Grain yield and yield components on an assortment of winter wheat (*Triticum aestivum* L.) genotypes cultivated under conditions of A.R.D.S. Teleorman

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Abstract. The study was carried out in the growing season 2014-2015, in the agrotechnology conditions of Drăgăneşti Vlaşca area, Teleorman county, Romania, where 8 genotypes of winter wheat (*Triticum aestivum* L.) were studied, including 4 wheat varieties cultivars (Dropia, Glosa, Katarina, Mulan) and 4 wheat hybrids varieties (Hystar, Hyfi, Hywin, Hybiza). Agrophytotechnical measures performed in the experimental field were representative of the technology applied in farms of southern Romania, using a sowing density of 500 germinating grains m^{-2} in the case of cultivars, and 200 germinating grains m^{-2} in the case of hybrids respectively. In this paper are presented data cocerining grain yield related to the unit area (kg ha^{-1}) and yield components represented by the plant density after emergence (plants m^{-2}), plant density in spring (main shoots and tillers m^{-2}), head plant density at the harvest time (ears m^{-2}), the weight of the grains in the spikes (g ear^{-1}), as well as main physical indices related to the quality, i.e. thousand kernels weight (TKW) and hectolitre mass (MH). The grain yield of the cultivar average (CT1) was 5,805 kg ha^{-1} compared with the hybrid average (CT2) which achieved 6,901.8 kg ha^{-1}. The number of harvestable spikes per square meter varied from 688 ears m^{-2} in hybrid Hybiza to 540 ears m^{-2} in cultivar Glosa. The grains weight per ear reached 1.49 g in the case of the cultivar average, comparative with the hybrids average which scored 1.85 g ear^{-1}. The winter wheat hybrid Hyfi obtained the highest yield, this can be recommended to be cultivated when the aim is to increase the yields per unit area.
Key Words: hybrid wheat, plant density, grains weight per ear, TKW, MH.

Introduction. Due to the global economic importance of wheat and his special roles in human nutrition, the basic trend now and in the future is to increase worldwide production. By cultivating it from very old times, the wheat bread [*Triticum aestivum* (L.) Thell ssp. *vulgare* (Will.) M.K.] is one of the most important crops (Zohary & Hopf 2000; Bonjean et al 2001).

World food production remains dominated by cereals, the demand for increasing global food security is one of the main objectives of breeding programs aimed at increasing yields associated with heterosis (hybrid vigor) in wheat (Whitford at al 2013; Longin et al 2012).

For high yield potential of wheat cultivars varieties, the number of harvestable ears should be between 600 and 700 m^{-2}, which can be accomplished by sowing 500-550 seeds m^{-2} (Cvetkovic et al 2016; Hristov et al 2012; Cociu 2014).

The winter wheat hybrids achieved grain yield performances that made them competitive with the best wheat varieties cultivated nowadays in the Romanian Plain, due to yield components and the quality physical indices (Guta et al 2015).

In a study conducted under the specific conditions of the Agricultural Research and Development Station Teleorman (A.R.D.S. Teleorman), where an large assortment of winter wheat varieties was studied, the yield obtained by the Dropia variety was 6,720 kg ha^{-1}, and the yield components mentioned for this variety was 447 harvestable ears m^{-2}, and the weight of the grains in the ear reached 1.5 g (Meluc et al 2011).

Concerning the hectolitre mass (MH) as quality index of grain yield, the minimum level acceptable for common wheat in industry of making bread is 75 kg hL^{-1} (Matei at al 2017).

A positive correlation was observed between number of tillers $plant^{-1}$ and grain yield $plant^{-1}$ at phenotypic levels (Abdus et al 2003; Narwal et al 1999).

About the influence of the soil tillage upon the yield in the climatic condition at Moara Domnească, Ilfov County, Romania, the hybrid wheat Hyspeed recorded 9,620 kg ha^{-1}, under minimum soil tillage conditions with chisel 40 cm (Marin et al 2015).

Achieving increased yields, with superior quality indices and low costs of production, requires adequate technical and the rational management of existing natural resources (Sin et al 2005).

The main objective of the present paper was to present the results obtained in the conditions of southern Romania of an assortment of winter wheat genotypes (local and foreign varieties) in terms of grain yield and yield component analyses.

Material and Method. The experimental results were obtained in the pedo-climatic conditions from A.R.D.S. Teleorman from Drăganești Vlașca, Teleorman County, Romania in the 2014-2015 growing season.

