NARDI FUNDULEA, ROMANIA
www.incda-fundulea.ro

ROMANIAN AGRICULTURAL RESEARCH, NO. 35, 2018
Print ISSN 1222–4227; Online ISSN 2067–5720

RELATIONSHIP AMONG YIELD AND YIELD COMPONENTS OF WINTER WHEAT (*TRITICUM AESTIVUM* L.) CULTIVARS, AS AFFECTED BY TILLAGE SYSTEMS

Alexandru I. Cociu

National Agricultural Research and Development Institute Fundulea
915200 Fundulea, Călăraşi County, Romania
E-mail: acociu2000@yahoo.com

ABSTRACT

The relationships among grain yield and yield components of 6 winter wheat cultivars in Romania, as affected by two contrasting tillage systems (no tillage-NT and chisel tillage-CT) were studied during five growing seasons (2011/12-2015/16) at Fundulea, which is located in the middle of Eastern Romanian Danube Plain. In order to determine the relationship between the investigated traits, both correlation method and linear regression were used on the level of significance 5%, 1% and 0.1%, dependant variables being considered as already late formed features in ontogenesis. Under both NT and CT tillage systems, mean positive correlations between number of kernels per spike and individual kernel weight per spike (r=0.783*and r=0.524**, respectively) and strong positive correlations between grain yield and number of spikes m^{-2} (r=0.893*** and r=0.905***, respectively) were established. Weak correlation between kernel weight per spike and thousand kernel weight (r=0.379* and r=0.456*, respectively) was also established. Due to lower nutrients availability in NT system versus CT system, one can ascertain a significant diminution of number of grains per spike and grain weight per spike together with spike density increasing. Under CT system versus NT system, the significant TKW diminution due to increasing of number of grains per spike could be attributed to the diminution of soil moisture preservation as follows of crop residue incorporation.**

Key words: winter wheat, conservation agriculture, no tillage (NT), chisel tillage (CT), correlations, regression, yield, yield components.

INTRODUCTION

Human efforts to produce ever-greater amounts of food leave their mark on our environment. Persistent use of conventional farming practices based on extensive tillage, especially when it is combined with removal or "*in situ*" burning of crop residues, have magnified soil erosion losses and the basic soil resource has been steadily degraded (Montgomery, 2007).

Conservation tillage has been proposed as a soil management system which involves some degree of tillage reduction that result in at least 30% of the soil surface being covered with crop residues after seeding of the subsequent crop (Jarecki and Lal, 2003). No tillage (NT) is the extreme form of minimum soil disturbance and compared to conventional practices, NT alters the soil environment in which the crop is growing.

Grain yield of winter wheat is a product of three yield components: the number of spikes per unit area, the number of kernels per spike and individual kernel weight (Bavec et al., 2002). The genotype (G) x environment (E) interaction likely dictates which component becomes the major determinant (Darwinkel, 1983). Differences in crop management may give rise to G x management x environment interactions. Cooper et al. (2001) examined the magnitude of G x management x environment interactions for grain yield in multi-environment trials involving 272 advanced breeding lines. They reported that the G x management component of the three-way interaction (G x management x environment) was the largest source of variation for grain yield. These findings indicate the importance of each component of the interaction to achieving high yields.

The objective of this study was to determine the relationship between grain yield and yield components of six winter wheat cultivars, released by NARDI Fundulea, as

Received 20 January 2017; accepted 15 January 2018. First Online: January 2017. DII 2067-5720 RAR 2018-5.

affected by two contrasting tillage systems, NT and chisel tillage (CT).

MATERIAL AND METHODS

Winter wheat cultivars chosen for this study were: Boema 1, Litera, Dropia, Glosa, Izvor and Miranda. Field experiments were conducted during five growing seasons (2011/12 – 2015/16) at NARDI Fundulea, which is located at 44°27′45″ latitude and 26°31′35″ longitude, East of Romanian Danube Plain and East of Fundulea town.

