Flowering and Pollination Time Affect Fruit Set of Foreign Almond Cultivars in Morocco

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Abstract

The associations 'Marcona'-'Fournat de Brézenaud' and 'Ferragnès'-'Ferraduel' are the cultivar combinations mostly planted in commercial orchards in Morocco. The blooming time and the effective pollination period (EPP) were determined for these associations in order to determine the effect of blooming and pollination times on the irregular yields observed in Morocco with these cultivars. 'Marcona' bloom was earlier than for 'Fournat de Brézenaud', but 'Ferragnès and 'Ferraduel' coincided in blooming. Fruit set and percentage of pistils with pollen grains showed a maximum when pollination was done at day 2 after emasculation. Fruit set and stigmatic receptivity decreased drastically from day 4 after emasculation. Fruit set in the open pollination treatment was lower than that obtained after hand pollination at days 0 and 2 after emasculation, especially in 'Marcona'. These results emphasize the importance of early pollination as well as the selection of new cultivars with the same flowering period than 'Marcona' to improve almond yields in Morocco.

INTRODUCTION

Almond (*Prunus amygdalus* Batsch) is one of the most important of the temperate tree fruits cultivated in Morocco after olive, with a total production reaching around 120.000 mt of kernels (FAO, 2007). The associations 'Marcona'-'Fournat de Brézenaud' and 'Ferragnès'-'Ferraduel' are the mostly planted cultivar combinations in commercial orchards in Morocco. These cultivars are self-incompatible, thus insect-dependent cross-pollination is required to reach an economically acceptable production in commercial orchards.

Almond yields in Morocco have been reported to be erratic (Loussert et al., 1989; Oukabli et al., 2008) because the pollination process is affected by weathers conditions during flowering and because of delayed blooming among cultivars. Fruit set has been shown to be dependent on the number of pollinated flowers (Kester and Griggs, 1959), but other factors affect final crop level. DeGrandi-Hoffman et al. (1989) reported that yield in almond is determined by the number of flowers per tree and the effective pollination period (EPP), and includes factors related to pollination efficiency, such as stigma receptivity, pollen tube kinetics, and ovule longevity (Sanzol and Herrero, 2001). The concept of EPP was introduced by Williams (1965) to assess floral receptivity in apple, and was defined as the period during which pollination was effective at producing fruit. This period is determined by the longevity of the ovules minus the time-lag between pollination and fertilisation, provided that this resulting value does not exceed the length of stigma receptivity (Sanzol and Herrero, 2001). Our objective was to assess the possible influence of EPP on fruit set and consequently on yield in ‘Marcona’ and ‘Ferragnès’ under Moroccan climatic conditions.

MATERIALS AND METHODS

Plant Material

Two cultivars, ‘Marcona’ and ‘Ferragnès’, were included in this study. Each cultivar was represented by three contiguous trees, planted in the experimental station established at the Institut National de Recherche Agronomique (INRA), Meknès, located at 33°55’N and 5°13’W, at 499 m over sea level. These cultivars were managed according to commercial recommendations for the area, and formed in an open vase.

Flowering time and Effective pollination period

Blooming date of the studied cultivars was determined according to IBPGR descriptors (Gülcan, 1985). EPP was estimated according to Williams (1970) on four-five homogenous branches selected at random around the canopy of the three trees. Flowers buds at stage ‘D’ were emasculated and hand self-pollinated 0, 2, 4, 6 or 8 d after emasculation. Fruit set (i.e., the percentage of pollinated flowers that produced fruit) was recorded in June.

Stigma receptivity

Stigma receptivity was determined on the same three trees. Flowers were emasculated and hand self-pollinated 0, 2, 4, 6, or 8 d after emasculation. After each pollination treatment, 10-15 flowers were collected 1 d after pollination, and prepared according to Socias i Company et al. (1976) in order to be observed under microscope with UV illumination. Each stigma was considered receptive when it was able to support pollen hydration, germination, and initial pollen-tube growth into the transmitting tissue of the style (Sanzol et al., 2003). The percentage of stigmas with pollen that germinated 1 d after pollination out of 25 - 30 stigmas examined, was determined as an index of stigma receptivity.

