MODE OF INHERITANCE OF DRY MATTER CONTENT IN ONION (*Allium cepa* L.) BULB

Nenad PAVLOVIĆ, Dejan CVIKIĆ, Jasmina ZDRAVKOVIĆ,
Mirjana MIJATOVIĆ, Milka BRDAR-JOKANOVIĆ

Institute for Vegetable Crops, Smederevska Palanka, Serbia

Pavlović N., D. Cvikić, J. Zdravković, M. Mijatović and M. Brdar-Jokanović (2011): *Mode of inheritance of dry matter content in onion (A. cepa L.) bulb. -* Genetika, Vol 43, No. 1, 19 -27.

Onion dry matter content is very important in terms of processing. The study was undertaken in order to investigate dry matter content inheritance pattern in fresh onion bulb. Five divergent onion genotypes, originating from different geographical areas, have been crossed. Full diallel crossing method (without reciprocals) was applied in order to obtain F_1 and F_2 generation offspring. Field trial including parents and F_1 and F_2 hybrids was performed at the Institute for Vegetable Crops experimental plot, Smederevska Palanka. The trial was conducted in randomized blocks, with five replications. Intermediate inheritance pattern prevailed for both F_1

_____

Corresponding author: Nenad Pavlović, Institute for Vegetable Crops, Karađorđeva 71, 11420 Smederevska Palanka, Serbia, Phone: 381 26 317 170, fax 381 26 323 785, e-mail: *npavlovic@institut-palanka.co.rs*

and F_2 generation. Additive genetic component value was higher than dominant for both F_1 and F_2 generation, which implies additive effect of genes. Hybrid combination PR x BB was characterized by the highest heterosis value (11.85%). Better general combining abilities were confirmed for three lines in comparison with other lines, whereas special combining abilities were significant for one F_1 hybrid. Neither general nor special combining abilities were significant for F_2 generation.

Key words: combining abilities, dry matter content, heterosis, onion

INTRODUCTION

Amongst the species of genus *Allium*, onion is the most important and high quality of the bulb is an imperative for breeders. Onion dry matter content is very important in terms of processing, owing to its negative correlation to quantity of fresh bulbs required for dry onion production. Dry matter content also influences shelf life and the quality of the bulbs (DEBAENE e*t al*., 1999, GRIFFITHS *et al.*, 2002, KUMAR *et al.*, 2007, ZDRAVKOVIĆ *et al.*, 2010).

An understanding of dry matter content mode of inheritance is an important task for breeders. The estimate of combining abilities of the starting material makes the choice of parental genotypes less difficult. The selection should be focused on the traits characterized by higher heritability (ORTIZ *et al.*, 2001).

This study was undertaken in order to investigate dry matter content inheritance pattern in onion bulbs.

MATERIAL AND METHODS

Five onion genotypes (Makoi bronzi, Piroška, AC101/Zlatno gnezdo, Jasenički crveni and Bunkino beo), differing in geographical origin, have been intercrossed.

Comparative field trial including parents, F_1 and F_2 generation, has been conducted at the experimental field of Institute for Vegetable Crops, Smederevska Palanka, Serbia. The trial was set in complete random block design, with five replications. Each replication included 30 plants. Standard agro technical procedures have been applied. Bulb dry matter content was determined by standard procedure.

Dry matter content inheritance pattern was estimated using the model that includes parents, F_1 and F_2 generation (BOROJEVIĆ, 1986). Genetic variance was partitioned by HAYMAN (1954) and MATHER and JINKS (1971) statistical methods. Combining ability analysis was performed by Method 2, Mathematical model 1 (GRIFFING, 1956).

RESULTS AND DISCUSSION

Among the parents, the average bulb dry matter content varied in the range from 9.45% (Makoi bronzi) to 15.69% (Bunkino beo). For F_1 generation, the lowest average content of dry matter has been determined in hybrid combination Makoi bronzi x Piroška (10.19%), whereas the highest dry matter content had hybrid Piroška x Bunkino beo (15.05%).

The content of dry matter in F_2 generation varied from 10.53% (Makoi bronzi x Piroška) to 14.85% (Jasenički crveni x Bunkino beo), Table 1. WAL and CORGAN (1999) pointed out higher dry matter content in bulbs of white onions, which has been confirmed in our research.

