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Water Absorption of Detached Sweet Cherries

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In the studies of sweet cherry cracking, a consistent result obtained by many works in that cherry cracking may be caused by absorbing rain water through fruit skin, and the attempts to prevent the cracking were mainly conducted on the basis of this concept. It was, though, observ ed in orchards that there is no cracking injury in heavy crop trees, in spite of severe injury in light crop trees. The fact suggests that the cracking is not always caused by only water absorption through fruit skin. The route for water enterance in to cherry fruits has not been ascertained in detail. In the present paper water absorption through various portions of fruit surface was investigated at different stages and under simulated rainy condition. Development of senescence in vascular bundles of fruit flesh was also observed.

Materials and Methods

Used cherry cultivar was 12-year-old 'Satōnishiki' grown in the orchard of Faculty of Agriculture, Yamagata University. When picked, the bases of fruit stems were excised in water once more as sooner as the fruit stems were detached out of spurs, ensuring water absorption through the stems. The fruits of similar size and maturity were collected as samples.

Water absorption through fruit surface :

Ten fruits were selected for each treatment, and vaseline was applied on the surface of fruit and stem except the part which water absorption was examined. Such fruits were immersed in water for 8 hours and the vaseline was removed as clear as possible, then the fruits were weighed at once. An amount of water absorbed was indicated as grams per fruit.

Water absorption through cut surface of stem and fruit transpiration:

This experiment was carried out from May 28 to June 14. A short piece of rubber tubing was slided into the base of stem and the other end of the tubing was connected to the slender end of a pipette, then the rubber tubing and the pipette were filled up with water avoiding inclusion of air bubbles. Absorption rate through cut surface was determined by a decrease of water in the pipette. A decrease in total weight of fruit and pipette indicated the transpiration rate of the fruit.

Senescence in vascular bundles of fruit flesh :

The base of fruit stems was immersed in red ink which was diluted 3-fold with water. The durations of immersion were 4 hours for immature fruits and 8 hours for mature ones. Vascular bundles stained with the red ink were observed by preparing transversal and longitudinal sections.

Water absorption through fruit skin by water spraying :

Twenty detached fruits were used for each treatment. The fruits sprayed with water and unsprayed were left, respectively, in a moist chamber for 8 hours. Status of water drops on surfaces of fruits sprayed with water were similar to that of actual rain as shown in Fig. 1.

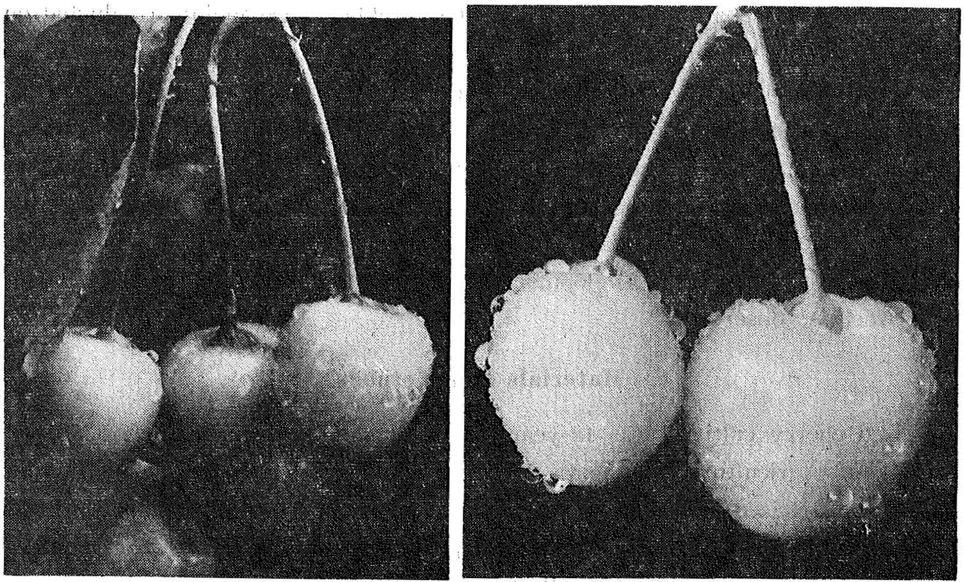

Fig. 1. Comparison of drops on cherry fruits between rain and water spraying.

