Red Fuji in Japan—
Choosing the Best Strain for Your Business Strategy

Hiromitsu Komatsu
Nagano Fruit Tree Experiment Station
492 Ogawara, Suzaka, Nagano 382, Japan

Fuji apples account for over 50% of all apple acreage in Japan today, but poor red coloration was a serious problem when Fuji was introduced. To overcome this problem, new red sports have been widely used in Japan. Many types of bud mutation have been developed from Fuji (Table 1). Red sports are found much more than other mutations because they are easy to discover and are highly marketable. Furthermore, Fuji seems to have a genetic tendency to produce red sports, a characteristic it gets from its parents, Ralls Janet and Red Delicious. The first red sport was discovered in 1965 by Mr. Hara, a grower in Nagano prefecture, and was given the name Naga-fu 1. This strain is a solid type and has not been planted in commercial orchards recently. Since this first discovery, spontaneous red sports have been found in almost every apple-producing area in Japan.

Evaluation of Fuji Sports

For the purpose of evaluating the many red sports and selecting promising ones, research stations collaboratively started performance trials. This 10-year collaborative study was carried out from 1971 to 1980. Fifteen stations joined the trial and exchanged their strains. Each sport was given a code number including an identification number and Chinese character to represent the name of the individual prefecture where the sport occurred, and ‘fu’ for Fuji, e.g., 'Naga-fu' (Table 2). Radiation-induced color sports from the Morioka Branch (now the Apple Branch) of the Fruit Tree Research Station and the Radiation-breeding Center were given identification numbers in combination with ‘Mori-ho-fu’ or ‘Ho-fu’ as they were discovered (Table 2). Ninety-nine clones were observed for general fruit characteristics, particularly for fruit size, skin color (type and intensity), taste and water-core, using the same format in all the research stations. The Morioka Branch of the Fruit Tree Research Station organized meetings to compare observations and to select promising sports. Some results of the comparative studies were summarized.

Evaluation of color sports varied, depending on the location where they were grown and the year when they were observed. Some clones did well in cold climate areas, but not in hot climate areas, and *vice versa*. These could not be considered promising strains.

Skin coloring type, stripe or solid (blush), was not always stable. Some strains first described as a solid coloring type later turned out to be a stripe type. On the other hand, some strains classified as a stripe type often produced solid coloring apples mixed with stripe-colored ones. Furthermore, some strains of stripe-coloring type reverted back to produce poor-colored apples like standard Fuji. The striped-type sports showed more tendency to develop red color in sectors than did the solid-type sports. The sports which have colored sectors are considered unstable in their coloring, and it remains a problem to fix the good color permanently.

Poor eating quality was detected in some red sports, more often in solid-type than in stripe-type. However, some striped-type clones were comparable with standard Fuji.

From this experience, it was found that growers do better to choose the clone which most suits each area, made from a selection test in each grower's own area. Nurseries should be careful to propagate strains which do not change coloring characteristic and the recommended clones should be chosen on the basis of eating quality as well as coloring. In addition, it is important that clones should not be influenced by viruses such as apple chlorotic leaf spot virus, apple stem grooving virus or others.

Considering site-to-site variations in sport performance, some prefectures tentatively recommended some strains, others left the choice of strains to growers. Nagano prefecture recommended Naga-fu 2, 6, 12 or a choice from other local elite strains. Akita prefecture recommended Aki-fu 1, Iwate prefecture recommended Iwa-fu 10. Aomori prefecture did not recommend particular strains.

Since that time, a great number of color sports have been found in many prefectures. Growers prefer the latest color sports and usually buy from nurseries. Nurseries recommend their own ones to growers and often give their own trade name to a new strain. Thus, strains are being planted in increasing numbers which have not undergone any objective selection or testing. Recently, a new problem occurred. Because growers choose their own favorite strain, warehouses have to deal with the variability of color of different color sports. Warehouse managers hope for a uniform color type apple to market in bulk with favorable terms.

Nagano prefecture started a new evaluation program in 1995 with the purpose of introducing the same strains for each location that delivers fruit to the same warehouse. Ten specialists, including scientists, extension workers, traders and growers, joined as examiners and subjectively evaluated color sports collected from each apple-producing area in Nagano. The characteristics evaluated

were color intensity (1: pale, 5: deep), color quality (1: dark, 5: bright), clearness of stripe (1: solid, 5: stripe) and total impression.

The strains were classified in 5 groups by cluster analysis based on each strain's scores for color intensity, color quality and clearness of stripe (Table 3). The 5 groups were named solid type, intermediate type, stripe type, standard type and pale color type. Coloring characteristic of each group was described by principal component analysis (Table 3). Standard type is comparable with standard Fuji and pale color type is less in color intensity than standard type. Some strains collected as red sports for this test were found to not have enough red. The other 3 groups, solid type, intermediate type and stripe type, are considered as real red sports and are higher in color intensity than others. Fruit of the solid type colors 90-100% deep solid red without stripe regardless of environment, but sometimes becomes darker red in a cold climate. The solid type is generally less desired commercially. Fruit of the stripe type has clear red stripes on yellow ground color. The stripes become redder and clearer in a colder climate. The stripe type has the highest commercial appeal; therefore, growers prefer a strain of this type. The disadvantage of the stripe type is that there is some loss of fruit color in a hot climate. Fruit of the intermediate type colors deep red with an unclear stripe over yellow ground color. With the intermediate type, the reduction of fruit color which is caused by hot weather is much less than with the stripe type. The intermediate type has been classified as the stripe type in markets recently, so that commercial desirability is higher than the solid and equal to the stripe. Most strains which are high in total impression belong to the stripe type and a few belong to the intermediate type (Table 3).

