NARDI FUNDULEA, ROMANIA
www.incda-fundulea.ro

ROMANIAN AGRICULTURAL RESEARCH, NO. 36, 2019
Print ISSN 1222–4227; Online ISSN 2067–5720

EFFECTS OF CULTIVAR, NITROGEN FERTILIZATION AND YEARS ON NUMBER OF SPIKES VARIATION IN WINTER WHEAT

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ABSTRACT

Number of spikes per unit area in yield trials with winter wheat cultivars and two levels of Nitrogen fertilization, was monitored during 2016 to 2018 at the National Agricultural Research and Development Institute at Fundulea. The aim was to estimate the contribution of this yield component to wheat grain yield, and the effects of cultivars, Nitrogen fertilization and years to the variation of spike number in the continental climate of South Romania.

The percentages of yield variation that could be explained by the variation of spike number were on average about 28% with N fertilization and almost 0 without N fertilization

The main sources of variation in the number of spikes per m^{-2} were the different conditions of the years, followed by the Nitrogen fertilization and by the differences between cultivars, while none of the interactions were significant. Several cultivars, like Unitar, Ursita and Şimnic 60, were noticed with superior number of spikes in most conditions.

Bezostaya 1, the only non *Rht-B1b* cultivar in the study, showed a much lower yield than could have been expected from its relatively high number of spikes.

The numbers of spikes at the two levels of Nitrogen fertilization were highly correlated (r=0.68), but Şimnic 60 deviated significantly from the general regression, suggesting that it might have the ability to form more spikes at lower Nitrogen availability.**

Keywords: number of spikes, winter wheat, cultivar, Nitrogen fertilization.

INTRODUCTION

Grain yield in wheat and other cereals can be described as the product of the number of grains per unit area and the weight of individual grains. Most studies found a clear positive relationship between yield and grains/m^2 in a wide range of conditions (Miralles and Slafer, 2007). Genetic progress in wheat yield was most frequently explained by an increase of the number of grains per m^2. For example, Brancourt-Hulmel et al. (2003) found a great increase in the number of kernels per unit area in winter wheat cultivars released in France from 1946 to 1992, and Donmez et al. (2001) reported that, in US Great Plains, kernel number per unit of soil area had the highest phenotypic correlation with grain yield and contributed most to its genetic gain. In contrast, in Northern China during 1960 to 2000, the genetic improvement in grain yield was primarily attributed to increased grain weight per spike, reduced plant height and increased harvest index (Zhou et al., 2007).

Kernel number per m^2 can be described as the product of the spike number per unit area and the kernel number per spike. Many studies reported that the genetic progress in kernel number per unit area was largely due to an increase in kernel number per spike (Slafer and Andrade, 1989) or to an increase in both kernel number per spike and spike number per unit area (Perry and D'Antuono, 1989; Donmez et al., 2001). Okuyama et al. (2004) found that the number of spikes m^{-2} and the number of grains per spike were the traits related to higher grain yield, both under irrigated and late season water stress conditions, and Slafer et al. (2014) stated that large changes in grains per m^2 were primarily associated with heads per m^2.

One can conclude that high yields can be obtained by various combinations of yield

Received 26 November 2018; accepted 17 December 2018. First Online: December, 2018. DII 2067-5720 RAR 2019-21

components, the optimum combination depending on the target environment and germplasm. Donmez et al. (2001) stated that, for the US Great Plains, yield components that form during vegetative phases (spike numbers per unit of soil area and kernels per spike), when conditions for growth are generally favourable, are more amenable to genetic improvement than kernel weight, which forms during maturation when moisture and temperature are often unfavourable.

On the other hand, yield components are strongly influenced by crop management, mainly by fertilization. For example, Hussain et al. (2006) reported that Nitrogen levels had significant effects on number of grains/spike, number of spikes/m^2, spike weight, etc.

Our research focused on estimating the contribution of the number of spikes per m^2 to wheat grain yield and the effects of cultivars, Nitrogen fertilization and years to the variation of spike number in the continental climate of South Romania.

