ВЛИЯНИЕ НА ГЕНОТИПА И АЗОТНИЯ ХРАНИТЕЛЕН РЕЖИМ ВЪРХУ ДОБИВА И ПОСЕВНИТЕ КАЧЕСТВА НА ДВУРЕДНИ И ШЕСТРЕДНИ СОРТОВЕ ЕЧЕМИК
EFFECT OF THE GENOTYPE AND NITROGEN FERTILIZATION LEVELS ON THE SEED QUALITY AND YIELD OF 2-ROW AND 6-ROW BARLEY VARIETIES

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Analyses of the effect of the genotype and nitrogen nutrition on the seed quality and yield of Bulgarian and European 2-row and 6-row barley varieties are presented. Major seed characteristics of 10 genotypes were evaluated (1,000 seed weight, uniformity, size, germination and seed yield), fertilized under 4 different nitrogen nutritional regimes. The moderate levels of fertilizers contributed to a better nutrition of the seed. Increase of the nitrogen supply was favorable for the production of bigger seed. Economical varieties with sufficient quality and yield, as well as more stable characteristics under various fertilization regimes were determined.

Key words: barley, nitrogen fertilization, organic farming, seed quality, seed yield.

INTRODUCTION

Seeds are one of the cheapest but most important factors, determinant of the crop productive potential. Seed qualities are defined by varietal identity and purity, analytical purity, germination capacity and seed health. Rapid germination and good emergence, resulting in appropriate plant population, are function of the uniformity, seed size and reserve components, and freedom of diseases. Those characteristics depends primary of the genotype, fertilization and chosen cultivation practice (Zaden et al., 2014).

The yield and quality of barley seeds are influenced by many additional factors, except the genetic inheritance which is subject of continuous and thoroughgoing breeding process. And if the winter conditions are hard to predict and fight, some agronomical practices can be optimized for better accomplishment of the genotypes on the field – time of sawing and harvest, fertilization rates and composition, disease control and many others (Yesmin et al., 2014).

Productive potential and 1000-grain weight has significant genetic inheritance (Eshghi et al., 2010). Meantime seed yield depends from the nitrogen nutrition regime (Yesmin et al., 2014). The uniformity, germination and growth patterns are also programmed by the genetic constitution of the species but the eventual expression of this pattern is frequently modified by the conditions of the environment under which the seeds grow – soil fertility and rainfall during the vegetation (Da Silva et al., 2007; Hrstkova et al., 2006).

Seed size and quality are major factors for the rapid germination and good emergency rate even in unfavorable soil conditions (Al-Niemi and Dohuki, 2010). Bigger size and higher content of reserve nutrition elements, especially Zn and Fe, facilitates development of stronger root system and better accumulation of dry matter in the initial stages of plant development.

The lighter and smallest seed fraction (below separator with < 2.2 mm) put in risk the good establishment of the crop as it cannot guarantee viable and concurrent seedlings in the autumn vegetation. This seed fraction has also higher frequency of loose smut infection and if it is not treated with fungicides (as in organic farming seed production) should not be used as seeds (ISTA 2000, Borgen, 2003).

The most important economic effect for the seed producers of barley is the real quantity of high quality seeds (free from diseases, bigger size and weight, uniform from the biggest fraction above separator of 2.5 mm, with good germination and emergence) from the field, produced with minimal inputs for fertilizers. Good management of seed production results in gain not only for the seed trader but for all involved in the production levels – farmers, food processors and others.

The aim of the present study is evaluation of the effect of the genotype and nitrogen nutrition on the seed qualities of Bulgarian and foreign two-row and six-row barley varieties.

MATERIALS AND METHODS

Variety testing field trial has been conducted in 2012 to 2014 with tree two-row and seven six-row Bulgarian and European barley cultivars. Object of this study were two-row genotypes Vanessa, Violetta, Vicky and six- rows Nikolleta, Aliseo, Heidy, Amorosa, Wendy, Gerlaih, Laverda, registered in European variety list and used in our grain production.

