SOMATIC SEGREGATION IN A SECTORIAL CHIMERA OF THE BARTLETT PEAR[1]

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INTRODUCTION

Mention is made in some of the older European pomologies of a considerable number of striped, banded or "panache" varieties or strains of pears. Apparently they never assumed much commercial importance and even academic interest in them must have largely disappeared, for more recent treatises have been inclined to overlook them and a search to-day would probably reveal the fact that most of them have disappeared from cultivation. Descriptions vary in their completeness, but it is evident that the fruits themselves were generally characterized by alternating sectors of the normal green and of yellow skin, extending from stem to calyx lobes, and that at least in many instances the bark of the shoots was similarly striped. Historical data pertaining to many of these sports are likewise incomplete, but the presumption is that most, if not all, originated as bud sports from normal solid green or self-colored varieties. Undoubtedly they would be now classified as sectorial chimeras.

In the summer of 1912 one of the authors of this article, in company with Dr. E. J. Kraus, then of the Oregon Agricultural Experiment Station, found a limb sport of this type in a tree of the Bartlett variety, near Medford, Oreg. Buds of this limb sport, set on quince stock on the grounds of the Oregon station at Corvallis, produced striped fruit like that borne by the original limb sport. No note was made at the time the original limb sport was found as to whether more or less than half of the surface of the fruits or of the shoots was yellow, or on the color distribution of either fruits or shoots as grown at the Oregon station. The sport was simply observed and propagated as a striped form. In 1923 scions obtained from the Oregon station trees were top grafted on some young Kieffer pear trees growing in the orchard of the Michigan experiment station, and the resulting grafts (four on one tree and two on another) have in turn furnished stock for more recent propagations. A study of the Michigan-grown stock of this strain has furnished the data relating to bud-sport origin reported in this paper.

DESCRIPTION OF MATERIAL

This striped bud sport of the Bartlett pear is apparently fairly representative of bud sports of similar type listed in the older pomologies. The developing fruits show alternating vertical stripes of yellow and green, the individual stripes being of various widths.

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(Fig. 1.) In some specimens the green predominates, in others the yellow. For the most part each stripe is continuous from base to apex of fruit, though many are broken, being green at the basal end and yellow at the apical end, or vice versa. This striping is clearly evident when the developing fruits are less than a quarter of an inch in diameter. As the fruits approach maturity, the stripes become less distinct because of the gradual disappearance of the green pigment. The fruit stems are not striped but are very much lighter in color than those of normal Bartletts, being distinctly yellowish in cast.

The young shoots of this sport similarly show an alternate striping with green and yellow; this condition likewise characterizes the new growth of the spurs. Toward the end of the growing season as the epidermis cracks and weathers and the corky layer of the cortex

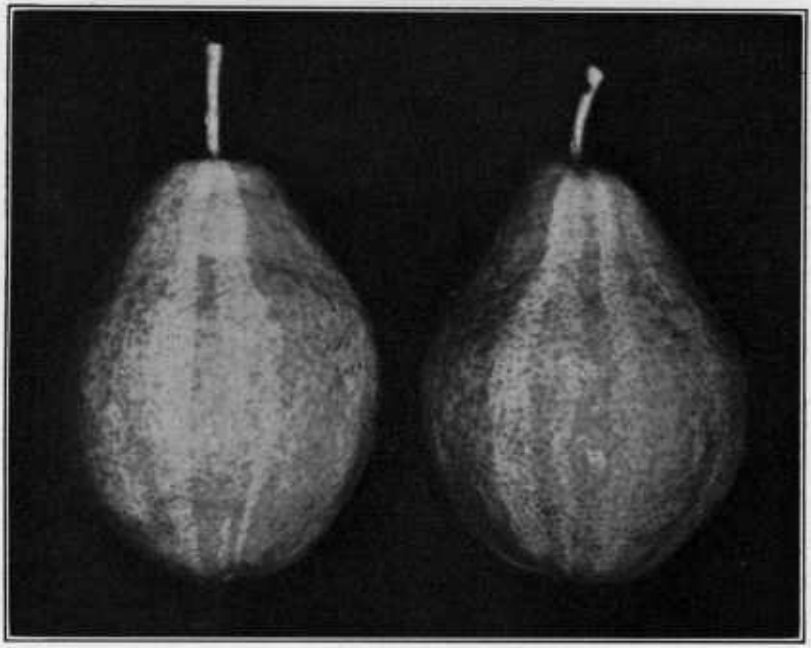

FIGURE 1.—Typical specimens of the striped Bartlett, fully grown but still firm, and before the normal green color changes to yellow

becomes exposed, the striping disappears and the year-old shoots can not be readily told from those of a normal Bartlett. The leaves of the bud sport show no visible evidence of variegation and appear to be as large and as green as those of the normal unstriped form.