MATERIAL AND METHODS

Yield trials with 25 winter wheat cultivars, using a balanced square lattice design with 3 replications were organized in 2015/2016, 2016/2017 and 2017/2018 at the National Agricultural Research and Development Institute at Fundulea (44°30’ N latitude and 24°10’ E longitude, 68 m altitude) on a chernozem soil (pH 6.3-6.8, humus 3%), with peas as preceding crop. Adjacent yield trials with 137 kg ha^{-1} Nitrogen application in spring and without spring N fertilization, on a uniform background of 90 kg ha^{-1} P_2O_5, were performed.

The climate is continental, with the annual average temperature about 10°C. Rainfall amount during the winter wheat vegetation period (October to July) totalled 435.1 mm in 2015/2016, 652.7 mm in 2016/2017 and 565.8 mm in 2017/2018.

Fourteen *Rht-B1b* semidwarf Romanian cultivars and the long term check cultivar Bezostaya 1 (*Rht8*) were tested all three years and were included in this analysis.

Number of spikes was counted after complete heading in three replications on 0.25 m^{-2} in 2016 and on 0.125 m^{-2} in 2017 and 2018, and calculated for 1 m^2. Grain was harvested with a Wintersteiger combine and calculated per hectare at 14% moisture.

The square of correlation coefficient between the spike number per unit area and grain yield (R^2) was used to estimate the contribution of this yield component variation and the variation of grain yield among cultivars. ANOVA and linear regression were used to analyse the data.

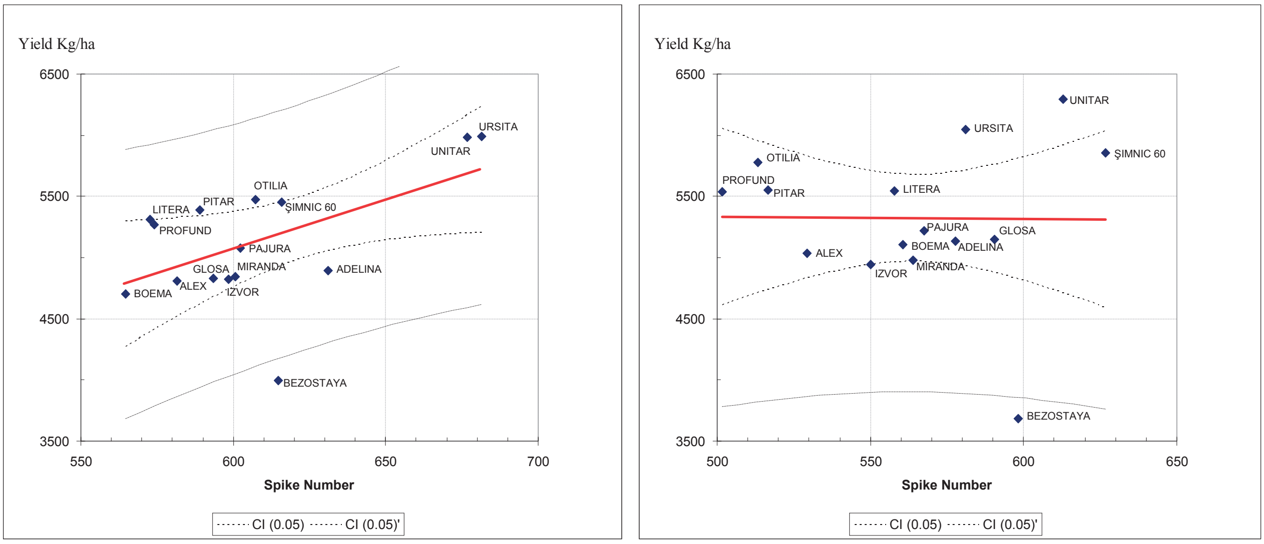
RESULTS AND DISCUSSION

The variation of the spike number per unit area among cultivars could explain between 10 and 31% of the grain yield variation in the fertilized trials performed in 2016 to 2018, and only 1.78 to 4% in the trials without N fertilization (Table 1). If three years average spike number and average yield were taken into account, the percentages of yield variation that could be explained by the variation of spike number were about 28% and almost 0 depending on N fertilization.

