promised to be very productive.

WILSON A.—A medium sized, healthy, vigorous plant; good foliage; peduncles long, holding flowers and fruit off the ground; promised to be very productive.

WILSON B.—A medium to small, semi-vigorous, healthy plant; foliage good; peduncles very short, not holding berries off the ground; promised to be a light yielder.

WILSON C.—Plant large, vigorous, healthy; good foliage; peduncles normal; promised to be very productive.

ETTERSBERG 75 A.—Plant very large, vigorous, healthy; good foliage; promised to be very productive.

ETTERSBERG 75 B.—Plant very large, vigorous, healthy; good foliage; promised to be very unproductive.

ETTERSBERG 75 C.—Plant large, vigorous, healthy; good foliage; promised to be very productive.

ETTERSBERG 75 D.—Plant large, vigorous, healthy; good foliage, promised to be very unproductive.

ETTERSBERG 121 A.—A very large, vigorous, healthy plant; good foliage; promised to be very productive.

ETTERSBERG 121 B.—Plant medium sized, moderately vigorous; good foliage, promised to be only medium to below in productiveness. At the time this plant was marked for propagation it appeared to be healthy. Later it was discovered that nematodes were working upon its roots. Probably it was due to their presence that the plant was smaller and less vigorous than others in the row, but as runners had been taken from this infected plant before the nematodes were discovered it was decided to obtain the records of its daughter plants to see if they would be weakened in any way by the injury to the mother-plant.

STATION SEEDLING 87 A.—Plant strong, vigorous, healthy; good foliage; promised to be moderately productive.

STATION SEEDLING 87 B.—Plant strong, vigorous, healthy; good foliage; promised to be completely barren.

STATION SEEDLING 180 A.—Plant strong, vigorous, healthy; good foliage; promised to be very productive.



thus reversing the standing of the two plants the season before. This may have been due partly to the heavy runner production of selection A and the very light runner production of selection B. It will be noted that for the two successive seasons selection A was heavy, and selection B a light, runner producer. Records were not taken in 1914 for selection A and B of Ettersburg 121 on account of the injury to one of the plants by nematodes. Tho no production records are available for 1915 on account of frost, it was noted that in the spring of that season selection A of Station Seedling 87 produced a normal number of flower clusters and that selection B of the same variety produced a single flower cluster. It evidently was not scheduled to remain barren a second year, but nevertheless gave promise of being very unproductive. Likewise selection B of Station Seedling 180 produced a few flowers, but a much smaller number than selection A.

### PRESENTATION OF RESULTS.

As has been stated before, the frosts destroyed the strawberry crop of 1915. Consequently it was not until the summer of 1916 that the first berries were harvested from the daughter plants of the in-

TABLE 3.—SHOWING RECORDS OF DAUGHTER PLANTS OF INDIVIDUAL PLANT SELECTIONS, 1916-1918

Variety	Selection	Date Set	No. of Plants	1916 yield in crates per acre	1917 yield in crates per acre	1918 yield in crates per acre
Wilson .....	A	1914	71	154	...	...
Wilson .....	B	1914	5	211	...	...
Wilson .....	A	1915	71	315	456	...
Wilson .....	B	1915	2	297	529	...
Wilson .....	C	1915	18	204	463	...
Clark .....	B	1915	3	107	126	106
Clark .....	C	1915	10	338	139	106
Ettersburg 75 .....	A	1914	48	178	...	...
Ettersburg 75 .....	B	1914	35	173	...	...
Ettersburg 75 .....	A	1915	45	274	396	...
Ettersburg 75 .....	B	1915	36	310	235	...
Ettersburg 75 .....	C	1915	54	140	394	...
Ettersburg 75 .....	D	1915	26	90	641	...
Ettersburg 121 .....	A	1914	46	747	...	...
Ettersburg 121 .....	B	1914	10	625	...	...
Station seedling 180	A	1915	37	475	112	...
Station seedling 180	B	1915	37	439	132	...
Station seedling 180	A	1916	34	...	269	208
Station seedling 180	B	1916	14	...	230	190
Station seedling 87..	A	1915	33	63	230	104
Station seedling 87..	B	1915	23	20	146	44

dividual plant selections of 1913 and 1914. Only one crop was taken from these plants. In 1917 and 1918, crops were harvested from plantings made in the spring of 1915 and 1916. Table 3 presents the 1916-1918 records of the several lots of daughter-plants.

