Developing DNA tests to Improve Strawberry Fruit Quality and Disease Resistance

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Summary

In this period of research report, we summarized results of new DNA markers developed for multiple disease resistance and fruit flavor/quality, and applications of markers to improve strawberry varieties. In this year season, approximately 60,000 seedlings were screened by various DNA markers, and about 15,000 were selected for the next year breeding season. Seedlings selected by DNA markers will be evaluated in the field.

DNA tests for cultivated strawberry

Strawberry DNA testing is available for fruity aroma (peach-like flavor), day-neutral flowering, fruit color (white strawberry), and multiple disease resistances (Phytophthora and Colletotrichum crown rot, charcoal rot, anthracnose fruit rot, and bacterial angular leaf spot). Using the high-throughput DNA tests, we can combine high levels of disease resistance with superior fruit quality in strawberry varieties.

Methods

To develop high-throughput and accurate DNA markers, we completed whole genome sequencing and assembly of 'Florida Brilliance'. This genome information is used to identify unique DNA sequences closely linked to genes for disease resistance and fruit quality. Gene-specific DNA markers were developed and combined with a rapid DNA extraction method to screen large number of breeding samples (Fig. 1). Small leaf punches are collected from seedlings, DNA rapidly extracted, and DNA tests run and scored. Only the seedlings with desirable trait combinations are retained, and the rest are discarded. Moreover, DNA markers were applied for validating crossing parents.

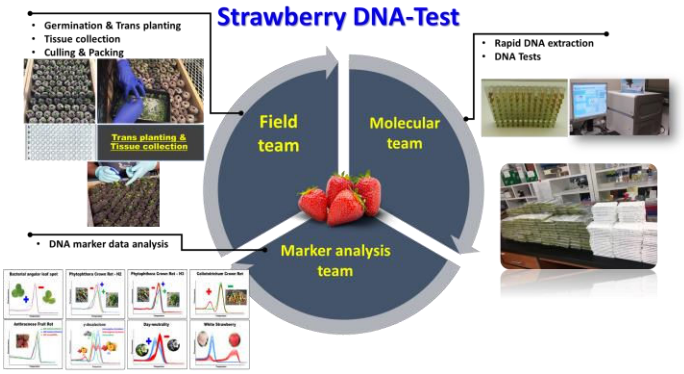

Figure 1. The procedure of high-throughput marker-assisted seedling selection (MASS) in UF strawberry breeding program.

Results

DNA tests for fruit flavor and quality

Strawberries produce numerous volatile compounds that contribute to the unique flavors of fruits. Among the many volatiles, gamma-decalactone (γ-D) is an important aroma compound contributing 'fruity', 'sweet' or 'peach-like' flavor in strawberry fruit. The presence or absence of γ-D is controlled by a single gene, *FaFAD1*. There are several major UF cultivars producing the peach aroma flavor (Table 1). The DNA marker for *FaFAD1* accurately predict the production of γ-D in various strawberry cultivars. Also, as showin in Figure 1, the concentration of fruit aroma is highly various among UF breeding germplasm. We are now able to predict accurately the level of peach aroma compound using the DNA marker. In this project period, this DNA marker was used for the selection of seedlings and parents for this year marker-assisted selection.

Table 1. UF strawberry cultivars producing 'peach-like' flavor.

Cultivar	*FaFAD1*	Average of Y-D	DNA Test
Sweet Charlie	Yes	High	Yes
WinterStar	Yes	High	Yes
Florida Beauty	Yes	High	Yes
Florida Brilliance	Yes	High	Yes
Sweet Sensation 'FL127'	Yes	High	Yes
Florida Elyana	Yes	High	Yes
Florida Radiance	Yes	Medium	Yes
Strawberry Festival	No	Absence	Yes
Winter Dawn	No	Absence	Yes

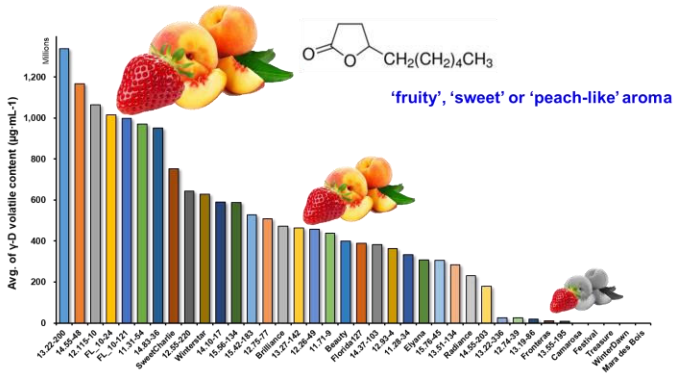

Figure 2. Presence of Fruity aroma, γ-decalactone (γ–D), in cultivated strawberry and UF breeding germplasm.

'Florida Pearl' is a new white strawberry cultivar released from UF breeding program. We identified that a single gene, *FaMyb10*, controls white fruit color when fully ripe. The newly developed DNA test perfectly predicts red or white fruit skin color from seedlings leaf tissues before any fruits are produced. This DNA marker was used to selected seedlings from crossings between varieties of white and red fruit. As shown in Figure 3, the absence of *FaMyb10* gene leads to completely white fruits lacking anthocyanins in the fruit skin. For the pinkish fruit, we are currently investigating what gene controls the pink rosette fruit.

Figure 3. A new strawberry variety 'Florida Pearl' from University of Florida that is white with a slight pink blush and red seeds when fully-ripe. Photo credit: Cristina Carrizosa, UF/IFAS Communications (left). Florida strawberry varieties with red, pink, or white fruit color. Photo Credit: Seonghee Lee (right).

DNA tests for multiple disease resistance

DNA markers for multiple disease resistance such as Phytophthora crown and root rot, Colletotrichum crown rot, anthracnose fruit rot, bacterial angular leaf spot, charcoal rot, and fusarium wilt, were used for the marker-assisted seedling selection. In this project period, we identified three genes conferring resistance to charcoal rot. DNA markers were developed and validated with UF breeding populations. In 2020, a total of 50,400 seedlings were screened by various DNA markers for a combination of multiple disease resistances, flavor and early harvest. In addition, approximately 68,000 seedlings were screened in the season 2021 for disease resistance and fruit quality (Figure 3). About 15,000 seedlings were retained for field evaluation in the 2020-2021 season.

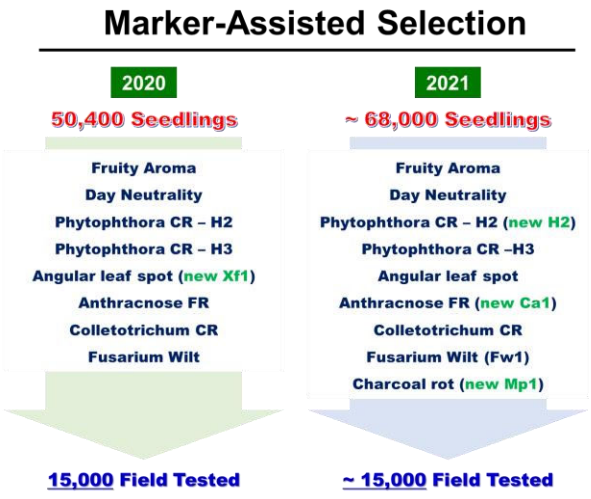

Figure 3. Summary of marker-assisted seedling selection conducted in seasons of 2020 and 2021.

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