Table 1. Percentage of wheat grain yield variation associated with variation of spike number/m^2

Data from	N_{137}	N_0
2016	31.09	1.78
2017	10.05	9.34
2018	18.63	3.99
Averages 2016-2018	28.30	0.01

The graphical representation of the relationship between spike number per m^2 and grain yield shows that Bezostaya 1, the only non *Rht-B1b* cultivar in the study, had a different behaviour than the other cultivars, showing a much lower yield than could have been expected from its relatively high number of spikes (Figure 1). This suggests that among the *Rht-B1b* cultivars the influence of spike number per unit area on grain yield might be stronger.



a) b)

Figure 1. Relationship between average number of spikes per unit area (2016-2018) and average grain yield.
a) In yield trials fertilized with 137 kg ha^{-1} N; b) Without N fertilization in spring

Most of the variation in the number of spikes per m^2 was produced by the different conditions of the years, followed by the Nitrogen fertilization and by the differences between cultivars (Table 2). Despite the large errors caused by the relatively non-uniform stands in the trials, the effect of the years and of the cultivars were significant, both if tested against the trial errors and against the corresponding interactions with the years, while the effect of the N fertilizer was only significant if tested against error.

Table 2. ANOVA for spike number per unit area in wheat cultivars yield trials

Source of Variation	SS	df	MS	F against error	F against interaction with years
Cultivars	253407.1	14	18100.5	2.133*	3.520*
Years	6678130.0	2	3339065.0	393.512**	649.386**
C*Y	143972.6	28	5141.9	0.605	0.875
Fertilization	202705.2	1	202705.2	23.889**	9.608
C*F	47004.8	14	3357.5	0.396	0.572
F*Y	42193.8	2	21096.9	2.486	3.592
C*F*Y	164443.5	28	5872.9	0.692	
Within	666989.3	180	3705.5		
TOTAL	9059207.0	269			

None of the interactions were significant and this suggest that the differences among cultivars have a good chance to be present at various levels of Nitrogen availability and in different weather conditions, more or less similar with the ones of the present study.

Table 3 presents the number of spikes per m^2 in the 15 studied cultivars and the three years of study.

Table 3. Number of spikes m^{-2} in wheat cultivars yield trials at Fundulea during 2016-2018

Cultivar	2016		2017		2018		Average 2016-2018		
	N_{137}	N_0	N_{137}	N_0	N_{137}	N_0	N_{137}	N_0	General average
Unitar	902	**897**	555	459	**564**	483	**674**	**613**	**643**
Ursita	**967**	800	547	477	**539**	467	**684**	581	**633**
Şimnic 60	778	**840**	**585**	**547**	535	493	633	**627**	**630**
Bezostaya	775	**845**	**603**	432	535	**517**	638	**598**	**618**
Adelina	835	760	**585**	**517**	529	456	**650**	578	**614**
Glosa	847	**849**	519	432	467	491	611	591	601
Miranda	847	777	511	467	477	448	612	564	588
Pajura	842	780	479	429	483	493	601	567	584
Izvor	878	784	500	405	459	461	612	550	581
Boema	811	821	533	413	441	448	595	561	578
Litera	789	740	485	491	465	443	580	558	569
Alex	798	697	552	411	473	480	608	529	569
Otilia	891	684	459	392	465	464	605	513	559
Pitar	863	739	456	379	452	432	590	517	554
Profund	866	679	416	381	428	445	570	502	536
All cultivars average	846	779	519	442	487	468	618	563	590
LSD 5%	69.9	52.4	56.7	58.1	52.0	39.4	34.5	31.9	23.5

Bolded numbers a significantly superior to the average of all cultivars.

A very large variation was registered, from 381 in cv. Profund in 2017 without Nitrogen, to 967 spikes m^{-2} in cv. Ursita in 2016 with Nitrogen fertilization. Despite the large variation in the number registered in the three years of study, several cultivars, like Unitar, Ursita and Şimnic 60, stood up with superior number of spikes.