It will be noted that but two seasons' records are available for the selections of Wilson, Ettersburg 75 and Ettersburg 121. Three seasons' records are available for the three other varieties. As was to be expected, the various selections showed considerable variation from season to season, owing to age of plants and environmental conditions. When the variations due to seasonal and other more or less obvious causes are accounted for, it is evident that *on the whole* there has been very little difference in the yields that have been obtained from the daughter-plants of high-yielding and those of low-yielding individuals. The daughter plants of low-yielding individuals outyielded those of high-yielding individuals as often as they underyielded them. This is particularly interesting, tho probably what was to be expected, in the case of the selections from Ettersburg 121, where the low-yielding parent proved later to be infested with nematodes. However, the healthy daughter-plant of this weakened individual were strong and vigorous and yielded nearly as heavily as the daughters of the healthy mother-plant. Apparently most of the individuals chosen as starting points for the bud-selection work, like those chosen by the Missouri Station, simply represented extreme degrees of development that were in the nature of fluctuating variations—variations that could not be perpetuated by bud propagation. On the other hand the selections made from Station Seedling No. 87 produced runners that did show a marked tendency to perpetuate the high and low producing qualities of the mother-plants. In the description of materials attention was called to the fact that selection B of this variety was barren the first year and the second year it produced only a single flower cluster; while selection A was moderately productive. For three successive seasons the daughter-plants of selection A yielded practically twice as much as those of selection B. The low yield of the daughters of selection B was due to two factors: (1) Some of these daughter plants bore nothing at all, remaining barren; (2) Those which did produce, bore lightly. Furthermore, inspection of the two lots of plants served to emphasize the difference between them. Tho both lots of plants were healthy and both would be classed as vigorous, those from selection A averaged a third or a half larger than

those from selection B. From the viewpoint of plant size the two lots might be mistaken easily for two varieties. Evidently here was the beginning of two distinct strains, a productive or normal strain and an unproductive or semi-barren strain. In this one instance bud selection had served to segregate these two forms. It is interesting to note in passing that the variation from the normal form which in this case could be perpetuated was in the direction of deterioration or degeneration. From a practical viewpoint, all bud selection accomplished was to keep the variety up to its own standard by the weeding out of an infertile or semi-barren strain.

### THE DETERIORATION OR DEGENERATION OF STRAWBERRY VARIETIES THROUGH BUD VARIATION.

Station investigators and growers as well, often have noticed that individual plants or groups of individual plants in a row of strawberries would become weak and perhaps die out because of a lack of vigor when other plants of the same varieties alongside them would remain strong, vigorous and productive. This phenomenon is generally more noticeable in experiment station or other trials of new varieties than in commercial plantings of standard kinds. Loss of vigor or dying out under such circumstances has been attributed to insect or disease attack, unfavorable soil, or to other local environmental causes, or to accident; and apparently little special attention has been given to the matter. The behavior of some of the seedling strawberry plants, or more accurately, runner-propagated daughter-plants of some of the seedlings, growing upon the grounds of the Oregon Experiment Station challenged attention in this connection. It is believed that the matter can be presented best by brief notes on the observations made upon several of these forms.

**Station Seedling 991** (a Glen Mary x Clark cross).—This plant was fruited first in 1913. It was very productive and was regarded as promising and allowed to form all the runners that it would. All of them (forty eight in number) were set out in the spring of 1914. In 1915, they bore no fruit on account of frost. In 1916, the plants were uniformly strong and vigorous but without exception they produced very few berries. The whole stock of the variety had suddenly deteriorated in so far as fruit production was concerned. In the spring of 1917 the plants were

still uniformly strong and vigorous, but on account of their deterioration in yield were destroyed.

**Station Seedling 1263** (a Clark x Arizona Everbearing cross).—This plant was fruited for the first time in 1913. It was very productive and regarded as promising and allowed to form all the runners that it would. All of these (fifty three in number) were set out in the spring of 1914. In 1915, they were uniformly strong and vigorous but bore no fruit on account of frost. In 1916, they measured up to the parent plant in vigor, but uniformly fell far below it in yield. In the spring of 1917, fifty-one of the plants were strong and vigorous, but again promised a very low yield; two plants were very weak, showing as much deterioration in their vegetative characters as all showed in producing qualities. On account of the deterioration shown by the plants as a whole they were destroyed.

