Color in Tomatoes

inheritance of pigment differences studied for true-color breeding

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It is of practical importance to the tomato grower and processor that the tomato or its product shall have a typical, readily identifiable color associated with an accustomed standard for tomatoes. The original tomato may have such a characteristic color, but the processed product may not. This is particularly true in products containing a percentage of oily or fatty nontomato ingredients, where owing to extraction of a high proportion of tomato pigments, the color of the tomato fraction appears untypically orange.

A study of the inheritance of pigment differences in the tomato has been initiated.

Some of the wild species of tomato—native to Peru—have fruits which are virtually devoid of carotenoid pigments. The green chlorophyll-containing fruit assumes an off-white color as it ripens. It is possible that the ancestral form of the cultivated tomato was similarly devoid of pigment, in which case the common red-fruited type must have appeared as a mutant from the unpigmented ancestor. Whether or not it is true that the red-fruited tomato was derived from an unpigmented ancestor, it is known that the red-fruited form has produced two mutants, the yellow and the tangerine. These have been known for so long that place and time of origin are uncertain.

The three color types in the cultivated tomato—the red, the yellow and the tangerine—contain complex mixtures of carotenoid pigments, and the formation of specific pigments in the three cases is responsible for the respective characteristic colors.

The carotenoids are insoluble in water, but dissolve readily in fat solvents. They range in color from deep red to pale yellow, and they derive their name from the characteristic pigments of the carrot, among which is carotene, the most important natural source, directly or indirectly, of vitamin A.

The red-fruited tomatoes contain several carotenoid pigments, but by far the most abundant is lycopene, which gives the tomato its characteristic red color and takes its name from the scientific name for the tomato, *Lycopersicon*.

The tangerine tomato derives its color from a closely related orange carotenoid pigment, prolycopene.

The yellow tomatoes have low total content of carotenoid pigments which are predominantly yellow in color. In some yellow tomatoes, small quantities of lycopene may be formed, which are found in irregular pinkish patches of color throughout the flesh.

Most commercial tomatoes contain an alkali-soluble yellow skin pigment which is noncarotenoid in nature.

The flesh of fruits with yellow skins in contrast to those with colorless skins do not receive the same radiation even though exposed side by side to the same sunlight. The presence or absence of skin pigment can only be evaluated in phenotypes—visible characters—whose genetic constitutions are identical except for this one factor, a difficult comparison to make.

Three crosses are possible between the three colored types; red crossed with yellow; red crossed with tangerine; and, yellow crossed with tangerine.

These were made, and a study of the first generation hybrids together with their selfed progeny indicates—in the first place—that the first generation hybrids are red regardless of the color of the parents. These reds all look alike and have the same pigment content. At the same time, they must have different genetic constitutions, because their selfed progeny segregate differently. The second indication is that the parental types are recovered in the second generation. Finally, in the third cross—yellow crossed with tangerine—the first generation is red, although neither of the parents is red. Furthemore, red tomatoes also appear in the selfed progeny of the red first generation hybrid.

Color Types Appearing in the First and Second Generation Hybrids of Three Tomato Crosses

Parents and first generation hybrids F_1	Second generation F_2: Expected frequency	Genotype (genetic constitution)	Phenotype (visible characters)
red (RRTT) x yellow (rrTT)	1	RRTT	—red
F_1 red(RrTT)—	2	RrTT	
	1	rrTT	—yellow
red (RRTT) x tangerine (RRtt)	1	RRTT	—red
F_1 red (RRTt)—	2	RRTt	
	1	RRtt	—tangerine
yellow (rrTT) x tangerine (RRtt)	1	RRTT	—red
	2	RrTT	
	2	RRTt	
	4	RrTt	
F_1 red (RrTt)—	1	rrTT	—yellow
	2	rrTt	
	1	RRtt	—tangerine
	2	Rrtt	
	1	rrtt	

This breeding behavior is explained by assuming that the two mutant types—yellow and tangerine—differ from the red varieties by two different and independent gene mutations—genes are those factors which determine the heritability of characters, such as color.

Each of the pure-breeding parental varieties may be symbolized—with the capital letter *R* representing a dominant red gene, the small *r* representing a subordinant or recessive red gene, *T* representing the dominant tangerine gene and *t* representing the recessive tangerine gene—as follows: red *RRTT*, yellow *rrTT*, tangerine *RRtt*.

Color Types Appearing in First Generation Hybrids and Their Progeny

Cross	First generation F_1	Second generation F_2
Red crossed with yellow	Red	Red, yellow
Red crossed with tangerine	Red	Red, tangerine
Yellow crossed with tangerine	Red	Red, yellow and tangerine

The above table may be amplified to show the genetic constitution of the different types together with their expected frequencies of occurrence.

It is clear from the table in column two that the first generation hybrid of the cross of red with yellow received a gene *R* from the red parent and a gene *r* from the yellow parent. The fact that the first generation—F_1—hybrid has the genetic constitution *Rr* with respect to these two genes, together with the fact that it is red and differs in no observable way from the red-colored parent *RR* indicate that one of the *R* genes is sufficient for the formation of the red-colored fruits.

The *R* gene is said to be dominant over *r*, or in other words, two doses of the *r* gene must be present before the yellow color is expressed. The random recombination of the gene pair *Rr* in the formation of the second generation gives two genetic types of reds: one *RR*, which breeds true like the parent, and the other *Rr*, which like the F_1 will again segregate in the ratio of three reds to one yellow in the next generation. All tomatoes in this first cross carried both dominant *T* genes.

