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Heterosis expression toward technological parameters in F_1 onion hybrids for drying

Хетерозисни прояви по технологични параметри в F_1 хибриди лук за сушене

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ABSTRACT

The suitability of newly developed F_1 onion (*Allium cepa* L.) hybrids for drying was evaluated in 3-year experiment by the expression of the heterosis effect toward the time for reaching to the minimal equilibrium moisture content during the drying process. Lines, varieties and F_1 onion hybrids of three types (hot, semi-hot and sweet) with yellow envelope flakes and different morphological characteristics were used. The drying time for the investigated variants ranged between 70 and 180 minutes. The bulbs of hybrid Liaskovski sterile x Jubilei 50 (LA x J50) F_1 were dried most rapidly. The hypothetical heterosis varied from -17.65% to 46.67%. Heterosis manifestations concerning drying time of onion bulbs were expressed but they have not economic importance. Therefore the heterosis breeding is not the way for increasing the suitability of onion for drying. Systematic investigations on the initial plant material before including in the hybridization in order to search parental components with optimal values of the drying parameters have to be on the focus.

Keywords: *Allium cepa* L., dry matter, drying curve, hypothetical heterosis, real heterosis

АБСТРАКТ

В тригодишен експеримент е оценена пригодността за сушене на новосъздадени F_1 хибриди лук (*Allium cepa* L.) чрез изследване на хетерозисния ефект по отношение на времето за достигане до минималното равновесно съдържание на влага по време на процеса на изсушаване. Използвани са три типа линии, сортове и F_1 хибриди лук (люти, полулюти и сладки) с жълти обвивни люспи и различна морфологична характеристика. Времето на сушене за изследваните варианти варира между 70 и 180 минути. Луковиците на хибрида Лясковски стерилен х Юбилей 50 (LA x J50) F_1 се изсушават най-бързо. Хипотетичният хетерозис варира от -17.65% до 46.67%. Установени са прояви на хетерозис, отнасящи се до времето на сушене на луковиците, но без икономическо значение.Това показва, че хетерозисната селекция при лука не е пътят, по който може да се увеличи пригодността му засушене. На фокус трябва да бъдат систематични изследвания на растителния материал преди включването му в хибридизация с цел търсене на родителски компоненти с оптимални стойности на параметрите на сушене.

Ключовидуми: *Allium cepa* L., истински хетерозис, крива на сушене, сухо вещество, хипотетичен хетерозис

INTRODUCTION

Onions (*Allium cepa* L.) are an important crop worldwide. The vast use both for fresh consumption and for processing is determined by the valuable components in the bulbs which make it a good antioxidant ingredient for food (Slimestad et al., 2007; Kaur et al., 2009; Colina-Coca et al., 2014).

Dried onion is used in a wide range of processed foods such as ketchup, sauces, soups, meat products, potato chips, cookies, etc. It is normally applied as flavour additive, being preferred to the fresh product because it has better storage properties and is easy to use (Kaymak-Ertekin and Gedik, 2005; Gamboa-Santos et al., 2012).

The main objective in the creation of dried products is the drying process not to affect the quality of raw materials (Kiranoudis et al., 1992; Adam et al., 2000; Mota et al., 2010). The colour and flavour are the most important characteristics that determine the taste of onion. The occurrence of browning is due to the reaction, which is a consequence of the reaction of aldehydes ketones and reducing sugars with amino compounds such as amino acids and proteins (Proudlove, 1989). It is induced by the drying process and results in a loss of colour and deterioration of the taste (Krokida and Maroulis, 1999; Ibarz et al., 2000).

The raw material for the production of dried onions should be of high dry matter content, high content of essential oils, thick and firm flesh, unsprouted and decayed inner flakes (Mitra et al., 2012; Penov and Petrova, 2013).

