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Relationships Between Frost Resistance and Macro and Micro Element Contents of Buds of Some Peach Cultivars

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SUMMARY

There was an important difference between the frost resistance ability of the tested cultivars. However, their frost resistance ability increased from December and reached to maximum in January and February, but decreased in March. Generally, Redhaven was found to be the hardiest cultivar and it was followed by J.H. Hale and Dixired.

Among the nutrients nitrogen, calcium and iron were higher in the winter, natrium was lower in the winter and higher in Nowember and march. As a result, it is generally concluded that the high level of nitrogen, calcium, iron has a possitive correlation with the ability of frost resistance of cultivar.

Key Words: Frost resistance, peach, macro and micro elements, buds.

ÖZET

Bazı Şeftali Çeşitlerinin Tomurcuklarında Dona Dayanım İle Makro ve Mikro Elementlerin Kapsamları Arasındaki İlişkiler

Cardinal, Dixired, Redhaven, J.H. Hale ve H. Giant şeftali çeşitlerinin dona mukavemet kabiliyetleri arasında önemli farklar bulunmuştur.

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Genel olarak çeşitlerin dona mukavemetleri Aralık ayından itibaren artmış ve Ocak, Şubat aylarında maksimuma ulaşmıştır. Çeşitler arasında Redhaven dona en dayanıklı olarak tespit edilmiş ve bunu J. Hale ile Dixired izlemiştir. Çeşitlerin tomurcuklarında yapılan analizler itibariyle, kış aylarındaa azot, kalsiyum ve demir daha yüksek; sodyum ise kış aylarında düşük, Kasım ve Mart aylarında daha yüksek olarak belirlenmiştir. Genel olarak, kış aylarında yüksek miktarda bulunan azot, kalsiyum ve demir ile çeşitlerin dona mukavemet kabiliyetleri arasında pozitif bir korelasyon görülmüştür.

Anahtar Kelimeler: Dona dayanım, şeftali, makro ve mikro elementler, tomurcuklar.

INTRODUCTION

Low temperature, including frost, represents one of the most important environmental constraints limiting the productivity and the distribution of the horticultural crops. Thus, it is essential to select the resistant types or cultivars for the critical zones, but further protection can be obtained by the application of some cultural parctices, because, several other factors, also influence the extent of frost injury. Such factors as nutrient deficiencies or excesses, diseases and pests, previous crop density, irrigation, tree vigor, pruning, preconditioning temperatures, short term temperature variations and the time at which the freezing occurs all affect the extent of injury (Westwood 1970, Weiser 1970, Eriş 1985).

Meader and Blake (1943), investigated the frost resistance of buds of 6 peach cultivars by applying artificial freezing tests at –21.1°C and –22.1°C from November to March. They found that all tested cultivars were much more hardy in January and February, whereas very sensitive in March. For example, in January at –21.2°C, 58.3 % and 55.1 % bud survial rates were obtained from Triogem and Golden Jubilee cultivars respectively, whereas in March, at the same temperature, in the same cultivars, the bud survival rates were 0.6 % and 0.6 % respectively.

In a study, determining the frost resistance of Halehaven, Golden Jubilee and Elberta peach cultivars Edgerton (1954) indicated that the cultivars showed the highest resistance in the period of deep dormancy and found that there was an important relation between the frost resistance of the buds and the ambient air temperature. He concluded that even in the time when the buds were resistant, if weather temperature increases for a while, the resistance of the buds decreases very sharply.

Proebsting (1959) investigated the frost resistance of buds of Elberta peach cv. and temperature at which 50 % of the buds were killed (T50). In ge-

neral, he found that T50 points were as follows; in November 19.4$_o$C, in December 20.0°C, in January –20.5°C, in February 15°C, in March 9.4°C in April – 4.4°C respectively. He further stated that there was a very close relationship between air temperature fluctuations and buds frost resistance. His point of view is that "Increase in hardiness during the dormant period was always associated with decreasing temperature".

Campbell and Handle (1960) reportad that a temperature of –23.3°C to – 28°C caused the majority of the buds of 33 peach cultivars to die. Furthermore, a temperature below these points caused injury of wood of the tested cultivars.

The availability of nutrients essential for plant growth is also important for development of maximum resistance to cold and frost (Alden and Hermann 1971, Kozlowski 1979). Conflicting reports have appeared regarding the effect of nitrojen fertilization on peach fruit bud hardiness. For example, McMunn and Dorsey (1935) reported that high nitrogen application did not increase or decrease fruit bud hardiness.

Edgerton and Harris (1950) observed that a high nitrogen application to Elberta peach cv. before defoliation, increased the bud hardiness.