RESULTS AND DISCUSSION

The bloom evolution of the studied cultivars showed that ‘Marcona’ was 4 days earlier than its pollinator ‘Fournat de Brézenaud’ (Fig 1). Oukabli et al. (2008) reported that during the last 20 years, a delay of bloom between these two cultivars was observed in some years. As a consequence, a deficient pollination and a reduction of fruit set and yield resulted. However, Ferragnès’ and ‘Ferraduel’ coincided in the flowering period (Fig 1). The delay of bloom periods between ‘Marcona’ and ‘Fournat’ could probably be due to their different heat requirements (Alonso et al., 2005).

Fruit set was higher in ‘Ferragnès’ than in ‘Marcona’ (Fig 2) and also varied depending on the time of pollination. Fruit set in the open pollination treatment was 27.2% for ‘Ferragnès’ and 20% for ‘Marcona’. These results clearly indicate the negative effect of a deficient pollination on fruit set and yield of ‘Marcona’. In both cultivars maximum fruit set was obtained 2 d after pollination, as also obtained in other almond cultivars (Kodad and Socias i Company, 2009; Ortega et al., 2004), with a progressive decrease thereafter (Fig 2). However, fruit set after pollination at day-6 was considered commercially acceptable in ‘Ferragnès’ but not in ‘Marcona’. Temperatures at bloom are considered the main factors affecting fruit set (Vasilakakis and Porlingis, 1985), and in the present study warmer temperatures during the first days after emasculation (Fig 3) could explain the reduction of fruit set with pollinations at day-4, particularly in ‘Marcona’.

EPP duration in fruit trees is related to stigma receptivity, pollen tube kinetics and ovule longevity, which are highly influenced by climatic factors such as temperature (Sanzol and Herrero, 2001). The evaluation of stigma receptivity, assessed by the percentage of flowers with germinated pollen, revealed that at 2 d after emasculation the stigmas were mature and were able to support pollen grain adhesion, germination and penetration. The highest fruit set was obtained at this stage, coinciding with the highest stigma receptivity (Fig 2). The reduction of fruit set 4 d after pollination in ‘Marcona’ could be due to the loss of stigma receptivity, as reported in other studies (Kodad and Socias i Company, 2009; Ortega et al., 2004). The percentage of stigmas with pollen grains used to determine the stigma receptivity in our study showed a close fit with fruit set in both cultivars (Fig 2), indicating that EPP is limited by stigma receptivity and this is limited by temperatures at bloom. Burgos et al. (1991) also observed a rapid stigma degradation under high temperatures in apricot, with a subsequent shorter EPP.

CONCLUSIONS

The present study shows that the varietal association chosen by the farmers is not adequate, especially for ‘Marcona’-‘Fournat de Brézenaud’. Thus, the selection of new cultivars with the same flowering period than ‘Marcona’ to improve almond yields in Morocco is advised. Our results show that the EPP, stigma receptivity and warm temperatures during bloom are possible limiting factors for fruit set and fruitfulness in ‘Marcona’ and ‘Ferragnès’. These results emphasize the importance of early pollination to ensure an acceptable yield. Finally, in the context of the warming context experienced in Morocco, the introduction and selection of adapted autogamous cultivars is advisable to increase and ensure almond production in Morocco.

Literature Cited

Alonso, J.M., Ansón, J.M., Espiau, M.T. and Socias i Company, R. 2005. Determination of endodormancy break in almond flower buds by a correlation model using the average temperature of different day interval and its application to the estimation of chill and heat requirements and blooming date. J. Amer. Soc. Hort. Sci. 130:308-318.

Burgos, L., Egea, J. and Dicenta, F. 1991**.** Effective pollination period in apricot (*Prunus armeniaca* L.) varieties. Ann. Appl. Biol. 119:533-539.

DeGrandi-Hoffman, G., Roth, S.A. and Lopper, G.M. 1989. ALMOPOL: a cross-pollination and nut set simulation model for almond. J. Amer. Soc. Hort. Sci. 114:170-176.