Variability expressed through coefficient of variation (*Cv*) was the lowest for line Bukino beo (0.37%) and the highest for Makoi bronzi (7.09%), concerning parents. For F_1 generation, *Cv* fell in the range from 2.57% (AC 101 x Bunkino beo) to 5.69% (Makoi bronzi x Jasenički crveni). Coefficients of variation calculated for F_2 generation were higher, as expected (Table 1). High variability, as well as significant influence of environment, agro-technology and processing on onion dry matter content have been reported by RANDLE (1997) and HENDRIKSEN and HANSEN (2001).

The most common mode of inheritance of dry matter content was intermediary, for both studied generations. The intermediary mode of inheritance has been confirmed for seven hybrid combinations in F_1 generation, as well as for five hybrid combinations in F_2 generation. Besides this mode of inheritance, the partial domination of the worse and domination of better parent has been observed (Table1).

Concerning F_1 generation, statistically significant heterotic effect has been found for hybrid combination Piroška x Bunkino beo only (11.85%), whereas in F_2 generation not a single hybrid had significant values of heterosis (Table 1). Low heterosis effect for dry matter content in bulbs has been found by MADALGAR and BOJAPPA (1986) and PANAJOTOVIĆ (1986).

The additive variance component (*D*) was higher than the dominant (H_1 and H_2) in F_1 and F_2 generation; therefore, the most of the genetic variability belongs to the additive gene reaction (Table 2). The negative *F* value shows that recessive alleles have higher impact in inheritance of this trait. The distribution of dominant and recessive alleles was not equal ($H_2/4H_1$ = 0.19 and 0.13). For hybrid F_1 generation, narrow sense heritability was 0.90 and broader sense heritability was 0.95. Values for heritability in F_2 generation were lower. High heritability values for dry matter content implying the genetic effects on the trait have been found also by RANDLE (1997) and PAVLOVIĆ *et al.* (2006).

Total number of dominant and recessive alleles ratio (Kd/Kr) was lower than 1 for both generations, implying higher effect of recessive alleles in inheritance of dry matter content in onion bulbs. The average level of dominance ($\sqrt{H_1/D}$ = 0.43 and 0.31) was lower than 1 for all crossing combinations, which indicated dominance as the mode of inheritance for dry matter content.

Three parental lines had significant GCA values (Table 4). Makoi bronzi and Piroška had negative significant values in F_1 generation, while the best GCA had Bunkino beo, which was ranked the highest. The results were similar in F_2 generation; however, the value for Piroška was insignificant.

Table 1. Mean value ($\bar{x}$), standard error (Sx), coefficient of variation (Cv), mode of inheritance, absolute and relative heterosis (Ha and Hr) for onion bulb dry matter content for parents, F_1 and F_2 hybrids.

Genotypes	F_1		F_2		Ha		**Hr**	
	$\bar{x}$ ±Sx	Cv (%)	$\bar{x}$ ±Sx	Cv (%)	F_1	F_2	F_1	F_2
Makoi bronzi (MB)	9.45 1.58	5.94	9.45 1.58	5.94				
MB x PR	10.19[i] 2.84	3.34	10.53 0.94	9.33	-0.14	0.19	-1.37	1.83
MB x AC 101	11.63[i] 3.20	3.94	11.20[i] 2.67	4.75	0.33	-0.21	2.86	-1.83
MB x JC	10.82[Pd] ⁻2.20	5.69	10.82[Pd-] 2.20	5.69	-0.92	-0.92	-7.83	-7.83
MB x BB	12.34[i] 3.83	3.04	12.56[i] 1.99	8.22	0.23	-0.01	-1.83	-0.07
Piroska (PR)	11.22 2.29	5.89	11.22 2.29	5.89				
PR x AC 101	12.31[i] 3.16	5.74	12.33[i] 1.81	8.50	0.10	0.12	0.84	0.95
PR x JC	12.63[i] 3.29	4.74	12.83[i] 1.90	8.80	0.01	0.21	0.04	1.65
PR x BB	15.05[d+] 4.49	4.17	14.80[d+] 5.05	2.48	1.60**	1.35	11.85	9.99
AC 101	13.20 3.27	5.41	13.20 3.27	5.41				
AC 101 x JC	12.72 3.24	4.97	12.45 1.27	10.61	-0.89	-1.17	-6.57	-8.60
AC 101 x BB	14.40[i] 4.86	2.57	14.27[i] 3.99	4.64	-0.05	-0.18	-0.33	-1.26
Jasenicki crveni (JC)	14.03 2.97	7.09	14.03 2.97	7.09				
JC x BB	14.85[i] 4.45	4.08	14.85 3.77	5.83	0.00	-0.01	0.02	-0.08
Bunkino beo (BB)	15.69 6.25	0.37	15.69 6.25	0.37				

