

## INFLUENCE OF SPRING FROST ON APPLE FLOWER BUDS AT VARIOUS DEVELOPMENTAL STAGES

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### Abstract

Spring frost often reduces the yield because of damaged flowers. Spring frost is a dangerous climatic hazard that can be responsible for yield losses to orchard trees. Frost damage is highly dependent on the stage of development of the flower buds. Flower buds samples were collected from 'Granny Smith', 'Golden Delicious Rainiers' and 'Gala Schniga' apple cultivars at different flower buds stages from BBCH 59 (most flowers with petals forming a hollow ball) to BBCH 65 (full bloom on trees), two days after frost that occurred on the morning at 5:00-7:00 of March 31, 2017 when the temperature dropped to -1.5 to -3.3 °C in the apple orchard of company Pollino Agrar near Fruška gora mountain. Pistils in flower buds samples at a hollow ball stage to full bloom were examined individually and classified as dead or alive based on tissue browning. The highest damage on flowers was recorded to cultivar 'Gala Schniga' (75.4%) and the lowest to cultivar 'Golden Delicious Rainiers'. Cultivar 'Gala Schniga' had more than 90% of damaged king flowers. Our results showed that the spring frost damage of pistils was variable according to stages of flower bud development and genotypes.

**Keywords:** cultivar, flowering, damage, bbch scale.

### Introduction

Apple (*Malus × domestica* Borkh.) is the most important of the deciduous tree fruits in terms of production and a focus of research worldwide. Frost, especially spring frost causes more economic losses than any other weather-related phenomenon to apple production. The bud burst phase of orchard trees is the most critical phase in relation to low temperature and frost since the most parts of the bud, especially the ovary, are very sensitive to low temperatures (Farajzadeh et al. 2010). Blossoming is the most sensitive period, e.g. to frost, and determines the fruit set of the apple trees (Chemielewski et al. 2011). Spring frost is a dangerous climatic hazard that can be responsible for yield losses to orchard trees (Hudina and Štampar 2006). In the context of global warming, the general trend towards earlier flowering dates of many temperate tree species is likely to result in an increased risk of damage from exposure to frost (Eccel et al. 2009). A comparison of the phenological data of two periods, Kunz and Blanke (2011) showed that apple cultivars manifested 10 days earlier full bloom.

Species and varieties can exhibit different damage at the same temperature and phenological stage (Lenz et al, 2013). Frost damage is highly dependent on the stage of development of the flower buds (Aygün and San 2005). Temperature fluctuation before and during bloom can also influence flower tolerance to low temperatures since warm conditions may increase flower vulnerability and cool temperatures may decrease it (Rodrigo, 2000). Grab and Craparo (2013) recorded that cultivar 'Granny Smith' had the earliest beginning and the shortest duration of flowering in comparison with cultivar 'Golden Delicious'

At bloom, the first symptom that is observed after freezing is the thawing of the flowers characterized by a brown discoloration at the base of the style; depending on the severity of the freeze, the damage may extend both to the style and to the ovary, resulting in death of fruit abortion (Rodrigo, 2000; Aygün and San 2005).

The flower buds that survive the rest period continue with its development until bloom (Salazar-Gutierrez et al. 2016), but with decreased of yield and fruits quality. The aim of this study was to determine sensitivity of apple bud flowers in different stage of development.

### Material and methods

In this study we investigated sensitivity of flower buds of tree apple cultivars 'Granny Smith', 'Golden Delicious Rainders' and 'Gala Schniga' to the spring frost. Two days after frost which occurred on the morning at 5:00-7:00 of March 31, 2017 when the temperature dropped to -1.5 to -3.3°C in the apple orchard of company Pollino Agrar near Fruška gora mountain, flowers buds samples were collected. Pistils in flower buds samples at a hollow ball stage to full bloom were examined individually and classified as dead or alive based on tissue browning.

The apple cultivars were at different flower buds stages from BBCH 59 (most flowers with petals forming a hollow ball) to BBCH 65 (full bloom on trees). To all cultivars the king flower and flower on position L1. The cultivar 'Gala Schniga' had open flowers in position L2 and L3, while other flowers in the buds were in red balloon stage. The cultivars 'Granny Smith' and 'Golden Delicious Rainders' had opened flowers in L2 position and flowers in other position L3 and L4 were in red balloon stage. The cultivars 'Granny Smith' and 'Golden Delicious Rainders' had a lot of buds flowers in L5 position which were in hollow ball stage. The experiment was built by a random field with five repetitions (20 flowers buds per tree were taken from every part of canopy, five trees were taken for a repeat). Analysis of variance has been done with STATISTICA 7 software package.

Also, we recorded another phenological properties such as time of bud burst, time of beginning of blooming, full and end of blooming. The period between bud burst and blooming was marked by a high daily temperature.

### Results and discussion

The earliest buds burst had cultivar 'Gala Schniga' and the latest 'Golden Rainders' (Table 1). Also, cultivars had same schedule in time of beginning and full blooming. All cultivars had finish of blooming in second decade of April. According to Milatovic et al. (2009) in same agricultural environment in period of 2004-2007 years, cultivars 'Gala Schniga' and 'Golden Rainders' manifested the latest beginning and full blooming.

Table 1. Phenological properties of apples cultivar

Cultivar	Buds burst	Beginning of blooming	Full blooming	End of blooming
'Gala Schniga'	12.03.	25.03.	02.04.	12.04.
'Granny Smith'	14.03.	27.03.	05.04.	17.04.
'Golden Rainders'	15.03.	28.03.	06.04.	17.04.