Climatic circumstances

Rainfall over 56 years at the experimental sites averaged 585 mm during 12 months (lower rainfall 491 mm were noted in 2011/12) and 84 mm from October to November, 66 mm from January to February, 83 mm from March to April and 136 mm from May to June (from October to June 414 mm). In our experiment, a shortage of water was noted in 2011/12 and 2012/13 from October to November (29 and 40 mm, respectively) and from March to April (40 and 78 mm, respectively), in 2013/14 from January to February (39 mm) and in 2014/15 and 2015/16 from May to June (82 and 129 mm, respectively), while during previous month, more than 100 mm rainfall was registered.

Long term (1960-2016) averages for temperature were 10.8°C. During experimental years, the averages for temperature ranged between 11.7 to 13.5°C from 2011/12 to 2015/16; in October 10.3 to 15.0°C, in January -0.7 to -4.3°C, in April 11.0 to 14.2°C in May 16.1 to 18.9°C and in June from 19.8 to 25.7°C.

Field management

The experiment was performed in 2011, within a long-term multidisciplinary research platform based on conservation agriculture (CA), initiated in 2010. The experiment was designed as a randomized complete block with split-split plot arrangement in three replications. Tillage systems were main plots, preceding crops represented subplots and winter wheat cultivars were sub-sub plots. Net sub-sub plot size has 3 m wide by 10 m long. The tillage plots were maintained in the same placement each year, but the subplots for preceding crops and sub-sub plots for winter wheat cultivars were re-randomized each year.

The tillage treatments were, as follows: (i) no-tillage (NT) – no soil disturbance was done except for drilling; (ii) chisel tillage (CT) – the soil was tilled to a depth of 15 cm with a chisel plough mounted with twisted shanks SG-M 730 (Knoche Maschinenbau GmbH, Bad Nenndorf, Germany). The preceding crop was: (i) maize and (ii) soybean. Residues of preceding crops were chopped and uniformly spread on soil surface.

Certified seed was planted with the twenty-four row TUME Nova Combi 3000 (Noka-Tume Oy, Turenky, Finland) seed drill with 12.5-cm row spacing with a rate of 450 viable grains per square meter. The size of plots was 30 m² at sowing and 20 m² at harvesting. Seeding took place from mid to late October each year. Plots were harvested with Wintersteiger Delta (Wintersteiger AG, Ried, Austria) harvester at beginning of July each year.

Common CA practice was used – fertilization for high yields according to soil analysis (nitrogen and phosphor fertilizers, 30 and 80 kg a.i.ha^{-1} respectively, were applied simultaneously with seeding, and a dose of 90 kg a.i.ha^{-1} nitrogen fertilizer was added by spreading in spring), herbicides (tifensulfuron-metil + tribenuron-metil and fluroxipir-meptil) and fungicides (tebuconazol) were applied once before first inter-node formation.

Sampling and methods

Results regarding grain yield are reported at the 14 % standard moisture. The yield components as, number of spikes per square meter, number of kernels per spike, kernel weight per spike and thousand kernel weight, were measured by analyzing 50 plants, sampled from each experimental plot, following the method described by Gómez-Macpherson et al. (2003).

Statistical analysis

In order to determine relationship between the traits investigated in this study, the method of simple correlation and regression method have been applied.

Correlation analysis method helps to determine relationship between investigated indicators by means of correlation coefficient (r). Pearson's correlation coefficients between grain yield and yield components were calculated using means across cultivars and tillage systems in experimental years (n=30) at P≤0.05 (*), 0.01 (**) and 0.001 (***). Within regression analysis, linear function form was applied, as it facilitates determination of yield changes depending on yield components. Evaluation of regression coefficient significance was derived by means of t-test, adopting zero hypothesis and risk level of 5%, 1% and 0.1%.

RESULTS AND DISCUSSION

As seen in Table 1, strong mean positive correlation was determined between grain yield and number of spikes per m², under both NT and CT systems (r=0.893*** and r=0.905***, respectively). Number of spikes per m² is often positively correlated with grain yield; this was also observed in other long-term experiments (Borojević, 1972; Bavec et al., 2002).