FAO. 2007. FAOSTAT AGRICULTURE. Food and Agriculture Organization of the United Nations. (http://www.fao.org/waicent/portal/statistics_es.asp).

Gülcan, R. 1985. Almond descriptors (revised). IBPGR, Rome.

Kester, D.E. and Griggs, W.H. 1959. Fruit setting in the almond: the effect of cross-pollinating various percentages of flowers. Proc. Amer. Soc. Hort. Sci. 74:214-219.

Kodad, O. and Socias i Company, R. 2009. Effect of pollination time on fruit set in an autogamous almond cultivar. J. Hort. Sci. Biotechnol. 84:350-354.

Loussert, R., Moussaoui, H. and Walali, L.D. 1989. L’amandier et sa culture au Maroc. Institut Agronomique et Vétérinaire Hassan II, Rabat (Maroc). 148 pp.

Ortega, E., Egea, J. and Dicenta, F. 2004. Effective pollination period in almond cultivars. HortScience 39:19-22.
Oukabli, A., Mamouni, A., Kodad, O. and Balaghi. R. 2008. Almond phenology as an indicator of climatic change in Morocco. Options Méditerr. (in press).
Sanzol, J. and Herrero, M. 2001. The effective pollination period in fruit trees. Scientia Hort. 90:1-17.
Sanzol, J., Rallo, P. and Herrero, M. 2003. Stigmatic receptivity limits the effective pollination period in ‘Agua de Aranjuez’ pear. J. Amer. Soc. Hort. Sci. 128:458-462.
Socias i Company, R., Kester, D.E. and Bradley, M.V. 1976. Effects of temperature and genotype on pollen tube growth of some self-compatible and self-incompatible almond cultivars. J. Amer. Soc. Hort. Sci. 101:490-493.
Vasilakakis, M.D. and Porlingis, I.C. 1985. Effect of temperature on pollen germination, pollen tube growth, effective pollination period, and fruit set of pear. HortScience 20:733-735.
Williams, R.R. 1965**.** The effect of summer nitrogen application on the quality of apple blossom. J. Hort. Sci. 40:31-41.
Williams, R.R. 1970. The effect of supplementary pollination on yield. In: Towards Regulated Cropping. (Williams, R.R. and Wilson, R.R., Eds.). Grower Books, London, UK. 7-10.