Because of warming conditions, Kunz and Blanke (2011) showed that apple cultivars expose 10 days earlier full bloom. The cultivar 'Granny Smith' had the longest duration of blooming of 21 days, while 'Gala Schniga' had the shortest of 18 days (Fig. 1).

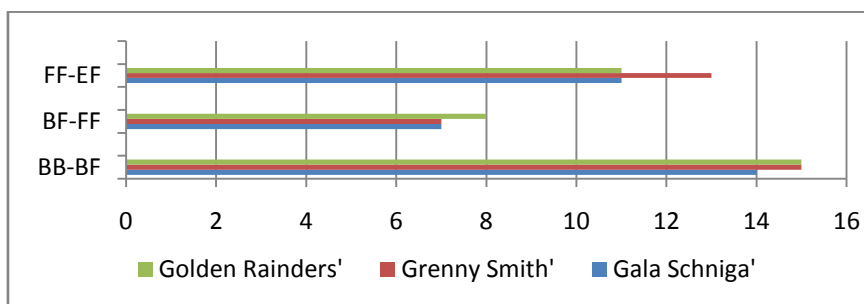


Fig 1. Duration of apple blooming in days (BB – bud burst; BF – beginning of flowering; FF – full flowering; EF – end of flowering)

The cultivar 'Gala Schniga' had the highest percentage of damaged flowers, more than 75.4% on all positions in flower buds, and the cultivar 'Golden Delicious Rainders' had the lowest, only 14% (Fig 2).

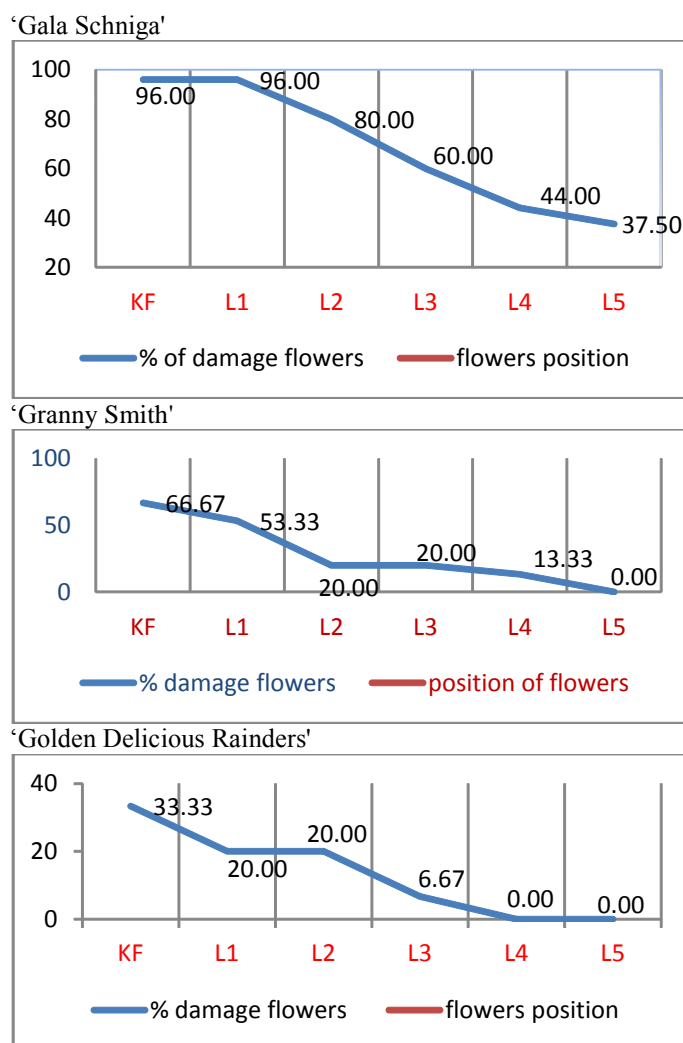


Fig. 2. Damage of flowers of apple cultivars

According to Rodrigo 2000, spring frost hardiness depended to a genotip. Aygün and San 2005, recorded that between seven cultivars 'Golden Delicious' had the highest survival flowers. All cultivars had the highest damage of king flowers (KF). A damage of KF ranged between 33% in 'Golden Delicious Rainders' to 96% in 'Gala Schniga'.

'Gala Schniga' had a same percentage of damage on flowers in L1 position in the clusters. Also, this cultivar had a statistical significant damage of flowers to all positions in the cluster in comparison to the other two cultivars. Statistical significant difference in damage flowers between cultivars 'Granny Smith' and 'Golden Delicious Rainders' were in a position L1 and L4. Jakopic et al. (2015) showed that fruits in this position in clusters might had satisfactory quality.

At the time of appearance of spring frost the cultivar 'Gala Schniga' was at nearly full blooming time, and that might be a reason why this cultivar had the highest damage of flowers. Westwood (1993) recorded that frost damage is highly dependent on the stage of development of the flower buds.

### Conclusions

Spring frost caused a very serious and significant damage to flowers buds. The highest damage was recorded to the cultivars 'Gala Schniga', which had a 74% of damaged flowers. Also, the cultivar 'Gala Schniga' had a earliest time of beginning and full blooming. In same agricultural conditions, in aim of avoidance of flowers damage and a better production results we recommend growing late flowering cultivars.

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