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# **Evaluation of Apricot Selections for the North Italian Environment**

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#### Abstract

Within a breeding program started by CReSO, a Regional Research Consortium, in order to diversify the range of apricot cultivars suitable to be grown in the Piemonte Region, progenies were obtained in 1999 between Tonda di Costigliole (T) (male parent) and either Goldrich (G), or Laycot (L). Tonda di Costigliole was expected to confer good environmental adaptability, aroma and taste; Goldrich and Laycot were chosen for the large size of fruits, the good flesh firmness, and the intense skin colour. Following a preliminary evaluation, 5 selections were chosen and tested for tree and fruit traits in the environment of Piemonte. In 2006 and 2007, apricot samples were analysed for soluble solid content, titratable acidity, pH, fruit firmness, skin colour and sensory characteristics. This two-year study showed that 2 selections are very promising for their good qualitative traits: LxT P14 that maintained or improved several characteristics of Tonda di Costigliole and LxT P8 that was appreciated for overcolour and aroma.

### **INTRODUCTION**

Italy produces about 7% of world total apricot amount (*Prunus armeniaca* L.) and it is the thirth producer country, after Turkey (17.2%) and Iran (9.1%) (FAO, 2007).

Campania, accounting for 33% of the national production and Emilia Romagna, for 26%, are the major producer Regions. Other important production areas are Basilicata (14%), Piemonte and Sicilia (5%) (ISTAT, 2007).

Apricot cultivation in Piemonte, is mainly spread in the area and surroundings of Costigliole di Saluzzo village (Cuneo province) and, to a lower extent, in the Asti province. In the last years the varietal choice has been addressed towards modern cultivars of recent introduction, but traditional varieties continue to be appreciated and cultivated. Tonda di Costigliole is the only autochthonous cultivar still grown in Piemonte and accounts about 40% of the whole regional production; its fruits are destined both to the fresh market and to processing as canned, dried and for jam production . This cultivar represents a case of perfect adaptation to local climatic conditions but has some limits,

such as the small size and the poor colour of the apricot; nevertheless the fruit is appreciated for sweetness, aroma intensity and juiciness.

Within a breeding program, started by CReSO Research Consortium, progenies were obtained in 1999 using Tonda di Costigliole as male parent. The main objective was to expand the range of apricot varieties suitable to be grown in Piemonte Region by obtaining new selections with improved quality preserving the positive traits, such as good environmental adaptability, aroma and taste, of the local cultivar Tonda di Costigliole.

#### **MATERIALS AND METHODS**

In 1999, progenies were obtained from Tonda di Costigliole (male parent) and either Goldrich (GxT) or Laycot (LxT). Following a preliminary evaluation carried out at the experimental station of Astra Innovazione Mario Neri – Imola (CRPV – Emilia Romagna), 5 selections were chosen to be tested for agronomic performance and fruit quality in the environment of Piemonte Region. The trial was planted in 2004 at the CReSO experimental farm located at Manta (Cuneo Province), 395 m above sea level. This paper presents the results of 2 years of observations (2006 and 2007).

#### **DNA** analysis

The identity of the selections and their parentage were checked by SSR (*Simple Sequence Repeats*) analysis. DNA was extracted from young leaves, according to the protocol described by Thomas *et al.* (1993), with some modifications. Samples were analyzed at 10 SSR loci: 2 loci of *Prunus persica* L. (UDP96-003, UDP96-409 – Cipriani *et al.* 1999) and 8 loci of *Prunus armeniaca* L. (Pa CITA 7, Pa CITA 10, Pa CITA 23 – Lopes *et al.* 2002; UDAp-414, UDAp-420, UDAp-410, UDAp-415 – Messina *et al.* 2004; AMPA100 – Hagen *et al.* 2004). The SSR analysis was performed by a 3130 Genetic Analyzer capillary sequencer. Results were elaborated with the Genescan software and alleles were defined by their size, determined in base pairs by comparison with the size standard (Genescan-500 Liz).