Results and discussion

1. Absorption rate of various parts of fruit surface :

Water absorption of the fruit and stem is shown in Table 1 and that of the fruit alone in Table 2. Water absorption rate was most remarkable in all over the surface of fruits, considerably great in the fruit stems and less in the cut surface of stems. When the fruits were separated from their stems, the absorption rate was more conspicuous in an apical half of fruits than in a basal half, and extremely less in stylar scars. It seems that water absorption through fruit skins relates closely to the distribution of stomata (SAWADA, 1935).

Water absorption rate when fruits were immersed in water of various tem-

Table 1. Water absorption rate in the surface of various parts in a fruit and stem of the detached cherries by Vaseline application and immersion for 8 hours. (May 13—23, 1972)

Absorption surface	Water absorption rate
Fruit	0.0139g/fruit
Stem	0.0111
Fruit and stem	0.0312
Cut surface of stem	0.0026
Non-application	0.0417

Table 2. Water absorption rate in the surface of various parts of fruits in the detached cherries by vaseline application and immersion for 8 hours. (May 13—23, 1972)

Absorption surface of fruit	Water absorption rate
Apical half	0.0105 g/fruit
Basal half	0.0078
Stylar scar	0.0025

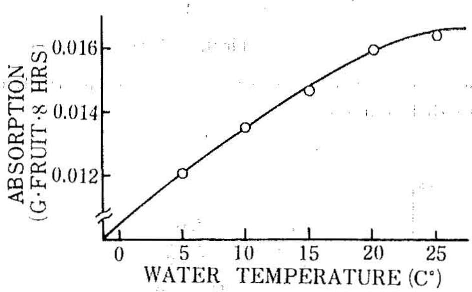

Fig. 2. Relationship between water absorption and temperature of water in which the detached cherries were immersed.

perature is shown in Fig. 2. As water temperature ascended from 0° C, water absorption rate increased up to 20° C the increasing became very slow, Q_{10} of water absorption calculated between 15° to 25° C gave a value of 1.013. BULLOCK (1952) found a Q_{10} of 1.55 for cherry cracking between the same temperature range. The rate of water absorption, hence, may be slower with ascending temperature. GERHART et al (1945) found that there was no injury for fruits immersed in water at 0° C for as long as 30 minutes. SAWADA (1931) showed that when a certain portion of fruit was immersed in water, cherry cracking was greater in the fruits immersed their stem cavity, and less in that of side parts. TOMARI (1970) obtained the similar results, too, it seems that greater water absorption of stem cavity is due to water absorbed through stem surface or cut surface of stems adjacent to fruits.

2. Comparison of water absorption through cut surface with fruit transpiration :

This experiment was carried out on May 28 to June 14. Rates of the fruit transpiration and the absorption through cut surface of stem bases were measured at intervals of a week for growing season and of 2 hours for one day. These results are shown in Fig. 3 and 4. Both the rates of absorption and transpiration

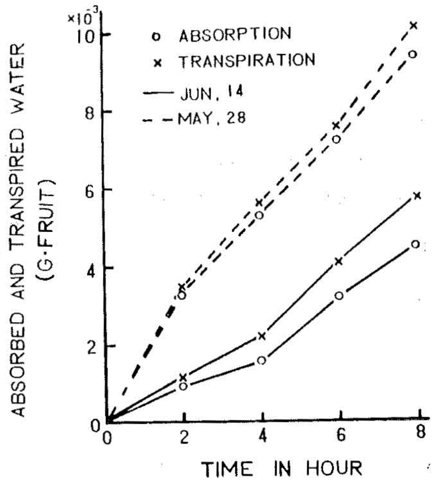

Fig. 3. Water absorption and transpiration of a detached cherry fruit with stem with the laspe of time in different days.