On the other hand, Proebsting (1960) reported that nitrogen application increased the bud hardiness of Elberta peach cultivar in either field or controlled conditions. Similar results were obtained by Solovieva (1974) in apples.

Pellet (1973), who worked on *Forsythia* and *Cornus,* found that nitrogen fertilization during the summer and fall had little effect on cold acclimation of roots or stem tissues. He observed that tissues N levels of roots decreased from August to September, but had increased again on October, and increased N and P fertilization affected tissue levels of N, P, K, Ca and Mg.

In a three years experiment Rybakov and Nazarov (1968) found that an NP fertilizer application or foliar application of B, Mn and Zn increased the frost resistance of some young peach cultivars.

Sucoff and Hong (1976), determining the effect on NaCl on cold hardiness of *Malus sp.* and *Syringia vulgaris,* observed that twigs receiving NaCl either from NaCl applications or from highway deicing salts, lost hardiness while NaCl free twigs remained hardy. Solutions of $CaCl_2$, and NaCl and $Na_2 SO_4$, which caused deficiencies of boron, magnesium and potassium as well as reduced growth, bronzing and chlorosis of grape fruit trees, also increased the severity of frost injury, but, Borate fertilizers improved the cold resistance of *Eucalyptus grandis* (Alden and Hermann 1971).

MATERIALS AND METHODS

One year old shoots of Cardinal, Dixired, Redhaven, J.H. Hale and H. Giant peach cultivars were taken from the collection orchard at Atatürk Central

Horticultural Research Institute in Yalova. All cultivars were at same age (6 years old at the beginning of the research) and treated in similar cultural practices.

Samples of one year old twigs were collected once a month (the 15th of each month) from November through March, and exposed to artificial freezing tests at –20°C and –15°C for the durations of 4, 8, 16, 24 and hours.

The twigs were put in a freezer which was automatically controlled by a temperature programmer-controller unit and then the temperature was lowered at the rate of 5°C per hour from 0°C to the desired freezing points.

Bud survival tests were made according to Eriş (1982) and Proebsting (1982). The twigs which completed the desired time in the freezer were taken and put in a refrigerator for one hour. Then they were planted in woody boxes which contained wet perlite and put in the glasshouse at 18°C ± 2°C temperature with 80 ± 5 % humidity. The bud sprouting observations were made during 8 weeks and after this time these buds which were not sprouted, were cross sectioned and rated alive or dead based on browning at the primordium. The experimental design was completely randomised block with three replicates. Each replicate consisted of at least 40 buds. Duncan's multiple range test was used in statistical analyses.

The analysies of nutrients were done once a month according to Kacar (1962 and 1972) and Lachica et al. (1968) during both experimental periods.

RESULTS

Freezing Tests

The bud survival, percentage after each freezing test, is summarised in the Table 1. The differences between the treatments and cultivars were significantly important.

In November, at –15 and –20°C there were significantly important differences between the durations of 4 and 8 hours, but in the case of 16 hours and longer exposures, since the buds were totally injured, there were not any significant differences. In this temperature (–15°C), again Redhaven were found to be the hardiest cultivar and Cardinal, in spite of being in the same group with other cvs., showed the lowest bud survival rate.

In December, at –15 and –20°C, Redhaven showed the highest bud survival rates, and it was followed by Dixired; whereas H. Giant showed the lowest bud survivals.

Due to the improvement in hardiness in January, even at –20°C, in 4 and 8 hours treatments, all cultivars showed bud survivals, but there was also bud survivals in 16 hours in Redhaven. The differences were significantly important.

Table: 1

Frost Resistance of 5 Peach Cultivars Exposed to Low Temperature in Different Times (As Bud Survival Percentage)

