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Characteristics of Almond Selections in Relation to Late Frost Spring

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Abstract: Almond is one of the most important nut crops in Iran. Due to the suitable climatic conditions, Iran is one of the most important growing centers for wild and domesticated species of almond in world. Native genotypes typically are early flowering, due to late spring frost, often; they have been damaged. So frost damage to the flowers and early developing fruits is one of the most limiting factors in the most almond cultivation regions of the world. This study was undertaken to help understand almond response to frost damage at different phenological stages, in order to develop criteria for the selection of cultivars with improved resistance to frost on the basis of field experiment with temperature fall (-4°C in 21 march 2010) was occurred naturally. In this stage, all early, medium and late flowering almonds damaged, but damage severity was different. Obviously, there was genetic diversity for cold resistant among genotypes and varieties of almond. Frost damage percentage of cultivars and genotypes after frost was measured at least 100 flowers of each cultivar with 3 replications. Results showed that the severity of frost damage was influenced by genotypes of almond and stage of flower bud development and other indices such as leafing stage. After the evaluating the 29 almond selections, based on flowering time and late frost spring resistance, they were divided into high cold resistant; medium cold resistant; low cold resistant and very low cold resistance. Also, it was found that one promising genotypes with high late frost spring resistant was medium flowering.

Key words: Almond % Late frost spring % Genotype

INTRODUCTION

Almond is one of the most important nut crops in Iran with 172000 ha. Area harvest and 110000 ton of production (F.A.O.2007). Due to the suitable climatic conditions, Iran is one of the most important growing centers for wild and domesticated species of almond in the world. Native genotypes typically are early flowering, due to late spring frost, often, they have been damaged (Imani, 1997). Therefore, not only almond cultivation in Iran but also in word is characterized by high degree of risk due to a rang of adverse climatic factors such as drought, soil salinity and particular spring frost (Rodrigo, 2000). Although the almond is resistant to low temperature in winter, but certain degree and duration of low temperature in spring frost is lethal to most reproductive organs at the blooming period. In some years even the most hard varieties can be damaged by low temperature (Ashworth and Wishiewski, 1991). The periods of major frost risk are in the beginning of the anthesis and towards to active growth (Proebsting and Mills, 1978). The minimum temperature in which almond cultivars can resist in various phenological stages, may define its adaptation to specific agro ecological zones. The temperature at which flower buds are injured depends primarily on their stage of development. Buds are most hard during the winter when they are fully dormant. As they begin to swell and expand into blossoms, they become less resistant to freeze injury (Miranda *et al.*, 2005; Friesen and Stuhnoff, 1985). Therefore in temperate climates, losses due to frosts during bloom are more important than those due to low winter temperatures.

Cold resistance in flower buds see to be the results of several factors in clouding; structural, physiological and morphological features (Ashworth and Wisniewski, 1991). Factors such as genotype, stage of development, formation of ice, moisture content and nutritive status of pistil, have been reported to relate to sensitive or

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tolerance of flower to spring frosts (Rodrigo, 2000). Resistance to frost among buds of different cultivars of same species is different. As critical temperature indices for almond have been obtained for the different stages of phenological development (Micke, 1996; Kester *et al.*, 1990).

Freezing temperatures can seriously damage plant tissues; the effects of spring frost on reproductive organs of almond are highly variable and depend on the characters of both the freezing stress and the plant material status (Burke *et al*., 1976; Strang *et al*., 1980; Niobium, 992; Lu and Rieger, 1993). The different responses to frosts observed among plant genotypes, tissues of the same plant and different seasons have led to study of the mechanisms of inJury (Anderson and Seeley, 1993; Stushnoff, 1972).

Cultivation techniques such as irrigation, reduction in nitrogen fertilizer rates, soil maintain systems and heater have been often used in commercial orchard to limit frost damage. However, the most effective way to combat damage, apart from simply avoiding frost prone areas, is to use frost spring resistant late flowering almond varieties. Selection of the less susceptible varieties among varieties with same phenological stages is the most effective indirect method of avoiding frost damage. The objective of the present study was to determine the damage caused to some late flowering almond cultivars and selections in field conditions by frost spring.

MATERIALS AND METHODS

This experiment was done at experimental station of fruit culture of Karaj (latitude 35.55 N, longitude 50.54 E elevation 1312.5 M) at 2010 in Iran. This region was characterized by a semiarid climate (dry and no rainfall summers) and soil texture was sandy with the 10% lime in depth 40cm. As annually rainfall during studies at Karaj situation reported 504.9 mm (I.R of Iran Meteorological Org (www.irimo.ir)).

Establishment of experimental orchard was in 2004. Experimental trees including local cultivars/genotypes and foreign cultivar from USA, Italy and Spain were planted 5×5 m apart and grafted on the bitter almond. This experiment was based on block randomly complete design with three replications. In this study, 29 genotypes and cultivars for late frost spring resistant base on field test were evaluated Flowering in almond was started from 14 March and ended on 5 April 2010.

Trees were subject to late frost spring with temperature fall (-4°C in 21 march 2010) naturally. 24h after frost spring, flowers of genotypes and cultivars were studied by using microscope (Barranco *et al*., 2005). Flowers were considered frost damaged when pistils in them were brownish. Since pistil is the effective organ for developing into nut.