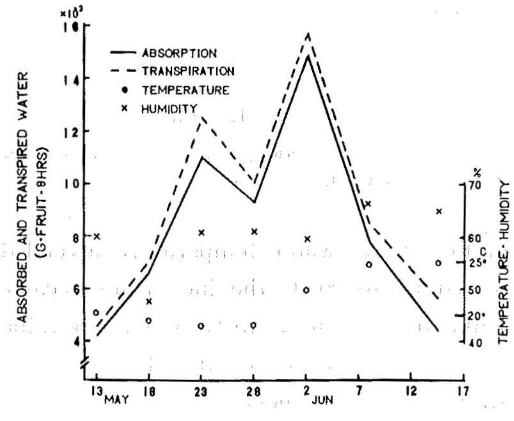

Fig. 4. Seasonal change in water absorption and transpiration of a detached cherry fruit with stem.

became greater with lapse of time, and the transpiration rate was greater than the absorption one both on May 28 and June 14. A difference in the rates between absorption and transpiration was larger on May 28 than on June 14. It is probable that intact fruits are supplied a water which corresponds to this difference by spurs. In growing season, the rates of absorption and transpiration increased at the begining of June, and after that time both the rates decreased with advancing of maturity. Always transpiration rate exceeded absorption one. Decrease in the rates on May 28 might be attributable to rain in successive several days.

3. Senescence in vascular bundles of fruit flesh :

Transversal and longitudinal sections of fruits in which red ink was absorbed, from May 20 to June 27, are presented in Fig. 5. Though senesence of bundles did not give rise until May 20, it began to occur at the begining of June. Decreasing

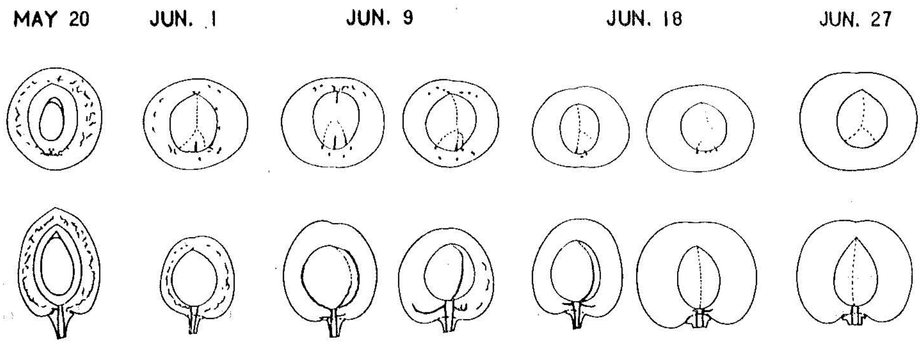

Fig. 5. Progress of senescence in the vascular bundles of flesh in cherries.

gradually, bundles reddened remained at ventral and dorsal parts. And main bundles reddened from stone base to apex along the stone. At late June, stained bundles remained dorsal bundles only. And further, reddened parts in these bundles decreased from apex toward the base gradually. At last, bundles were not stained. In the growing stage of fruits bundles began to senesce when green color of fruits turn into pale green. SIMONS (1968) found that senescing or death of the vascular tissue in 'Starking' apple fruit occurred at point of divergence and that cell proliferation was contiguous to the vascular tissue. It is not clear whether the bundles do not pass red ink as solute but pass water alone or do not pass the both. Actually, a flesh absorbs water through stem bundles.

4. Water absorption through fruit skin by water spraying :

On June 6, the stem bases of fruits sprayed with water and unsprayed were immersed in water in a moist chamber. Sprayed fruits absorbed water about a half as great as the fruits immersed entirely, and about 5 times as great as the unsprayed fruits in the moist chamber as seen in table 3. VERNER (1939) esti-

Table 3. Water absorption rate of a fruit with stem immersed in moist chamber for 8 hours. (June 6, 1972)

Treatment	Absorption rate
Immersion of fruit and stem	0.0269 g/fruit
Sprayed and immersion of stem base	0.0146
Unsprayed and immersion of stem base	0.0028

mated that the time required for cherry cracking is 2 times as long in rain as in immersion. The result in this experiment agreed with VERNER'S one. Fruits were picked at 5 : 00, 10 : 00 a. m. and 3 : 00 p. m. When the fruits were sprayed in the moist chamber, water absorption was most remarkable in the fruits picked at 10 : 00 a. m. as indicated in Table 4. The result suggests that cherries may or may not allow cracking by light rain depending upon the time in a day.