#### Pomological and chemicals fruit traits

In 2006 and 2007, flowering and ripening times were recorded. In addition, fruits were sampled from the 5 selections and their parent cultivars. The following parameters were determined each year on three replicates of 10 fruits each: fruit weight, flesh firmness (using Durofel), total soluble solids (T.S.S.), pH and titratable acidity (T.A.).

Skin color was measured by a Minolta colorimeter. In this system of color representation, the values  $L^*$ ,  $a^*$  and  $b^*$  describe a uniform three-dimensional color space: the  $L^*$  value corresponds to a dark-bright scale,  $a^*$  is negative for green and positive for red, and  $b^*$  is negative for blue and positive for yellow.

The amounts of the main sugars, polyalcohols and organic acids of the juice were determined using a DANI 86.10 capillary gaschromatograph after silanisation (Valentini and Botta, 1999).

Total polyphenolics, antioxidant activity and anthocyanin content were measured, in order to evaluate the antioxidant capacity of the selections. Anthocyanin content was quantified according to the pH differential method by Cheng and Breen (1991). Anthocyanins were estimated through absorbance measurement at 515 and 700 nm in buffers at pH 1.0 and pH 4.5 Results were expressed as mg of cyanidin-3-glucoside (C3G) per 100g of fresh fruit. Total polyphenolics were determined with the Folin-Ciocalteau reagent by the method of Slinkard and Singleton (1977) using gallic acid as standard. Results were expressed as mg gallic acid- equivalents (GAE) per 100g of fresh fruit. For the evaluation of the antioxidant activity the FRAP (Ferric Reducing Antioxidant Power) assay was used, following the method by Pellegrini *et al.* (2003), with some modifications. The method is

based on the reduction of the Fe<sup>3+</sup>-TPTZ complex to the ferrous form at low pH: this reduction is monitored by measuring the absorbance change at 593 nm. 120 $\mu$ l of diluted sample were mixed with 900 $\mu$ l of FRAP reagent prepared daily and the absorbance was recorded after 30' at 37°C. FRAP was calculated by a standard curve produced by the addition of freshly prepared solutions containing FeSO<sub>4</sub> x 7H<sub>2</sub>O 100-1000  $\mu$ M.

#### Sensory analysis

Sensory evaluation was carried out on samples of the 2007 harvest by a trained panel of 10 tasters of O.N.A.Frut. (National Organization of Fruit Tasters). Each sample was coded with a randomly selected three-digit number and consisted of more apricots cut into bite-size pieces. They were equilibrated to room temperature and presented together to each panellist in a randomised order. A total of 8 descriptors were used to evaluate organoleptic traits by quantitative descriptive analysis (QDA) method. The descriptors were: flesh colour, flesh odour intensity, flesh firmness, juiciness, sweetness, acidity and aroma. Samples were scored for each descriptor using a continuous scale ranging from 0 to 10, where 0 = absent and 10 = very high. In order to have preliminary information about overall quality of each sample, the panellists were also required to indicate their preference.

Chemical and sensory data were statistically analysed by ANOVA and means were compared by Tukey test.

#### **RESULTS AND DISCUSSION**

The genetic profiles obtained by SSR analysis (Table 1) confirmed the parentage of the selections and univocally identified them and the parent cultivars.

Fruits of the selections showed weight (Table 2) comparable or larger than Tonda di Costigliole, with significant differences in both years for LxT P15, and GxT P10. In addition, weight and size increased in 2007 in comparison with 2006, for all the selections. Fruit firmness improved in all selections but GxT P7 (Table 2); yet, only the selections LxT P15 and LxT P8 showed significant differences with Tonda di Costigliole in both years. The results of year 2007 were confirmed by sensory analysis.