F_1 lsd$_{0.05}$ = 1.09 F_2 lsd$_{0.05}$ = 1.59   lsd$_{0.01}$ = 1.44   lsd$_{00.1}$ = 2.07

[i] intermediary inheritance, [Pd] partial dominance, [d] dominance, [Sd] superdominance

Table 2. Components of genetic variance for onion bulb dry matter content

Components	Value F_1	Value F_2
D	5.782	5.260
H_1	1.083	0.560
H_2	0.827	0.300
F	-0.595	-0.460
E	0.147	0.303
$H_2/4H_1$	0.191	0.134
$\sqrt{H_1/D}$	0.433	0.315
Kd/Kr	0.787	0.770
hn^2	0.90	0.89
hb^2	0.95	0.91

Analysis of combining abilities for dry matter content in onion bulbs showed significant values for GCA (general combining abilities) only, while the values for SCA (special combining abilities) were insignificant. GCA value of 35.6 for F_1 generation and 41.9 for F_2 generation were higher that the corresponding values of SCA (Table 3), which could be explained by prevalence of additive gene effect in inheritance of the trait. Similar results have been reported by PANAJOTOVIĆ (1986).

Table 3. Analysis of variance for combining abilities for onion bulb dry matter content

Source of variation	df	(SS)		(MS)		F-exp	
		F_1	F_2	F_1	F_2	F_1	F_2
GCA	4	44.82	43.56	11.20	10.89	76.08**	35.97**
SCA	10	3.14	2.59	0.31	0.25	2.13	0.85
error	28			0.14	0.30		
GCA/SCA				35.38	41.92		

GCA $F_{0.05} = 2.71$ $F_{0.01} = 4.07$
SCA $F_{0.05} = 2.19$ $F_{0.01} = 3.03$

The highest value of SCA for F_1 generation expressed hybrid Piroška x Bunkino beo. It was the only hybrid with significant SCA value. For F_2 generation none of the hybrid combinations showed significant values for SCA (Table 5). Low number of combinations with good SCA could be explained by high additive genetic variance. PANAJOTOVIĆ (1986) reported similar results. On the contrary, HAVEY and RANDLE (1996) reported significant values for both GCA and SCA.

*Table 4. GCA values for onion bulb dry matter content in parental lines*

Parents	Value of SCA F_1	Rank	Se	B Value of SCA F_2	Rank	Se
MB	-1.760[**]	5		-1.732	5	
PR	-0.514[*]	4		-0.446	4	
AC101	0.182	3	0.205	0.073	3	0.294
JC	0.408	2		0.420	2	
BB	1.684[**]	1		1.684	1	

$lsd_{0.05}$=   0.410 $lsd_{0.05}$=0.588
$lsd_{0.01}$=   0.545 $lsd_{0.01}$=0.782
Se - standard error

Table 5. SCA values for onion bulb dry matter content in F_1 and F_2 generation

Genotypes	SCA F_1	Se	SCA F_2	Se
MB x PR	-0.236		0.032	
MB x AC 101	0.526		0.102	
MB x JC	-0.532		-0.544	
MB x BB	-0.289		-0.068	
PR x AC 101	-0.056	0.458	0.026	4.257
PR x JC	0.030		0.182	
PR x BB	1.174[*]		0.885	
AC 101 x JC	-0.572		-0.724	
AC 101 x BB	-0.172		-0.168	
JC x BB	0.0581		0.064	

$lsd_{0.05}$ =0.917 $lsd_{0.05}$ = 1.315
$lsd_{0.01}$ = 1.220 $lsd_{0.01}$ = 1.749
Se - standard error

        Regression coefficients (*b*=0.90 and 0.95) were not significantly different than 1, implying the absence of interallele gene reaction in inheritance of the dry matter content.

        The regression line was very close to the limiting parabola for both generations, which proves additive gene reaction in dry matter content inheritance (Graph 1 and 2). The average of the expected regression line with *Wr* axis was above the coordinate beginning, which is one of the parameters that imply partial dominance as the mode of inheritance of this trait.