In a general way both fruits and shoots of the top grafts in the orchard of the Michigan station closely resemble those of the original limb on the parent tree near Medford, Oreg.

EXPERIMENTAL PROCEDURE

COLOR STRIPING OF SHOOTS

After the top grafts at the Michigan station had made two or three years' growth, it was noted that certain of the striped shoots on tree 1 were predominantly yellow, their green stripes being reduced to narrow

vertical lines and constituting not more than 10 per cent of the surface of the shoots; other shoots were predominantly green, their yellow stripes being similarly reduced to narrow bands, but constituting perhaps one-fourth of the total surface. Buds were selected from several of these shoots showing different proportions of the two color stripes and were set in seedlings pear stocks to determine whether it is possible to segregate from this striped strain other strains or substrains distinct in the relative amounts of green and yellow pigment in their bark.

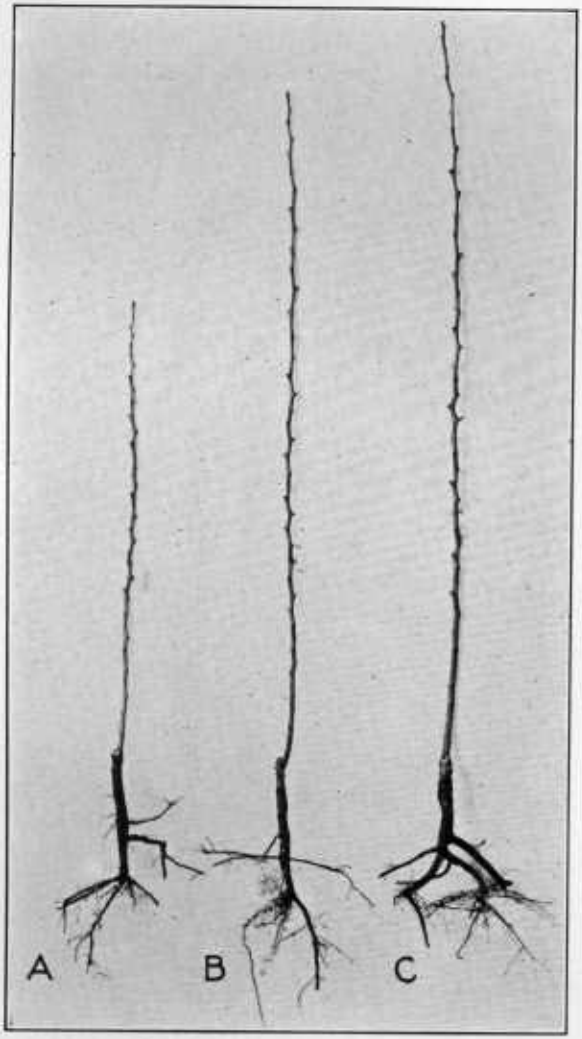

FIGURE 2.—Typical 1-year-old nursery trees of Bartlett selection: A, Striped form in which yellow color predominates; B, striped form in which green color predominates; C, normal trees with solid green bark. Note differences in size

Nursery trees grown from buds cut from striped shoots in which the green tissue predominated grew satisfactorily, though more slowly than adjoining trees of the normal Bartlett. Those grown from buds cut from striped shoots in which the yellow predominated made a very slow growth and at the end of the first season in the nursery were little over half the size of normal stock. (Fig. 2.) At the end of the second year in the nursery the differences were still more pronounced, the trees from the predominantly yellow buds stocks being very small, much-branched and having the general appearance of inferior seedlings, though they had received the best of care. Any nurseryman would classify them as culls, and it is doubtful if any experienced propagator or pomologist would recognize them as being of the Bartlett variety.

The best of the 2-year-old nursery trees of these predominantly yellow selections were set out in the orchard in the spring of 1928,

along with some of those of the striped but predominantly green type, and some of the normal Bartlett for comparison. Several of those of the predominantly yellow type died; those that lived have made a comparatively weak growth. Figure 3 shows a representative tree of each selection after two years' growth in the orchard. After five years' growth in the orchard the difference in size between these groups of trees, though still great, was less pronounced than at the end of the first two years.

