

The Phenology Of Flowering And Ripening Of Almond Cultivars Nonpareil, Texas, Ferraduel And Genco In Herzegovina

ABSTRACT

Aims: Area of sub-Mediterranean Herzegovina, including the area of Mostar, is favourable for growing of almonds. However, this advantage has not been sufficiently exploited so far. A wide selection of almonds varieties is available, so it is a challenge to select the best variety for successful cultivation in agroecological conditions of Herzegovina, and to justify the economic investment. Therefore, it is necessary to evaluate their phenological characteristics in order to determine their adaptability to environmental conditions of Herzegovina area. The paper describes the dynamics of flowering and fruit ripening of introduced four varieties of almonds in climatic conditions of Herzegovina, in Mostar. The goal of this paper is to establish the dynamics of flowering of cultivar almonds types in the Mostar area: **Nonpareil, Texas, Ferraduel and Genco.**

Study Design: For the purposes of research work, there was an experiment set up by the "**Method of random pool arrangement**", with three trees of each cultivar.

Place and Duration of Study: The experimental part of this work was carried out in a part of private property located near the village of **Gnojnice**, Municipality of **Mostar**. The survey was conducted in two repetitions, more precisely in two vegetation, during 2013. and 2014.

Methodology: The dynamics of flowering were recorded for each cultivar through three phenophases:

- Beginning of flowering - the date when 10% of tree flowers are opened;
- Full flowering - the date when 90% of tree flowers are opened;
- End of flowering - the date when more than 90% of leaf petal fell of the tree.

Results: The research results showed a big correlation between flowering phenophases flow and meteorological conditions in some research years. In 2014, the flowerings begin earlier for 14 to 18 days (depending on variety) in comparison to 2013. The earliest flowering was recorded for the variety "Texas", and the latest was recorded for varieties of Ferraduel and Genco.

Conclusion: Flowering duration was pretty equal for all the varieties (from 17 to 21,3 days), while the shortest duration was recorded for the varieties Genco (17) and Ferraduel (17,3) in 2013. All the varieties had earlier fruit ripening in 2014 in comparison to 2013. Fruits of Texas variety had the latest ripening, while the varieties Nonpareil, Ferraduel and Genco ripened at the same time. All the monitored varieties showed an extreme adaptability to agro-ecological conditions of Herzegovina and may be recommended for commercial cultivation.

Keywords: almond, phenophase, flowering, ripening

1. INTRODUCTION

Almond is a neglected fruit culture in Bosnia and Herzegovina, and its cultivation is mostly limited to the garden areas, while it is poorly represented in plantages or planting stocks. Current production of almond in Bosnia and Herzegovina is not even close to meet market demands. The problem is more obvious, because the region of submediterranean Herzegovina has got special agroecological conditions and it is extremely favorable for the cultivation of this fruit culture.

One of the most important prerequisites for the improvement of almond production in Bosnia and Herzegovina is the selection of suitable cultivars, especially the choice of late-blossoming cultivars with good biological-productive characteristics.

The goal of this paper is to establish the dynamics of flowering of cultivar almonds types in the Mostar area: **Nonpareil**, **Texas**, **Ferraduel** and **Genco**. The successful realization of this goal will serve as a basis for comparing the already existing results of the researchers in some other areas, as in the territory of Bosnia and Herzegovina such data do not exist.

Almond blooms very early, in the period from the end of January to the end of March, which depends on cultivars, forms and weather, at first. Flowering phenophases usually last from 5 to 25 days. When it is about almonds, there are: early-flowering, mid-flowering, late-flowering and very late-flowering cultivars, therefore, the flowering time is significantly different for some cultivars. According to **Bulatović (1985)** almonds usually blossom at a temperature of 8 ° C to 10 ° C.

It is an almost autosterile (self-incompatible) fruit tree, so it is important to take care of cultivars with pollinants when raising plants. The appearance of autosterilism is caused by non-germination; pollen impurity or incompatibility of diploid and triploid species. According to **Šoškić (2008)**, almond is a fruit species belonging to a group of non-pollinated (foreign fertile, cross-pollination) fruit species with self-fertilization that occurs sporadically.