The same general comment applies with respect to the other two hybrids. In

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the second hybrid—red crossed with tangerine—only the *Tt* pair segregates, while all plants have both *RR* genes. Thus, the *T* gene is dominant over the *t* gene. In the case of the third hybrid—yellow crossed with tangerine—both of the gene pairs segregate.

From a study of the three hybrids and their progeny, it is clear that at least one *R* and one *T* is necessary for the formation of the red carotenoid pigment, lycopene. The precise role of these two gene pairs in the formation of carotenoid pigments is not entirely clear. There are two uncertainties that will require further study. First, the double recessive *rrtt* has not yet been identified. Second, certain yellow tomatoes collected in Mexico are definitely anomalous. When collected, they were classified as doubtful yellows. When grown in Berkeley, they did not behave as pure yellow varieties, but were consistently intermediate between red and yellow.

Independent studies carried on at Riverside suggest that three gene pairs determining pigment differences segregating in the species cross—*Lycopersicon esculentum* crossed with *L. peruvianum*—one of the green-fruited wild species. This fact together with the two uncertainties mentioned indicate that only a beginning has been made in the study of inheritance of tomato pigment differences.

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ORCHIDS

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In full-grown plants the symptoms are similar to those on seedlings. Infections start on any part of a leaf but the most dangerous location is at the base because then the infection quickly moves into the growing point and the plant is doomed.

Phalaenopsis plants of all ages are equally susceptible to the disease.

In Cattleya brown spot is often confined to the upper part of the leaf. The progress of the disease is not as rapid as in Phalaenopsis. The lesion has well-defined margins and the color is nearer black than brown. The disease very seldom causes death in Cattleyas.

Control of brown spot is achieved by the use of one part 8-quinolinol benzoate to 2,000 parts of water or the sodium salt of o-hydroxidiphenyl—Natriphene—also at the rate of 1:2,000. In Cattleyas brown spot may be treated locally by swabbing it with a solution of corrosive sublimate, 1:1,000. If necessary, the treatments may be repeated within a week or so.

Soft Rot

Soft rot of Cattleya orchids caused by *Erwinia carotovora* is a rare disease. Its advent is sudden and the results are devastating. It is caused by the common soft rot bacterium—a soil inhabitant—which attacks such crops as celery, carrots, and potatoes.

The disease can start in fresh wounds on Cattleya leaves and with high temperature and very high humidity it will rapidly change the leaf into a sack containing liquefied tissues. The leaf wrinkles and droops. Later it breaks open and the contents leak out.

Plants affected by it can not be saved. Control consists in early recognition of the disease and burning all the affected plants. The room in which the trouble occurred should be promptly and thoroughly disinfected.

Brown Rot

Cypripediums are the only orchids in California subject to the brown rot disease in orchid houses. It is caused by a bacterium, *Erwinia cypripedii,* which prefers a temperature of 65° F or above and a humidity of 70% or higher.

The disease is characterized by small to medium-sized circular, somewhat greasy spots which, on running together, form large sunken patches. The color varies with the age of the lesion and in the final stages is deep chestnut brown. The spots are frequently located close to the base of a leaf. Under favorable conditions the organisms migrate into the crown and thence into other buds causing death of all the living components of the clump. To save plants already attacked the treatment described above for brown spot of Phalaenopsis should be applied.

Bacterial Scorch

Bacterial scorch and pseudobulb rot has been observed recently on Miltonia orchid hybrids. It is most severe under conditions favorable for Miltonia growing—cool and moist greenhouses.

The disease starts in wounds which are always present on the brittle leaves of Miltonia. The bacteria are exuded copiously on the surface of the leaf and may be spread by the water in syringing operations from one pot to another, thus creating an epidemic.

The affected leaves are water soaked in early stages of the disease but later turn gray and even light brown and appear scorched or blighted. Sometimes the disease is in the form of a narrow or wide streak, terminating in the growing point on the pseudobulb which turns at first a delicate yellow changing into orange red or red. The leaves finally drop off and numerous orange red pseudobulbs can be seen in the pot. From the pseudobulb the organism migrates into the rhizome and will travel from plant to plant.

The disease is very infectious and requires immediate attention as soon as it is first recognized. The control consists in applying 8-quinolinol or Natriphene as for brown spot in Phalaenopsis. Sanitary measures must be observed and operators should disinfect their hands after handling infected Miltonias so as not to spread the disease.

Black Spot

The shippers of orchid blossoms also have troubles. Vanda blossoms shipped from a distance sometimes develop a black spot right in the throat of the blossom. Sometimes minute black spots scattered on the petals of the flower ruin its market value. The trouble is due to *Glomerella* sp., a fungus similar in its habits to the gray mold fungus *Botrytis cinerea* which sometimes attacks the flowers of Cattleya in greenhouses and in transit.

Black spot infection of Vanda flowers occurs before they are cut and shipped. When it reaches its destination the flower begins to lose its color and black spots appear. The fungus develops slowly at the low temperature prevailing in shipment but in the higher temperature of the sales room the fungus grows and produces the black spot. Black spot infection of Vanda blossoms has been prevented by the use of 8-quinolinol benzoate 1:2,000 as a spray. This concentration of the chemical did not injure the appearance of the flowers.

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vail, a serious shortage could result. Such a shortage would undoubtedly give an upward boost to the price structure on canned fruits all the way from the grower to the consumer.

With January and February temperature playing a critical role in the final outcome, it will be mid-March or early April before accurate estimates of the situation can be made. By then the blossom periods for most species will have been reached or past and a real estimate of the fruit actually set can be made.

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