MONTH		1985 - 1986 (–20°C)					1988 - 89 (–15°C)				
		TREATMENTS (HOURS)									
	Cultivar	0	4	8	16	24	0	4	8	16	24
NOVEM.	Cardinal	92.3	0.0 b	0.0 b	0.0	0.0	94.1	13.6 b	4.4 b	0.0 b	0.0
	Dixired	93.3	2.7 ab	1.3 b	0.0	0.0	94.7	13.7 b	8.0 b	0.0 b	0.0
	Redhaven	92.2	8.6 a	4.6 a	0.0	0.0	95.2	34.9 a	26.3 a	10.0 a	0.8
	J.H. Hale	94.9	4.5 ab	0.0 b	0.0	0.0	95.5	15.4 b	10.3 b	0.0 b	0.0
	H. Giant	–	–	–	–	–	96.1	13.9 b	10.7 b	0.0 b	0.0
		N.S.			N.S.	N.S.	N.S.				N.S.
DECEM.	Cardinal	90.8	0.0 b	0.0 b	0.0	0.0	96.5	21.7 b	13.4 b	6.1 bc	4.3 ab
	Dixired	92.2	2.0 b	0.0 b	0.0	0.0	96.2	33.0 b	29.3 a	11.6 b	5.8 a
	Redhaven	93.9	5.5 a	1.8 a	0.0	0.0	96.5	48.8 a	37.4 a	24.6 a	10.1 a
	J.H. Hale	94.5	0.0 b	0.0 b	0.0	0.0	97.3	28.0 c	19.5 b	6.4 bc	1.5 c
	H. Giant	94.7	0.0 b	0.0 b	0.0	0.0	96.3	18.0 d	16.1 b	5.3 c	3.3 bc
		N.S.			N.S.	N.S.	N.S.				
JANUA.	Cardinal	95.2	9.0 b	4.4 b	0.0 b	0.0	96.5	28.4 c	23.3 d	18.4 b	9.1 bc
	Dixired	92.9	7.4 b	0.0 c	0.0 b	0.0	95.6	45.3 b	30.0 c	16.5 b	11.3 b
	Redhaven	95.0	24.2 a	18.3 a	4.2 a	0.0	99.2	55.6 a	47.5 a	38.8 a	29.2 a
	J.H. Hale	93.6	18.7 ab	6.9 b	0.0 b	0.0	97.9	44.9 b	25.8 cd	22.8 b	13.7 b
	H. Giant	95.1	13.8 ab	0.0 b	0.0 b	0.0	98.1	36.7 b	36.8 b	10.7 c	4.2 c
		N.S.				N.S.	N.S.				
FEBRU.	Cardinal	93.0	6.0 ab	5.2 ab	0.0 c	0.0	99.4	44.0 c	33.4 c	14.4 c	7.6 c
	Dixired	92.1	14.3 a	9.7 a	0.0 c	0.0	99.2	54.1 b	49.2 b	23.5 b	16.6 a
	Redhaven	93.8	14.4 a	13.8 a	4.2 a	0.0	99.9	73.0 a	61.5 a	38.8 a	33.9 a
	J.H. Hale	90.1	11.5 a	9.6 a	2.5 b	0.0	98.0	45.5 c	35.4 c	22.0 b	14.7 b
	H. Giant	95.9	3.5 b	2.3 b	0.0 c	0.0	99.2	46.3 c	37.6 c	18.8 bc	10.2 c
		N.S.				N.S.	N.S.				
MARCH.	Cardinal	93.7	7.0 bc	2.1 b	0.0 c	0.0	99.2	3.7 b	0.0 b	0.0	0.0
	Dixired	93.5	12.7 ab	3.9 ab	0.0 c	0.0	99.9	4.3 b	0.0 b	0.0	0.0
	Redhaven	94.5	16.2 a	7.4 a	4.2 a	0.0	99.9	14.6 a	2.7 a	0.0	0.0
	J.H. Hale	95.2	10.4 ab	6.2 ab	2.7 b	0.0	99.9	3.4 b	0.0 b	0.0	0.0
	H. Giant	96.3	5.3 c	2.6 b	0.0 c	0.0	99.9	3.6 b	0.0 b	0.0	0.0
		N.S.				N.S.	N.S.			N.S.	N.S.

Mean separation within columns by Duncan's multiple range test at 5 % level (N.S. Not Significant).

However, in 24 hours treatments the buds of all the cultivars were totally injured (Table: 1).

In this month (January) for all treatments, again, the highest bud survivals were obtained from Redhaven which seems to be the hardiest cultivar and it was followed by Dixired and J.H. Hale.

The highest bud survivals were also obtained in February from Redhaven at both (–20°C and –15°C) temperature regimes.

In March, at –15°C, despite higher temperature exposure comparing with March of 1986, lower bud survivals were obtained Moreover, except Redhaven the other cultivars did not show any bud survival even for 8 hours treatment (Table 1). Even Redhaven showed only 2.7 % of bud survival rate.

As can be seen in the Table 1, in all periods and for all cultivars, as the exposure time increased, the bud survival rates decreased and thus the differences between the frost exposure times were significantly important.

The Seasonal Changes of Nutrient

The seasonal changes of macro and micro element contents of the buds of tested cultivars are shown in Table 2 and 3. The results of the analysis of macro and micro nutrients showed that, the level of nitrogen, potassium, calcium, iron and manganese were high in the winter months when the frost resistance of the cultivars was also high, but, the level of natrium, contrarily, was low in the winter, especially in January and February.