The assay were conducted on *Pellic Vertisol,* FAO on the experimental field of Institute of Agriculture, Karnobat in 2011–2013. Experimental design was block method with 4 replicas with 10 m^2 plots. Barley was sown in the optimal for the region date (5 to 20 October) with all traditional cultivation practices. Fertilizing with "low"- N_8, „moderate" - N_{12} and ""high" - N_{16} rates, applied in the autumn (1/3 of the total) and early spring (2/3) fertilizing. As control were used unfertilized variant N_0.

Main seed characteristics were determined – uniformity (%) trough separator 1.8, 2.0, 2.2, 2.5 and 2.8 mm, germination (%) of the separated fractions, 1000 grain weight (g) of each one and yield of seeds with respective size (kg/da). Laboratory assays were conducted in 4 replicas.

Analyses of 30 cm soil layer of the Pellic Vertisol indicates average reserve of total humus (2, 18%), law acid to neutral pH reaction in water 6.25, good reserve of mobile K_2O (25–34 mg/100 g), low to medium content of mobile P_2O_5 (3.5–5.5 mg/100 g) and poor reserve of mineral N (below 30 mg/1000 g) (Koteva, 2013).

Meteorological conditions during the vegetation period are described by rainfall sum during the autumn, winter and spring and average air temperature in winter (Tabl. 1).

RESULTS AND DISCUSSION

The vegetation period of the investigated cultivars in 2011–2013 was favored by rainfalls around or slightly above the average perennial values (Tabl. 1). Some drought was observed in 2011, but no negative effect on the crop occurred.

Risky winter conditions were observed in the second year of the experiment 2012. Passing thru a relatively mild December temperatures with normal vegetation and no sufficient vernalisation some of the plants hardly survived the freezing temperatures in the next two months.

January and February were colder than average perennial values and different degree of winter losses were recorded in our experimental variants (Marcheva and Koteva, 2015). The winter in 2013 was mild and the all cultivars survived with no frost injuries and winter killed plants.

Two – row malting barley cultivars has bigger 1000 grain weight than 6 –row varieties in all fertilization variants (Tabl. 2).

Data analyses revealed that moderate nutrition regime allows barley plants to feed complete seeds. Increase of the fertilization rates provokes decrease in 1000-grain weight in almost all variants. Low nitrogen supply and unfertilized control, as observed in seed production for organic farming, has negative effect on this seed characteristic.

Major requirement for certified seeds in trade is uniformity in size, suggesting good germination and rapid emergence in field conditions. Usually as seeds are used the biggest fractions, kept above separator of 2.8 and 2.5 mm.

Table 1. Average rainfall and air temperature in the barley vegetation 2011–2013

Periods	Years			Average 2001-2010
	2011	2012	2013	
Montly rainfall, mm				
Autumn (October–November)	86	150	105	101
Winter (December–February)	118	182	197	128
Spring (March–June)	143	193	165	209
Vegetation (October–June)	347	525	467	438
Monthly average air temperature, °C				
December/Декември	3.2	3.9	1.7	3.2
January/Януари	1.5	-0.3	2.0	1.5
February/Февруари	1.3	1.0	4.4	1.3

Table 2. Barley 1000 kernel weight, g

Variety	N_0		N_8		N_{12}		N_{16}	
	$\bar{x}$	VC,%	$\bar{x}$	VC,%	$\bar{x}$	VC,%	$\bar{x}$	VC,%
Vanessa	40.0	10.0	44.5	12.9	49.3	16.1	48.9	17.0
Violetta	39.6	9.1	43.9	10.5	45.1	13.6	44.7	14.0
Vicky	42.0	8.3	48.6	9.1	50.4	16.3	49.6	15.9
Nikoleta	39.9	8.0	44.2	8.6	45.0	16.2	45.7	15.5
Aliseo	35.4	11.0	38.4	15.2	42.8	16.8	41.9	15.0
Heidy	39.7	9.0	40.7	10.1	42.5	16.1	42.0	17.0
Amorosa	39.9	9.4	40.5	10.6	41.5	17.7	40.9	15.5
Wendy	37.9	9.0	40.6	11.0	42.9	18.6	41.4	18.0
Gerlach	38.0	10.4	40.5	13.9	42.2	12.8	41.9	13.0
Laverda	39.0	9.7	41.4	11.3	44.3	11.0	42.9	11.5

The lighter and smallest seed fraction (< 2.2 mm) put in risk the good establishment of the crop as it cannot guarantee viable and concurrent seedlings in the autumn vegetation. This seed fraction has also higher frequency of loose smut infection and if it is not treated with fungicides (as in organic farming seed production) should not be used as seeds (ISTA 2000, Borgen, 2003).

