

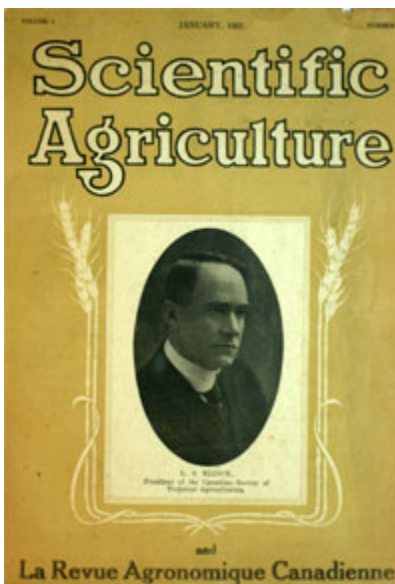


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SOME BASIC FACTORS INVOLVED IN THE PRODUCTION OF BETTER GRADES OF APPLES*

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The public has come to expect uniformity in practically all of the commodities it buys. This is true in natural as well as manufactured products. As a result business has standardized nearly everything and attempts to group products into grades. The purchaser then knows, or should know, what the contents of any given package or container will be. Such a situation stimulates confidence and tends to eliminate dissatisfaction.

But it is difficult to produce at will a crop like apples that can be graded according to prearranged standards because of the many variable natural factors involved. This results in disagreements with the middleman and disappointments with the consumer. As horticulturists, it is our problem to analyze the basic factors involved and learn if we can how to control them to our advantage.

Each large region is likely to vary somewhat in the requirements set up for its different grades. The market catered to will largely determine what these requirements shall be. At least three factors are bound to be involved in every consideration of grades: namely, size, color, and finish of the fruit, the latter to include freedom from blemishes. Soundness of the fruit is of course to be assumed. It will be these three that will receive our attention in this paper. Two other factors should also be recognized, however, as basic even to those mentioned above. These are the personal element in production and the variety itself. A district cannot accomplish much without an enlightened and coöperative group of growers, for the grower is the real unit. He should be familiar with the grades and methods of grading and should be constantly urged to improve the quality of his products. It is too late to influence the quality after the fruit is delivered to the packing-house. Likewise, the variety must still be considered the corner-stone of our fruit industry for we cannot rise any higher in the production of size, color or quality of the product than the genetic possibilities bound up in it.

SIZE OF FRUIT

Packages usually are marked with the number or size of apples they contain. Grading machines are built to sort the fruit into sizes, and color and blemishes must be detected by eye. True, size does not determine the grade since either a small or a large apple may be "fancy," and grading laws do not specify the size required for any given grade, yet it is bound to enter into any consideration of this subject. Usually the fruit averages too small rather than too large so that the orchard operations that will eliminate the

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small and poorly developed fruit and increase the percentage of larger fruit are usually to be employed. Gaston (3) of Michigan cites one grower in that state who had 94.4 per cent of his Baldwin apples go into the B grade because of poor size, another one 63.0 per cent for the same reason. He states that in 1924 more than one-half, and in 1925 nearly one-third of the B-grade apples in the packing houses under observation, were placed in that grade because of lack of size. Baldwin, Wagener, Jonathan, Canada Red and Grimes Golden are the varieties listed in Michigan as most likely to be below A grade because of poor size. An analysis of the problem in other Eastern states would doubtless show much the same situation with most of these varieties. The remedy for this situation will vary depending upon the cause but three practices have a bearing, aside from selecting varieties that average large under most conditions. These are thinning, pruning and soil treatment.

Thinning of the fruit is by all odds the most important method of securing fruit of commercial size. Much data have been secured to show the direct effect on the size of fruit the year in which the thinning is done. It is needless to cite these data in this paper but we may say that some renewal of this work at the Ohio Station has again shown its value. In Ohio the growers generally are thinning apples and peaches more than at any time in the past. The practice is bound to increase in an effort to solve this problem of fruit grades.