Colour has a significant impact on consumer perception of apricot quality especially regarding fruit attractiveness and the percentage of overcolour varies depending on the genotype (Ruiz & Egea, 2008). By colorimetric analysis (Table 3), it was showed that the red component of the skin colour resulted improved in most selections. Overcolour (Table 3) was lower, on the average, in 2006 than in 2007 when all selections developed overcolour but GxT P10, that did not show this trait in both years; LxT P8 and LxT P14, in particular, were significantly more overcoloured than Tonda di Costigliole.

Results of chemical analysis (Table 4, 5 and 6) showed a quite large range of variation among the selections as concerns the amounts of acids and sugars. In both years, total soluble solids (Table 4) were higher than 13°Brix in all selections but GxT P10, and were over 16°Brix in LxT P14. The acidity is also another important descriptor to determine fruit taste: apricots of Tonda di Costigliole, Laycot and LxT P14 showed the lowest values of titratable acidity (Table 4). All of the other selections showed an increased value of acidity in 2007, except Tonda di Costigliole, LxT P15 and GxT P7.

Sucrose was always the prevalent sugar (Table 6), with percentages over total sugars ranging from 62% (LxT P8) to 72% (GXT P10) in 2006 (data not shown) and from 55% (LxT P14) to 79% (GxT P10) in 2007. The GXT P10 selection showed the highest percentage of sucrose in the 2 years. Glucose and fructose resulted respectively the second and the third sugar, accounting together approx. 30% total sugars. Some selections had relevant amounts of sorbitol (over 3%) as in

Tonda di Costigliole: the selections LxT P8, LxT P15 and LxT P14 maintained this trait in both years. Two selections showed relevant amounts of raffinose (over 1%): LxT P8 in 2006 (data not shown) and GxT P7 in 2007. In general, the total amount of minor sugars was remarkable (over 4%) for many selection (Table 6).

Fruit antioxidant capacity (FRAP value) was significantly higher than in Tonda di Costigliole (Table 7) in the selections GxT P10 and LxT P8; total phenolic content was significantly higher than Tonda di Costigliole only in the selection GxT P10. Anthocyanin content was very low in apricot (data not shown): in 3 selections the method did not detect any quantity, in other 2, the value were lower than in the parents.

The main descriptors used in sensory evaluation for characterizing the different selections were skin colour, intensity of apricot odour, firmness, sweet and bitter taste and apricot aroma intensity (Fig. 1). Regarding flesh firmness and colour traits, the breeding sorted good results; in fact panellists described all selections as firmer and more coloured than Tonda di Costigliole. Taste and aroma were positive features of Tonda di Costigliole to be maintained in the progeny: sweetness was rated higher in LxT P14. Acidity varied among samples but data of selections were not significantly different from the value of Tonda di Costigliole. LxT P15 selection was described as having slightly more bitter fruits than the others. One selection (LxT P8) resulted improved for aroma. In general, almost all selections were appreciated by panellists that expressed an overall quality judgment (Goldrich 5.56c; Laycot 6.67abc; Tonda di Costigliole 6.63abc; LxT P8 8.19a; LxT P14 7.88ab; LxT P15 6.06bc; GxT P7 7.11abc; GxT P10 6.22abc) and rated LxT P8 the highest, followed by LxT P14.

#### CONCLUSIONS

Apricot is a plant far less cultivated than other *Prunus* species, particularly peaches, and its cultivation is mainly limited to the Mediterranean areas. The breeding goals, therefore, are frequently restricted to climatic requirements and they do not consider many other objectives (Egea, 2006). In order to match a larger number of objectives, yet, it is fundamental to maintain biodiversity and, in particular, to preserve the good traits of the local and typical varieties. This will favour the breeding of cultivars joining adaptability to each particular environment with good physical and chemical characteristics, that are required to ensure consumers' acceptability (Abbot, 1999).

The results of the two years of observations showed that 2 selections are very promising for their good qualitative traits. LxT P14, in particular, mantained or improved several characteristics of Tonda di Costigliole, the local reference cultivar. LxT P 8 was appreciated for the good overcolour and aroma.