Two-row barley cultivars have not more than 6 % of small seeds in all fertilizing variants (Tabl. 3). Biggest seed lot above separator 2.8 mm from Vanessa, Violetta and Vicky is produced with moderate nitrogen fertilizing levels.

This tendency is not confirmed in six-row barley varieties, as their head structure and seed shape is different. Major for those cultivars is the seed fraction above separator with 2.5 mm. Exception is marked only for Laverda, where the maximum values for total percent of the two biggest fraction is produced with moderate nitrogen nutrition level. The absence of mineral fertilization in the control variant did not affected the seed uniformity and the last two fractions above separator with 2.5 mm are equal to those, produced with optimal nitrogen regime in two-row barleys. Same tendency is observed for six-row varieties.

The germination and emergence rates of different fractions of barley seeds from two-row and six-row barley cultivars do not vary significant within the fertilizing variants (Tabl. 4).

Best germination level is observed in the biggest seed fraction, above separator with 2.8 mm, cultivated with moderate and elevated nitrogen fertilizing. Despite the fact that all analyzed seeds samples germinated more than 70%, the requirements for seed material are above 85%. This could be serious issue for organic seeds of Violetta, Nikoleta and Gerlach, produced without fertilizing. If they are implemented in biofarming system it should be considered that as seeds can be used only those from the biggest fraction above separator with 2.8 mm.

The most important economic effect for the seed producers of barley is the real quantity of high quality seeds (free from diseases, bigger size and weight, uniform from the biggest fraction, with good germination and emergence) from the field, produced with minimal inputs for fertilizers. This indicator for convenient barley genotype for certain conditions strongly varies between cultivars and implemented fertilization levels (Tabl. 5).

For example, while the higher yield of seeds from the biggest fraction for variety Vicky is produced with lower nitrogen nutrition regime, in seed production of variety Nikoletta the maximum quantity of seeds (and still smaller than the two-row cultivar Vicky) is obtained with very high levels of nitrogen fertilizing.

Meanwhile the are barley genotypes, such as six-row Heidy, with much more stable productive potential and in these cases variation in the fertilization levels do not affect in such dramatic way the yield of seeds from the biggest fraction.

Different pattern of alteration of productivity depending of the mineral nitrogen fertilization is observed in variety Wendy. The lack of nitrogen nutrition in the crop, for the tree experimental years, has been more favorable for producing bigger quantity and size of seeds than implementation of reduced mineral fertilization levels.

Six-row barley varieties Laverda и Gerlach has another behavior in respond to nitrogen nutrition. Barley cultivar Gerlach form equal seed yields with low and moderate fertilization levels, but further increase of the nutrition leads to significant higher quantities of good seed material.