It is something of a moot question as to whether pruning will increase the size of fruit. Evidence can be presented upon both sides of this question. The writer, while familiar with the contrary evidence, favors annual light pruning of trees, partly for the beneficial effect that frequently results on the quality of fruit produced. The experienced fruit grower is familiar with the fact that young trees are likely to produce larger fruit than old ones. Hence any practice that tends to keep trees "young", tends to maintain higher yield. Pruning has a rejuvenating effect and in our Ohio experience usually results in a beneficial effect upon size. With such a variety as Rome Beauty which is largely grown in my state it is essential to follow a definite system of pruning to eliminate small size and poor color.

It cannot be argued that the application of fertilizers and the use of good cultural methods will, of themselves, increase size of fruit. Frequently the opposite is true because fertilizers may result in an increased set of fruit. However, a vigorous condition of the tree favors normal development in size provided the tree is thinned to the proper distance.

COLOR OF FRUIT

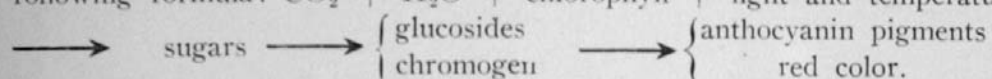
In most fruit sections a high development of red color is the limiting factor in the production of the better grades. Likewise it is the most difficult of all factors to improve. Until recently little definite work has been done on this problem as it relates to orchard fruits, yet its economic importance is very great.

WHAT IS COLOR?

The question may properly be asked, What is color? Of what does it consist? Under what conditions does it develop? Color is, of course, familiar

to us in nature. Green is most common, although other colors in flowers, fruits and leaves are likewise familiar. These colors are due to small colored bodies within the cells known as plastids, and the plastid pigments are responsible for the orange, yellow and green colors. Such colors as blue, purple, violet, magenta and nearly all the reds are due to soluble anthocyanin pigments. Still other colors such as scarlet, orange-red, browns and black are often produced by the presence of both plastid and anthocyanin pigments together in the tissues. Yellow color is frequently due to carotin and xanthophyll, both constituents of the chlorophyll of green leaves. (4).

The anthocyanin pigments arise from a product known as chromogen, which in turn depends for its existence on a supply of carbohydrates (sugars) which are the first products of the green leaf. Hence, if there is a shortage of reserve foods in the plant the anthocyanin may fail to develop because of a lack of chromogen. This relationship may be roughly represented by the following formula: $\text{CO}_2 + \text{H}_2\text{O} + \text{chlorophyll} + \text{light and temperature}$



This relates the whole problem of color back to the nutritional condition of the tree, together with favorable sunlight and temperature. So long as the nitrates entering the plant unite with practically all the available sugar to form proteins there will be no accumulation of carbohydrates from which chromogen is formed. This is the situation in trees making excessive growth and producing fruit of poor color.

Fletcher (1) and Gortner (3) both give evidence that the artificial "feeding" of plants with sugars has resulted in anthocyanin formation. The former applied 10 to 20 pounds of "Cerelose" per tree to apple varieties of York Imperial, Rome Beauty, Williams and Summer Rambo. Where 20 pounds of sugar and nitrate of soda were applied to the tree there was a development of 67 per cent of "solid blush" that was very clear and bright, as compared to the control trees which showed 34 per cent red color that was "rather dull". Where nitrate was omitted the effect of the sugar was less pronounced.

RELATION OF LEAF AREA TO COLOR

It would follow then that a tree with insufficient leaf area to properly mature its crop would produce fruit of relatively poor color, since the sugars are produced in the green parts. This situation has been produced experimentally by Magness (5) in the State of Washington. We take the liberty of using the following data from his work.

