PLANTING DENSITY AND FERTILISATION EFFECTS ON GENERAL SPRING BARLEY TILLERING

UTICAJ GUSTINE SETVE I ĐUBRENJA NA OPŠTE BOKORENJE JAROG JEČMA

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Abstract: *Barley has a long and intensive tillering period with a far greater stem number produced than the final spike number per harvest. The formation of a higher number of stems and spikes (total and productive tillering, respectively) is a negative malting barley trait because it induces smaller and shrivelled grains which considerably reduce its value for malt production. The investigation of the effect of fertilisation and planting density on the total tillering of spring barley was conducted over a three-year period at the trial field of the Small Grains Research Centre in Kragujevac. Five two-rowed spring barley cultivars (the A factor) were investigated and they were: Kraguj, Dinarac, Dunavac, Jastrebac and Novosadski 294. The planting was carried out at optimal dates (February-March). Three planting densities (B) of 300, 400 and 500 germinating grains m^{-2} were used. N, P_2O_5 and K_2O were each incorporated at the rate of 52.5 kg ha^{-1} by basic fertilising and top-dressing was carried out in the tillering phase using 0, 30 and 60 kg ha^{-1} N (the C factor) during the month of April. The average total tillering for all investigated cultivars, planting densities and nitrogen rates in the three-year research period was 4.17. The highest average tillering for all planting densities and nitrogen rates was established in the Jastrebac cultivar (4.52), and the lowest one in the Kraguj cultivar (3.93). The planting density increase brought about a reduction in tillering. The difference in tillering between the planting densities applied, in all three research years, was highly significant. As opposed to this, increasing nitrogen rates used for top fertilisation induced a tillering increase. A highly significant tillering difference was recorded in all three years between the control variant N (0) and the rate of 60 kg ha^{-1} N. The differences between N (0) and N (30 kg ha^{-1}) were statistically significant in the first two study years, and highly significant in the third year.*
The difference in tillering between nitrogen rates N (30 kg ha^{-1}) and N (60 kg ha^{-1}) was significant only in the first two research years. In the third research year, a statistically highly significant interaction between the cultivar and planting density (AxB) was registered, with the Jastrebac and Kraguj cultivars having expressed different tendencies compared to other cultivars.

Izvod: *Ječam se dugo i intenzivno bokori stvarajući znatno veći broj stabala nego što je konačni broj klasova u žetvi. Formiranje većeg broja stabala i klasova (ukupno i produktivno bokorenje) pred-stavlja negativnu osobinu za pivarski ječam, jer deluje na nastanak sitnijih i šturih zrna koja znatno umanjuju njegovu vrednost za proizvodnju slada. Ispitivanje uticaja đubrenja i gustine setve na ukupno bokorenje jarog ječma obavljeno je u trogodišnjem periodu na imanju naučnog Centra za strna žita u Kragujevcu. U eksperimentu je ispitivano pet sorti (faktor A) jarog dvoredog ječma Kraguj, Dinarac, Dunavac, Jastrebac i Novosadski 294. Setva je obavljena u optimalnim rokovima (februar-mart). Za setvu su primenjene tri gustine (faktor B) od 300, 400 i 500 klijavih zrna m^{-2}. Osnovnim đubrenjem uneto je po 52,5 kg ha^{-1} N, P_2O_5 i K_2O, a prihrana je obavljena u fazi bokorenja sa 0, 30 i 60 kg ha^{-1} N, (faktor C) tokom aprila meseca. Prosečno ukupno bokrenje za sve ispitivane sorte, gustine setve i doze azota u trogodišnjem periodu iznosilo je 4,17. Najveće prosečno bokorenje za sve gustine setve i doze azota ustanovljeno je kod sorte Jastrebac (4,52) a najmanje kod sorte Kraguj (3,93). Povećanje gustine setve dovelo je do smanjenja bokorenja. Razlika u bokorenju između gustina setve, u sve tri godine ispitivanja, bila je visoko značajna.. Suprotno ovome, rastuće doze azota u prihrani delovale su na povećanje bokorenja. Visoko značajna razlika bokorenja, konstatovana je u sve tri godine, između kontrolne varijante N (0) i količine od 60 kg ha^{-1} N. Razlike između N (0) i N (30 kg ha^{-1}) su statistički značajne u prve dve godine, a u trećoj godini razlika je visoko značajna. Razlika u bokorenju između doza azota N (30 kg ha^{-1}) i N (60 kg ha^{-1}) je značajna samo u prve dve godine istraživanja. U trećoj godini ispitivanja konstatovan je statistički visoko značajan inter-akcijski efekat između sorte i gustine setve (AxB), pri čemu su sorte Jastrbac i Kraguj ispoljile različitu tendenciju u odnosu na ostale sorte*

