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## PHENOTYPING OF STRAWBERRY BREEDED FROM TURKEY BREEDING PROGRAM

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### Abstract

The standardized phenotyping protocol for strawberries was agreed upon by the breeding team in Oregon, Michigan, New Hampshire, California and Florida and includes four trait categories: phenology and other flower-related traits, plant characteristics, fruit characteristics, and fruit chemistry traits. This study aims to introduce this category to the breeding programs in our country to characterize 15 cultivars of strawberries that are bred in our country. In this context, 25 properties are evaluated. As a result, our cultivars are globose conic in respect of external fruit properties, appearance is above average, achene colour is dark, achene position is even, external colour is red, gloss is average, skin strength is soft, calyx size is above equal, calyx position is flat. In terms of fruit internal properties, firmness is soft, internal colour is light red, depth of internal colour is at 51.8% level and average level, aroma is at high level.

**Keywords:** Strawberry, phenotyping characterization, plant qualities, breeding.

### Introduction

Most plant breeding programs revolve around identifying novel and ideal phenotypes. The phenotype is the characteristic of an individual that can be observed and results from the interaction of its genotype with the environment. Success of a breeding program is defined by identifying the optimum traits needed for an individual to be released as cultivar. Most breeding programs still utilize traditional approaches to identify desirable phenotypes. Marker-assisted breeding (MAB) can facilitate and speed up the release of new cultivars. This technology is becoming easier to integrate into a traditional breeding program due to decrease in costs, increased efficiency, and marker availability (Bliss, 2010; Mathey et al. 2013). The U.S. Department of Agriculture-National Institute of Food and Agriculture (USDA–NIFA) Specialty Crop Research Initiative-funded RosBREED project aims to ‘bridge the chasm’ between genomics and traditional rosaceous crop breeding programs (Iezzoni et al., 2010). Large-scale phenotyping protocols have been published for apple (Evans et al. 2011) and peach (Frett et al. 2012) and presentations of the standardized phenotyping can be viewed for all crops (apple, peach, cherry and strawberry) at [www.rosbreed.org](http://www.rosbreed.org). Through the efforts of the U.S. Department of Agriculture-National Institute of Food and Agriculture (USDA–NIFA) Specialty Crop Research Initiative-funded project “RosBREED”, large scale standardized phenotyping protocols were established by breeding teams in diverse environments in the United States (California, Florida, Michigan, Oregon, and New Hampshire) for strawberry to capture phenological and flowering related traits, plant characteristics, fruit characteristics and fruit chemistry (Hancock et al. 2016; Iezzoni et al. 2010; Mathey et al. 2013). The RosBREED’s strawberry group evaluated 890 genotypes that represent the breadth of diversity in the strawberry breeding germplasm and their wild relatives. Within this group was a set of 36 crosses representing eastern and western North American short day and remontant genotypes (Mathey et al. 2017). The objectives are to describe a panel strawberry cultivars breeding programs from Turkey. The traits evaluated were related to fruit quality (shape, appearance, capping, calyx position, percent of filled achenes, achene color, gloss, skin toughness, external and internal color, depth of internal color, flavor, average weight), fruit chemistry (soluble solids, titratable acidity, pH) and plant development (peduncle length, flowering location, presence of anthers, truss size, crop estimate).

### Material and methods

The study was carried out in Mustafa Kemal University Faculty of Agriculture Department of Horticulture between 2015-2016. As a plant material were used to 15 strawberry cultivars (Arnavutköy, Ata77, Bolverim77, Doruk77, Dorukhan77, Ebru, Eren77, Erenoğlu77, Hilal77, Kaşka, Osmanlı, Sevgi, Yalova104, Yalova15, Yalova416) obtained from Atatürk Horticultural Central Research Institute. The experiment was conducted in the glasshouse. The planting were potted with fresh plants at the end of November. Drip irrigation method was used in the study. In this study, 25 phenotypic traits identified in Table 1 were evaluated.

Table 1. Description of the 25 strawberry phenotypic traits (Mathey et al. 2013).

Trait	How trait was evaluated
<b>Phenology</b>	
Peduncle length	Scored 1-5; 1= divides close to crown, 2= divides at 25% from crown, 3= divides 50% from crown, 4= divides 75% from crown, 5= divides right before flower/fruit
Flowering location	Determined at bloom; Scored 1-2; 1= above or 2= below canopy
Presence of anthers	Determined at bloom; Scored 1-2; 1= yes, 2= no
Truss size	Number of flowers per truss
<b>Plant characteristics</b>	
Crop estimate	Amount of fruit on plant; Scored 1-9; 1= no fruit; 9= over-cropped
Vigor	Plant health/growth; Scored 1-9; 1= dead; 9= extremely vigorous
<b>External fruit characteristics</b>	
Shape	Scored 1-9; 1= long conic, 3= globose, 5= globose conic, 7= cordiform, 9= oblate
Appearance	Scored 1-9; 1= very malformed; 9= symmetrical and attractive
Achene color	Scored 1-9; 1=dark; 9=very light brown or green
Achene position	In relation to fruit surface; Scored 1-3; 1= sunken, 2=even, 3=protruding
Percent of filled achenes	Percent of all achenes that were filled (10% increments)
External color	Scored 1-9; 1= white; 9= "black"
Gloss	Scored 1-9; 1=dull; 9=very glossy
Skin firmness	How easily fruit was abraded when thumb firmly dragged over flesh; Scored 1-9; 1=soft; 9= tough
Cap size	Calyx size in relation to fruit width; Scored 1-3; 1=calyx smaller, 2=calyx equal, and 3=calyx larger
Calyx position	Scored 1-5; 1=raised (necked), 3= flat (even with shoulders), 5= sunken
<b>Internal fruit characteristics</b>	
Firmness	Firmness of flesh when a fully ripe fruit was compressed between thumb and forefinger Scored 1-9; 1= mush; 9= hard
Ease of capping	Ease with which cap was removed when pulled by fingers; Scored 1-9; 1= does not remove; 9= very easily removed
Internal color	Fruit sliced down the meridian; Scored 1-9; 1= white; 9= "black"
Depth of internal color	Percentage of solid color (10% increments)
Flavor	Perception of sweetness and presence of off flavors; Scored 1-9; 1= not sweet, bad off flavors; 9= very sweet, no off flavors
<b>Fruit characteristics measured in the lab including weight and chemistry</b>	
Fruit weight	Average weight of five primary fruit harvested when plant had 30-50% rip fruit, g
pH	pH of fruit puree
Soluble solids	Brix (g 100 g <sup>-1</sup> ) of fruit puree; determined using refractometer
Titrateable acidity	G L <sup>-1</sup> citric acid of fruit puree; determined using auto-titrator with pH 8.1 end-point