The statistical analysis was performed using Microsoft Excel (2007) and SAS software (SAS Institute Inc, 1990) and means were compared using Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Results of the evaluating the 29 almond selections based on flowering time, late frost spring resistance after temperature falling to -4°C in 21 march 2010, in field conditions have been showed in Table 1. They were divided into 4 groups; high cold resistant (frost damage: 0-10%); medium cold resistant (frost damage: 10-50%); low cold resistant (frost damage: 50-90%) and very low cold resistant (frost damage: 90-100%) (Table 1).

Results of field fest showed that the severity of frost damage was affected by variety, phenological stage of flower buds and leafing time. Genotypes typically are early flowering and leafing due to late spring frost, often, they have been damaged. In this study, it was found that one promising genotype with high late frost spring resistant was medium-late flowering (Table 1).

Frost injury of the flower buds depended on growth stages and rate and duration of frost (Burke *et al.*, 1976; Friesen and Stushnoff, 1985; Ashworth and Wishiewski, 1991; Barranco *et al*., 2005).

Frost was more detrimental during anthesis forward than the bud swell to backward stage. For instance, at the popcorn stage, the Ferragness were damaged 25% when exposed to $-4\ ^{0C}$, while its damage at the anthesis stage was100% at- same temperature (Table 1). Phenological stage seems to be important regarding the degree of frost damage, as trees were more affected at full bloom than at the popcorn stage. Almond has demonstrated hardiness at pre-bloom and less hardly at post bloom (Micke, 1996). Miranda *et al*(2005) concluded that *prunus* species such as almond resists to frost without major damage before the pre bloom phase, but is susceptible to frost during and after anthesis. The results presented here have confirmed that almond is most susceptible to frost from first swell bud stage on ward and much less susceptible in fully dormant.

Table 1: Characteristics of genotypes and cultivars in relation to late frost spring

Cultivar /gegenotype	Tree vigor	Flower density	Flower size	Leafing stage (leaflet number)	Flower color	Flowering stage	Frost damage (%)
Bome	vigor	Very high	large	5	white	Petal fall	100a*
Tuono	vigor	Very high	small	2	white	70% open	10d
Feragness	vigor	Very high	medium	3	white	5% open	100a µ
Fragiuolo	vigor	high	medium	3	white	100% open	100a
Marcona	vigor	Very high	small	2	ping	100 %open	60c
A93	vigor	Medium to high	large	2	white	Petal fall	90b
K-15-25	vigor	Very high	small	3	white	50% open	0d
K-11-10	Medium	Medium to high	large	2	white	100% open	50c
K-14-12	vigor	Very high	small	2	white	70% open	0d
Almond-Peach	vigor	Medium to high	large	3	Ping to red	100% open	0d
K-9-7	vigor	Very high	small	2	white	100% open	0d
K-9-20	Medium	Very high	medium	2	Ping to white	50% open	100a£
K-9-32	vigor	Very high	medium	2	Ping to White	50% open	2d
K-10-39	Medium	Very high	medium	3	White to ping	60% open	0d
K-9-40	vigor	Very high	large	4	white	100% open	0d
Wild	vigor	Very high	large	1	ping	90% open	50c
K-13-8	vigor	Very high	small	5	white	Fruit set	100a
K-13-13	vigor	Very high	large	1	white	Petal fall	100a
K-13-29	vigor	medium high	large	2	white	30% open	0d
Sh-21	vigor	Very high	large	2	white	Petal fall	90b
Supernova	vigor	Very high	small	1	white	60% open	5d
Sahand	vigor	Very high	small	3	white	50% open	0d
Shekofeh	Medium	medium high	small	1	white	Popcorn	0d
Sifid	Medium	Very high	medium	7	white	Petal fall	100a
Rabie	vigor	Very high	medium	5	white	100% open	50c
Yazd144	vigor	Very high	medium	5	white	Petal fall	100a
Falsa-bares	vigor	Very high	small	1	White to ping	90% open	0d
Sh-7	vigor	Very high	small	3	white	Flowering start	0d
K-H-87	Medium	medium high	medium	1	white	90% open	0d

*The values with the same letter are statistically homogeneous in LSD test

µ100% and 25% open flower and popcorn were damaged respectively

£ µ100% open flower was damaged and no popcorn damage

It was found that there was the variation in spring tolerance between genotypes and cultivars of almond at same phenological stages for example K-H-87(medium flowering) more resistance than Ferragness (late flowering) (Table 1). This variation could be due to difference in the several factors including structural, physiological phenological and morphological features. In this study, high variability between different cultivars/selections to frost spring tolerance was observed. An explanation for these results is the many factors still unknown or difficult to control which influence bud or flower handiness. So Proebsting and Mills (1978) found that frost resistance varies within the tree itself in the same extent varies within orchard, cultivars, flowers of cultivars in the same phenological stage. And in a similar position on the tree often present differences in frost resistance (Ashworth and wishniewski, 1997; Friesen and Stushnoff, 1985; Strang *et al*., 1980a).

The risk of frost injury of the reproductive organs may increase with phenological and development stages and low temperature. This emphasizes the important attention on structural, phenological, morphological and physiological features of almond cultivars when selection plant material for new varieties, as this is a mechanism of frost escape.

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