Regression equations show how one trait, dependent variable, changes if an independent variable changes for one unit (Table 2).

Table 1. Correlation coefficients between grain yield and yield components of winter wheat cultivars in the case of two different tillage systems, NT and CT

Investigated traits	Tillage system	X1	X2	X3	X4
X1 – number of spikes per m²	NT				
	CT				
X2 – number of kernels per spike	NT	-0.397*			
	CT	-0.154			
X3 – kernel weight per spike	NT	-0.578***	0.783***		
	CT	-0.318	0.524**		
X4 - TKW	NT	-0.310	-0.262	0.379*	
	CT	-0.159	-0.515**	0.456*	
Y – grain yield	NT	0.893***	-0.031	-0.175	-0.244
	CT	0.905***	0.098	0.102	-0.061

Table 2. Regression equation, standard error of regression between grain yield and yield components of winter wheat cultivars in the case of two different tillage systems, NT and CT

Investigated traits	Tillage system	Regression equation	t-value	Significance
No. of spikes per m² and grain yield	NT	y=0.0097x1+1.4859	10.556	***
	CT	y=0.0122x1+0.9421	11.244	***
No. of spikes per m² and no. of kernels per spike	NT	y=-0.0124x+36.385	2.286	*
	CT	y=-0.006x+36.115	0.822	ns
No. of spikes per m² and kernel weight per spike	NT	y=-0.0008x+1.5788	3.745	***
	CT	y=-0.0005x+1.5702	1.744	ns
No. of kernels per spike and kernel weight per spike	NT	y=0.0332x+0.2226	6.662	***
	CT	y=0.0207x+0.675	3.252	**
No. of kernels per spike and thousand kernel weight	NT	y=-0.2339x+47.681	1.435	ns
	CT	y=-0.6088x+61.482	3.178	**
Thousand kernel weight and kernel weight per spike	NT	y=0.0179x4+0.5312	2.160	*
	CT	y=0.0153x4+0.7482	2.720	*

The regression equation describing the relationship between grain yield and number of spikes per m² was evaluated as highly significant on the level of 0.1%, under both NT and CT systems, having the following linear equation form: y=0.0097x1+1.4859 and y = 0.0122x1+0.9421 respectively. It shows that by increasing the number of spikes per m² by one, grain yield increases by 9.7 kg ha⁻¹ on average under NT and by 12.2 kg ha⁻¹ on average under CT (Table 2 and Figure 1).