Since year-by-year variation for physical, chemical and sensorial attributes in apricot can be significant (Audergon *et al.*, 1991; Ruiz and Egea, 2008) a third year of observations and the evaluation of yield will be necessary to complete the study and define the value of the selected material.

#### **ACKNOWLEDGEMENTS**

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# **Tables**

| Cultiver / Colection | loci (allele size expressed in base pairs) |       |           |     |          |     |          |     |          |     |  |
|----------------------|--|-------|-----------|-----|----------|-----|----------|-----|----------|-----|--|
| Culuvar / Selection  | UDP96-003                                  |       | UDP96-409 |     | PaCITA7  |     | PaCITA10 |     | PaCITA23 |     |  |
| L X T P8             | 94   | 112   | 133       | 163 | 188      | 194 | 164      | 174 | 141      | 141 |  |
| L X T P14            | 112  | 112   | 155       | 163 | 211      | 211 | 164      | 174 | 147      | 152 |  |
| L X T P15            | 112  | 112   | 155       | 163 | 211      | 211 | 172      | 174 | 141      | 147 |  |
| G X T P7             | 98   | 112   | 133       | 137 | 194      | 211 | 174      | 174 | 141      | 147 |  |
| G X T P10            | 112  | 112   | 137       | 155 | 211      | 211 | 174      | 174 | 141      | 147 |  |
| Laycot               | 94   | 112   | 141       | 163 | 188      | 211 | 164      | 172 | 141      | 147 |  |
| Goldrich             | 98   | 112   | 133       | 137 | 206      | 211 | 174      | 176 | 143      | 147 |  |
| Tonda di Costigliole | 112  | 112   | 133       | 155 | 194      | 211 | 174      | 174 | 141      | 152 |  |
| Cultivar / Selection | UDA  | p-410 | UDAp-414  |     | UDAp-415 |     | UDAp-420 |     | AMPA100  |     |  |
| L X T P8             | 139  | 152   | 173       | 173 | 147      | 158 | 158      | 166 | 213      | 217 |  |
| L X T P14            | 139  | 152   | 152       | 173 | 147      | 158 | 158      | 170 | 213      | 217 |  |
| L X T P15            | 139  | 152   | 173       | 173 | 147      | 158 | 166      | 180 | 207      | 207 |  |
| G X T P7             | 123  | 125   | 152       | 169 | 163      | 163 | 166      | 180 | 195      | 207 |  |
| G X T P10            | 123  | 152   | 169       | 173 | 163      | 163 | 170      | 172 | 195      | 207 |  |
| Laycot               | 139  | 139   | 165       | 173 | 147      | 163 | 158      | 180 | 207      | 213 |  |
| Goldrich             | 123  | 123   | 165       | 169 | 163      | 173 | 172      | 180 | 195      | 207 |  |
| Tonda di Costigliole | 125  | 152   | 152       | 173 | 158      | 163 | 166      | 170 | 207      | 217 |  |

Table 1. Genetic profiles at 10 SSR loci of the apricot selections and of their parent cultivars.

Table 2. Physical data of the apricot selections and of their parent cultivars in 2006 and 2007. Means with the same letter do not significantly differ for  $p \le 0.05$ .

| Cultivar / Selection — | Weig    | ht (g)   | Selection | Firmness | Firmness (durofel) |          |  |
|------------------------|---------|----------|-----------|----------|--------------------|----------|--|
|                        | 2006    | 2007     | weight    | 2006     | 2007               | firmness |  |
| Goldrich               | 65.37 a | 94.20 a  | 1         | 41.83 d  | 59.77 c            | 1        |  |
| Laycot                 | 65.17 a | 70.40 b  | 1         | 36.69 d  | 64.37 bc           | 1        |  |
| Tonda di Costigliole   | 34.23 c | 41.23 e  | 1         | 54.72 c  | 58.30 cd           | 1        |  |
| LxT P8                 | 39.80 b | 42.23 e  | +         | 64.17 b  | 68.47 ab           | ++       |  |
| LxT P14                | 30.60 c | 49.77 d  | +         | 67.08 b  | 63.93 bc           | +        |  |
| LxT P15                | 42.60 b | 55.10 cd | ++        | 80.68 a  | 71.83 a            | ++       |  |
| GxT P7                 | 32.43 c | 51.47 d  | +         | 43.80 d  | 52.23 d            | 1        |  |
| GxT P10                | 39.07 b | 59.73 c  | ++        | 70.52 b  | 61.10 c            | +        |  |

