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NOTE

ASSESSING THE DORMANCY CHARACTERISTICS OF SOME COMMERCIAL ALMOND CULTIVARS FOR DIFFERENT CLIMATES

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ABSTRACT

The chilling and heat-sum requirements of seven commercial almonds ['Managa'(early-bloom), 'Ne Plus Ultra' and 'Azar' (mid to late-bloom), 'Sahand', 'A200', 'A230' and 'Shokofe' (late-bloom)] were studied in 1994-96, with a view to assessing their adaptability under different climatic conditions. 'Sahand', 'A200' and 'A230' maintain their late blooming qualities because of their high chill and heat-sum requirements, and 'Azar' is a middle-bloom cultivar with a medium chilling requirement and low heat-sum requirements. Therefore, this cultivar will probably flower late in warmer climates. 'Managa' can be grown in warmer climates with no problems due to its low chilling requirement and minimum heat requirement. 'Shokofe' is a late-blooming cultivar, despite its lower chilling and heat-sum requirements than 'Ne Plus Ultra' and therefore more compatibility studies will be required for various zones. 'Ne Plus Ultra' is not recommended for cold climates owing to its limited chilling and heat-sum requirements and early blooming.

Key words: Almond, Chilling requirement Dormancy, Heat requirement.

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بررسی ویژگی های خفتگی چند رقم بـــادام تجـــاری در شرایط آب و هوایی مختلف

جلیل دژم پور و وازگین گریگوریان

به ترتیب پژوهشگر مرکز تحقیقات کشاورزی استان آذربایجان شرقی و دانشـیار گروه باغبانی دانشکده کشاورزی دانشگاه تبریز، جمهوری اسلامی ایران.

چکیده

به منظور برآورد نیازهای سرمایی و نیاز گرمایی چند رقم بادام تجاری و بـا هدف ارزیابی سازگاری آنها با شرایط آب و هوائی مختلف، در سال هـای ۱۳۷۴ و ۱۳۷۵ ، آزمایشی روی هفت رقم بادام تجاری با زمان گلدهی متفاوت در بهـار بـه نـام هـای 'سـهند' ، 'A200' ، 'A230' و 'شـکوفه' بـه عنـوان ارقـام دیرگـل، 'نوپلوس اولترا' ('Ne Plus Ultra') و 'آذر' به عنوان ارقام بـه نسـبت دیرگـل و 'منقا' به عنوان رقم زودگل در ایستگاه تحقیقات باغبانی آذرشهرانجام شد. یافتـه ها نشان داد که ارقام 'سهند' ، ' A200' و 'A230' به دلیل برخورداری از یک نیاز سرمایی و نیاز گرمایی بیشتر به عنوان ارقام دیرگل در شرایط آب و هوایـی مختلف آذربایجان و سایر نقاط مشابه، صفت دیرگلدهی خود را حفظ خواهند کرد و رقم 'آذر' در منطقه آذربایجان به عنوان یک رقم میان-گل تظاهر خواهـد کـرد. در حالی که همین رقم در مناطق به نسبت گرم، به صـورت یـک رقـم دیرگـل عمـل

خواهد کرد. رقم 'منقا' با خفتگی فیزیولوژیکی کمتر و نیاز گرمایی جزیی در مناطق گرمتر بدون هیچ مشکلی قابل کشت می باشد. رقم 'شکوفه' با وجود داشتن نیاز سرمائی و گرمایی کمتر از 'نو پلوس اولترا' دیرتر گل می دهد. بنابراین در کاشت آن در مناطق مختلف باید مطالعات سازگاری بیشتری انجام شود. رقم 'نو پلوس اولترا' با نیاز سرمایی و گرمایی محدودتر توام با گلدهی زود هنگام، برای کشت در مناطق سرد توصیه نمی شود.

INTRODUCTION

Knowledge of the dormancy characteristics and estimates of dormancy of fruit trees in temperate zones are essential for economic production (10). The early flowering almond is always under the threat of spring frost damage. Therefore, late flowering is a high priority for breeding programs in temperate zones, particulary the Azarbaijan region with large areas of land allotted to almond cultivation.

The flowering date of every temperate-zone deciduous plants, including almond is influenced by the amount of chilling and its heat-sum requirements (9). Therefore, the chilling and heat-sum requirements must be determined for obtaining late-blooming cultivars and consequently saving the product from spring low-temperature injury, especially in regions where spring frost is a frequent threat. Various methods have been used to evaluate dormancy, such as the identification of the rate and potential of respiration in vegetative buds (12, 21), concentrations of gibberellins (GA) (2, 23, 24), abscisic acid (ABA) and cytokinins (CK) (1, 12, 13, 15, 17, 19) in vegetative buds, assesssment of growth rate of the flower primordia (4, 5, 25), appearance of tetrads in anthers (5, 6, 25) and the relationship between the chilling requirements of buds and those of seeds (8, 9).