The marked differences in vegetative growth between these two striped strains and between them and the normal Bartlett, even

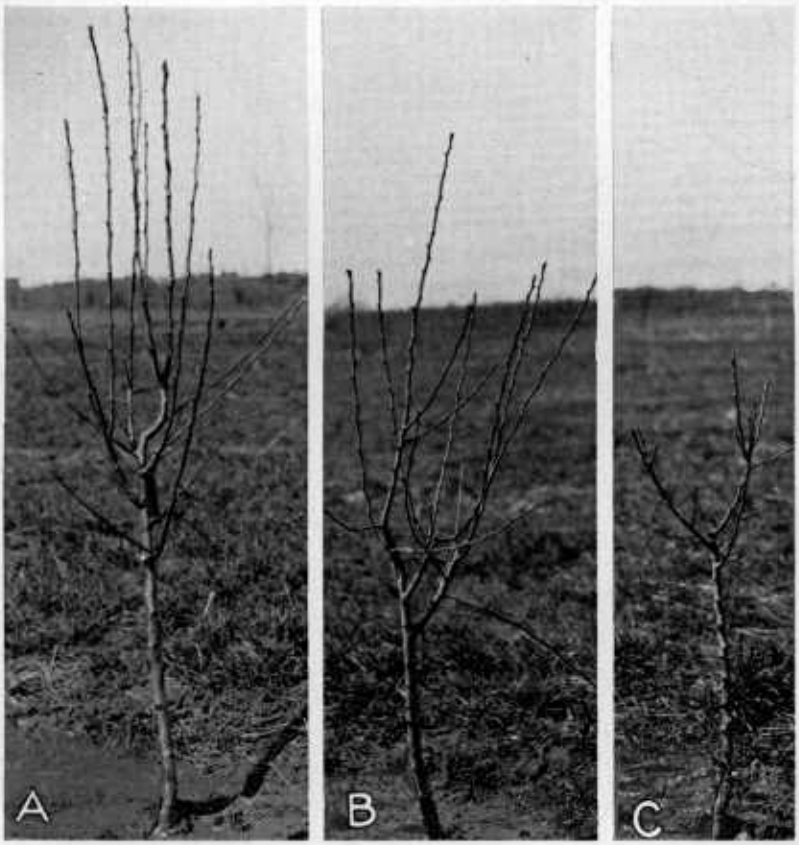

FIGURE 3.—Typical 2-year-old orchard tree of Bartlett selection: A, A normal all-green tree; B, a striped form with the green predominating; C, a striped form with the yellow predominating

though there were no apparent differences in size, thickness, or color of leaves, suggested the desirability of chlorophyll determinations on both leaves and bark of the shoots. Such determinations were made on young nursery stock of the three strains, samples being taken July 11 and August 13, 1932. The data are presented in Table 1. It is clear that, even though to all appearances the leaves of the two striped forms were as dark green as those of the check, or normal Bartlett, they actually contained distinctly less chlorophyll. The bark of the

striped strain in which the yellow color predominated was very low in the green chlorophyll pigments, and it likewise contained much less xanthophyll and carotin than did the bark of the normal Bartlett shoots. The bark of the striped shoots in which the green color predominated showed an intermediate condition. Incidentally these analyses, together with the growth records of the nursery and young orchard trees, suggest that the bark is a more important contributing factor in general vegetative growth and development than has been commonly thought.

TABLE 1.—*Chlorophyll and yellow pigment content of leaves and bark of shoots of normal and striped Bartlett strains*

[Expressed in terms of milligrams per 10 g of fresh material]

Date and strain	Chlorophyll (A+B)		Xanthophyll		Carotin		Total yellow pigments	
	Leaves	Bark	Leaves	Bark	Leaves	Bark	Leaves	Bark
July 11, 1932:								
Normal solid green Bartlett	15.02	4.44	1.27	0.21	1.18	0.24	2.45	0.45
Striped, with green predominating	9.66	3.27	1.18	.15	.77	.26	1.95	.41
Striped, with yellow predominating	9.63	-------	1.16	.02	.95	.03	2.11	.05
Aug. 13, 1932:								
Normal solid green Bartlett	25.51	3.68	1.92	.20	.90	.15	2.82	.35
Striped, with green predominating	21.39	2.94	1.49	.11	.91	.09	2.40	.20
Striped, with yellow precominating	18.54	2.65	1.77	.09	.96	.06	2.73	.15