The study focused on observations and comparative determinations on some genotypes of winter wheat, local and foreign origin (cultivars and hybrids), as follows: 4 wheat cultivars: Dropia, Glossa, Katarina, Mulan and 4 wheat hybrids: Hystar, Hyfi, Hywin, Hybiza. The experimental variants were placed according to the randomized block method, in three replications. The harvest surface of each plot was 10 m^2. Sowing was done at the optimum time, using a sowing density of 500 germinating grains m^{-2} in the case of varieties and 200 germinating grains m^{-2} in the case of hybrids, at a distance between rows of 12.5 cm and the sowing depth of 4-5 cm. The agrotechnical management performed in the field was similar with the local technology applied by the farmers from South Romania. The interpretation and analysis and of the results was based on variance analysis, according to the mono-factorial method of field setting (Saulescu & Saulescu 1967).

The main purpose of the research was to find out the influence of genotypes on grain yield related to the unit area (kg ha^{-1}) and yield components, such as the plant density after emergence (plants m^{-2}), plant density in spring (main shoots and tillers m^{-2}), plant density at the harvest time (ears m^{-2}), the weight of the grains in the spikes (g ear^{-1}), as well as the main physical index, i.e. thousand kernels weight (TKW) and hectolitre mass (MH).

Results and Discussion. From a climatic point of view (Table 1), in the winter months, the evolution of the thermal factor was favorable for cereal crops, regardless of the species. Although temperatures below the freezing point were set early (in November).

Table 1

Climatic conditions at Drăgănești-Vlașca, Teleorman County during the 2014-2015 growing season vs. average* amount of the area

Month	*Temperature (ºC)*		*Rainfall (mm)*	
	Average for 2014–2015	*Average**	*Average for 2014–2015*	*Average**
October	12.2	11.4	66.4	36.3
November	5.3	4.3	37.6	41.4
December	0.8	-0.3	146.8	40.6
January	-0.1	-3.4	40.2	36.4
February	3.3	-0.6	28.0	36.8
March	6.0	4.6	61.4	40.6
April	11.2	11.9	35.8	40.8
May	18.6	16.9	20.4	40.8
June	20.4	20.6	104.0	70.7
Average (Oct-Jun)	8.63	7.26	540.6	384.4

* - average for 15 years.

The monthly average temperatures of the 2014-2015 growing season were higher than the normal average in the area, according to the climatological norm. High temperatures were registered starting with October (0.5ºC) and continuing with November (1ºC), December (0.5ºC) and February (2.7ºC). The coldest month of the year was January, when it was -0.1ºC, with 3.3ºC higher than the normal average. Thus, we can say that wheat crops benefited from a mild winter from a thermal point of view. Starting from March, the monthly average temperatures were higher or at the same level with the normal average, in March (+1.4ºC), April (-0.7 ºC), May (+1.7ºC) and June (-0.2ºC). May had an unfavorable influence on crop growth, given to the temperature and rainfall influence.

The rainfall amount during the vegetation period (1 October 2014 – 30 June 2015) was 540.6 mm, i.e. 156.2 mm, over the normal amount in the area. Heavy rainfall was recorded in the months of October (66.4 mm of rainfall, 29.8 mm more than the normal amount in the area), December (146.8 mm, 105.1 mm more than normal amount in the area), January (40.2 mm, 3.8 mm more than normal amount in the area), March (61.4 mm, 11.4 mm more compared to the normal amount in the area) and June (104.0 mm, 33.0 mm more compared to the normal amount in the area).

A rainfall deficit was recorded in the: November (-3.4 mm less from normal amount in the area), January (-1.2 mm less from normal amount in the area), February (-8.7 mm less from normal amount in the area), April (-4, 8 mm less from normal amount in the area) May (-20.2 mm less from normal amount in the area).

Concerning the climatic conditions, in the 2014-2015 growing season, were favorable for cereals crops due to the presence of water from the rainfall for a long time repartition (practically from late October to late March), unevenly distributed of the rainfall compared to the water requirements of winter wheat and the temperature range between day and night in June (>10ºC).

The sowing densities has complied the technological norms for each genotype (cultivars and hybrids). Thus, the obtained cultivars densities after emergence were considered very good. It ranged from 476 plants m^{-2} at Katarina variety to 497 plants m^{-2} at Mulan variety. The densities achieved for wheat hybrids were also the recommended ones, so that after emergence 200 plants m^{-2} were recorded (Table 2).