**Station Seedling 1190** (A Marshall x Clark cross).—This plant was fruited for the first time in 1913. It was strong and vigorous and very productive and regarded as promising. It was allowed to form all the runners that it would. All of these (ninety-four in number) were set out in the spring of 1914. They grew well during 1914 and in the fall of that season presented a fairly uniform appearance. In 1915, they bore practically no fruit on account of frost, and consequently were able to turn all their energies into vegetative growth. All runners were removed promptly, as in the case of all the other varieties mentioned in this connection, hence vegetative growth in this case means crowns, roots and leaves. During this season, however, many plants showed marked vegetative deterioration, tho other plants alternating with them in the row retained normal vigor. In 1916 the row as a whole bore a light crop, on account of the plant deterioration of so many individuals. The plants that were normal in vigor bore normal heavy crops. On April 13, 1917, sixteen plants were still strong and vigorous; forty-seven were weak and degenerate; thirty-one had died, apparently on account of lack of vigor. Twenty-five runners were obtained from one of the remaining strong normal plants of this variety and twelve runners from the weak and degenerate plants and set in a new location. In May of the following year (1918) twenty-four of the twenty-five plants obtained from a normal mother were alive; and twenty of these twenty-four were strong, vigorous and normal. Four were only medium in vigor, tho none of those four would be classed as degenerate.

At the same time (May 1, 1918) only three plants were alive of those which were propagated from the weak degenerate mother-plants. The other nine had died. Of the three which were alive one would be classed as vigorous, one as medium in vigor, and one as weak and degenerate. Here is a case of a comparatively large percentage of the stock of the variety more or less suddenly deteriorating and the deteriorated strain then perpetuating itself by means of runners.

**Station Seedling 1202** (A Clark x Glen Mary cross).—This plant was fruited first in 1913. It was a very strong vigorous plant, extremely productive, and yielding berries high grade in every way. It was allowed to produce all the runners that it would. They were set out in the spring of 1914. They grew well at first but in the fall of 1914 did not look so strong and vigorous as the record of the parent plant would seem to promise. In the spring of 1915 they showed distinct evidence of deterioration in vigor. They flowered freely, but leaf growth was sparse and small. All of the plants behaved in this way. That this behavior was not due to soil or other environmental conditions is indicated by the fact that plants of other varieties in adjacent rows were normally strong and vigorous. A frost early in May destroyed the crop, so that practically the entire energy of the plants could be put into vegetative growth during the season of 1915. In spite of this they made very little leaf growth and averaged only a little more than one runner per parent-plant; and these were weak runners. In 1916, these plants appeared still weaker and more degenerate, produced no runners, only a few flowers and a few small inferior berries. In April, 1917, practically all of the plants were alive, but that is about all that could be said of them. Degeneration was practically complete. In the spring of 1915 runners were taken, tho at this time the plants showed distinct signs of degeneration. They were set in a new piece of ground and given exceptionally good care. These plants did fairly well during the season, but showed a wide range in vigor. Some were quite strong, others were weak. They fruited during the seasons of 1916, 1917 and 1918, gradually increasing in vigor and becoming more uniform during that period. In 1918, they yielded at the rate of 122 crates an acre even tho the season was extremely dry and unfavorable, and in addition they produced a fairly good crop of runners. If allowance were made for the effect of the dry weather it is believed that the statement is warranted that practically the entire stock of

the variety had returned to normal. Ordinarily when the entire stock of a variety is modified in one direction in this way the change is looked upon as accommodative or adaptive and some feature of environment is regarded as its cause. The change, however, in both kind and in direction corresponds to that in Station Seedling 1190 where only a part of the stock was affected and hence where it would be classed clearly as bud variation. The fact that plants of a number of other varieties under the same conditions showed no tendency to undergo such changes, but continued normal in both vegetative and fruiting characters, affords added evidence for the belief that the variation was due primarily to internal rather than external factors.

**Marshall.**—In this connection it seems worth while to mention the behavior of some plants of the Marshall strawberry growing upon the Station grounds. In the spring of 1914, small lots (twelve to fifteen plants each) of plants of the Marshall variety were obtained from Logan, Utah; Fort Collins, Colorado; Geneva, New York, and Niles, California. These, together with a number from a locally grown plot were planted in a row on the Station grounds. Tho not planted on the same day, there was not enough difference in time of planting of the different lots to account for any appreciable difference in later growth. The plants from the several sources showed variation, but only such minor differences as would be expected from having been grown in soils and under different climatic conditions. Regardless of the source, the plants showed in a clear cut manner the distinguishing characteristics of the Marshall strawberry. After a season's growth in the field under the hill system of culture the plants all showed a fairly high degree of uniformity. There were some frosts in the spring of 1915, enough to injure the crop seriously; but the Marshall plants produced a few berries. There was some difference in yield between the different lots, the plants from California averaging considerably less fruit per plant than those from other sources. During the season of 1915, marked differences in vegetative growth developed. All of the California plants showed a vegetative deterioration. This was so great that some did not survive the winter of 1915-16, none bore more than a very light crop in 1916, and all died out before the spring of 1917. The New York plants remained uniform thruout this period but were only medium in vigor. The Utah plants likewise remained uniform but gradually lost their vigor. Those from Colorado continued to grow uniformly, ex-



cept for one which had deteriorated and become very weak by the spring of 1917. On the other hand all of the plants that had been obtained locally presented a uniformly strong and vigorous appearance in the spring of 1917 when the plantation was plowed up.