+ = better than Tonda di Costigliole in one year; ++ = better than Tonda di Costigliole in 2 years.

| Cultivar / Selection | Ground colour L* |        | Ground colour a* |        | Ground colour b* |          | Overcolour % |        |
|----------------------|------------------|--------|------------------|--------|------------------|----------|--------------|--------|
|                      | 2006             | 2007   | 2006             | 2007   | 2006             | 2007     | 2006         | 2007   |
| Goldrich             | 56.2f            | 63.5c  | 21.2a            | 18.5a  | 47.1abc          | 48.9a    | 1            | 1.3d   |
| Laycot               | 59.0e            | 64.5bc | 18. 9b           | 17.5a  | 45.1cd           | 45.7cde  | 11.3c        | 18.0bc |
| Tonda di Costigliole | 68.7a            | 71.5a  | 8.8c             | 7.7d   | 48.5a            | 44.1ef   | 0.7d         | 6.0d   |
| LxT P8               | 63.3c            | 65.9b  | 17.8b            | 12.9b  | 46.1abcd         | 46.8 bcd | 22.5b        | 28.8a  |
| LxT P14              | 66.3b            | 70.3a  | 9.6C             | 10.7bc | 45.7bcd          | 47.94ab  | 31.0a        | 29.3a  |
| LxT P15              | 61.5d            | 64.0c  | 18.5b            | 18.7a  | 42.3e            | 42.62 f  | 0.17d        | 10.8cd |
| GxT P7               | 66.0b            | 70.3a  | 9.5c             | 8.4cd  | 43.6de           | 45.19de  | 0.77d        | 6.4d   |
| GxT P10              | 61.2d            | 63.4c  | 19.3ab           | 17.4a  | 47.6ab           | 47 bc    | 1            | 1      |

Table 3. Skin colour of apricot selections and parent cultivars. Means with the same letter do not significantly differ for  $p \le 0.05$ .

Table 4. Soluble solids and titratable acidity of ripen apricot selections and parent cultivars. Means with the same letter do not significantly differ for  $p \le 0.05$ .

| Cultivar / Soloction | 2006        | 2007        | 2006                | 2007                |  |  |
|----------------------|-------------|-------------|---------------------|---------------------|--|--|
| Cultivar / Selection | RSR (°Brix) | RSR (°Brix) | Acidity (meq/100ml) | Acidity (meq/100ml) |  |  |
| Goldrich             | 14.8 c      | 12.1 c      | 30.8 b              | 36.0 a              |  |  |
| Laycot               | 16.1 a      | 14.1 b      | 18.3 h              | 23.9 d              |  |  |
| Tonda di Costigliole | 16.4 a      | 14.7 b      | 21.5 f              | 17.5 f              |  |  |
| LxT P8               | 15.4 b      | 13.8 b      | 27.1 d              | 30.1 b              |  |  |
| LxT P14              | 16.4 a      | 16.1 a      | 20.3 g              | 21.6 e              |  |  |
| LxT P15              | 16.4 a      | 14.6 b      | 28.5 c              | 27.8 c              |  |  |
| GxT P7               | 14.2 d      | 14.2 b      | 26.3 e              | 22.5 de             |  |  |
| GxT P10              | 12.6 e      | 11.4 c      | 31.5 a              | 31.1 b              |  |  |

Table 5. Amounts of main organic acids of ripen apricot (mg/100g fresh fruit) in 2007. Means with the same letter do not significantly differ for  $p \le 0.05$ .