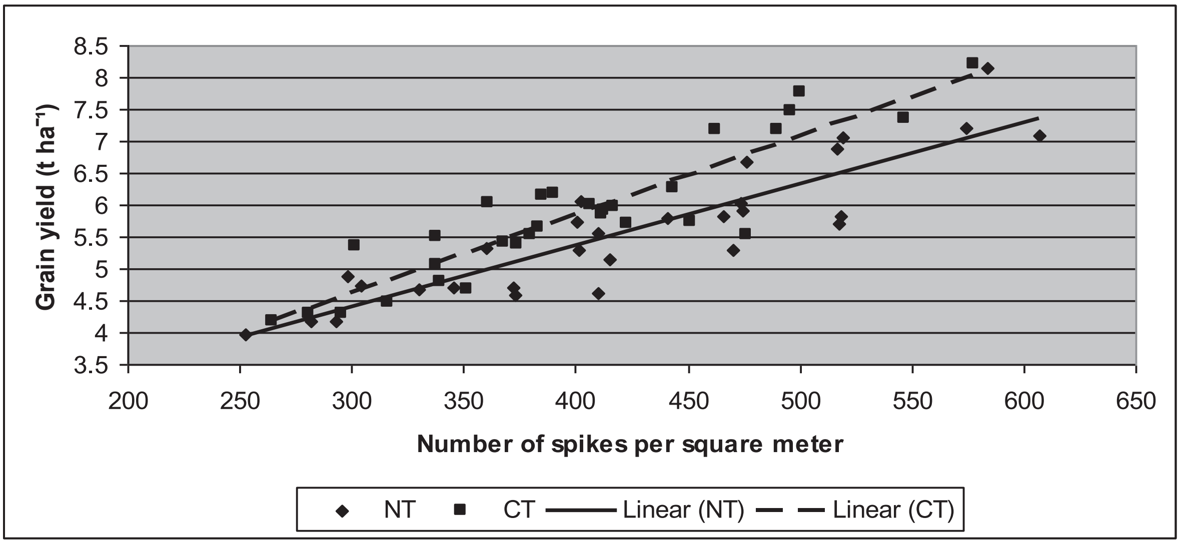

Figure 1. Regression analysis between the number of spikes per m² and grain yield for winter wheat cultivars in the case of two different tillage systems

Correlation analysis (Table 1) proves that the number of spikes per m² negatively influenced the number of kernels per spike at the limit of significance (r = -0.397*), within NT system, and not significantly affected within CT system (r = -0.154).

Linear regression equation of significant regression coefficient on the level of 5% was established between number of spikes per m² and number of kernels per spike, within NT system, where increased number of spikes per m² decreased the number of kernels per spike (Table 2 and Figure 2).

The correlation analysis presented in Table 1, reveals a strong negative relationship between number of spikes per m² and kernel weight per spike under NT system (r = -0.578***), and a not significant relationship under CT system (r = -0.318).

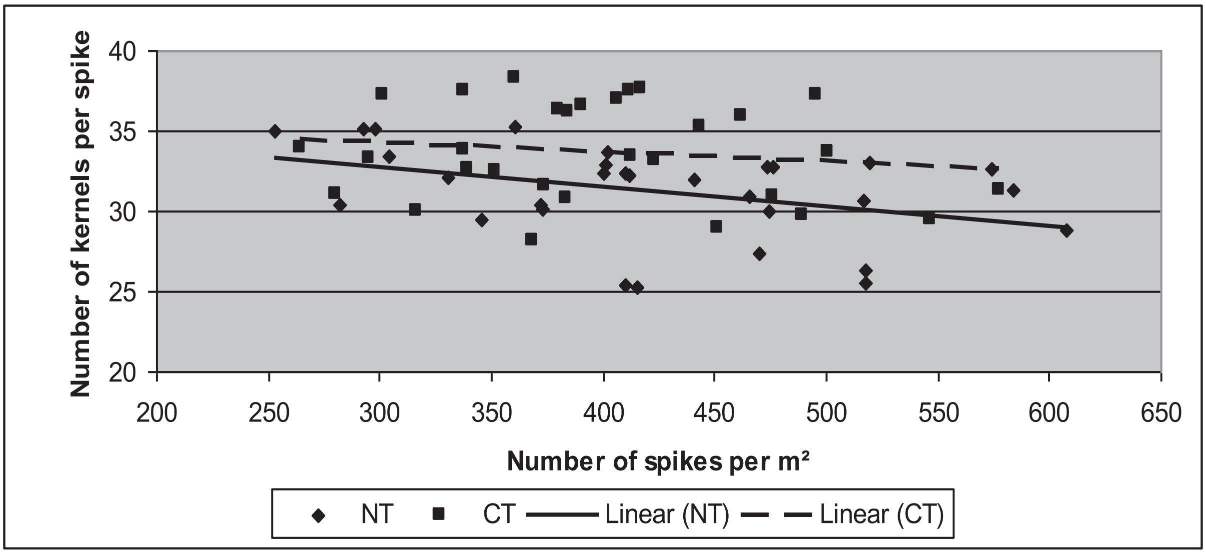

Figure 2. Regression analysis between the number of spikes per m² and the number of kernels per spike for winter wheat cultivars in the case of two different tillage systems

A linear regression equation with significant regression coefficient on the level of 0.1% was established between number of spikes per m² and kernel weight per spike, within NT system, highlighting the fact that the increasing number of spikes per m² leads to the decrease of kernel weight per spike (Table 2 and Figure 3).