Graph 1: *VrWr* regression for onion bulb dry matter content in F_1 generation
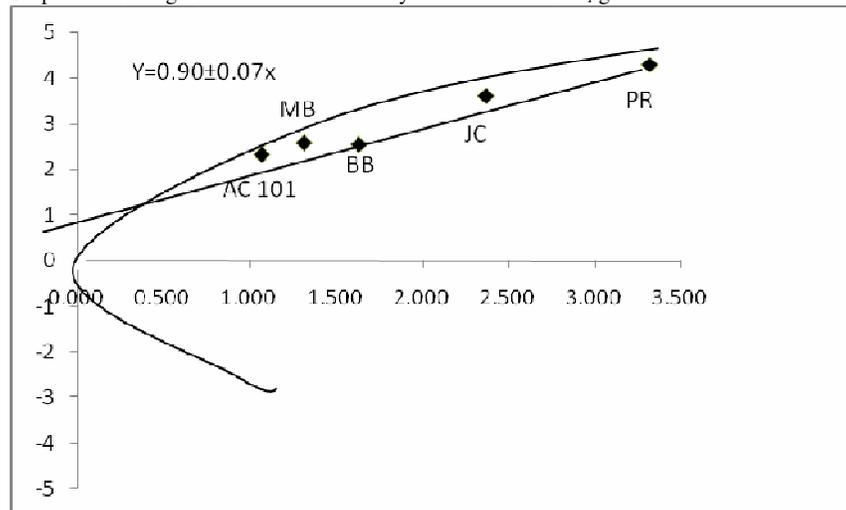
Graph 2: *VrWr* regression for onion bulb dry matter content in F_2 generation
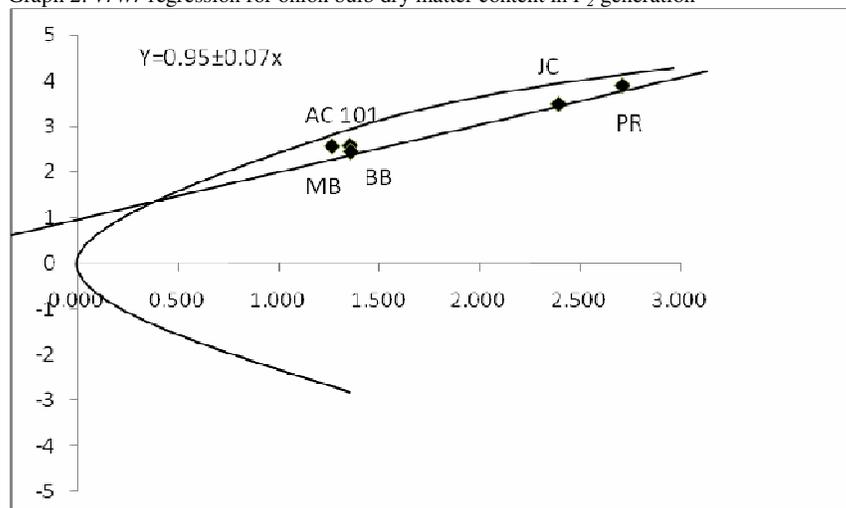
Parental genotype closest to the coordinate beginning was the genotype with the highest number of dominant genes; in F_1 generation it was AC 101 and in F_2 generation Makoi bronzi. The highest number of recessive genes in both generations had genotype Piroška.

CONCLUSION

Results obtained in our experiments did show that the most common mode of inheritance of onion dry matter content was intermediary. Statistically significant heterosis value has been found only in hybrid combination Piroška x Bunkino beo in F_1 generation, whereas in F_2 generation none of the hybrids had significant values of heterosis. The best general combiner was Bunkino beo. The highest value of SCA in F_1 and F_2 generation had hybrid Piroška x Bunkino beo.

REFERENCES

BOROJEVIĆ, K. (1986): Genes and Population. Forum, Novi Sad (in Serbian)

DEBAENE, J.E.P., I.L. .GOLDMAN, B.S. YANDEL (1999): Postharvest flux and genotipe x enviroment effects for onion-induced antiplatelet activity, pungency and soluble solids in long-day onion during postharvest cold storage. J. Amer. Hort. Sci., *124*, 366-372

GRIFFING, B. (1956): Concept of general and specific combining ability in relation to diallel crossing systems. Aust. J. Biol. Sci., *9*, 463-493