TABLE 2.—*Production of shoots and fruits of different color types by striped Bartlett grafts in 1932*

Color type of shoots and fruits	Number of shoots and fruits by tree and branch indicated					
	Tree 1, branch A	Tree 1, branch B	Tree 1, branch C	Tree 1, branch D	Tree 2, branch A	Trees 2, branch B
Shoots:						
Predominantly yellow	13	25	35	19	29	0
Predominantly green	5	7	3	3	4	1
Solid green	3	0	1	[a] 6	7	0
Fruits:						
Predominantly yellow	52	30	10	150	34	27
Predominantly green	22	7	8	95	41	87
Solid green	3	0	0	[b] 32	0	3

[a] Including shoots produced by the lower branch that had reverted to the normal Bartlett type.
[b] Including fruits produced by the lower branch that had reverted to the normal Bartlett type.

The success that attended the segregation of the original striped Bartlett into two striped color strains led to a careful scrutiny of all the shoots on the two trees in the orchard at East Lansing in the summer of 1932 to determine whether or not further segregation was taking place. The results of the observations are presented in Table 2. Most of the shoots were striped, but on four of the original six grafts one or more all-green shoots were produced, that is, in these cases there had been a complete reversion to normal. Of the 144 striped shoots on these 6 top grafts, 121 were classified as having yellow predomi-

nating, 23 as having green predominating. There seems to be no definite proportion of pure green or of principally green segregates characterizing all the grafts. One summer shoot (fig. 4) had its growth stopped in early June and then produced three secondary lateral branches, one of which was pure green, the second striped with green predominating, and the third striped with yellow preodminating. Here is a case of both partial and complete color segregation in branches arising from successive nodes on the same shoot. An even more interesting case of color segregation, this one taking place in a single shoot, is illustrated in Figure 5. In this instance the entire

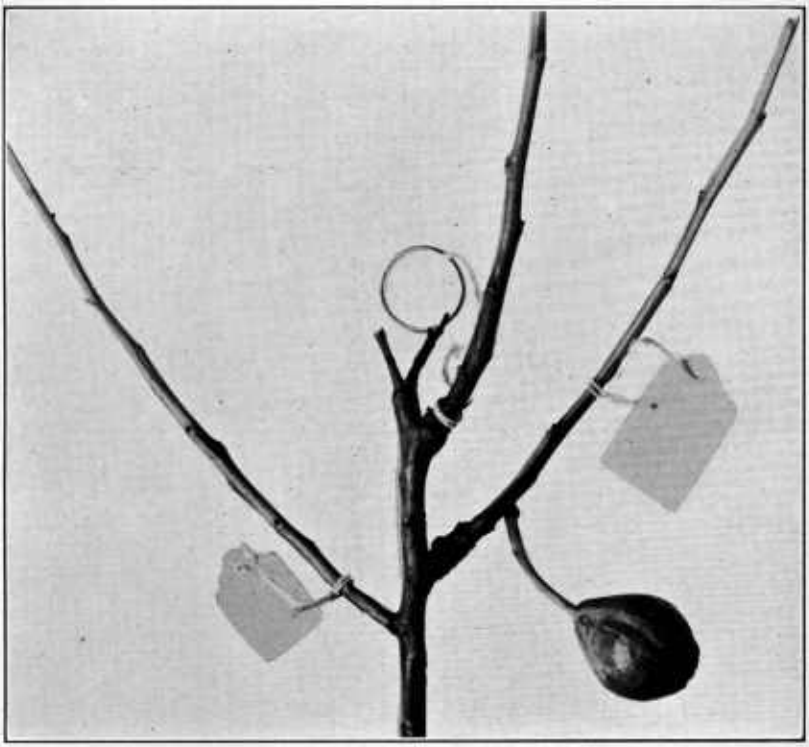

FIGURE 4.—A striped shoot of the striped Bartlett that had its growth stopped in midsummer and then gave rise to three lateral branches. The one at the left is striped but predominantly green; the one at the right is likewise striped but predominantly yellow; the one in the center is the normal solid green