There are many models for determining the chilling requirements. The "Utah" chill unit model is favored because it has differe nt values for every given temperature during dormancy and nowadays most chilling requirement estimates are determined using this method (14, 20).

This experiment was conducted to evaluate the chilling and heat-sum requirements of some late and early blooming almond cultivars recently introduced by the East Azarbaijan Agricultural Research Center with the aim of identifying suitable cultivars for different climates.

MATERIALS AND METHODS

An experiment was conducted with seven commercial almond cultivars ['Sahand', 'A200', 'A230', 'Shokofe' (late-bloom), 'Ne Plus Ultra', 'Azar' (mid to late-bloom) and 'Managa' (early-bloom)] at Azarshahr Horticultural Research Station during 1994-96. This station is situated in southwest of Tabriz (36° 45` N., 38° 15` W., elevation 1390 m). Its soil is sand/lime, average daily temperature is between 42 °C and 28 °C. The average annual rainfall is 250 to 321 mm.

The design of experiment was a randomized block and eight years old trees grafted on seedling rootstocks were used for this experiment. During the two years of the experiment, all trees received similar cultural practices.

From mid-summer to the start of flowering in the spring of the following year, shoots of the same diameter and length were sampled from all sides of the trees. After defoliating the shoots, single-bud cuttings (8, 16) were placed in moist perlite (3 tees × 3 replications × 60 cuttings) per replication. The cuttings were kept in a growth chamber (21±1°C temperature, 70-80% RH, 2500-3000 lux light, 12 hr photoperiod) for 30 days. the average sprouting rates of the vegetative buds were indentified for each stage and the different dormancy phases for each cultivar were determined (6, 8, 11, 16). The chilling requirement estimate was calculated using the 'Urah' model and positive and negative chilling units were calculated for certain temperates until 50% bud break. The sprouting rate was calculated as $\bar{R} = \frac{\Sigma n}{\Sigma D.n}$ where $\bar{R}$= average sprouting rate, n= number of sprouting buds, D=day of sprouting). Thus the sum of estimated hourly temperatures until the completion of dormancy was calculated (3, 20).

The eştimate of heat-sum requirements to 50% bud break and speouting rate in controlled conditions to 50% bud break in the field was calculated. The accumulation of the temperature above the base temperature of 4.50C was calculated and then the growing degree hours (GDH) were recorded (6, 20,26).

RESULTS AND DISCUSSION

Statistical analysis indicated significant differences ($P<0.01$) among different stages of sampling within all cultivars and among the trees chosen ($P<0.05$) in the cases of 'A200' and 'Shokofe'

True dormancy was evident in all cultivars. Among the three chosen trees, there was difference for 'A200' and 'Shokofe' in the course of dormancy. This may be due to rootstock type and tree vigour in keeping with the discoveries of Chandler *et al.* (3) about fruit trees.

Results of the study on average sprouting rate and percentage of vegetative buds during 30 days and in the different experimental stages indicated that dormancy of 'A200' and 'Sahand' begun sooner and was longer and deeper (Figs. 1and 2), whereas that of 'Shokofe' and 'Ne Plus Ultra' begun later and was short-lived. This time difference was less in 1995 'Sahand', 'A200' and 'A230' as late-blooming cultivars had more chilling and heat-sum requirements (Figs, 3 and 4) and finally completed their dormancy by the mid-autumn. Most shoots of 'Shokofe' were vulnerable to late fall-early winter frosts due to late entrance into dormancy and low resistance against cold,. but the floral buds of this cultivar were more resistant to cold than those of the other cultivars. In 1994, 'Ne Plus Ultra' (mid to late-bloom) and 'Shokofe' (late-bloom) entered dormancy almost in late-autumn with severe cold weather (-20 °C) (Figs. 1 and 2). These data, to some extent, confirm the results of Rettigan and Hill (18).

'Azar' has medium chilling requirement and low heat-sum requirement and seemingly its late-bloom characteristic is most affected by its chilling requirements. 'Managa' as an early bloom cultivar has very low chilling requirement (50-100 C.U.), less heat-sum requirement (400-5800 GDH), and its dormancy is short and superficial (Table 1). The relationships between

flowering time and chilling and heat-sum requirements of the different cultivars, are positive and significant (respectively, r=0.75). Apparently, a cultivar with higher chilling and heat-sum requirements is also late blooming because this characteristic is genetically controlled (20, 21). So this cultivar can be used as a suitable parent in almond breeding and improvement programs.