Table 2

Influence of the genotype on the evolution plant density from emergence to the harvest

Wheat varieties	*Sprouting density (plants m^{-2})*	*%*	*Main shoots and tillers m^{-2}*	*%*	*Harvestable ears m^{-2}*	*%*
Glosa	484	100	898	90	540	88
Dropia	480	99	956	96	608	99
Katarina	476	98	1048	105	672	110
Mulan	496	102	1086	109	632	103
Cultivar average (CT1)	484	100	997	100	613	100
Hystar	200	100	975	98	604	96
Hyfi	200	100	956	96	680	108
Hywin	200	100	1042	105	552	87
Hybiza	200	100	1009	101	688	109
Hybrid average (CT2)	200	100	995	100	631	100

Concerning the determination of the density (number of plants includes the main shoots and tillers m^{-2}), they were performed when the vegetation resumed. Thus, for the cultivars obtained by breeding, the average densities were between 1,086 main shoots and tillers m^{-2} for the Mulan variety and 898 main shoots and tillers m^{-2} for the Glosa variety. In the case of winter wheat varieties obtained by hybridization, the effective density per unit area was between 1,042 main shoots and tillers m^{-2} in Hywin variety and 956 main shoots and tillers m^{-2} in Hyfi variety.

The final element of the plant density expression of the 8 winter wheat varieties is the number of ears they formed per unit area (1 m²). The fertile tillers capacity is specific to each genotype studied, led to a mean number of harvestable ears between 540 ears m^{-2} in Glosa variety to 672 ears m^{-2} in Katarina variety. This one variety formed the largest number of fertile tillers $plant^{-1}$. In the case of hybrids, we notice that, the density at the harvest time of the spikes per square meter varied between 552 ears m^{-2} in Hywin variety and 680 ears m^{-2} in Hyfi.

These densities were formed by main shoots and tillers, determined at the end of tillering stage, led to fertile tillers which will form spikes, but not all the tillers will form spikes, so they will not be productive. The phenomenon of losing tillers during the vegetative growth and organogenesis, represents an adaptation to the ecological and technological conditions that the winter wheat plants during the vegetation period.

Tillering capacity is another favorable factor that influences the grain yield. The genotypes tested in the experiment, highlight the special value of the cultivars tested, but also the clear superiority of the data obtained in the winter wheat hybrids, in terms of tillering capacity (Table 3).

Table 3

Influence of the genotype on tillering capacity and the grain weight ear^{-1}

Wheat varieties	*Spring density (tillers $plant^{-1}$)*	*%*	*Harvest density (fertile tillers $plant^{-1}$)*	*%*	*Grains weight ear^{-1} (g)*	*%*
Glosa	1.86	90	1.12	88	1.52	102
Dropia	1.99	97	1.27	100	1.54	103
Katarina	2.20	107	1.41	111	1.79	120
Mulan	2.19	106	1.27	100	1.09	73
Cultivar average (CT1)	2.06	100	1.27	100	1.49	100
Hystar	4.88	98	3.02	104	1.79	97
Hyfi	4.78	96	3.40	117	2.01	109
Hywin	5.21	105	2.76	95	1.56	84
Hybiza	5.05	101	2.44	94	2.03	110
Hybrid average (CT2)	4.98	100	2.90	100	1.85	100

The data shows that these wheat hybrids formed almost a double number of tillers $plant^{-1}$. At this stage of the determinations, in the case of the cultivars, this indicator was between 1.27 fertile tillers $plant^{-1}$ for the Dropia and Mulan varieties and 1.41 fertile tillers $plant^{-1}$ in the Katarina variety. This last variety proved to be the best in terms of productive tillering capacity, among the analyzed cultivars varieties.

The wheat hybrids studied formed a double number of fertile tillers $plant^{-1}$, surpassing in all cases of wheat cultivar varieties. Thus, we note that the number of fertile tillers in the case of hybrids was between 2.44 fertile tillers $plant^{-1}$ in Hybiza variety and 3.40 fertile tillers $plant^{-1}$ in the Hyfi wheat hybrid.

The weight of the grains ear^{-1} was below and over 2 g (Table 3). The grains weight of the ear in the case of hybrids was between 1.56 g in Hywin variety and 2.03 g in the hybrid Hybiza, while in the case of cultivar varieties the grains weight of the ear was between 1.09 g in the Mulan variety and 1.79 g to Katarina. Maximum values of ear mean weights reached by the hybrid average (CT2) with 1.85 g ear^{-1} compared with cultivar average (CT1) which recorded 1.49 g ear^{-1}.

From the point of view of the productive potential of the 8 winter wheat genotypes studied, a great variability is observed (Table 4). The hybrids realizing grain yields per unit area superior to the cultivars varieties. Thus, in the case of cultivar average (CT1), the grain yield was 5,805 kg ha^{-1} with values between 5,210 kg ha^{-1} for the Dropia variety and 6,616 kg ha^{-1} for the Mulan variety. The grain yields of the hybrid average (CT2) tested in the experiment was 6,901.8 kg ha^{-1} with values between 6,792 kg ha^{-1} for the Hystar hybrid and 7,024 kg ha^{-1} for the Hyfi hybrid. This last hybrid has proven to be the most valuable in terms of productivity.