shoot was striped; its basal third was predominantly yellow, the green stripes being reduced to mere pencillike lines; its median section was predominantly green, the yellow stripes being reduced to mere lines; the apical third was predominantly yellow, like the basal third. A close inspection of Figure 5 shows that these color changes occur at the nodes. A vertical green stripe that traverses a number of nodes and internodes may be replaced by a vertical yellow stripe that traverses the next one or more internodes, or vice versa; or a broad green and narrow yellow stripe that traverses one or more internodes may be replaced by a narrow green and broad yellow stripe at some node, or vice versa. One other shoot was found (besides that in fig. 5) in which there was a similar change from internode to internode in the

relative proportions of green and yellow, though none was found in which one or more internodes of an otherwise striped shoot were pure green or in which one or more internodes of an otherwise pure green shoot were striped.

The 1932 records of shoots of these six top grafts would therefore seem to indicate that this particular striped strain is, at least from a vegetative standpoint, in a more or less inconstant or ever-sporting condition and raise a question as to whether it can ever be fixed or segregated into constant substrains. Fortunately some light is thrown on these questions by the progeny trees propagated from two of these six top grafts. Altogether, several hundred nursery trees have been grown from these selections, and a number have been planted in the orchard and carried along until they are now 5 years of age. All trees thus far grown from buds cut from shoots that were striped, but with the yellow stripes predominating, have produced shoots that almost without exception have been like the parent shoots. Those that have grown from buds cut from shoots that were striped, but with the green stripes predominating, have for the most part produced shoots that similarly were like the parent bud sticks, but there have been a few reversions to the pure green normal Bartlett form, and there has likewise been some segregation of striped and predominantly

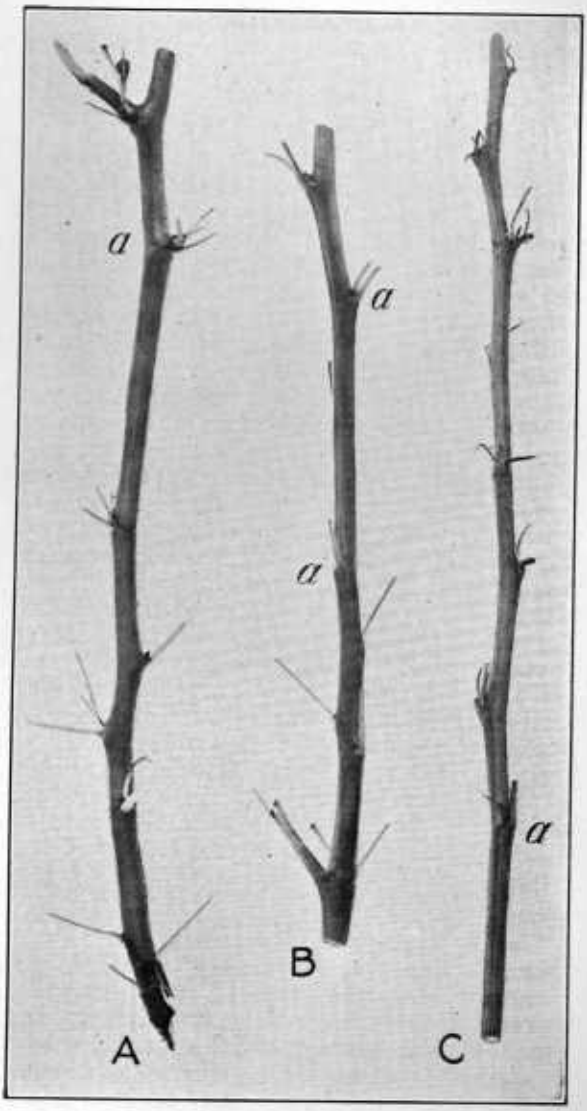

FIGURE 5.—Basal (A), median (B), and subterminal (C) sections of a single shoot of the striped Bartlett in which the basal section is predominantly yellow, the median section predominantly green, and the subterminal section predominantly yellow. Note the color changes taking place at certain of the nodes (*a*), a green stripe traversing one or several internodes being replaced by a yellow stripe, or vice versa

yellow types. The parent form, as found in Oregon, plainly was not constant or fixed. The subtypes (except for the reversion to the normal all-green Bartlett type) that have segregated from it are likewise not entirely fixed; but they are nevertheless much more constant, and experience with them indicates that they can be kept reasonably constant by suitable care in the selection of bud wood—and only in that way.