Table 4. Water absorption rate of a fruit with stem of the detached cherries spayed with water at various picked times and placed in a moist chamber for 8 hours.

Picked time	Absorption rate
5 : 00	0.0382 g/fruit
10 : 00	0.0532
15 : 00	0.0348

Actual rain water hung on fruits to be large and small sizes of water drops as shown in Fig. 1 and these drops grow great enough to flow. At last they flow on fruit surface. It seems that an amount of water absorption is less in contact with smaller area when rain than when immersed. Stoma, however, distribute more in an apical half of fruit surface than a lower half part (SAWADA, 1935). Cherry cracking is to occur frequently in the shoulder part of fruits. VERNER (1931) from results obtained by covering large branches and by times of irrigation, and SAWADA (1939) from results obtained by water pressure against cut surface of a branch, by immersion of the pot in which cherry trees were grown and by tension within branch bundles after heavy rain, postulated that cherry cracking may be caused by rain water through fruit, whereas HARTMAN et al (1929) stated that cherry cracking may result from too much moisture in soil or from exposure of the fruit to rain.

According to TOMARI (1970), methylene blue solution entering through stomata extended toward tangential direction in subepidermis rather than radial one. It seems that also pure water is permeable toward the same direction as methylene blue solution. If cherries crack with water absorbed through stomata, cracking will be fine and shallow and also will not distribute at suture and antisuture. When water conducted from roots gives rise cracks, water will be rapidly filled up any tissues of flesh through vascular bundles and every tissue will be turgid. As noted by TUKEY et al (1938), turgid cells swell radial direction in any tissues of flesh owing to cell shape in each fruit tissue. Cherry cracking, however, may not occur by only rain water absorbed through stomata, in addition water absorbed from soil will promote to crack.

Summary

It is said that cherry cracking may occur by absorption of rain water through fruit surface. Hence, it was investigated that which part of surface absorbs water mostly. Surface of fruits absorbed water most among various surfaces of fruits and stems, and an apical half of fruit surface absorbed more than a basal half. When the fruit with stem was immersed in water at various temperatures, the absorption rate increased with rising of temperature up to 20℃, and little increase was observed over 20℃. When water was absorbed from the cut surface of fruit stem and the transpiration from the fruit surface was determined, transpiration rate always overrided absorption one, and the both rates were greater at immature stage than at mature stage. During one season, absorption and transpiration showed the maximum rates at the begining of mature stage. All vascular bundles in fruit flesh were stained with the red ink absorbed through cut surface of stem at immature stage. As maturity of fruits advanced, stained bundles decreased gradually. At last only the bundles between the stone and the end of stem was stained, while water was absorbed still.

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摘　　要

摘み取ったオウトウ果実の吸水について

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オウトウの裂果は雨水が果面から吸収されて起こるといわれている．そこで水が果面のどこの部分より多く吸収されるかを調査した．果実の全面が，果こう面や果こうの切口よりも多かった．特に果面の頂半部が基半部よりも多く吸収した．

種々の温度の水に浸すと，20℃まで吸収量は増加したが，それ以上では増加しなくなった．果こうの切口を水に浸し，吸水と果面からの蒸散をみると，蒸散量は吸水量に勝り，両者は成熟期より未熟期の方が多く，生育期間中成熟直前で最高に達した．

果肉の維管束は未熟期に赤インクを果こうの切口よりよく吸収したが，果実の成熟が進むにつれて吸収は低下した．最後には種子と果こうの先端の間の維管束だけ染まった．しかし，水はいぜん果肉に供給された．