Increasing the number of spikes per m² has generally been found to lead to lower kernel number per spikes and lower weight of individual kernels (Darwinkel, 1978). In this study, this fact is significantly described only of NT system. The explanation could be that under non-tilled soils the nitrification process is more reduced and lack of nitrogen leads to a higher competition between spikes under formation if the density increases.

The relationship between number of spikes per m² and thousand kernel weight, as well as between number of kernels per spike and grain yield was not significant, within both tillage systems (Table 1).

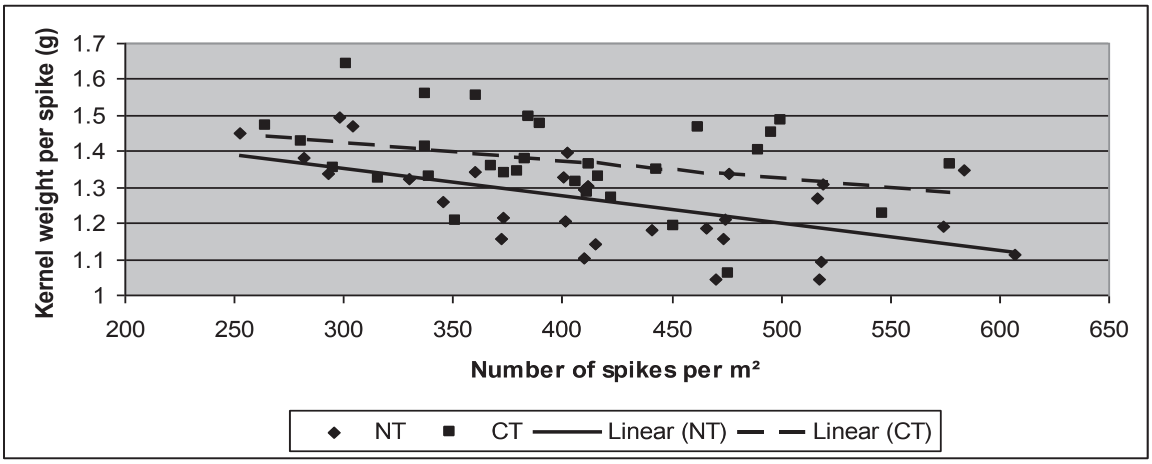

Figure 3. Regression analysis between number of spikes per m² and the kernel weight per spike for winter wheat cultivars in the case of two different tillage systems

Strong positive correlations were established between number of kernels per spike and kernel weight per spike under both NT and CT systems (r = 0.783*** and r = 0.524**, respectively) (Table 1). Relationship between number of kernels per spike and kernel weight per spike was clearly described by linear regression and had a significant regression coefficient on the level 0.1% within NT system and on the level of 1% within CT system (Table 2 and Figure 4).

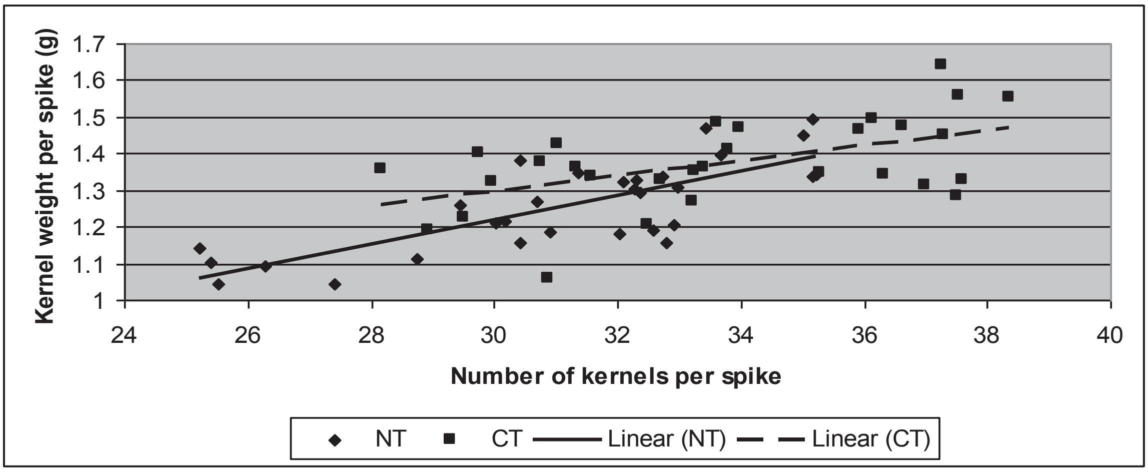

Figure 4. Regression analysis between the number of kernels per spike and kernel weight per spike for winter wheat cultivars in the case of two different tillage systems