In the last years the breeding investigations on onion at Maritsa Vegetable Crops Research Institute have been directed to development of F_1 hybrids with increased yield potential, resistant to economically important diseases and appropriate for high quality production of dried onion (Genova, 2013; Genova and Pevicharova, 2013a, 2013b). Heterosis breeding in onion provides an opportunity for improvement in productivity, earliness, uniformity and yield attributing characters (Evoor et al., 2007; Abubakar and Shehu, 2008). High heterosis was also found for onion fresh weight (Pavlović et al., 2015), number of open layers in the bulb (Pavlović et al., 2012), good storage life (Lawande et al., 2009). No information was found about the heterosis on the appropriateness of onions for drying. The aim of the present study was to evaluate the suitability of newly developed F_1 onion hybrids for drying by expression of heterosis effect toward the time for reaching to the minimal equilibrium moisture content during the drying process.

MATERIALS AND METHODS

Plant material: Lines, varieties and F_1 onion (*Allium cepa* L.) hybrids of three types (hot, semi-hot and sweet) with yellow envelope flakes and different morphological traits were used in 3-year experiment. Six F_1 hybrids were included. They were developed as a result of hybridization of two female parental components (P_1) - Ispanski sterile 482 (IA) and Liaskovski sterile (LA) with five male ones (P_2) - Liaskovski 90 (L90), Jubilei 50 (J50), Makovski (M), Diamandx Granada (DxG) and Ptuiskix Makovski (PxM). The developed hybrids were as follows: IA x M (F_1), IA x L90 (F_1), LA x J50 (F_1), LA x L90 (F_1), LA x (PxM) (F_1), LA x (DxG) (F_1).

Field design: The experiment was carried out on trial plots of 4.8 m^2. The sowing was performed in March on a profiled high flatbed manually. The seeds were sown according to the technology of one year-old onion growing without seedlings in four row strips in a 85+25+25+25 cm scheme. Standard agronomic practices (fertilization, plant protection, etc.) were applied during the vegetation period. The irrigation was done by sprinkling. All cultivars were harvested in the second half of August. Right after harvesting the bulb dry matter was measured.

Sample preparation and drying process: A sample of 2 kg onions was washed, peeled, washed again, sliced 3 mm thick, finally washed and stacked on mesh trays. Then the sample was dried in a laboratory convection drying unit of chamber type at 50°C until the equilibrium moisture was reached. The drying process kinetics was investigated based on the experimental data and obtaining the curve of the drying process: t = f (U^c). The equation for drying speed was derived from the drying process curve applying graphic differentiation:

$$U^c = f\left(\frac{dU^c}{dt}\right)$$

where U^c was the equilibrium moisture content (%) and t was the drying time (min). The drying speed at the first process period was described by the following equation:

$$C = \frac{(U_h^c - U_{kp}^c)}{\Delta t_1}$$

(%/min), where U_h^c and U_{kp}^c were the initial and critical moisture content values for the product respectively. Approximating the drying curve at the second process period to a straight line the drying rate was described by theequation:

$$\frac{dU^c}{\Delta t} = K(U^c - U_p^c)$$

where K was the drying coefficient (min^{-1}).

Statistical analysis: The data obtained were statistically processed by Duncan's multiple range test and correlation analysis using software *SPSS 12*. The coefficient of determination was also calculated. The heterosis was determined by Omarov (1975). The hypothetical heterosis toward the mean parental evaluation and the real heterosis toward the better parent were evaluated.