According **Kodad O. et al. (2011)**, **Effective Pollination Period (EPP)**, receptivity to stigma for pollen with high temperatures during pollination may have an effect on fertility and set of fruits. The results of their research suggest the importance of early pollination (pollination must be on time) to ensure acceptable and good yield.

Moghaddam V. et al. (2012) found that cultivar **Genco** had 30% of fetched fruits with their own pollen, as opposed to 35% of fetched fruits that were fertilized with pollen-compatible cultivars.

Arsov T. et al. (2002) indicated that in the first year of research, more than 50% of the flowers were damage because of late spring frosts, and in the second year of research, the percentage of damage flowers was 100%. The results of these studies show that almond is sensitive to late spring frosts.

2. MATERIAL AND METHODS

2.1 Experimental Location and Materials

The experimental part of this work was carried out in a part of private property located near Mostar, on south of Herzegovina. **Ferragnes**, **Tuono** and **Supernova** cultivars were also present in the investigated plantation, together with the cultivars that were already included in the study. Bitter almond was used as a rootstock for all cultivars.

For the purposes of research work, there was an experiment set up by the **"Method of random pool arrangement"**, with three trees of each cultivar. The survey was conducted in two repetitions, more precisely in two vegetation, during 2013. and 2014.

The research plantation was planted in 2006. and 2007., with the planting area of 4.5 x 3.5m. The whole plantation occupied the area of 3000 m². The maintenance of the soil in the plantation is carried out by treating the area with inter row crop cultivar and the fertilization in the autumn, while the inter row area is maintained in condition of grassy surface, the only intervention was mowing of grassy surfaces. Also, all other contemporary agrotechnical measures such as plant protection, fertilization with mineral and organic fertilizers, irrigation, pruning are applied in the plantation.

2.2 Treatments and Methodology

The dynamics of flowering were recorded for each cultivar through three phenophases:

- Beginning of flowering - the date when 10% of tree flowers are opened;
- Full flowering - the date when 90% of tree flowers are opened;
- End of flowering - the date when more than 90% of leaf petal fell of the tree.

It is necessary to record the period of botanical maturity to determine the maturation time of investigated cultivars for the two-year period, it is the date when the green coat (pericarp) is cracked.

3. RESULTS AND DISCUSSION

3.1. The phenology of flowering

Table 1. Average dates of the flowering phenophase

Cultivar	Texas		Nonpareil		Ferraduel		Genco	
Year	2013	2014	2013	2014	2013	2014	2013	2014
Beginning of flowering	10.03.	24.02.	13.03.	28.02.	16.03.	26.02.	16.03.	26.02.
Full flowering	16.03.	28.02.	20.03.	07.03.	20.03.	04.03.	23.03.	06.03.
End of flowering	28.03.	16.03.	02.04.	19.03.	02.04.	19.03.	01.04.	20.03.
Duration of flowering (days)	18	20	20	19	17	21	16	22

The table presents the average dates of the flowering phenophase of the cultivars investigated during the research period and the duration of the flowering phenophase for the given average dates.

It is evident that the beginning flowering phenophase (research form 2013), **Texas** cultivars started to bloom first on March 10th.03., and at the latest blooming cultivar was **Genco**, it started to bloom on March 16th. During the exploration in 2013, the earliest occurred phenophase was in **Texas** cultivars, on March 16th and the latest phenophase was recorded in **Genco** cultivars on March 23rd. The end of flowering phenophase, was first occurred in **Texas** cultivars on March 28th, and the latest phenophase was occurred in **Ferraduel** and **Nonpareil** cultivars on April 2nd (research form 2013).

Studies have shown that in the course of 2014, the phenophase beginning of flowering was first occurred in **Texas** cultivars on Feb 24th, and the latest phenophase beginning of flowering was recorded in **Nonpareil** cultivars on Feb 28th. Full flowering phenophase (during the 2014 research year), was first occurred in **Texas** cultivars on Feb 28th and the latest full flowering phenophase was recorded in **Nonpareil** cultivars on March 7th. **Table 1** shows the end of flowering phenophase during research in 2014. It was first occurred in **Texas** cultivars, on March 16th. Also, it is evident if that this phenophase was most recent in **Genco** cultivars on March 20th, from 2014.