TABLE I.—*Relation of leaf area to sugar content and color. Delicious apples, Wenatchee, Wash., 1928, from Magness (5).*

No. of leaves per apple	Sugar Content, Percent			Solid Red Color Average Percent of Surface
	Reducing	Non-Reducing	Total	
			10.06	
10	9.19	0.45	9.64	23
20	10.23	1.01	11.24	
	8.96	2.12	11.08	26
30	9.96	1.51	11.47	
	9.20	2.44	11.64	42
50	10.11	3.07	13.18	
	9.62	3.60	13.22	51
75	10.84	3.29	14.13	
	9.92	4.86	14.78	58

An increase in color is developed as the number of leaves per apple increases, according to table 1. Therefore, up to a certain point, the more leaves the higher the color, provided they do not excessively shade the fruit. That excessive crops are poorly colored has frequently been observed. We recall an experience some 20 years ago when some thinning work was carried on in the orchards of W. W. Farnsworth near Toledo, Ohio. The heavily thinned Grimes Golden trees developed apples of a golden yellow color and frequently with a pink blush on the exposed cheek, while the adjacent trees bearing a very heavy crop were small and greenish in color, indicating an insufficient supply of organic material in the latter.

These observations may be supplemented with some recent ones at the Ohio Station when in 1929 C. W. Ellenwood conducted some thinning tests in a Jonathan block. An unthinned tree produced 1005 pounds of fruit and the fruit from this tree showed 61.55 per cent with sufficient red color to meet the U.S. standard for Fancy grade. The apples on an adjoining tree were thinned to 14 inches apart so that the tree bore only 623 pounds of fruit. There were 87.27 per cent of them Fancy in color. Another pair of trees were each thinned to 10 inches apart. One tree bore 840 pounds and the other 394 pounds. The one with the heavier crop had 68.17 percent and the other one 93.58 per cent Fancy. Many other data could be cited to support the contention that a limitation of sugars, however it is brought about, is likely to result in a lack of red color even though the amount of sunlight is in no way limited.

Fruit is also likely to be lacking in good red color in a season of excessive drought. Surely in such a season there is plenty of sunlight but some other requirement is lacking. Both the over-laden tree and the one under excessively dry conditions produce fruit that is low in sugar and hence is low in color.

LIGHT AS A FACTOR IN COLOR

For many years horticulturists were likely to say that red color was due entirely to the exposure of the fruit to sunlight and as evidence it was pointed out that shaded fruit was poor in color. There is so much truth in that statement that it is not at all strange that a more thorough analysis was slow in developing. Red color in apples, pears and peaches requires presence of sunlight on the fruit for there is no increase of it in storage. On the other hand the strawberry, cherry, blackberry, and grape will develop anthocyanin without the presence of light. (6).

In experiments in which apples were covered with black bags through which no light was transmitted no red color developed except on Williams Favorite. Furthermore, it has been shown that it is the blue end of the spectrum which is responsible for the development of the red color. Magness detached apples from the tree after they were developed but uncolored and placed some under glass which screens out much of the ultra violet rays. A sample was also exposed to direct sunlight. The following condensed table shows the great reduction in red color after twelve days when the violet rays were screened out of the light reaching the apples.

TABLE II.—*Color development of detached apples under glass and in direct sunlight. From Magness (5).*

VARIETY	Percentage of Solid Red Color					
	When Started		After 5 days		After 12 days	
	Under glass	Full Sunlight	Under glass	Full Sunlight	Under glass	Full Sunlight
Jonathan	6.8	8.6	10.5	37.7	44.0	96.0
Delicious	4.5	5.4	5.6	24.2	17.3	74.0
Rome Beauty	2.5	2.0	4.0	8.0	9.3	36.3

Magness states that color develops only one-fourth as fast under glass as in direct sunlight. In this connection it should be remembered that much of the ultra-violet rays are screened out of the light at low altitudes by dust, smoke, and other particles. At high altitudes this is not true and the colors of flowers and fruits are known to be much higher under such conditions.

Therefore, light is an indispensable factor in the development of color pigments in the apple, but only after there is a development and accumulation of certain sugar derivatives.

RELATION OF COOL WEATHER TO COLOR

It is a common experience to see fruit turn red when the cool nights of autumn arrive and the statement is commonly made that cool weather produces red color. However, experiments in which fruit was placed in a low temperature at night and exposed to sun during the daytime did not result in near so good color as fruit held at 70° instead of at 32°F. Despite this fact experience would indicate that high color and cool weather are at least correlated.