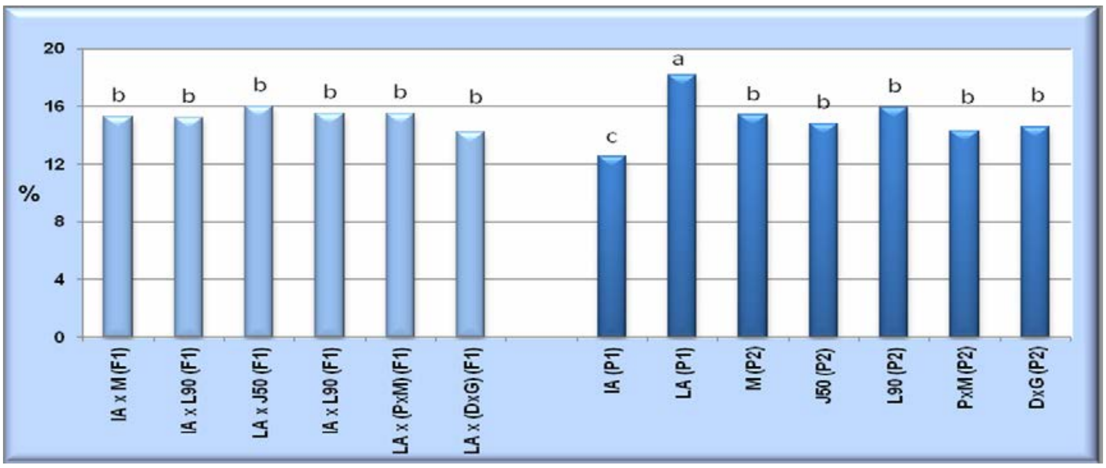
RESULTS AND DISCUSSION

The male parental lines were very close toward bulb dry matter content right after the harvest (Figure 1). Both female components had the highest and the lowest values of the investigated parameter. They differed statistically from the male ones. All hybrids were of dry matter content very similar to that of the male paternal lines.

The drying time for the studied variants ranged between 117 and 180 minutes (Table 1). As a whole, the time for drying was shortest in LA (P_1). The bulbs of hybrid LA x J50 (F_1) were dried most rapidly. Hybrid IA x L90 (F_1) kept the highest value of this technological parameter.

The comparatively low value of the correlation coefficient calculated by data for dry matter content and time for drying (r = -0.444) illustrated the influence of other factors related to the moisture separation speed on the drying processes of onion. The lack of correlation between both parameters demonstrated the impossibility to predict the drying speed of plant material by dry matter content from 10 to 20 per cent using a standard technology for drying. In order to establish the suitability of onion cultivars and hybrids for drying it is recommended to go through the whole technological process and the assessment to be done using the parameters of drying curves.

The drying curves of the experiment followed the design of logarithmic curve (Figure 2). They were of high value of determination coefficient which proved the adequateness of the process.



[a,b,c] Duncan's multiple range test (P<0.05); IA (P_1)- Ispanski sterile 482, female parental component; LA (P_1) - Liaskovski sterile, female parental component; M (P_2) -Makovski, male parental component; J50 (P_2) - Jubilei 50, male parental component; L90 (P_2) - Liaskovski 90, male parental component; PxM(P_2) - Ptuiski x Makovski, male parental component; DxG(P_2) - Diamand x Granada, male parental component

Figure 1. Dry matter content (%) after bulb harvesting

Table 1. Onion drying time

Parental components	Drying time (min)	F_1 hybrids	Drying time (min)
IA (P_1)	137^{ab}	IA x M (F_1)	143^{ab}
LA (P_1)	117^{b}	IA x L90(F_1)	157^{a}
M (P_2)	123^{b}	LA x J50(F_1)	127^{b}
J 50 (P_2)	140^{ab}	LA x L90(F_1)	147^{ab}
L90 (P_2)	130^{ab}	LA x (PxM)(F_1)	140^{ab}
PxM (P_2)	140^{ab}	LA x (DxG) (F_1)	143^{ab}
DxG (P_2)	127^{b}		

a.b...- Duncan's multiple range test ($P<0.05$)
IA (P_1) - Ispanski sterile 482, female parental component; LA (P_1) - Liaskovski sterile, female parental component; M (P_2) - Makovski, male parental component; J50 (P_2) - Jubilei 50, male parental component; L90 (P_2) - Liaskovski 90, male parental component; PxM (P_2) - Ptuiski x Makovski, male parental component; DxG (P_2) - Diamand x Granada, male parental component