Table 3. Uniformity of seeds of barley varieties, %

Separator mm:		N_0	N_8	N_{12}	N_{16}	Separator mm:		N_0	N_8	N_{12}	N_{16}
1.8	Vanessa	0.3	0.4	0.2	0.3	1.8	Heidy	0.7	0.7	0.3	0.6
2		0.7	0.7	0.5	0.8	2		1.4	1.5	0.9	1.3
2.2		3.5	4.7	3.4	5.2	2.2		9.1	14.1	7.8	12.1
2.5		25.0	33.4	19.8	31.3	2.5		50.8	57.2	50.1	57.1
2.8		70.3	60.6	75.8	62.2	2.8		37.7	25.8	40.5	28.4
1.8	Violetta	0.2	0.3	0.2	0.3	1.8	Amorosa	0.7	0.3	0.6	1.1
2		0.7	0.7	0.4	0.5	2		1.0	0.7	0.7	2.3
2.2		3.6	3.6	3.1	3.8	2.2		8.3	6.6	7.9	18.8
2.5		30.6	34.4	33.1	45.1	2.5		61.0	41.9	63.5	67.0
2.8		64.7	61.0	63.0	50.1	2.8		28.3	50.1	27.3	9.9
1.8	Vicky	0.2	0.2	0.1	0.2	1.8	Wendy	0.2	0.7	0.3	0.3
2		0.5	0.3	0.4	0.5	2		0.6	1.0	0.8	0.8
2.2		2.6	1.7	1.9	1.6	2.2		4.2	10.2	5.0	6.4
2.5		14.5	18.1	16.1	19.1	2.5		35.9	67.0	40.6	45.6
2.8		82.3	79.6	81.5	78.4	2.8		58.9	20.7	53.3	46.8
1.8	Nikoleta	0.5	0.3	0.3	0.3	1.8	Gerlach	0.3	0.4	0.3	0.6
2		1.3	0.7	0.7	0.9	2		0.8	0.9	0.8	1.4
2.2		11.7	9.3	6.8	9.7	2.2		6.8	9.8	7.5	17.2
2.5		61.6	59.0	54.6	58.7	2.5		45.9	61.0	57.6	63.5
2.8		25.0	30.3	37.6	29.6	2.8		46.8	27.9	33.9	16.8
1.8	Aliseo	0.6	0.5	0.3	0.5	1.8	Laverda	0.3	0.4	0.3	0.2
2		1.2	1.1	0.7	1.2	2		0.7	0.8	0.7	0.7
2.2		10.4	13.0	8.4	13.9	2.2		6.0	11.9	5.2	5.6
2.5		66.7	66.3	70.5	69.5	2.5		44.0	62.3	37.1	42.0
2.8		20.8	18.7	20.2	14.8	2.8		48.8	24.4	56.8	51.0

Table 4. Germination of barley seeds, %

Separator mm:		N_0	N_8	N_{12}	N_{16}	Separator mm:		N_0	N_8	N_{12}	N_{16}
1.8	Vanessa	74	76	74	85	1.8	Heidy	74	79	77	80
2		77	82	87	90	2		80	80	81	96
2.2		86	93	93	97	2.2		85	89	88	96
2.5		90	96	95	98	2.5		87	95	94	98
2.8		92	99	97	100	2.8		90	96	100	100
1.8	Violetta	79	78	79	84	1.8	Amorosa	77	79	81	84
2		80	80	88	92	2		84	82	84	93
2.2		81	91	96	97	2.2		89	87	89	96
2.5		84	93	97	98	2.5		84	91	90	98
2.8		90	98	99	98	2.8		89	93	91	99
1.8	Vicky	76	79	79	81	1.8	Wendy	70	80	87	88
2		79	84	87	90	2		79	84	87	92
2.2		80	90	90	92	2.2		80	87	87	97
2.5		89	94	94	94	2.5		84	91	92	99
2.8		90	96	99	100	2.8		89	94	100	100
1.8	Nikoleta	72	79	82	84	1.8	Gerlach	74	82	89	87
2		79	88	88	91	2		74	82	89	89
2.2		79	92	87	94	2.2		81	89	86	89
2.5		81	93	96	96	2.5		89	90	95	99
2.8		91	97	98	100	2.8		92	94	100	100
1.8	Aliseo	77	77	80	79	1.8	Laverda	75	77	80	80
2		80	81	86	90	2		77	86	86	93
2.2		84	92	89	94	2.2		87	80	89	94
2.5		86	93	91	96	2.5		90	93	96	96
2.8		92	96	99	98	2.8		94	95	100	100