Key words: *Tillering, planting density, nitrogen, spring barley.*
Ključne reči: *Bokorenje, gustina setve, azot, jari ječam.*

INTRODUCTION

Spring malting barley grain is a basic raw material for high-quality malt and beer production. Apart from the varietal traits, special importance is given to the effect of climatic and soil conditions which have a considerable impact on variations of both yield and quality of malting barley (Atlin N. G., McRac B. K., Lu X. 2000). Furthermore, the use of different cultivation measures is of vast significance for obtaining high and profitable grain yield having good technological traits. In malting barley growing practices, nitrogen nutrition and planting density are highly important (Becker, 1981, Malesevic, 1985, Maksimovic, D., Knezevic, D., Paunovic S. A., 1996, Paunovic, 2001, Prochazkova B., Malek J., Dovrtei J. 2002, Koutna K., Cerkal R., Zimolka J. 2003).

Tillering refers to an emergence of lateral stem shoots springing from the tillering node. General tillering is made up of lateral shoots and a primary stem. Barley has a long and intensive tillering period with a far greater stem number produced than the final spike number per harvest (Malesevic, Starcevic, 1992, Paunovic, 2001).

The formation of a higher number of stems and spikes (total and productive tillering, respectively) is a negative trait of malting barley because it induces smaller and shrivelled grains which considerably reduce its value for malt production (Paunovic, 1994).

In moist regions, increased tillering may induce yield reductions due to increased density and lodging incidence. According to Malesevic et al. (1993), tillering intensity is mostly affected by planting date or the plant emergence time, cultivar characteristics, vegetative space size, potential soil fertility and planting depth.

MATERIAL AND METHOD

The trial was established in four replications by a randomised block design, at the trial field of the Small Grains Research Centre in Kragujevac. In the three-year period, five spring malting barley cultivars were investigated, being as follows: Kraguj, Dinarac, Dunavac, Jastrebac and Novosadski-294. The elementary plot size was 5 m^{-2}. Pure nitrogen, phosphorus and potassium fertilisers were each incorporated into the soil by basic dressing at the rate of 52.50 kg ha^{-1}. Nitrogen top dressing was carried out with 30 kg ha^{-1} and 60 kg ha^{-1}, and a non-fertilised control variant was also used. Three planting densities of 300, 400 and 500 germinating grains m^{-2} were applied. 30 plants from each separate plot were examined.

Testing of the significance of mean differences was carried out by the method of factorial analysis of variance (cultivar x planting density x nitrogen; 5x3x3). The significance of individual mean differences was examined using the Lsd test for general means and interaction.

RESULTS AND DISCUSSION

Average general tillering, table 1, for all cultivars, planting densities and nitrogen rates, in the three-year study period, amounted to 4.17. Average general tillering for all cultivars in the first and second years was 3.79 and 3.57, respectively. The highest average general tillering of 4.98 was registered in the third year.

The highest average general tillering in the three-year period was recorded with the Jastrebac cultivar (4.52) and the lowest one with the Kraguj cultivar (3.93).

During the three-year investigation, a decreasing trend in general tillering with a planting density increase was observed. Nitrogen fertilising effect induced a general tillering increase.