COLOR STRIPING OF FRUITS

Year after year it has been noted that the fruits themselves of the striped sport vary considerably in width of the alternating yellow and green sectors and in the percentages of the surface covered by the two colors. Not until 1932 were detailed records made relating to this color distribution. They are summarized in Table 2. Considering the crop as a whole, there were many more of the fruits in which the yellow predominated, just as in the shoots, though there was no uniformity in percentages between the different branches. The fruits borne by successive spurs on the same year's growth were in some cases all of one type, and in others presented all possible combinations. In some instances where two fruits were borne by one spur they were alike in color markings, in others one was predominantly green while the other was predominantly yellow. In one case one of a pair coming from a single flower cluster was striped and the other was solid green, a complete reversion to the normal parent Bartlett form. Apparently the successive nodes of the fruit-cluster base present the same opportunity for variation in the width of sectorial color stripes as is presented by successive nodes of the normal vegetative shoot. One whole branch (from graft 1D) that developed from the basal bud of the original scion showed complete reversion to the normal Bartlett type, producing solid green shoots and solid green fruits only, while the main growth of this graft, coming from the upper bud of the scion, has been producing the characteristically striped fruits. Evidently this one branch, in its origin and subsequent behavior, is comparable to one of those shown in Figure 4, and the parent scion for graft 1D corresponded closely to the upper 4 inches of the primary shoot shown in Figure 4.

SHAPE OF FRUIT

The Bartlett pear, like certain other pear varieties, presents considerable variation in shape of fruit, though, so far as the writers are aware, evidence has not been presented showing that the variety presents definite dimorphism or polymorphism in this respect. However, close examination of the fruits borne by the six top grafts of its striped sport in the experiment station orchard at East Lansing would suggest the existence of a dimorphic or possibly polymorphic condition. (Fig. 6.) It was therefore thought advisable in 1932 to keep separate the crops as harvested from the six grafts, measure each fruit, and calculate its form index. Table 3 shows the frequency distribution of these form indices (obtained by dividing the total axial by the total transverse diameter, each measured to the closest eighth of an inch). What the writers would consider an ideally shaped, typical, or normal Bartlett has a form index of approximately 1.25 to 1.35, that is, its axial diameter is about a quarter to a third

greater than its transverse diameter. A typical Kieffer pear has a form index of approximately 1.00. It will be noted that two of these striped Bartlett grafts (2A and 2B) produce fruits more or less closely approaching the typical Kieffer shape, their mean form indices being 1.07 and 1.03, respectively. Grafts 1A, 1B, 1C, and 1D bear fruits showing wider ranges in form than do the fruits of grafts 2A and 2B, but many of them are typical Bartletts in form and their mean form indices are much closer to the 1.25 to 1.35 form index than they are to the 1.00 form index of Kieffer. These differences in shape can not be attributed to stock influence because all the scions were top worked on the one stock (Kieffer).

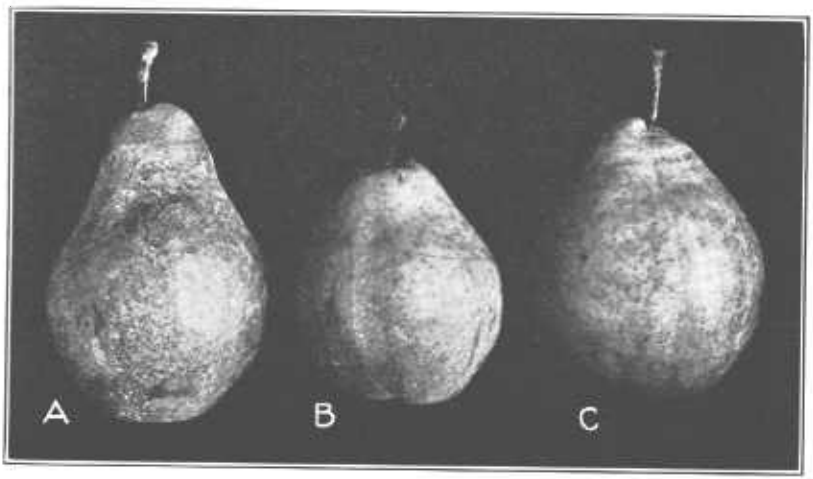

FIGURE 6.—Normal (A) and "Keiffer-shaped" (B and C) specimens of the striped Bartlett. These particular fruits show only indistinct stripes because of their advanced degree of maturity