Correlation analyses of Table 1 shows that TKW was negatively influenced by number of kernels per spike at p≤0.01, within CT system (r = -0.515**), and not significantly affected within NT system (r = -0.262).

Linear regression equation of significant regression coefficient on the level of 1% was established between the number of kernels per spike and TKW within CT system, where increased number of kernels per spike decreased TKW (Table 2 and Figure 5).

Table 1 show that the relationship between grain yield and kernel weight per spike was not significant, within both tillage systems. Weak correlation between kernel weight per spike and TKW, under both NT and CT systems (r = 0.379* and r = 0.456*, respectively) was established.

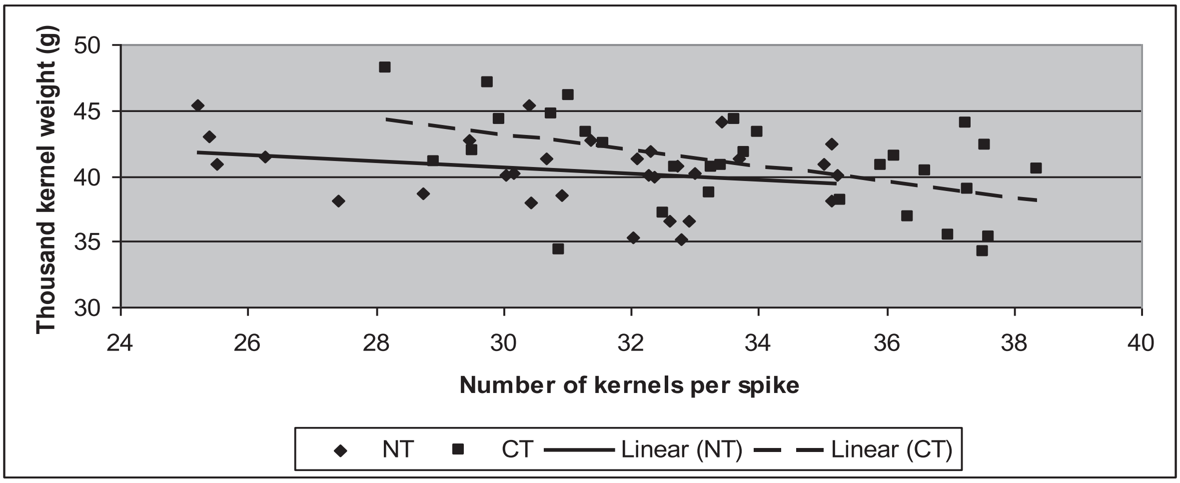

Figure 5. Regression analysis between the number of kernels per spike and TKW for winter wheat cultivars in the case of two different tillage systems

Linear regression equation between the TKW and kernel weight per spike was established, having, under both NT and CT systems, a significant regression coefficient on the level of 5%, highlighting the fact that increasing TKW increased the kernel weight per spike (Table 2 and Figure 6).

This study underlines that the correlation between grain yield and TKW was not significant, under both tillage systems (Table 1). Changes of one yield component can be offset by others, having as results minimum change of grain yield (Beuerlein and Lafever, 1989).