The numbers of spikes at the two levels of Nitrogen fertilization were highly correlated (r=0.68**). However, at least one cultivar (Şimnic 60) appeared to deviate significantly from the general regression, suggesting that it might have the ability to form more spikes at lower Nitrogen availability (Figure 2).

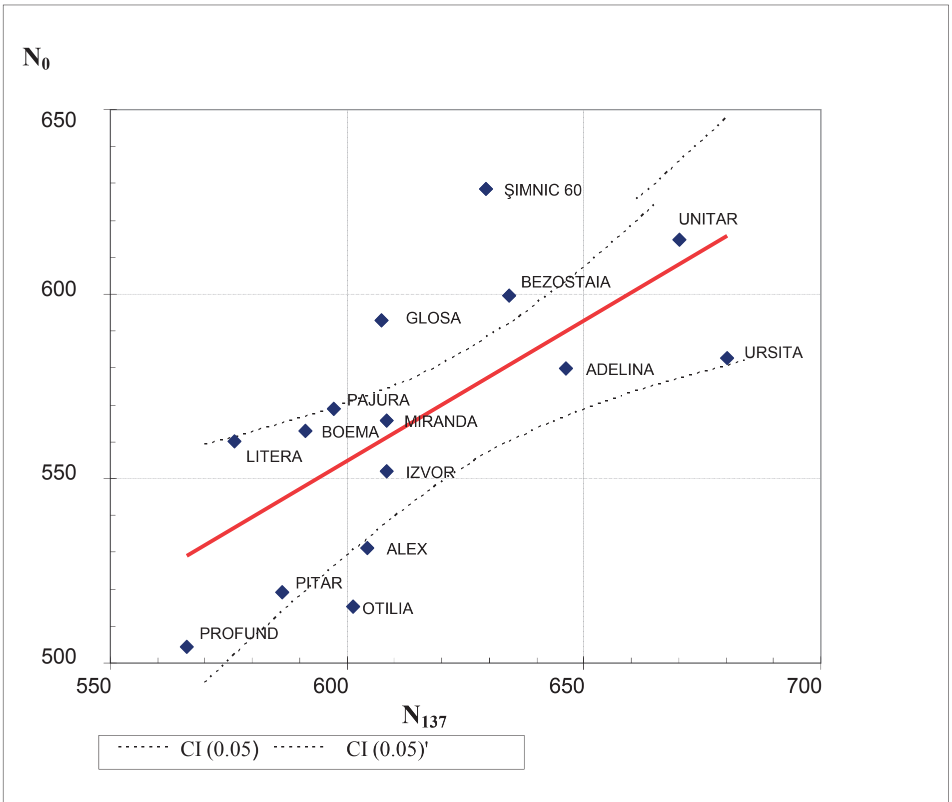


Figure 2. Relationship between number of spikes per m^2 in plots with 137 and 0 kg ha^{-1} Nitrogen fertilization in spring

CONCLUSIONS

The number of spikes per unit area proved to have a variable, but important contribution to grain yield variation in trials with Nitrogen fertilization, but not without N fertilization in spring. The percentages of yield variation that could be explained by the variation of spike number were on average about 28% with N fertilization and almost 0 without N fertilization.

The main sources of variation in the number of spikes per m^2 were the different conditions of the years, followed by the Nitrogen fertilization and by the differences between cultivars.

Despite the large variation registered in the three years of study, several cultivars, like Unitar, Ursita and Şimnic 60, were noticed with superior number of spikes.

None of the interactions were significant and this suggests that the differences among cultivars have a good chance to be present at various levels of Nitrogen availability and in different weather conditions, more or less similar with the ones of the present study.

Bezostaya 1, the only non *Rht-B1b* cultivar in the study, had a different behaviour than the other cultivars, showing a much lower yield than could have been expected from the relatively high number of spikes. This could suggest that among the *Rht-B1b* cultivars the influence of spike number per unit area on grain yield might be stronger.

The numbers of spikes at the two levels of Nitrogen fertilization were highly correlated (r=0.68**), but cv. Şimnic 60 deviated significantly from the general regression, suggesting that it might have the ability to form more spikes at lower Nitrogen availability.

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