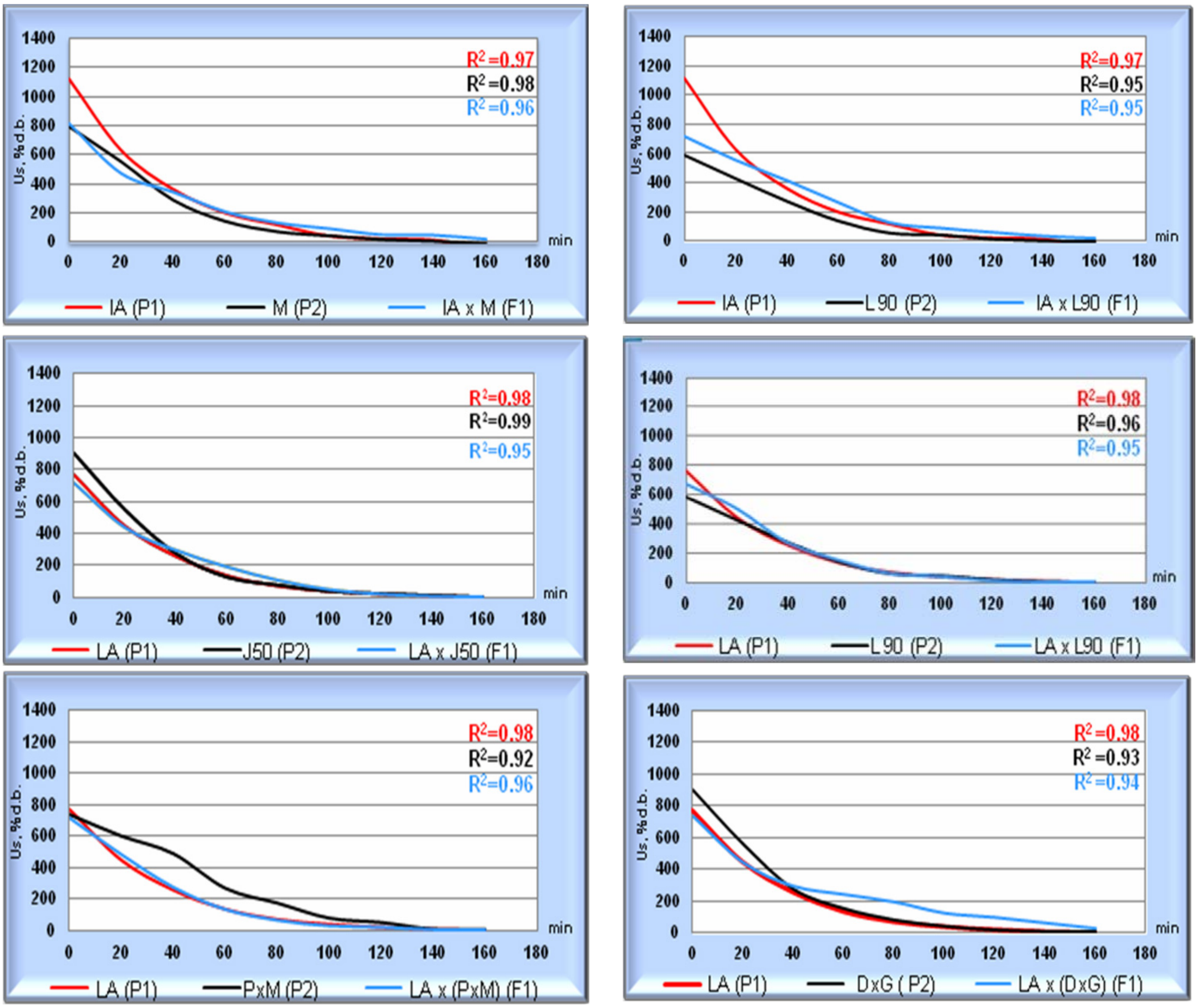


Figure 2. Drying curves of onion varieties, lines and hybrids(IA (P_1) - Ispanski sterile 482, female parental component; LA (P_1) - Liaskovski sterile, female parental component; M (P_2) - Makovski, male parental component; J50 (P_2) - Jubilei 50, male parental component; L90 (P_2) - Liaskovski 90, male parental component; PxM (P_2) - Ptuiski x Makovski, male parental component; DxG (P_2) - Diamand x Granada, male parental component)

In principle, the drying curve has a certain practical value using belt or chamber dryers. According to the course of the curve, settings mode for drying could be made for a particular variety or hybrid. During the first drying period when the free water evaporates from the raw material the temperature could be raised to 100°C and a little over 100°C depending on the starting position and the slope of the drying curve. During this period the drying curve was steepest for IA (P_1) and DxG (P_2), where the critical point was reached between the 35th and 40th minute from the start of the drying process, respectively (Figure 2). The drying speed was also relatively high (Table 2). The hypothetical heterosis varied from -17.65 per cent to 46.67 per cent (Table 3).