| Cultivar / Selection | Succinic acid | D-malic acid | Citric acid | Quinic acid | Total |
|----------------------|---------------|--------------|-------------|-------------|-------|
| Goldrich             | 42 abc        | 814 ab       | 1994 a      | 61 ab       | 2911  |
| Laycot               | 53 ab         | 699 abc      | 1513 ab     | 82 a        | 2347  |
| Tonda di Costigliole | 22 c          | 582 cd       | 1241 b      | 25 cd       | 1870  |
| LxT P8               | 27 bc         | 612 bcd      | 1693 ab     | 12 d        | 2344  |
| LxT P14              | 35 abc        | 839 a        | 1292 b      | 27 cd       | 2193  |
| LxT P15              | 29 abc        | 754 abc      | 1541 ab     | 48 bc       | 2372  |
| GxT P7               | 59 a          | 593 cd       | 1805 ab     | 44 bc       | 2501  |
| GxT P10              | 36 abc        | 413 d        | 1970 a      | 83 a        | 2502  |

| Cultivar / Selection | D-sorbitol | myo-<br>inositol | Sucrose | D-(+)-<br>raffinose | Fructose | Glucose | D-(+)-<br>xylose | Total |
|----------------------|------------|------------------|---------|---------------------|----------|---------|------------------|-------|
| Goldrich             | 108 de     | 64 cd            | 5469    | 47                  | 624 b    | 2652 bc | 54               | 9018  |
| Laycot               | 610 ab     | 78 bc            | 6767    | 126                 | 562 bc   | 1994 cd | 64               | 10201 |
| Tonda di Costigliole | 433 bc     | 76 bcd           | 6959    | 53                  | 695 ab   | 3214 ab | 28               | 11458 |
| LxT P8               | 735 a      | 61 d             | 5422    | 83                  | 614 b    | 2118 cd | 26               | 9059  |
| LxT P14              | 415 bc     | 97 a             | 6625    | 50                  | 868 a    | 3949 a  | 46               | 12050 |
| LxT P15              | 704 a      | 64 cd            | 5739    | 87                  | 664 b    | 2168 cd | 42               | 9468  |
| GxT P7               | 274 cd     | 77 bcd           | 12754   | 455                 | 382 cd   | 2627 bc | 62               | 16631 |
| GxT P10              | 20 e       | 85 ab            | 7252    | 31                  | 261 d    | 1509 d  | 58               | 9216  |

Table 6. Amounts of main sugars and sugar-alcohols in ripen apricot (mg/100g fresh fruit) in 2007. Means with the same letter do not significantly differ for  $p \le 0.05$ .

Table 7. Antioxidant activity and amounts of total phenolics of ripen apricot (2007). Means with the same letter do not significantly differ for  $p \le 0.05$ .

| Cultivar/Selection   | FRAP<br>(mmol<br>Fe <sup>2+</sup> /kg) | Total<br>polyphenolics<br>(mg gallic<br>ac./100 g) | Cultivar/Selection | FRAP<br>(mmol<br>Fe <sup>2+</sup> /kg) | Total<br>polyphenolics<br>(mg gallic<br>ac./100 g) |
|----------------------|--|--|--------------------|--|--|
| Goldrich             | 11.55 ab                               | 119.03 ab  | LxT P14            | 6.83 c                                 | 51.31 d  |
| Laycot               | 11.06 ab                               | 64.33 cd   | LxT P15            | 12.40 ab                               | 114.35 ab  |
| Tonda di Costigliole | 10.65 b                                | 97.78 bc   | GxT P7             | 12.37 ab                               | 98.68 bc   |
| LxT P8               | 13.28 a                                | 101.17 bc  | GxT P10            | 13.33 a                                | 143.40 a   |

# **Figures**



Fig. 1. Sensory profiles of apricot cultivars and selections (2007); \*  $p\leq0.05$ ; \*\*  $p\leq0.01$ .