Texas cultivars started to bloom, 14 days earlier in 2014, compared with the beginning of bloom in the 2013. **Table 1:** It is evident that **Ferraduel** cultivars started the phenophase beginning of flowering, even 18 days earlier in 2014., compared to the 2013. Also, the **Nonpareil** cultivars, in 2014. started with beginning of flowering phenophase earlier, compared to the research form 2013., and the difference was 13 days. The same case is with **Genco** cultivars, form 2014., which started the phenophase beginning of flowering 18 days earlier, compared to the research from 2013.

Table 1 shows that **Genco** cultivar had the shortest flowering period (16 days) during the research in 2013., and the same cultivar had the longest flowering (22 days) in the course of the research from 2014.

Table 2. Avarage duration of flowering phenophase

	Texas	Nonpareil	Ferraduel	Genco
2013	19	20,7	17,3	17
2014	19	18,6	20	21,3
Avarage	19	19,6	18,6	19,1

Table 2 presents the average duration of flowering phenophase for all three representative samples of all tested cultivars. **Table 2** also shows that the flowering phenophase was the shortest in **Genco** cultivars, during the research in 2013 (17 days), but it also was the longest one in the research from 2014 (21.3 days). If we consider the average for both research years, we can conclude that the flowering phenophase was longest for **Nonpareil** cultivars (19.6 days) and the shortest one was in **Ferraduel** cultivar (18.6 days). We can conclude that the duration of the flowering phenophase was fairly equal if we look at the average for both study years in all four studied cultivars, that period lasted from 18.6 to 19.6 days.

Research has shown that from the point of view of the moving phenophase beginning of flowering, we have noted similar results as many other researchers. **Ak B.E. et. al. (2005)** indicated that the movement of the beginning of flowering phenophase was recorded for **Ferraduel** cultivars on March 23rd, which is similar to our results. **Ristevski B. et. al. (1998)** stated that the **Nonpareil** cultivars in the ecological conditions of Skopje, began the phenophase beginning of flowering on March 19th, which is similar to the results of our research. **Ak B.E. Et al. (2005)** stated that the **Nonpareil** cultivars on the rootstock bitter almond started the phenophase beginning of flowering on March 16th, which is similar to the results of our research.

According to the aspect of the full flowering date, we get similar results with other researchers. **Ak B.E. Et al. (2005)**, stated that this phenophase started on March 21st for **Nonpareil**, which is very similar to our research. The results of **Kaska N. et al. (1998)** demonstrate that the **Ferraduel** cultivars of the full flowering phenophase appeared on March 20th, which is different with the results of our research.

From the aspect of the overall duration of flowering phenophase, in **Texas** cultivars we have noted similar results with other researchers. So, the research of **Ak B.E. Et al. (2005)** showed that the flowering phenophase in **Texas** cultivars lasted for 19 days, which is very similar to the results of our research during the research from 2013., for **Texas** cultivars.

Our results are also similar to the results obtained by **Manušev B. et al. (1978)** under the conditions of Herzegovina area (villages of **Buna** and **Hodbina**, near **Mostar**) from the aspect of the duration of the phenophase flowering of **Texas** cultivars. Mentioned researchers noted that the flowering phenophase lasted for 16 days in 1977., which is similar to the results of our research. However, the same research by these authors shows that during the research in 1976., the flowering phenophase of **Texas** cultivars lasted for 34 days, which is different with the results of our research. In these studies, it is stated that the beginning of flowering phenophase of **Texas** cultivars in 1976. started on Feb 28th, the full flowering phenophase started on March 24th, and the end of flowering phenophase was on April 2nd. Also, the mentioned autors indicate that the beginning of flowering phenophase during the 1977. started on March 6th, the full bloom phenophase started on March 9th, and the ending of the flowering phenophase was on March 22nd.