Here again was an instance of the deterioration or degeneration of a part of the stock of a variety thru bud variation. That environment is not the only controlling factor is indicated by the fact that none of the plants from certain of the sources, particularly the locally grown plants, suffered deterioration. That it is a contributing factor is indicated by the different behavior of the plants from the several sources.

### BUD VARIATION ASSOCIATED WITH PARENTAL CHARACTERISTICS

In the summer of 1914 some crosses were made between the Wilson strawberry and plants of the wild *F. chiloensis*. The pubescence on the petioles of Wilson leaves is invariably spreading. That on the petioles of the *F. chiloensis* used in this work is appressed and ascending. The resulting seedlings, fruited first in 1915, were variable in respect to this character. That is, some of them bore leaves with spreading pubescence on their petioles; the leaves of other plants had appressed and ascending pubescence. A single plant of this parentage bore some petioles of the one kind and some of the other. This one plant was permitted to produce all the runners that it would. In the spring of 1916, these runners, (seventy-nine in number) were transplanted. In the spring of 1917, the resulting plants were examined carefully to determine the direction of the pubescence on the petioles. Seventy-five of the plants were like the original seedling—that is, each had some petioles with appressed and ascending pubescence and some with spreading pubescence. Two plants had petioles with appressed and ascending pubescence only; and two had petioles with spreading pubescence only. The original seedling and the main stock of the variety propagated from it represented a condition that may be more or less accurately described by the term "divided dominance." Neither parent was dominant over the other in this respect thruout the entire plant; but each parent completely dominated over the others in parts of each plant. The bud variations here noted gave rise to strains in which in the one case the male parent and in the other the female parent dominated over the other thru-

out the entire plant. Of course these particular bud variations are of no value either to the strawberry grower or the strawberry breeder, but they are interesting in that they show that strains may arise in the strawberry thru bud variation which are not in the nature of degenerate forms and which theoretically at least might be the means of providing improved strains.

### DISCUSSION.

The data which have been presented indicate, in common with the data of a number of other investigations along bud-selection lines, that bud variation is of several kinds. Three distinct kinds have been met with in this work. It is possible that there are still other types or classes of bud variation, some of which may be of importance equal to or greater than that of the ones met with here. It is believed that a proper recognition of these distinct classes or types of bud variation will go far toward systematizing the work of bud selection and will enable both breeders and growers of bud-propagated plants like the apple and strawberry to judge fairly accurately as to where, when, and for what it may be employed with profit.

Without doubt a very large part of bud variation in general is of a fluctuating nature. These fluctuations extend to all features of the plant, are in every direction and often are extreme in degree. They give rise to most of the innumerable variants which go to make up the mediocrity of the race or variety and likewise they give rise to most of the extreme individuals, those which stand out from their neighbors because they represent unusual degrees of development. Both of the apple trees and all of the strawberry plants which formed the starting points of the bud-selection work of the Missouri Station, and most of the strawberry plants with which the Oregon Station began its work, were variants of this kind. When put to the propagating test they proved incapable of impressing their unusual degrees of development upon their daughter plants.

Another type of bud variation involves a kind of degeneracy, a running out, of the variety. Apparently this deterioration, or running out, may take any one of several forms. In the work of the Oregon Station with strawberries it took the form of (1) a more or less complete loss of the ability to produce fruit, (2) a partial loss of ability to produce runners, and (3) a marked

reduction in vegetative vigor, resulting in weak, degenerate plants. It may involve the entire stock of a variety which is being grown under a given set of conditions, or only a part of that stock. The work of the Oregon Station would indicate also that a deteriorated or degenerate strain may occasionally return to the normal form from which it sprang,—that is, it may “come back”—or occasionally it may give rise to normal plants. Attention is here called to the same phenomenon noted by Stewart<sup>13</sup> in the case of a degenerate strain of potatoes. Some of the degenerate forms met with in citrus fruit<sup>9</sup> are evidently of the same general nature. Thus it would seem that while bud selection may not seem to be such an effective means of improving the variety as it was at one time believed, the importance of judicious bud selection in keeping the variety up to standard,—in eliminating or weeding out inferior or degenerate forms,—is not to be overlooked. Crop improvement is not less important to the grower than varied improvement. It is needless to say that the loss occasioned by this type of variety degeneration is apt to be found very variable. Without doubt there are bud-propagated crops or varieties, or there are seasons or sections when, where and with which it is a negligible factor. On the other hand investigators and the propagators and growers of bud-propagated plants should be on the watch for plants that show signs of deterioration. Obviously such deteriorating plants should not be used for purposes of propagation.