During the two of the three experimental years negative heterosis effects toward the additive average were established only in hybrid LA x J50 (F_1). The values of the hypothetical heterosis of the other crossings were zero or positive. This means that the developed hybrids were distinguished by the same or longer drying time in comparison with the average parental value.

In the whole experimental period the heterosis effects for breeding purpose were positive towards better parent. In crossing LA x J50 (F_1) the character was inherited with positive overdominance in the first year and with incomplete dominance toward the parent of shorter drying time in the second and third ones.

Table 2. Speed and speed coefficient of onion drying

Parental components	Speed (%/min)	Speed coefficient (K)	F_1 hybrids	Speed (%/min)	Speed coefficient (K)
IA (P_1)	17.03^{abc}	0.83^{ab}	IA x M (F_1)	8.21^{d}	1.14^{ab}
LA (P_1)	12.44^{abcd}	0.53^{b}	IA x L90(F_1)	8.08^{d}	0.97^{ab}
M (P_2)	11.87^{abcd}	0.46^{b}	LA xJ50(F_1)	10.37^{bcd}	0.88^{ab}
J 50 (P_2)	14.97^{ab}	0.46^{b}	LA x L90(F_1)	11.41^{abcd}	1.67^{a}
L90 (P_2)	8.82^{bcd}	0.02^{c}	LA x (PxM)(F_1)	12.18^{abcd}	1.68^{a}
PxM (P_2)	17.79^{a}	0.46^{b}	LA x (DxG) (F_1)	9.80^{cd}	0.94^{ab}
DxG (P_2)	14.53^{abcd}	0.01^{c}			

a.b...- Duncan's multiple range test ($P<0.05$)

IA (P_1) - Ispanski sterile 482, female parental component; LA (P_1) - Liaskovski sterile, female parental component; M (P_2) - Makovski, male parental component; J50 (P_2) - Jubilei 50, male parental component; L90 (P_2) - Liaskovski 90, male parental component; PxM (P_2) - Ptuiski x Makovski, male parental component; DxG (P_2) - Diamand x Granada, male parental component

Table 3. Heterosis during the bulb drying

	Hypothetical heterosis, %			Real heterosis, %			Degree of dominance F_1 (hp_1)		
	1st year	2nd year	3rd year	1st year	2nd year	3rd year	1st year	2nd year	3rd year
IA x M (F1)	0.00	18.52	15.79	6.67	23.08	22.22	0.00	5.00	3.00
IA x L90(F1)	0.00	18.52	42.86**	6.67	23.08	50.00**	0.00	5.00	9.00
LA x J50(F1)	9.68	-3.45	-17.65	13.33	7.69	16.67	3.00	-0.33	-0.60
LA x L90(F1)	9.68	23.08	29.41*	13.33	23.08	83.33***	3.00	-	1.00
LA x (PxM)(F1)	0.00	0.00	46.67**	6.25	7.69	83.33***	0.00	0.00	2.33
LA x (DxG)(F1)	9.68	21.43	28.57*	13.33	30.77*	50.00**	3.00	3.00	2.00

IA x M (F_1) - Ispanski sterile 482 x Makovski (F_1); IA x L90(F_1) - Ispanski sterile 482 x Liaskovski 90 (F_1); LA x J50 (F_1) - Liaskovski sterile x Jubilei 50 (F_1); LA x L90 (F_1) - Liaskovski sterile x Liaskovski 90 (F_1); LA x (PxM) (F_1) - Liaskovski sterile x (Ptuiski x Makovski) (F_1); LA x (DxG) (F_1) - Liaskovski sterile x (Diamand x Granada) (F_1)

In hybrid LA x (DxG) (F_1) the time for bulb drying was inherited with positive overdominance during the period of investigation. In the other crossings the inheritance ranged from additive (hp_1 = 0) to overdominant. The degree of dominance was not calculated for hybrid combination LA x L90 (F_1) because the drying times of both parents were equal during the second year.

CONCLUSIONS

Heterosis manifestations concerning drying time of onion bulbs were expressed but they have not economic importance. Therefore the heterosis breeding is not the way for increasing the suitability of onion for drying. Systematic investigations on the initial plant material before including in the hybridization in order to search parental components with optimal values of the drying parameters have to be on the focus.

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