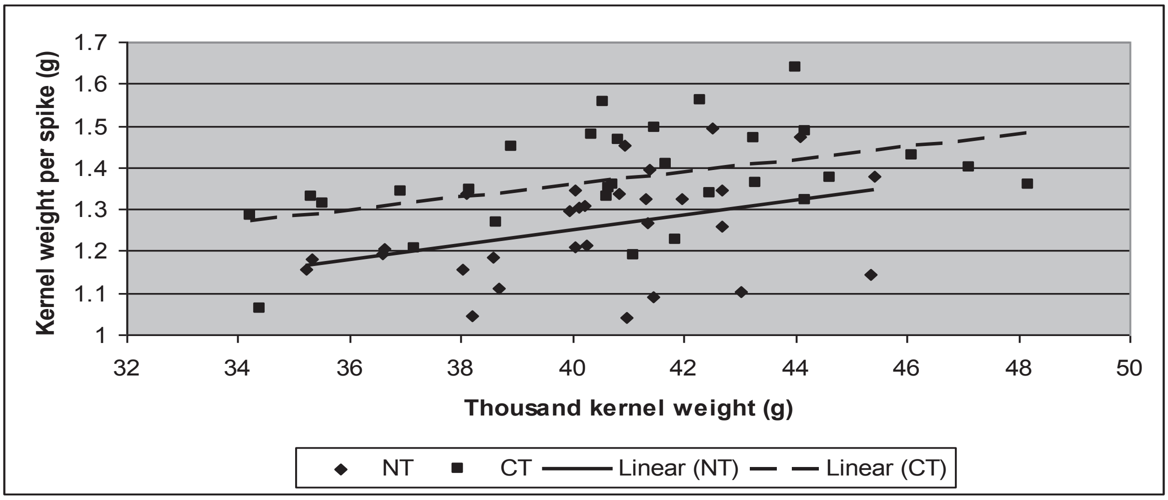

Figure 6. Regression analysis between the TKW and kernel weight per spike for winter wheat cultivars in the case of two different tillage systems

CONCLUSIONS

Based on five years of research about the relationship between grain yields and some yield components of six winter wheat cultivars, as affected by two contrasting tillage systems, the following conclusions can be drawn:

- mean positive correlations between number of kernels per spike and kernel weight per spike and strong positive correlations between the number of spikes per m² and grain yield within both tillage systems were established;

- weak correlations between kernel weight per spike and TKW, under both NT and CT tillage systems were also established;
- under NT tillage system, but not under CT, by increasing the number of spikes per m², the number of kernels per spike and the kernel weight per spike are reduced;
- under CT tillage system, but not under NT, by increasing the number of kernels per spike, TKW is reduced.

REFERENCES

Bavec, M., Bavec, F., Varga, B. and Kovačević, V., 2002. *Relationships among yield, its quality and components in winter wheat (Triticum aestivum L.) cultivars affected by seeding rates*. Die Bodenkultur, 53(3): 143-151.

Beuerlein, J.E. and Lafever, H.N., 1989. *Row spacing and seeding rate effects on soft red winter wheat yield, its components and agronomic characteristics*. Applied Agricultural Research, 4: 106-110.

Borojević, S., 1972. *Utilization of the Genetic Potential of High-yielding Wheat Varieties*. Zeitschrift für Pflanzenzuchtung, 68: 1-17.

Cooper, M., Woodruff, D., Phillips, I., Basford, K. and Gilmour, A., 2001. *Genotype-by-management interactions for grain yield and grain protein concentration of wheat*. Field Crops Res., 69: 47-67.

Darwinkel, A., 1978. *Patterns of tillering and grain production of winter wheat at a wide range of plant densities*. Netherlands Journal of Agriculture Science, 26: 383-398.

Gomez-Macpherson, H., van Hervaaden, A.F. and Rawson, H.M., 2003 – *Constraints to cereal based rainfed cropping in Mediterranean environments and methods to measure and minimize their effects*. In: Explore On-farm trials for adapting and adopting good agricultural practices FAO, Roma: 1-18.

Jarecki, M.K. and Lal, R., 2003. *Crop management for soil carbon sequestration*. Crit. Rev. Plant Sci., 22: 471-502.

Montgomery, D.R., 2007. *Soil erosion and agricultural sustainability*. Proc. Natl. Acad. Sci. USA, 104: 13268-13272.