Table 1

General tillering

Year		1996				1997				1998				Average
Cultivar [A]	Density (grains/m^2) [B]	Nitrogen (kg/ha) [C]												
		∅	30	60	ξ	∅	30	60	ξ	∅	30	60	ξ	
Kraguj	300	4.27	4.30	4.35	4.30	2.90	3.40	4.40	3.56	5.20	5.65	6.00	5.61	4.49
	400	3.07	3.27	3.80	3.38	3.10	3.30	3.40	3.26	5.07	5.15	5.17	5.13	3.92
	500	3.30	3.32	3.47	3.36	2.40	3.35	3.75	3.16	3.75	3.60	3.70	3.68	3.40
	Average	3.54	3.63	3.87	3.68	2.80	3.35	3.85	3.32	4.67	4.80	4.95	4.80	3.93
Dinarac	300	3.67	4.30	5.17	4.38	3.60	3.80	4.80	4.06	5.05	5.30	5.37	5.24	4.56
	400	3.65	3.70	3.80	3.71	2.95	3.45	4.10	3.50	4.80	5.40	5.65	5.28	4.16
	500	3.17	3.35	3.52	3.34	3.00	3.15	3.35	3.16	4.25	4.40	4.40	4.35	3.61
	Average	3.49	3.78	4.16	3.81	3.18	3.46	4.08	3.57	4.70	5.03	5.14	4.95	4.10
Dunavac	300	4.05	4.47	5.02	4.51	3.90	4.00	4.05	3.98	5.35	5.40	5.52	5.42	4.63
	400	3.65	3.90	4.05	3.86	3.25	3.70	3.90	3.61	5.15	5.47	5.40	5.34	4.27
	500	3.67	3.75	3.85	3.75	3.60	3.75	3.80	3.71	4.00	4.10	4.25	4.11	3.85
	Average	3.49	4.04	4.30	4.04	3.58	3.81	3.91	3.76	4.83	4.99	5.05	4.99	4.25
Jastrebac	300	3.86	4.60	5.00	4.48	2.95	3.70	4.50	3.71	5.85	5.70	5.97	5.84	4.67
	400	3.52	4.10	4.37	3.99	3.25	3.50	4.10	3.61	5.00	5.10	5.47	5.19	5.26
	500	3.55	3.60	3.75	3.63	2.90	3.35	3.40	3.21	4.05	4.12	4.17	4.11	3.65
	Average	3.64	4.10	4.37	4.03	3.03	3.51	4.00	3.51	4.96	4.97	5.20	5.04	4.52
Ns-294 (standard)	300	3.75	4.47	4.50	4.24	3.30	3.75	4.30	3.78	5.40	5.40	5.45	5.41	4.47
	400	2.92	2.95	3.07	2.98	3.05	3.45	3.50	3.33	5.05	5.10	5.30	5.15	3.82
	500	2.40	3.06	3.60	3.02	3.45	3.75	4.05	3.75	4.70	5.10	5.25	5.01	3.92
	Average	3.02	3.49	3.72	3.41	3.26	3.65	3.95	3.62	5.05	5.20	5.33	5.19	4.08
Average for densities and cultivars	300	3.92	4.42	4.80	4.38	3.33	3.73	4.41	3.81	5.37	5.49	5.66	5.50	4.56
	400	3.56	3.58	3.81	3.58	3.12	3.48	3.80	3.53	5.01	5.24	5.39	5.21	4.28
	500	3.21	3.41	3.63	3.42	3.07	3.47	3.67	3.39	4.15	4.26	4.35	4.25	3.68
	Average	3.56	3.80	4.08	3.79	3.17	3.56	3.96	3.57	4.48	4.99	5.13	4.98	4.17

Coefficients for testing the least significant difference for general tillering

		A	B	C	AB	AC	BC	ABC
1996	**Lsd** 0,05	0.34	0.26	0.26	0.59	0.59	0.45	1.03
	Lsd 0,01	0.44	0.34	0.34	0.78	0.78	0.60	1.36
1997	**Lsd** 0,05	0.40	0.32	0.32	0.69	0.69	0.53	1.21
	Lsd 0,01	0.52	0.42	0.42	0.91	0.91	0.70	1.59
1998	**Lsd** 0,05	0.30	0.23	0.23	0.53	0.53	0.41	0.91
	Lsd 0,01	0.39	0.31	0.31	0.70	0.70	0.55	1.20

An analysis of variance of average general tillering in the first research year showed that the effects of cultivars, planting density and nitrogen rates brought about highly significant differences in general tillering.

The Lsd testing of individual differences between the cultivars determined that the difference expressed in general tillering between the cultivars Kraguj (3.68), on the one hand, and Jastrebac (4.03) and Dunavac (4.04), on the other, was highly significant. The Novosadski 294 cultivar also had highly significantly lower tillering than the cultivars Dunavac and Jastrebac, and statistically significantly lower compared to the cultivar Dinarac. Other differences in general tillering were not significant.

In the first study year, the highest stem number was recorded with the lowest planting density applied (4.38). The difference in stem number between the lowest density and the densities of 400 and 500 grains m^{-2} was highly significant. However, the difference between densities of 400 and 500 grains m^{-2} was not statistically justifiable.

Increasing nitrogen rates used in top fertilising induced general tillering increase. The analysis of variance of average general tillering indicated that the control variant highly significantly differed from the variant using the 60 ha^{-1} nitrogen rate and the difference between the nitrogen rates of 30 kg ha^{-1} and 60 kg ha^{-1} was significant.

In the second research year, the lowest general tillering (3.57) was determined. Testing of individual differences between the cultivars investigated showed a significant difference between Kraguj and Dunavac cultivars. Other differences were not justifiable.

The planting density effect, in the year concerned, showed a highly significant difference between the densities of 300 and 500 grains m^{-2}. Other differences were not statistically justifiable.

Increased nitrogen rates, in the second study year, induced highly significant differences in general tillering between the nitrogen rates of 60 kg ha^{-1} and the control variant. Other differences were not statistically justifiable.