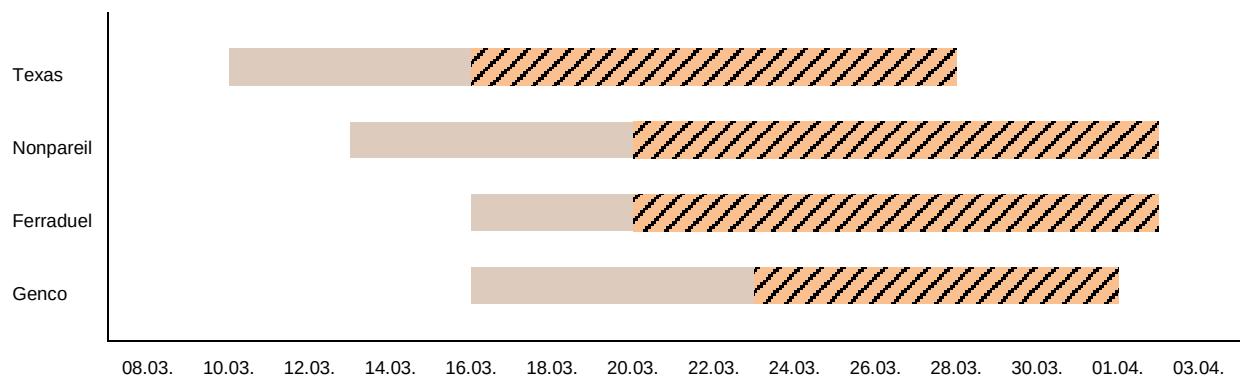


Figure 1. Phenogram almond flowering in 2013.

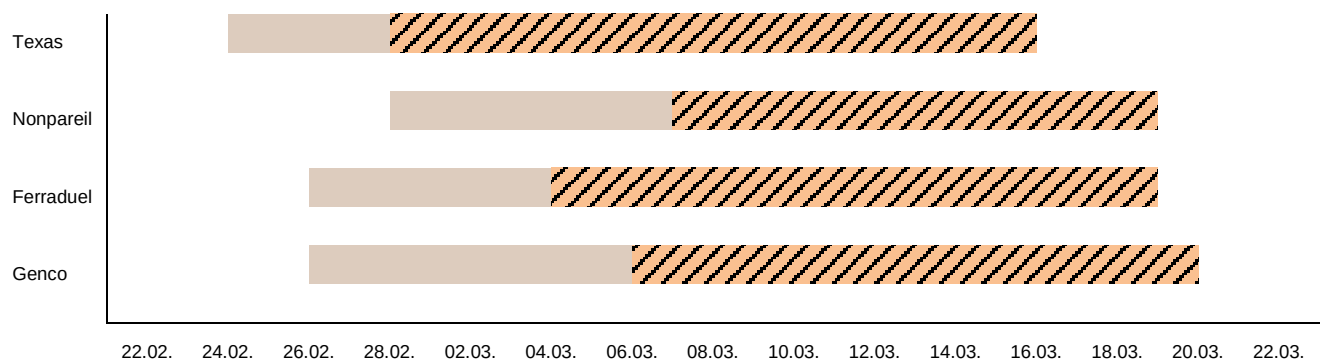
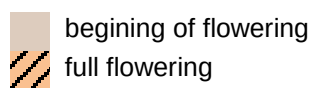


Figure 2. Phenogram almond flowering in 2014.



3.2. Fruit ripening

Table 3. Harvest time investigated cultivars

	Texas	Nonpareil	Ferraduel	Genco
2013	20.09.	05.09.	05.09.	05.09.
2014	16.09.	30.08.	30.08.	30.08.

The table 3. presents the harvest time, the ripening fruit of investigated almonds cultivars during the research period. It is evident that the fruits ripened earlier in 2014., than in 2013. The fruits of **Texas** cultivars ripened later than other investigated cultivars whose fruits were simultaneously ripened in both years of research. In the course of the research form 2013., **Texas** cultivar fruits ripened four days later compared to the 2014., while the fruits of remained three cultivars, in 2013. research year, ripened six days later than in 2014.

Ak B.E. Et al. (2005) indicated that the harvest time of fruits for **Nonpareil** cultivar almonds that was done by Sep 6th in 1997. is similar to the results of our research. Also, the same paper states that the fruits of **Texas** cultivars ripened on Sep, 6th which does not match with the results of our research. In the same research, in 1998., the authors state that the fruit ripening of **Nonpareil** cultivars was on Sep, 4th, which is similar to the results of our research. However, on that date there was the ripening of **Texas** cultivars, which is different from the results of our research. Also, the same research shows that harvest of **Ferraduel** cultivars in 1998. was done on Sep 9th, which is different in relation to the results of our research.