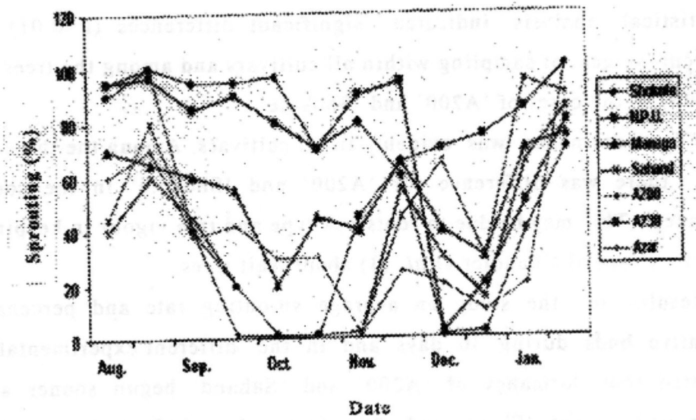

Fig. 1. Average sprouting percentage of vegetative buds of almond cultivars under controlled conditions in 1994-95.

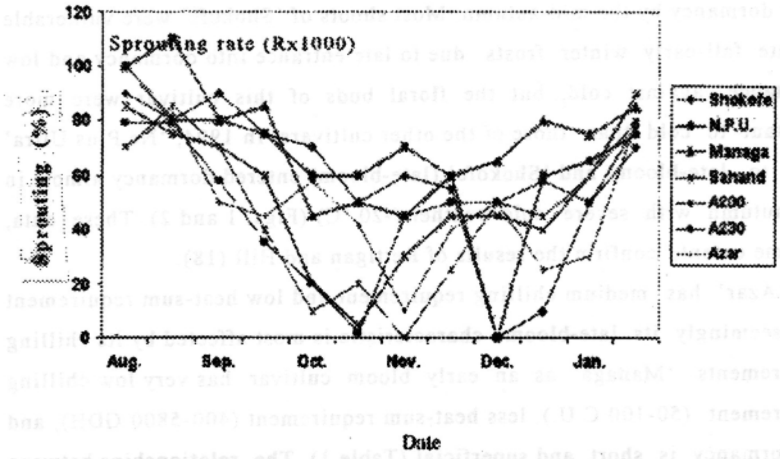

Fig. 2. Average sprouting rate of vegetative buds of almond cultivars under controlled conditions in 1994-95.

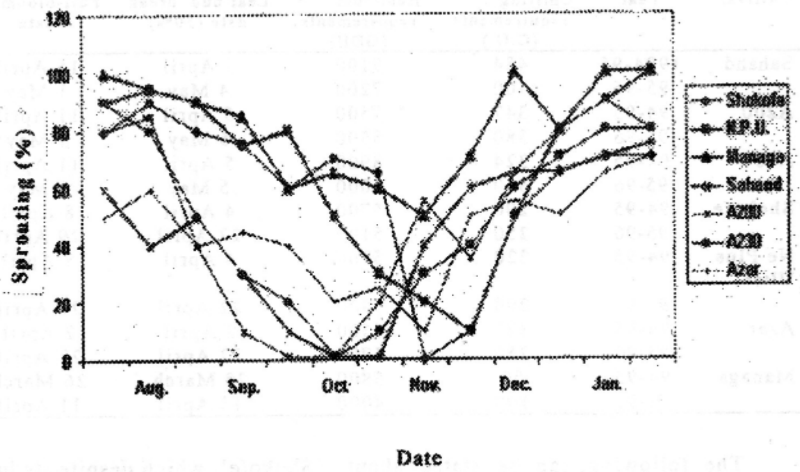

Fig. 3. Average sprouting percentage of vegetative buds of almond cultivars under controlled conditions in 1995-96.

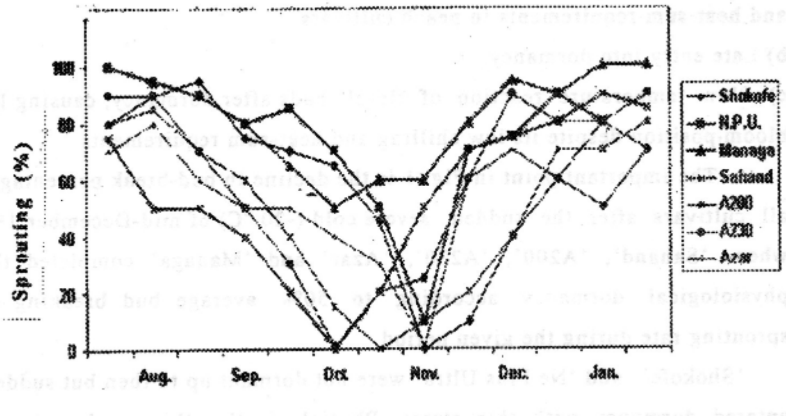

Fig. 4. Average sprouting rate of vegetative buds of almond cultivars under controlled conditions in 1995-96.