## Results and discussion

Some of the genotypes from Turkey strawberry breeding programs are located to cultivar such as 'Arnavutköy', 'Aliso' ve 'Tioga' in the Yalova (Konarlı et al. 1984); again Yalova 'Osmanlı', 'Yalova104', 'Tufts', 'Cruz' ve 'Tioga' cultivars crosses of different combinations of varieties (Erenoğlu et al. 1998). The characterization used in the phenotypic description are presented in Table 1. The mean values of the phenotypic characteristics of the strawberry cultivars from Turkey strawberry breeding programs are presented in Table 2.

Table 2. Mean, minimum and maksimum values for 25 traits of the referans cultivars and breded from Turkey.

Variable	Referans Cultivars (RC) (Hancock et al. 2015)		Local Cultivars (LC)	
	Mean	Cultivar Numbers	Mean	Range
<b>Phenology</b>				
Peduncle length	3.5	15	3.47	1-5
Flowering location	1.4	15	1.41	1-2
Presence of anthers	-	15	1.12	1-2
Truss size	5.1	15	8.06	5-11
<b>Plant characteristics</b>				
Crop estimate	4.1	15	6.38	5-9
Vigor	4.3	15	6.53	3-8
<b>External fruit characteristics</b>				
Shape	5.8	15	5.50	1-9
Appearance	5.2	15	5.56	3-8
Achene color	4.4	15	2.88	1-7
Achene position	2.2	15	1.88	1-3
Percent of filled achenes	88.6	15	92.5	80-100
External color	6.8	15	6.13	2-8
Gloss	6.1	15	5.75	3-9
Skin firmness	5.4	15	3.94	1-6
Cap size	1.2	15	2.24	1-3
Calyx position	3.3	15	3.0	1-5
<b>Internal fruit characteristics</b>				
Firmness	5.6	15	4.19	1-7
Ease of capping	5.3	15	4.94	2-9
Internal color	5.1	15	4.63	1-8
Depth of internal color	78.1	15	51.88	10-100
Flavor	4.4	15	7.19	6-9
<b>Fruit characteristics measured in the lab including weight and chemistry</b>				
Fruit weight	9.7	15	7.1	3.5-14.0
pH	3.4	15	3.6	3.25-3.94
Soluble solids	8.9	15	6.1	3.2-8.7
Titrateable acidity	0.9	15	0.82	0.43-1.27

In terms of the phenological characters examined local strawberry cultivars, average peduncle length was determined as 3.47. When the flowering location was 1.41, it is possible to say that the flowering location are near to crown, the number of truss size per flower was determined as 8.06 in

our strawberry varieties. In terms of yield estimates of plant characteristics, the value set as 4.1 in RC was 6.38 in LC. Plant vigor, the RC value was 4.3 and the LC value was 6.53. As a result, plant characteristics, LC and RC gave similar results. The value determined by shape of the fruit exterior characteristics was determined as 5.50 in local strawberry cultivars and found to be close to the global conical. In terms of aken position; similar and above; percent of filled achenes; high and filled, external color; similar and red, gloss; similar and bright, calyx size; equal, calyx position; flat, appearance; medium, in terms of aken color, the RC color is clearly defined; LC is determined as dark. Among the fruit exterior characteristics, fruit skin firmness in the RC was determined as hard, but LC was found to be softer (Table 2). It has been determined that there is a significant diversity between RC and LC in terms of fruit interior characteristics. When RC was determined to be harder than YC in terms of firmness, it was determined that LC calyx easily breaks in terms of ease of capping. In terms of internal color and depth of internal color, it was determined that LC is lighter than RC. In terms of taste/aroma, it appears that our LC cultivars are aromatic (Table 2). When fruit weight and chemical properties are examined, fruit weight was determined to be 9.7 g/fruit as average of RC, and this value was determined as 7.1 g/fruit in YC. pH and titratable acidity were similar in both groups; it was found that YC gave a somewhat lower value in terms of soluble solids (Table 2).

### Conclusions

In this study, it was aimed to phenotypically identify 15 strawberry local strawberry (LC) cultivars from our country strawberry breeding programs using reference strawberry (RC) cultivars from different breeding programs. In this context, 26 features were examined. We have determined that we have improved plant characteristics of strawberry breeding programs of Turkey and varieties similar to the varieties used as reference in terms of plant characteristics. As a result, shape of fruit external features; spherical conical, appearance; the albinism is on the middle, fruit color; bold, flowering position; on, external color; red, brightness; medium, skin firmness; soft, calyx size; on the median, calyx position; flat, fruit firmness; soft, internal color; light red, and in terms of taste/aroma, we seem to be improving the varieties at a high level.

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