On the other hand, phosphorus and magnesium levels were low and did not show any important change during both experimental periods. The amount of zinc, copper and borate were inconsistent during the experimental periods and thus, there was not obtained any physiological relationship between these three elements and the frost resistance ability of the tested cultivars.

DISCUSSION

In general, frost resistance in peaches, varies greatly among the cultivars. Despite the differences, it has been shown that, their frost resistance increases throughout winter months (Meader and Blake, 1943, Edgerton 1954, Campbell and Handle 1960, Weaver et al. 1968, Quamme 1978, Proebsting and Andrews 1982).

The data obtained in this study are also in agreement with these inventions. According to the data obtained, all cultivars, for all treatments were found to be sensitive to –20°C and –15°C in November and March (Table: 1).

As the air temperature decreased in January and February, in spite of the differences between the cultivars, their frost resistance increased at –20°C as

Table: 2
The Seasonal Changes of Macro Element Contents of the Buds of 5 Peach Cultivars (%)

CULT.	DATES	1985 - 1986					1988 - 1989				
		N	P	K	Ca	Mg	N	P	K	Ca	Mg
CARDINAL	Novem.	1.35	0.16	0.46	1.76	0.26	1.53	0.24	0.57	3.05	0.25
	Decem.	1.55	0.17	0.44	1.83	0.24	1.57	0.23	0.59	3.09	0.23
	Janua.	1.55	0.15	0.45	1.84	0.28	1.99	0.22	0.58	2.34	0.22
	Febru.	1.84	0.23	0.55	1.68	0.27	1.99	0.25	0.61	2.18	0.23
	March	2.02	0.22	0.82	1.48	0.24	2.35	0.29	1.20	1.94	0.26
DIXIRED	Novem.	1.39	0.15	0.46	1.60	0.24	1.35	0.21	0.59	3.10	0.24
	Decem.	1.41	0.13	0.45	1.64	0.20	1.36	0.23	0.67	3.23	0.25
	Janua.	1.55	0.15	0.45	1.76	0.24	1.49	0.23	0.58	2.96	0.25
	Febru.	1.96	0.24	0.62	2.01	0.29	1.53	0.24	0.68	2.68	0.22
	March	2.21	0.29	1.03	1.64	0.29	2.35	0.29	1.20	2.05	0.29
REDHAVEN	Novem.	1.18	0.22	0.36	1.23	0.21	1.26	0.18	0.57	2.75	0.22
	Decem.	1.23	0.18	0.40	1.42	0.22	1.26	0.17	0.56	2.84	0.21
	Janua.	1.54	0.15	0.43	1.30	0.24	1.46	0.22	0.57	2.70	0.23
	Febru.	1.59	0.22	0.52	1.75	0.24	1.66	0.23	0.63	2.39	0.22
	March	1.85	0.23	1.32	1.42	0.27	2.67	0.30	1.42	1.62	0.30
J.H. HALE	Novem.	1.25	0.15	0.48	1.71	0.25	1.32	0.15	0.57	2.76	0.19
	Decem.	1.27	0.14	0.46	1.73	0.21	1.36	0.18	0.61	2.99	0.23
	Janua.	1.64	0.14	0.47	1.78	0.24	1.50	0.23	0.55	2.85	0.23
	Febru.	1.68	0.18	0.51	1.75	0.22	1.68	0.23	0.66	2.33	0.21
	March	1.98	0.20	0.95	1.53	0.26	2.46	0.26	1.24	1.94	0.29
H. GIANT	Novem.	–	–	–	–	–	1.37	0.21	0.56	3.05	0.24
	Decem.	1.48	0.14	0.46	1.55	0.20	1.58	0.22	0.67	2.94	0.23
	Janua.	1.73	0.13	0.47	1.47	0.23	1.58	0.24	0.67	2.68	0.21
	Febru.	2.05	0.23	0.71	1.89	0.31	1.59	0.25	0.70	2.66	0.21
	March	2.09	0.23	1.12	1.54	0.29	2.41	0.27	1.24	1.78	0.28

well as at –15°C (Table: 1). These results are in agreement with those of Edgerton (1954), Weaver et al. (1968), and Weaver and Jackson (1969) that were obtained from other peach cultivars.

In March, however, as air temperature increased and the cultivars completed the true rest period, in general, their frost resistance decreased. Similar results obtained from some other peach and cherry cultivars (Meader and Blake 1943, Chaplin 1948, Weaver et al. 1968, Proebsting and Mills 1972).