EFFECT OF FERTILIZERS ON COLOR

That applications of nitrogen or excessive cultivation frequently reduce color is well known to the experienced orchardist. The explanation should be clear from the discussion earlier in this paper. As a result of denser foliage and proportionate reduction of reserve carbohydrates the fruits develop little color. Such apples are much more prone to scald in storage than well colored fruit, although this trouble can be greatly reduced by wrapping in oiled papers.

The chief question which is raised, however, is as to the value of potassium, phosphorus and iron in producing a better color. This question has been under discussion and experiment for many years and somewhat contradictory results are reported. Most of the data offered so far show no advantage to color by the use of these elements or a complete fertilizer. Of course if nitrogen is withheld the growth and yield are likely to be markedly reduced and the color improved but that is a poor solution of the problem, for both growth and yield are adversely affected. In general a fruit that is high in protein and low in carbohydrates is likely to be of poorer color than one in the reverse condition. It becomes a question of a compromise between the amount of growth and yield desired on the one hand and the color of the fruit on the other.

THINNING AS AN AID

As stated before it is to be expected that thinning the crop will usually increase the color, both of apples and peaches. The physiological explanation would seem to be the same as that already given, namely, an increase in the supply of storage sugars to the remaining fruits. This would seem to be a better postulate than an increase in exposure to sunlight. Whatever the explanation, it is a practical method of solving the color problem as well as desirable from other standpoints.

SURFACE QUALITY OF THE FRUIT

As a third consideration in the matter of grades we must give brief consideration to the matter of surface "finish" or quality. In this we would include freedom from blemishes, such as those caused by fungous diseases and insects, from limb rubs, and russetting caused by caustic sprays.

A clear, bright, smooth finish is paramount, for unless the fruit be clean it cannot be packed into the better grades. Yet fruit may be entirely free of blemishes caused by insects and diseases and yet fail to qualify for the superior grades that bring the grower the larger profits. This may be due to under-size, poor color or russetting.

In this regard we do not make any suggestion or recommendation as to spray practice in Nova Scotia or anywhere in Canada but cite our Ohio experience in attempting to reduce spray burn both of fruit and foliage. True we do not always have an option as to the spray to use, depending upon the nature of the troubles that must be controlled. In the main we have discarded bordeaux mixture as a spray in Ohio. There are certain exceptions to this statement but in general this is true. It was discarded because of the injury to fruit and foliage that frequently attended its use and not because of its inefficiency as a fungicide. Lime sulphur took its place and was used for some twenty years pretty much without change.

About eight years ago the Ohio Station undertook a series of experiments in attempt to reduce spray injury and improve the grade of fruit produced. F. H. Ballou (1) particularly interested himself in this problem. Four changes in the spray practice in Ohio have come about as a result of this work or are in the process of being realized. First, there is a reduction in the quantity of ingredients used per unit of spray solution. Both bordeaux mixture and lime-sulphur solutions were diluted and without a reduction in control of pests where the work was thoroughly done. Bordeaux is used as weak as $\frac{3}{4}$ pound copper sulphate, $2\frac{1}{4}$ pound high grade calcium lime to 50 gallons of spray material. Lime sulphur solution was reduced from 1 gallon of the solution to 40 gallons of water to 1 to 80, and with good results. A second change is in the use of dry lime-sulphur in place of the liquid. This has resulted in excellent control of the fungous troubles with which we usually must deal and has given a better finish to the fruit. A third innovation is the addition of five pounds of high grade calcium lime to 50 gallons of lime sulphur spray solution. This has materially reduced injury to the fruit and given a better finish and color to the fruit. The fourth result of this effort is the use of dust in place of sprays. Dust usually gives a better finish, reduces russetting and often gives a slightly better color. Dusting is

not recommended as an orchard practice to the exclusion of spraying in Ohio. However, progress is being made and it is likely to develop into a general, or at least a supplementary, treatment of all foliage sprays.

In conclusion we must say that there is no shortcut formula that will guarantee high color. Withholding of excess nitrogen or other practices that stimulate growth, reduction of yield by thinning, a moderate pruning practice, avoidance of caustic sprays that russet the fruit, and finally the use of red varieties, particularly red sports or strains of the old varieties, all contribute to a solution of the color problem.

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