In the third study year, highly significant differences between the cultivars NS-294 and Kraguj (0.39) were recorded and differences between other cultivars were not justifiable.

At all planting densities, in the third research year, highly significant differences in general tillering were registered.

The Lsd testing of the significance of differences in general tillering between different nitrogen rates showed that tillering was statistically highly significantly higher when nitrogen rates of 30 and 60 kg ha^{-1} were applied compared to the control. The difference between the nitrogen rates of 30 and 60 kg ha^{-1} in the total stem number per plant was not statistically significant.

In the third research year, highly significant interactive effects between the cultivar and planting density (AxB) were expressed. The interactive effect analysis showed that the cultivars Jastrebac and Kraguj expressed the opposite tendency compared to other cultivars.

CONCLUSIONS

In the three-year period, an examination was made of the effects of planting density and nitrogen nutrition on general tillering in two-row spring barley cultivars Kraguj, Dinarac, Dunavac, Jastrebac and NS 294. Based on the results obtained, the following conclusions may be drawn:

Average general tillering, in the three-year period, for all cultivars investigated, planting densities and nitrogen rates was 4.17. The highest average tillering for all planting densities and nitrogen rates was recorded with the cultivar Jastrebac (4.52) and the least for the cultivar Kraguj (3.93).

In all study years, it was established that a planting density increase induced general tillering reduction. The tillering difference, which was due to the effect of different planting densities, in all study years, was highly significant.

Increasing nitrogen rates in plant nutrition gave rise to a tillering increase in all study years. The difference between the control variant and the 60 kg ha^{-1} rate was highly significant in all three research years, and the difference between the control variant and the 30 kg ha^{-1} rate was significant in the first two study years, and highly significant in the third year. The difference between the rates of 30 and 60 kg ha^{-1} was significant only in the first two years.

The interactive effect determined in the third research year between the cultivars investigated and planting density showed that the cultivars Jastrebac and Kraguj had expressed an opposite tendency compared to other cultivars studied.

LITERATURE

ATLIN, N. G., MCRAC B. K., LU. X., *Genotype x Region Interaction for Two-Row Barley Yield in Canada.* Crop Science, Vol. 40, No 1, 2000, 1-6 pp.

BECKER, ANGELIKA., *Stickstoffaufaufnahme von Sommergerste wahrend der Reife in Abhnagigkeit von Stickstoffgaben*. Tagungsbericht, Akademie der Landwirtsch., Berlin, 1981, 169-172 pp.

KOUTNA K., CERKAL R., ZIMOLKA J., *Modification of crop management and its influence on the structure of yield and quality of spring barley grain*. Plant Soil Environ, Vol 49 (10), 2003, 457-465.

MAKSIMOVIĆ, D., KNEŽEVIĆ, D., PAUNOVIĆ, S. A., *The productive traits and grain quality of winter and spring malting barley*. Proceeding of VII International Barley Genetic Symposium (eds A. Slinkard, G. Scoles and B. Rosengal), Canada, 1996, 26-29 pp.

MALEŠEVIĆ, M., *Vreme, gustina setve, sorte i prinos jarog pivskog ječma*. Savremena poljoprivreda, No 5-6, Novi Sad, 1985, 186-207 pp.

MALEŠEVIĆ, M., STARČEVIĆ, LJ., *Proizvodnja pivskog ječma*. Pivski ječam i slad. V monografija, MRAZ, Čelarevo, 1992, 14-52 pp.

MALEŠEVIĆ, M., STARČEVIĆ, LJ., KONSTANTINOVIĆ, J., CRNOBRNAC, J., *Tehnologija proizvodnje pivskog ječma sa osvrtom na sortnu specifičnost*. Zbornik radova, Institut za ratarstvo i povrtarstvo, sveska 21, 1993, 319-342, Novi sad.

PAUNOVIĆ, S. A., *Ispitivanje nekih svojstava sorata pivarskog ječma i određivanje najpogodnijih za proizvodnju slada* (*Hordeum sativum* Jessen. ssp. *distichum* L.). Magistarski rad, Univerzitet u Kragujevcu, Agronomski fakultet, Čačak, 1994, 1-129 pp.

PAUNOVIĆ, S. A., *Genotipska variranja prinosa i kvaliteta zrna jarog ječma u zavisnosti od ishrane azotom i gustine setve*. Doktorska disertacija, Univerzitet u Kragujevcu, Agronomski fakultet, Čačak, 2001, 1-147 pp.

PROCHAZKOVA, B., MALEK, J., DOVRTEI, J., *Effect of different straw management practices on yields of continuous spring barley*. Rostilna Viroba, 48 (1), 2002, 27-32 pp.