Table: 3

The Seasonal Changes of Micro Element Contents of the Buds of 5 Peach Cultivars (ppm)

CULT.	DATES	1985 - 1986				1988 - 1989					
		Fe	Mn	Cu	B	Fe	Mn	Zn	Cu	Na	B
CARDINAL	Novem.	211	20	35	31	220	11	27	18	500	46
	Decem.	237	21	24	52	291	19	40	31	500	57
	Janua.	580	25	38	44	561	21	34	30	450	43
	Febru.	510	32	40	55	443	23	47	23	400	67
	March	567	25	39	34	476	19	58	20	800	47
DIXIRED	Novem.	188	20	22	31	220	11	28	25	500	46
	Decem.	291	29	20	38	250	15	36	27	550	48
	Janua.	580	22	36	49	352	17	36	36	350	50
	Febru.	660	25	36	62	402	21	47	22	400	57
	March	546	30	40	60	392	16	55	18	800	50
REDHAVEN	Novem.	213	17	16	37	167	11	26	18	400	42
	Decem.	265	22	22	46	324	15	36	18	450	43
	Janua.	520	21	27	48	372	17	35	32	350	40
	Febru.	570	22	36	48	483	24	51	22	400	59
	March	567	38	30	43	476	20	62	18	750	50
J.H. HALE	Novem.	231	24	27	31	185	16	32	18	550	37
	Decem.	306	25	22	32	324	17	44	22	550	44
	Janua.	530	22	38	36	394	17	33	34	350	50
	Febru.	885	24	37	50	462	21	55	28	400	54
	March	601	27	36	49	448	19	64	25	850	37
H. GIANT	Novem.	–	–	–	–	290	20	34	18	500	36
	Decem.	256	27	24	40	250	19	34	26	550	32
	Janua.	570	19	32	48	566	23	35	24	550	31
	Febru.	820	33	39	45	508	24	41	16	500	33
	March	692	32	35	55	532	19	58	15	825	31

Redhaven was found to be the hardiest cultivar either at –20°C or at –15°C in all periods and it was followed by J.H. Hale and Dixired. These results are partially in agreement with the results obtained by Weaver et al. (1968). Also Weaver and Jackson (1969) found that Redhaven was hardier than Dixired. The results show that Cardinal and H. Giant were more sensitive.

Among the macro nutrients the levels of nitrogen were high in January and February during both experimental periods. This results suggests that nitro-

gen has a positive effect on the frost resistance of the buds of tested cultivars. Edgorten and Harris (1950) and Proebsting (1960) obtained the similar results for Elberta peach cultivar. The levels of phosphorus were quite low and did not show any clear fluctuation regarding to the season, so, it may be concluded that the effect of phosphorus is not very important on frost resistance. Pellet (1973), also observed a very little effect of phosphorus on the frost resistance of *Forsythia* and *Cornus*.

Potassium levels were higher and increased in February in both experimental periods and it seems that there is a little effect of potassium on frost resistance of peaches. Alden and Hermann (1971) and Solovieva (1974) found the similar results for oranges and apples.

However, calcium seems to have an important effect on frost resistance of the buds of tested cultivars. Because, the levels of calcium were quite high in the winter months, in all the cultivars when frost resistance of the buds were also high. Magnesium levels, on the other hand, did not show any change during both experimental periods. Thus, the physiological relationship between the level of magnesium and frost resistance of the buds is not clear.

Among the micro nutrients Zn, Cu and B levels were inconsistent during experimental periods, therefore, it is difficult to evaluate the importance of these three elements on the frost resistance of the buds of peach cultivars. However, B seems to be promising, because the levels of B were high in February in the buds of all cultivars. This results is in agreement with those of Rybakov and Nazarov (1968).

Iron levels increased from December throughout the winter in both experimental periods, in the buds of all tested cultivars. This indicates that iron content has a important positive effect on the buds of tested cultivars. Contrarily to iron, natrium levels were low during winter, but high in November and March. The low levels of natrium coincide with the buds highest frost resistance. Thus it may be concluded that the high level of natrium has a negative effect on the frost resistance. This result is also in agreement with those of alden and Hermann (1971) and Sucoff and Hong (1976).

The level of manganese, in all the buds of cultivars showed a steady and slight increase from December in both experimental periods. This may enhance the frost resistance of the buds. Rybakov and Nazarov (1968), also found a positive effect of manganese on the frost resistance of some peach cultivars.

For the future studies, itwould be very valuable, to evaluate and search the seasonal changes of calium and iron in detail regarding to frost resistance of fruit trees.

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