Table 1. Chilling and heat-sum requirements of seven almond cultivars.

Cultivar	Year	Chilling requirements (C.U.)	Heat-sum requirements (GDH)	Leaf bud break date (50%)	Full-bloom date
Sahand	1994-95	484	9100	7 April	15 April
	95-96	400	7200	4 May	1 May
A200	94-95	347	7500	5 April	11 April
	95-96	380	5500	5 May	1 May
A230	94-95	324	8900	5 April	11 April
	95-96	350	6000	5 May	1 May
Shokofe	94-95	200	5700	4 April	8 April
	95-96	250	5100	22 April	29 April
Ne Plus Ultra	94-95	220	5700	4 April	8 April
	95-96	200	5900	22 April	27 April
Azar	94-95	329	6500	2 April	2 April
	95-96	250	5700	22 April	22 April
Managa	94-95	50	5800	28 March	26 March
	95-96	100	4000	13 April	11 April

The following can be stated about 'Shokofe', which despite its low chilling and heat-sum requirements, is recognized as late-blooming in the Azerbaijan region.

a) Probable high base temperature in 'Shokofe' as stated by Werner *et al.* (26) about flowering time difference despite the equal estimates of chilling and heat-sum requirements in peach cultivars.

b) Late entry into dormancy.

c) Slow temperature reaction of floral buds after dormancy, causing late-bloom position despite its low chilling and heat-sum requirements.

The important point in Fig. 1 is the decline in bud-break percentage of all cultivars after the sudden severe cold (-20 °C) of mid-December 1994, when 'Sahand', 'A200', 'A230', 'Azar' and 'Managa' completed their physiological dormancy according to 50% average bud breaking and sprouting rate during the given period.

'Shokofe' and 'Ne Plus Ultra' were not dormant up to then but suddenly entered dormancy with this stress. Physiologically, this may be related to lack of complete dormancy of 'Azar', 'A200', 'A230' and 'Managa' by that date and their inability to return to dormancy with freezing temperatures or related to the inhibition effect of below-zero temperatures (as is the case with temperatures over 15°C) on the accumulated promoting temperatures. Finally, this can be put down to the enhancing role of severe cold in the dormancy of the 'Shokofe' and 'Ne Plus Ultra' but in 1995 the dates of entering into dormancy and their durations were different because of a lack of sudden harsh cold as in 1994, and consequent lack of late dormancy return (Fig. 3). Therefore, 'A200' had shorter dormancy period in 1995 and this may be due to more promotion temperatures in that year.

In the study of cultivar flowering date the interaction of chill and heat requirements are of paramount significance; with more chilling accumulation, the need for heat-sum decrease and the contrasting chilling requirement deficiency while increase the heating requirement of the buds (Table 1). In fact there is an inverse relationship between chilling and heat-sum requirements of the buds (22). So the flowering time of 'Azar' despite its relatively high chilling requirement, is under control of its heat-sum requirements in the cold region of Azarbaijan. In regions with warmer winters, the chilling requirement determines flowering date because of warm temperature and limited cold. It seems 'Azar' functions as a late-blooming type for warm climates.

'Managa' as an early-blooming type can be used without difficulty in warmer regions because of its light dormancy and low chilling requirement. So in the Azarbaijan climate the flowering time of this cultivar is largely affected by its heating requirement and the base temperature of this cultivar will probably be as low as any other early bloom cultivar.

The chilling and heat-sum requirement estimates of the two years differ. In 1995, the chilling requirements of the cultivars were high and the heat-sum requirements were quite low. But the order and regularity between chilling and heat-sum requirements and floweing dates were similar in both years (18). It seems the chilling and heat-sum requirement estimates in different years and climatic conditions vary according to the break of cold and fluctuations in temperature.

'Sahand' is a very late-blooming cultivar with higher chilling and heat-sum requirements. It is the best cultivar in this respect and followed in order by 'A200' and 'A230'. It is assumed that these cultivars can preserve their late-blooming characteristic in various climatic regions and can be utilized as real late-bloom cultivars in plantations or in breeding programs.

'Shokofe' has not been used in improvement programs to obtain late-bloom cultivars and more adaptability studies are needed for cultivation of 'Shokofe' in temperate zones. But this cultivar is the best cultivar in regions with climates similar to that of Azarbaijan due to its interesting characteristics in terms of fruit quality, bearing, grøwth characteristics and tree form.

All the estimates obtained in Azarbaijan climate are consistent with the 'Uath' model and to allot these results to be used for other regions, information on flowering date and the climatological statistics of past years should be considend.

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