TABLE 3.—*Frequency distribution of the form indices of fruits borne by different striped Bartlett grafts*

[Form index determined by dividing the axial diameter of the fruit by its transverse diameter, both having been measured to the nearest eighth of an inch]

Form-index class	Number of pears in class borne by tree or branch indicated										
	1–A	1–A–1	1–A–2	1–A–3	1–A–4	1–A–5	1–B	1–C	1–D	2–A	2–B
0.93 to 0.97									3	7	8
0.98 to 1.02	4	1		1	2				13	19	44
1.03 to 1.07	15	5		2	8		1	1	57	42	42
1.08 to 1.12	20	10		1	8	1	2	3	49	29	22
1.13 to 1.17	20	16			4		18	9	92	17	3
1.18 to 1.22	6	4			1	1	13	9	90	6	1
1.23 to 1.27	12	7	1		4		22	7	50		
1.28 to 1.32	3	2			1		5	6	11		
1.33 to 1.37	3	1	1		1		7	3	4		
1.38 to 1.42							3		1		
1.43 to 1.47							1				
1.48 to 1.52											
1.53 to 1.56								1			
Total	83						72	39	370	120	123
Weighted average of form indices	1.15						1.24	1.23	1.15	1.07	1.04

Before harvesting it was noticed that the fruits borne by graft 1A not only seemed somewhat less typically Bartlett in form than those of grafts 1B, 1C, and 1D, but also that several of the individual branches of this graft differed rather markedly from each other. Consequently they were harvested separately. The form indices of the fruits borne by these different lateral branches appear in separate columns in Table 3. Obviously, the numbers are not great enough to warrant attaching much significance, and another year's or several years' records must be obtained and propagation tests resorted to before conclusions can be drawn. It may be pointed out, nevertheless, that the same tendency toward dimorphism or polymorphism, toward segregating out into fairly distinct shape types, is evident in the lateral branches of graft 1A as is evident when grafts 1A, 1B, 1C, and 1D are compared with grafts 2A and 2B.

It is recognized that the forms that are here called form segregates are probably incomplete segregates, just like the first color selections. Especially is this true of the so-called normal Bartlett form that is found to some extent in grafts 1A, 1B, 1C, and 1D.

Field and laboratory studies now in progress indicate that many normal Bartlett trees, that is, those producing the normal green fruits, now growing in commercial orchards present this same diversity in fruit shape and that more or less segregation of the type here described is taking place.

No correlation was found between degree or amount of color striping and segregation as to form, some of the predominantly yellow fruits being Kieffer shaped, others typically Bartlett shaped. Similarly, some of the fruits that were predominantly green were Kieffer shaped, while others were of the normal Bartlett form. The evidence, therefore, indicates that out of the one parent limb sport at least four strains have been segregated—two in color and two in shape. The color segregates were the result of artificial selection; the form segregates were purely accidental.

DISCUSSION

Though the data here recorded pertain to a type of variation that in itself is of little importance in fruits, they throw light on what seems to be a fundamental, though little recognized, characteristic of many bud variations in fruits. This particular variation obviously did not appear as a departure from type at once permanent and fixed, ready to propagate true indefinitely as a uniform new strain or variety (uniform in the sense of meeting the usual specifications of a vegetatively propagated variety). It was a new strain, but a variable, segregating strain from which several fairly definite concrete forms could be developed. This was possible only by what has generally been termed bud selection, and furthermore the evidence indicates that these forms, once developed, can be maintained as clear-cut entities only by a continuation of the same process. This is not surprising in view of what has come to be common practice among experienced propagators of certain ornamental plants such as *Pandanus veitchi*. Incidentally the facts presented raise the question as to whether or not, if more or less continuous selection is necessary in maintaining the identity of certain bud sports, is it not likewise necessary in maintaining the identity of some of the parent varieties from which they may be derived?

SUMMARY

There is described a sectorial chimera of the Bartlett pear from which has been segregated two color forms and two forms differing from each other in shape of fruit.

The bark of the young shoots of the predominantly yellow segregate contains much less and its leaves contain somewhat less chlorophyll than corresponding tissues of the predominantly green segregate or of the parent all-green form.

Segregation as to color of bark and skin of fruit is independent of segregation as to shape of fruit.

The evidence indicates that continued selection is necessary properly to maintain, as well as to isolate, the types resulting from segregation.

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