Table 4

Results of the grain yields (kg ha^{-1}) obtained at A.R.D.S. Teleorman

Wheat varieties	*Grain yield (kg ha^{-1})*	*%*	*Difference from CT1 (kg ha^{-1})*	*Significance*	*Difference from CT2 (kg ha^{-1})*	*Significance*
Glosa	5865	101	60	-	-577	o
Dropia	5210	90	-595	oo	-1232	ooo
Katarina	5529	95	-276	-	-913	oo
Mulan	6616	114	811	xx	174	-
Cultivar average (CT1)	5805	100	-	CT1	-	CT2
LSD 5% = 345		LSD 1% = 583			LSD 0.1% = 876	
Hystar	6792	98	-109.8	-	987	xxx
Hyfi	7024	102	122.2	x	1219	xxx
Hywin	6882	100	-19.8	x	1077	xxx
Hybiza	6909	100	7.7	x	1104	xxx
Hybrid average (CT2)	6901.8	100	-	CT2	-	CT1
LSD 5% = 367		LSD 1% = 658			LSD 0.1% = 924	

Following the determinations concerning the main physical indicators that show the quality of wheat grains, respectively the thousand kernels weight (TKW) and the volumetric weight (MH) we noticed that there were no significant differences between the 8 varieties of winter wheat tested in the experiment (Table 5).

Table 5

Influence of the genotype on physical quality indices TKW and HM

Wheat varieties	*TKW (g)*	*%*	*MH (kg hL^{-1})*	*%*
Glosa	46.7	101	78.9	94
Dropia	47.5	103	79.3	101
Katarina	45.6	99	78.8	97
Mulan	44.9	97	77.9	103
Cultivar average	46.2	100	78.7	100
Hystar	43.7	99	75.3	97
Hyfi	43.4	99	76.9	99
Hywin	43.9	100	78.8	102
Hybiza	44.8	102	78.9	102
Hybrid average	43.9	100	77.5	100

Thus, the TKW values in the case of cultivars were between 44.9 g in Mulan and 47.5 g in Dropia, which, as it is already known, is one of the most valuable Romanian varieties in terms of quality. In the case of hybrids, the TKW values varied between 43.4 g for the Hyfi hybrid and 44.8 g for the Hybiza, the latter also demonstrating a great productive potential.

Concerning the hectolitre mass of grains, we note that this indicator we recorded in the case of cultivar values between 77.9 kg hL^{-1} and 79.3 kg hL^{-1} and in the case of hybrids values between 75.3 kg hL^{-1} and 78.9 kg hL^{-1}, all genotypes exceeding the minimum value of the hectolitre mass provided for the bakery destination, respectively 75 kg hL^{-1}.

Conclusions. Results of the research in the 2014-2015 growing season placed at ARDS Teleorman, in the southern part of Romania, in Drăgănești-Vlașca area, summarized in

this paper, contribute to the formulation of some conclusions concerning the competition between the cultivar varieties and hybrids wheat studied.

1. The density of plants after emergence was on average 484 plants m^{-2} in the case of winter wheat cultivars tested in experiment, and in the case of analyzed hybrids it was in average 200 plants m^{-2}, the values of this indicator increasing significantly in spring (after tillering stage) to at 997 plants m^{-2} for varieties and 995.5 plants m^{-2} for tested hybrids.

2. The grains weight of the ear in the case of hybrids was between 1.56 g in Hywin and 2.03 g in the Hybiza hybrid, while in the case of cultivars, the grains weight per ears was between 1.09 g in the Mulan variety and 1.79 g for Katarina.

3. Among the assortment of 8 genotypes studied, the most valuable in terms of productivity was the Hyfi hybrid with a yield of 7,024 kg ha^{-1}, a hybrid that can be recommended to be cultivated in the soil and climatic conditions specific to the Romanian Plain, when aiming to increase yields per unit area.

4. In the case of wheat cultivar varieties, the TKW values were between 44.9 g and 47.5 g, the maximum value being recorded by the Dropia variety and in the case of hybrids, the TKW values varied between 43.4 g for the Hyfi hybrid and 44.8 g for Hybiza.

5. The volumetric weight of the 8 genotypes studied shows that this indicator has exceeded the minimum value provided for the milling - bakery destination, 75 kg hL^{-1} respectively, being thus considered good for this destination.

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