Table 5. Seed yield, divided by categories of size, of barley varieties, kg/da

Separator mm:		N_0	N_8	N_{12}	N_{16}	Separator mm:		N_0	N_8	N_{12}	N_{16}
1.8	Vanessa	1.6	2.2	1.3	1.6	1.8	Heidy	4.5	4.7	1.6	3.9
2		3.7	4.0	2.8	5.0	2		8.9	10.0	5.7	8.2
2.2		18.1	28.9	21.5	32.6	2.2		57.9	94.4	49.5	79.0
2.5		131.2	205.1	124.6	195.6	2.5		312.8	384.6	317.6	374.6
2.8		368.6	372.4	478.2	389.3	2.8		239.5	173.6	256.8	186.3
1.8	Violetta	1.2	1.7	1.1	1.9	1.8	Amorosa	4.2	1.9	3.9	6.4
2		3.9	4.5	2.5	3.4	2		5.6	4.2	5.0	14.6
2.2		21.1	24.5	23.0	28.0	2.2		48.7	42.4	55.7	119.3
2.5		181.8	237.0	245.6	344.1	2.5		262.0	267.3	449.9	426.1
2.8		384.7	420.3	467.5	382.3	2.8		168.1	319.3	193.6	111.0
1.8	Vicky	0.8	1.1	0.7	1.0	1.8	Wendy	2.4	4.0	1.7	2.1
2		2.4	2.2	2.5	3.4	2		3.4	5.8	5.3	5.5
2.2		13.8	12.2	13.3	10.8	2.2		26.1	62.5	34.9	43.9
2.5		77.1	129.8	112.4	128.0	2.5		223.0	410.7	285.9	315.1
2.8		437.6	572.3	570.2	528.5	2.8		366.4	126.9	375.8	323.0
1.8	Nikoleta	2.9	2.0	1.8	2.1	1.8	Gerlach	1.7	2.9	1.8	3.6
2		8.0	4.7	5.0	6.3	2		5.0	6.1	5.6	9.1
2.2		74.4	61.4	48.2	67.6	2.2		44.6	69.9	50.3	111.0
2.5		391.5	391.8	386.2	413.2	2.5		299.4	437.4	405.1	710.5
2.8		158.7	200.9	266.2	207.5	2.8		309.0	199.7	238.7	108.4
1.8	Aliseo	3.4	3.3	2.0	3.6	1.8	Laverda	2.2	3.1	2.2	1.3
2		7.4	8.1	5.1	8.3	2		5.2	5.7	4.8	4.2
2.2		63.8	96.4	65.5	99.4	2.2		44.4	91.0	38.5	36.4
2.5		408.9	460.0	552.7	499.0	2.5		327.9	476.2	274.0	273.0
2.8		127.2	138.2	158.0	105.9	2.8		364.0	186.5	422.1	331.5

Variety Laverda is the same time has an opposite reaction. The higher fertilized variant has the lowest seed yield. The control with no input of additional mineral elements shows better results, followed by the moderate fertilized variant. As shown before, the uniformity, size and germination rate are also appropriate and gives us the possibility to mark the genotypes as suitable for seed production in organic farming.

CONCLUSIONS

1. The genetic potential of the chosen barley variety and different fertilization levels has significant impact of the seed qualities of two-row and six-row barley cultivars, experimented in tree year's field trial in Southeast Bulgaria. The moderate levels of nitrogen nutrition allow all variants to fill completely and in a most successful way the seed.

2. Increasing fertilization levels has positive effect on the percent of the seeds from the biggest fractions above separator with 2.5 and 2.8 mm. Two-row barley genotypes Vanessa, Violetta and Vicky produce biggest seed fraction above separator with 2.8 mm in cultivation practices with moderate levels of nitrogen regime.

3. Six-row barley varieties have different seed symmetry and their major fraction is above 2.5 mm. The higher percent of such seed is observed in variant with high fertilization. Exception is marked for cultivar Laverda, in which the total percent for the two biggest fractions is higher for the moderate nutrition regime.

4. The germination rate only of the biggest fraction of seeds of the cultivated without mineral fertilizing variants of Violetta, Nikoleta and Gerlach is appropriate and answers the requirements for seed material.

5. The yield of barley seeds, corresponding to the expected qualities as shown above, vary depending the genotype and nitrogen fertlilization level.

6. More economic two-row barley variety with higher quantity of seeds and with bigger size, under low inputs for nitrogen fertilization, is **Vicky**.

7. The six-row barley genotype **Heidy**, has much more stable productive potential and the variation in the fertilization levels do not affect in such dramatic way the yield of seeds from the biggest fraction.

8. Different pattern of alteration of productivity depending of the mineral nitrogen fertilization is observed in variety **Wendy**. The lack of nitrogen nutrition in the crop, for the tree experimental years, has

been more favorable for producing bigger quantity and size of seeds than implementation of reduced mineral fertilization levels. Barley cultivar form equal seed yields with low and moderate fertilization levels, but further increase of the nutrition leads to significant higher quantities of good seed material.

9. Variety **Laverda** in higher fertilized variant has the lowest seed yield.

10. Barley varieties Vicky, Heidy, Wendy and Laverda can be marked as genotypes suitable also for seed production in organic farming.

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