GRIFFITHS, G., L. TRUEMAN, T. CROWTHER, B. THOMAS, B. SMITH (2002): Onions-a global benefit to health. Phytother Res, *16*, 603-615

HAVEY, M.J. and W.M. RANDLE (1996): Combining abilities for yield and bulb quality among long- and intermediate-day open-pollinated onion populations. J Am Soc Hortic Sci, *121*, 604-608

HAYMAN, B. J. (1954): The theory and analysis of diallel crosses. Genetics, *39*, 787-809

HENDRIKSEN, K. and S.L. HANSEN (2001): Increasing the dry matter production in bulb onions (*Allium cepa* L.). Acta Hort, *555*, 147-152

KUMAR, S., M. IMTIYAZ, A. KUMAR (2007): Effect of differential soil moisture and nutrient regimes on postharvest attributes of onion (*Allium cepa* L.). Sci Hortic, *112*, 121-129

MADALGAR, B.B. and K. M. BOJAPPA (1986): Heterosis in dialel cross of onion. Indian J Hort, 43, 108-111

MATHER, K., J.L. JINKS (1971): Biometrical Genetics. Sec. Ed., Champan and Hall, London

ORTIZ, R., S. MADSEN., W.W. WAGOIRE, J. HILL, S. CHANDRA, O. STOLEN (2001): Additive main effect and multiplicative interaction model for a diallel-cross analysis. Theor Appl Genet, *101*, 1103-1106

PANAJOTOVIĆ, J. (1986): Investigation of the combining ability of inbred lines and heterosis expression in onion (*Allium cepa* L.) PhD thesis, University of Belgrade, Faculty of Agriculture, pp 91 (in Serbian)

PAVLOVIĆ, N., D. CVIKIĆ, M. ZDRAVKOVIĆ, R. ĐORĐEVIĆ, S. PRODANOVIĆ (2006). Variability and heritability coefficient of average dry matter content in onion (*Allium cepa* L.) bulb. Book of Abstracts of the Third Symposium of the Section of the Breeding of Organisms of the Society of Geneticist of Serbia and Fourth Scientific-Research Symposium on Breeding and Seed Production of the Serbian Association of Plant Breeders and Seed Producers, Zlatibor, p. 91

RANDLE, M.W. (1997): Genetic and environmental effects influencing flavor in onion. Acta Hort, *433*, 299-311

WALL, D.A. and N.J. CORGAN (1999): Yield and dry weight of dehydrated onions after uprooting at maturity and delaying harvest. HortScience, *34*, 1068-1070

ZDRAVKOVIĆ, J., N. PAVLOVIĆ, Z. GIREK, M. ZDRAVKOVIĆ, D. CVIKIĆ (2010): Characteristics important for organic breeding of vegetable crops. Genetika, *42*, 223-233

NAČIN NASLEĐIVANJA UKUPNOG SADRŽAJA SUVE MATERIJE U LUKOVICI CRNOG LUKA (*Allium cepa* **L.**)

Nenad PAVLOVIĆ, Dejan CVIKIĆ, Jasmina ZDRAVKOVIĆ, Mirjana MIJATOVIĆ, Milka BRDAR- JOKANOVIĆ

Institut za povrtarstvo, Smederevska Palanka

I z v o d

Sadržaj suve materije je izuzetno važan sa aspekta dehidratacije crnog luka u prehrambenoj industriji. U cilju ispitivanja načina nasleđivanja ove osobine izvršeno je ukrštanje između pet divergentnih genotipova crnog luka, različitog geografskog porekla. Primenjen je metod punog dialela bez recipročnih ukrštanja, radi dobijanja potomstva F_1 i F_2 generacije. Poljski ogled sa roditeljima i hibridima F_1 i F_2 generacije postavljen je po slučajnom blok sistemu u pet ponavljanja u Institutu za povrtarstvo, Smederevska Palanka.

Najčešći način nasleđivanja bilo je intermedijarno posmatrano u obe generacije ispitivanja. Vrednost aditivne genetičke komponente je veća od dominantne u oba analizirana generacijska nivoa (F_1 i F_2), što ukazuje da veći deo genetičke varijabilnosti pripada aditivnom delovanju gena. Najveća vrednost za heterozis (11,85%) izračunata je kod hibridne kombinacije PR x BB. Signifikantne vrednosti OKS su izračunate kod tri linije, a PKS kod jednog F_1 hibrida. U F_2 generaciji nisu utvrđene signifikantne vrednosti.