Authors of Kaska N. et al. (1998) stated that harvest of cultivars **Ferraduel** and **Genco** was done on Aug 29th, which is very similar to the results of our research.

Table 4. Period required for the ripening fruits

	Texas	Nonpareil	Ferraduel	Genco
2013	175	160	161	161
2014	185	164	164	163
Prosjeek	180	162	162,5	162

The table 4. shows the period required for the ripening of the fruit, the average number of days for all three representative samples of the studied cultivars, the period from the end of the flowering to the harvest. It is evident that this period was a bit longer during the research in 2014. The **Texas** cultivars had the longest period needed for the ripening of the fruits in both years of research, compared to the other three studied cultivars, for which the period was fairly equal.

From the aspect of the time needed to ripening the fruits, the results of our research show that this period was longer for **Texas**, **Nonpareil** and **Ferraduel** cultivars than research results conducted by **Ak B.E. Et al. (2005)**.

4. CONCLUSION

According to the research results of flowering dynamics, the following conclusions can be drawn:

- The earliest flowering in the examined period (2013-2014) was recorded in **Texas** cultivars on Feb 24th., and at the latest flowering was recorded for **Ferraduel** and **Genco** cultivars on March 16th. Studies have shown that in the course of the research in 2013., beginning of flowering phenophase started with the difference of 1-6 days in all cultivars, the period of March 10th to March 16th, while in the course of 2014, the flowering phenophase started from Feb24th to Feb 28th for all studied cultivars with the difference of 1-4 days. It was noticed that this phenophase was best overlapped among **Ferraduel** and **Genco** cultivars.
- Full flowering phenophase in the examined period (2013-2014) was first occurred in **Texas** cultivars on Feb 28th, and at the latest was in **Genco** cultivars on March 23rd. The difference at the beginning of the full flowering phenophase, in 2013., was 1-7 days for all cultivars, and all cultivars started and ended the phenophase in the period from March 16th to March 23rd. Also, in the course from 2014., the difference in the beginning of full flowering phenophase was 1-7 days, and it ook place over a period from Feb 28th to March 7th. Full flowering phenophase in 2013., was best overlapped among **Ferraduel** and **Nonpareil** cultivars, and in the course from 2014. the best overlapped was recorded among **Nonpareil** and **Genco** cultivars .

- During our research, the end of flowering was first occurred in **Texas** cultivars in on March 16th and at latest was for **Nonpareil** and **Ferraduel** cultivars on April 2nd. Studies have shown that in the course of the research from 2013., the end of flowering phenophase occurred with a difference of 1-5 days (March 28th to April 2nd), in all studied cultivars, and in the course from 2014., there was the difference of 1-4 days (March 16th to March 20th). During these two years of research, phenophase had best overlapping results in **Ferraduel** and **Nonpareil** cultivars.
- From the aspect of the average duration of flowering phenophase, for all three representative samples of studied cultivars, we can conclude that the lowest duration was occurred in **Genco** cultivars (16 days) during the research from 2013. Also, the flowering phenophase was the longest in **Genco** cultivars, but in the course from 2014 (22 days).
- If we consider the average duration of flowering phenophase for all representative samples of studied cultivars, and for both years of research, we can conclude that the flowering lasted from 18.6 to 19.6 days, which is fairly equal.
- The fruits of **Texas** cultivars, ripening later compared to the other three studied cultivars in both years of research.
- The period required for ripening the fruit was the longest in **Texas** cultivars in both years of research, while this period was fairly equal for the other three studied cultivars in both years of research.

If we analyze the results of our research from the aspect of the flowering dynamics of the studied cultivars, we can conclude that most of flowering phenophases overlapped, which is very important in polination, because almond is mostly a cross-pollinated of fruit. Such overlapping of flowering phenophase gains significance because there are mutually good pollinators, combinations of **Texas-Nonpareil** and **Ferraduel-Texas** among the studied cultivars studied. According to the aspect of the beginning of the flowering phenophase the mild inferiority was demonstrated by **Texas** cultivar, while for the three remaining studied cultivars the period of flowering phenophase started later, which is important when selecting cultivars to grow, because the cultivars that start the flowering phenophase later are more preferred.

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