Naga-fu 12 was classified as an intermediate type and has been recommended in Nagano. Naga-fu 2 and 6, which have been planted as recommended strains for a long time, differ in coloring remarkably according to the growing location. However, Naga-fu 12 is stable in coloring in each location. Thus, it has been decided to recommend only Naga-fu 12 in Nagano for the present and not to recommend Naga-fu 2 and 6. Some strains are recommended only in the area where they originated (Table 4).

Fruit Color Management

Most red Fuji strains described above need careful coloring management such as removing leaves and turning fruits in order to color the fruit well. Coloring management is indispensable in order to produce beautiful-appearing fruit colored evenly that can be sold at a high price as an elite red Fuji. Coloring management is a serious problem because it means the grower cannot reduce labor hours or increase production acreage. The Aki-fu 47 strain offers growers a chance to overcome this problem because Aki-fu 47 colors evenly without coloring management. It is a red sport of Fuji

discovered in 1978 by Y. Sasaki, a grower in Akita prefecture. It was introduced by the Akita Fruit Tree Experiment Station in 1987. Growers in Akita prefecture call it Mishima Fuji. Mishima is the name of the place where this mutant was discovered. Rakuraku-Fuji and 2001 Fuji, which have the same unique characteristic of coloring, seem to be basically the same mutant. The coloring of these strains is unique. The part of the fruit directly behind the leaves does not color well in normal Fuji and common red sports. In Aki-fu 47, this part colors well except for the small part which touches the leaves. Therefore, it colors almost evenly without coloring management. Aki-fu 47 colors well in diffuse light compared with other clones of Fuji. Unfortunately, Aki-fu 47 is not the best for coloring in Nagano because its color is slightly brownish and less red than other elite red Fuji. Moreover, the fruit of Aki-fu 47 produced without coloring management colors less uniformly than fruit which has complete coloring management. So, in the Japanese market, the price for Aki-fu 47 is sometimes lower than the price of fruit using complete coloring management. Some business strategy to make the most of the good characteristic of Akifu-47 seems necessary if growers are to introduce Aki-fu 47 and cultivate it without coloring management.

Summary

There are two main strategies for growing red Fuji. One is to choose a strain which will produce a beautiful red apple with careful coloring management, including bagging. The product will be sold at top prices. The other is to choose a strain which will color almost evenly without coloring management. These products will get a somewhat lower price, but production costs will be lower and the profit will increase. It is inevitable that apple growers in Japan will choose the former strategy because most growers have orchards small enough to allow coloring management and can maximize their income in this way. A few growers in Japan who have big orchards will choose the latter strategy because their orchards are too big to do coloring management completely. They know that coloring management is laborious and it is difficult to get cheap labor. However, they seem to prefer coloring management if they can get cheap labor. When growers introduce red Fuji, they should choose a coloring method which best suits their business strategy.

Table 1. Types of Fuji bud mutation (sports, strains) found in Japan.

Type	Name
Red sport	Naga-fu 1, 2, 6, 12, Iwa-fu 47, Aki-fu 1, 47 Mori-ho-fu 3, etc.
Early maturing	Yataka, Takano-wase, Mori-ho-fu 14
Early maturing and Red sport	Beni-Shogun
Spur type and Red sports	Seirin-spur
Tetraploid	Tensei

Table 2. Original system of naming color sports of Fuji and the number of strains named in each prefecture up to 1997.

Prefecture of origin	Code name	No. of strains[z]
Hokkaido (central)	Kita-fu	0
Hokkaido (south)	Kita-fu[y]	0
Aomori (western)	Ao-fu	16
Aomori (eastern)	Ao-fu[y]	9
Iwate	Iwa-fu	10
Miyagi	Miya-fu	1
Akita	Aki-fu	47
Yamagata	Yama-fu	2
Fukushima	Fuku-fu	1
Gunma	Gun-fu	3
Nagano	Naga-fu	12
Toyama	Tomi-fu	0
Ishikawa	Ishi-fu	5
Morioka Branch, Fruit Research Station	Mori-ho-fu	16
Radiation-breeding Center	Ho-fu	6

[z]Total number of strains is not the same as the number of strains observed in collaborative study from 1971 to 1980 because some strains were discovered after 1980.

[y]Given numbers from 101.

Table 3. Scores for coloring characteristic among 5 coloring types of Fuji.

Coloring type	No. of strains	Subjective score				No. of strains with a score of 3.0 or more for total impression
		Color intensity[z]	Clearness of stripe[y]	Color quality[x]	Total impression[w]	
Solid	5	3.6	1.6	2.3	0.2	0
Intermediate	30	4.3	2.3	3.3	2.2	6
Stripe	28	3.9	4.0	3.8	3.0	13
Standard	20	3.1	3.9	3.0	1.6	0
Pale coloring	13	2.0	4.0	2.1	0.5	0

[z]1 to 5 scale; 1: pale, 5: deep.

[y]1 to 5 scale; 1: solid, 3: dim stripe, 5: clear stripe.

[x]1 to 5 scale; 1: dark, 5: bright.

[w]Given three scores as 0 for no value, 3 for remarkable, and 5 for excellent.

Table 4. Recommended sports in Nagano in 1997.

Name	Suitable area	Coloring type	Remarks
Naga-fu 12	All growing area in Nagano prefecture	Intermediate	Often produce fruit classified in stripe type according to climates and locations
Azumi strain	Azusagawa village	Stripe	Maybe the original Naga-fu 2
Kamijo strain	Matsumoto city	Intermediate	Sport of Naga-fu 6
Miyazaki strain	Nagano city	Stripe	Sport of Naga-fu 2
Godu strain	Omachi city	Stripe	Sport of unknown red sport