Figures

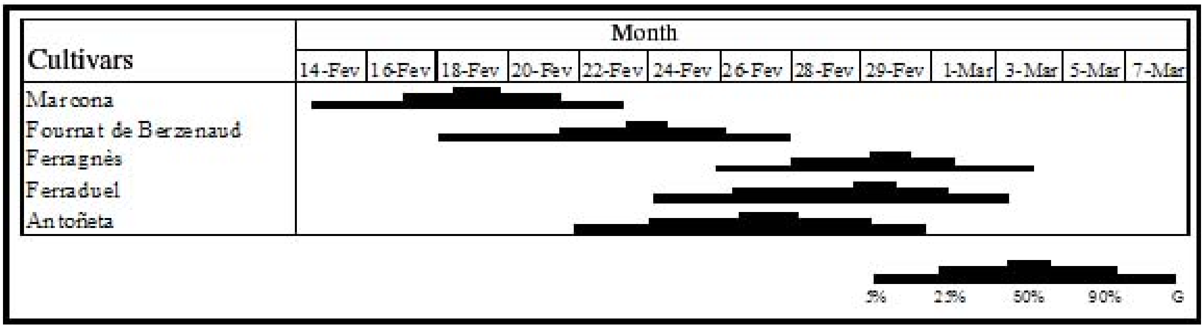

Figure 1. Bloom evolution of the studied cultivars at the experimental site

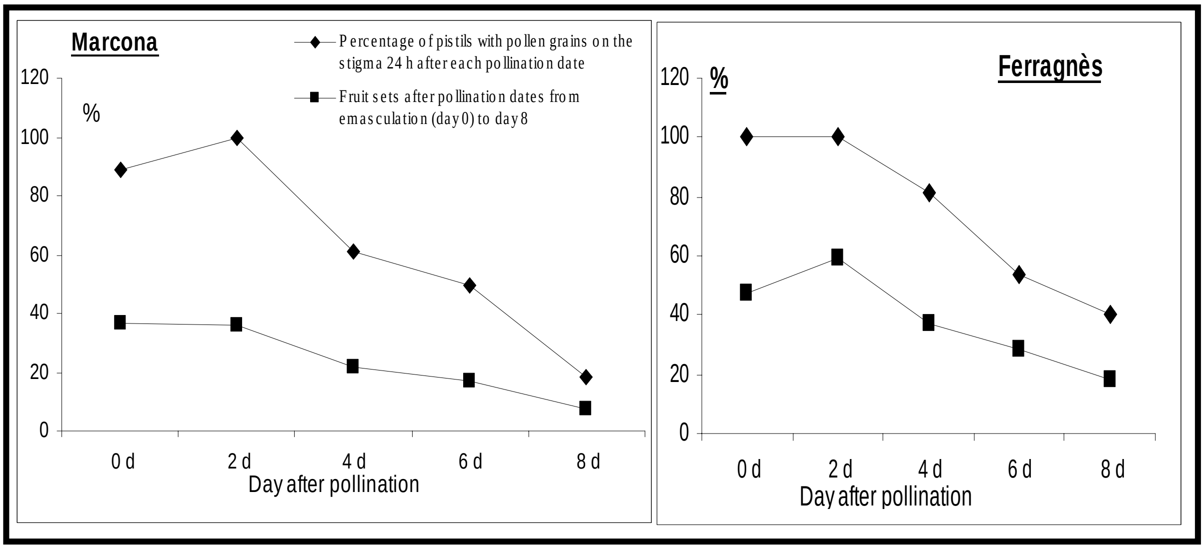

Figure 2. Fruit set and percentage of pistils with pollen grains on the stigma 24 h after each pollination date from emasculation (day-0) to day-8

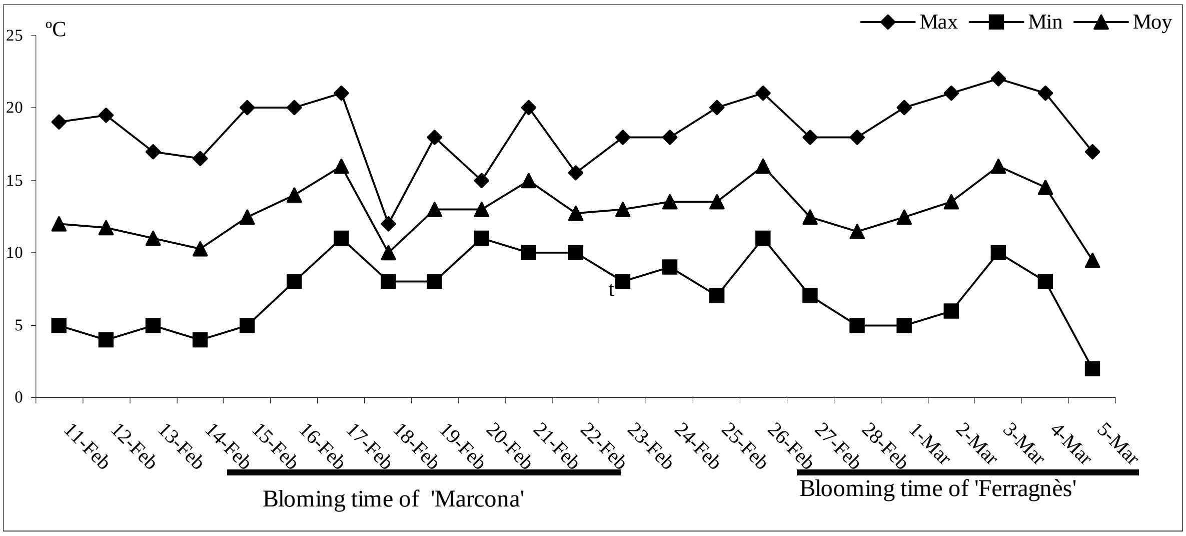

Figure 3. Maximum, minimum and mean daily air temperatures from emasculation to day-8 after emasculation at the experimental site.