The results obtained with the Marshall strawberry plants from different sources are too meager to be hardly more than interesting. Yet taken in connection with the behavior of a number of the Station seedling varieties they suggest that tests of new varieties of bud-propagated plants, like the strawberry, especially when the stock is obtained from a distance, should be made and reported upon with greater care than sometimes is customary. It has been recognized for many years that when seed-propagated plants are introduced to a new environment often they do not demonstrate what they really will do there until several seasons have lapsed. If judged by their first year's record they might be condemned as worthless; but after a few seasons in the new locality they become acclimatized or locally adjusted. Recently, Cook<sup>3</sup> has pointed out some of the most important factors in this process. Apparently bud-propagated plants have not been thought of as undergoing such a process of disturbance and of adjustment

when taken to a new locality, tho in his article on *Place-Effect Influence on Seed Potatoes*, Stuart<sup>14</sup> deals with one aspect of the problem.

In the light of the results obtained in this investigation it would seem that variety tests of bud-propagated plants in order to be fair and adequate should run long enough for the varieties to pass thru their period of disturbance, if they have one and survive it, and become adjusted or acclimated thru the elimination of inferior or degenerate strains should they produce them. The suggestion is made that many strawberry varieties have been condemned for certain sections or localities because their initial trials resulted in the appearance of a number of these poor strains which were averaged in and taken as a measure of what the variety necessarily would continue to do in the new environment. Possibly this is one of the reasons why the recommendations based upon experiment station trials with strawberry varieties so often have been different from those based upon the experience of commercial growers.

A third type of bud-variation met with in the work of the Oregon Station is one that plainly is due to and takes the form of a reversion to one of the parental forms. Such bud variations are not fluctuating in nature, nor are they to be regarded as evidence of deterioration or degeneration of any kind. They are simply cases of changed or reversed dominance. Many of the so-called bud sports met with in nature are of this kind. It is thru this type of bud variation that new improved strains or varieties may be, and are, obtained. The fact that the two strains thus obtained from the Wilson x *F. chiloensis* cross of the Oregon Station did not happen to be of any practical value does not affect the economic significance of this type of variation and bud selection. Probably bud variations of this type are much less common than those of a degenerate nature, but the breeder and the grower as well can well afford to be on the watch for them.

### SUMMARY

This article reports upon a series of bud-selection experiments begun by the Missouri Agricultural Experiment Station with apples and strawberries in 1895 and a corresponding series of experiments begun by the Oregon Agricultural Experiment Station in 1913.

The apple trees propagated from the high-yielding parent averaged about the same in quantity and grade of fruit produced as

those propagated from the low-yielding parent. The two lots of trees alternated with each other in their seasons of heavy and light bearing. There was a large amount of variation between the individual trees in each lot.

Ten successive generations of runner selection from high-yielding and from low-yielding strawberry plants at the Missouri Station failed to produce strains whose yield was higher or lower than the average of the variety.

A considerable number of the bud variations selected for bud propagation at the Oregon Station likewise proved to be simple fluctuations, incapable of impressing their high-producing or low-producing qualities upon their daughter-plants.

Several varieties or selections under trial at the Oregon Station showed a type of bud variation that may be described by the terms "degeneration" or "running out." This running out was of several kinds: (1) A more or less complete loss of ability to produce fruit, (2) a partial loss of ability to produce runners, and (3) a marked reduction in vegetative vigor, resulting in weak, degenerate plants. Bud selection may be a means of eliminating these forms of deterioration and thus of keeping the variety up to standard. When dealing with bud variation of this type, bud selection is a means of crop improvement rather than of variety improvement.

It is suggested that in order to make fair and adequate variety tests of bud-propagated plants like the strawberry, due consideration should be given to this form of deterioration, and the possibility of eliminating inferior or degenerate strains should be determined.

A third type of bud variation was met with at the Oregon Station—a type in which the variants bring into expression characters found in one of the parents of the variety but which is not expressed, at least in the same way, in the main stock of the variety itself. Such a variation may represent a real improvement over the parent form and thru bud selection it may be isolated and perpetuated.

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