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AGRONOMIC CHARACTERISTICS OF EMMER WHEAT VARIETIES

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ABSTRACT

Production parameters (number of productive tillers per m^2, stem length, weight of grains per spike, TGW, share of glumes and yield) of four emmer wheat varieties – Agnone, Farvento, Molise sel Colli, Guardiaregia cultivated under the conditions of organic farming system in the south region of the Slovak republic during 2010 – 2011 and 2011 – 2012 growing seasons were evaluated. Weather conditions during experimental years showed higher influence on selected production parameters than tasted varieties. Statistical analysis confirmed significant differences between varieties only in parameters: weight of grains per spike and TGW. The average theoretical yield of emmer wheat varieties was 7.09t.ha^{-1}, TGW averaging about 47.67 g, average weight of grains per spike was 1.63 g. The stem length varying from 84.78 cm to 87.65 cm, average share of glumes was 28.16 %. Numbers of productive tillers was averaging about 445 per m^2. Generally spoken, emmer wheat varieties are suitable for organic farming from the point of its morphological features.

Keywords: Emmer wheat varieties, organic farming system, production parameters

INTRODUCTION

Production of healthy foodstuffs and elimination of negative effects of the farming on the environment are the main purpose of the organic farming system. As the organic farming is limited by a lot of legislative regulations the use of supportive instruments (e.g. soluble nitrogenous fertilizers, pesticides, etc.), the efficiency of growing of cereals decreases. Therefore, organic farmers aim to take advantage of a wide diversity of cultural crops and find such crops able to provide a sufficient yield rate and good – quality products, even if grown in low – input conditions. Wheat genetic resources do not usually manage to achieve the productivity of modern bred dominating cultivars **(Ehdaie *et al.*, 1991; Konvalina *et al.*, 2010)**. In spite of this fact farmers are interested in them because landraces are less demanding and more adaptable to the environmental conditions. They provide lower but more stable yield rate **(Collins, Hawtin, 1998).** In organic farming, yield is much more influenced by the interaction of genotype and environment than in conventional farming. Therefore, an evaluation of the suitability of a variety for a certain environment should be ideally carried out under the local conditions **(Moudrý, 2003)**. According to **Wolfe (2002)**, varieties suitable for organic farming are characterized by good absorption of nutrients, high competitiveness to weeds, resistance to diseases and pests and the required qualitative and quantitative parameters of production.
The tetraploid emmer wheat – *Triticum dicoccum* (Schrank) Schuebl – is one of the crops considered suitable for low – input and organic farming systems where modern conventional varieties are not able to develop its production potential very well because they had been selected for different land and climatic conditions. It is one of the hulled wheat species which have been grown and uses as a part of the human diet for a very long time **(Marconi, Cubadda, 2005)**. As people are paying more attention to the diversity and good quality of food products, they have become more interested in this cereal species **(Hammer, Perinno, 1995)**. Emmer wheat landraces have a number of advantages which assure them an important place in the interest of farmers and consumers: they are resistant and tolerant to drought, the roots system are able to better absorb nitrogen **(Trčková *et al.*, 2005).** The emmer wheat is a suitable alternative crop to the durum wheat, which has similar characteristics and is suitable for low – input and organic farming system **(Konvalina *et al.*, 2011)**.
This paper presents the results of a study of influence of growing season and varieties on production parameters (the number of productive spikes, stem length, the weight of grains per spike, the weight of thousand grains – TGW, share of glumes and theoretical yield) of selected emmer wheat varieties grown under the conditions of organic farming in the south Slovakia.

MATERIAL AND METHODS

A field stationary experiment was carried out at the Research Experimental Station of the Slovak University of Agriculture in Nitra situated in south region of Slovakia near village Dolná Malanta (48°19´N, 18°07´E). Field experiments were establishment during 2010 – 2011 and 2011 – 2012 growing seasons on a Haplic Luvisol developed at proluvial sediments mixed with loess. The altitude of experimental base is 178 meters above sea level. Experimental location has continental climate, belongs to warm agro – climatic region, arid subregion with predominantly mild winter with average long – term (1961 – 1990) annual precipitation 532.5 mm, for a vegetative period 309.4 mm. The average long – term temperature is 9.8°C and for vegetative period it is 16.4°C. The field trail was ordered into randomized blocks (the average plot size was 10m^2) in three repetitions. Pre – crop was pea. Emmer wheat was cultivated in organic farming system without fertilization and any chemical treatment.
Production parameters were analyzed in four varieties of emmer wheat – Agnone, Farvento, Molise sel Colli, Guardiaregia in three repetitions. The production parameters – the number of productive spikes (pc), the stem length (cm), the weight of grains per spike (g), the weight of thousand grains – TGW (g), share of glumes (%) and theoretical yield (t.ha^{-1}) were determined. Theoretical yield was determined as weight of grain in spike x number of spikes per area unit. Parameters the weight of grains per spike, TGW and yield were recalculated to a humidity of 14%. The achieved data were statistically evaluated by STATISTICA 7.0. by using multifactor analysis of variance (ANOVA). Significant differences were evaluated by Fisher´s least significant difference (LSD) test at $P < 0.05$.

Table 1 Crop management data for emmer wheat varieties grown in 2011 and 2012

Growing season	Sowing date	Harvest date	Precipitation (mm)	Average temperature (°C)
2010 - 2011	13/10/2010	18/07/2011	339.10	8.61
2011 - 2012	06/10/2011	12/07/2012	305.30	9.59

Table 2 Temperature and precipitation characteristics of the location in Dolná Malanta (growing season from October to July)

	Month										Mean/ sum in the growing season
	10	11	12	1	2	3	4	5	6	7	
Longtime normal values between 1961 and 1990											
Temperature (°C)	10.1	4.9	0.5	-1.7	0.5	4.7	10.1	14.8	18.3	19.7	8.2
Precipitations (mm)	41	54	43	31	32	33	43	55	70	64	466
2011											
Temperature (°C)	6.9	7.6	-2.3	-0.9	-0.6	5.9	12.7	15.8	19.8	21.2	8.61
Precipitations (mm)	22.8	72.6	52.7	5.5	3.6	0.2	13.2	48.4	91.1	29	339.1
2012											
Temperature (°C)	8.6	3.0	2.2	1.4	-2.5	7.4	11.2	17.3	20.9	26.4	9.59
Precipitations (mm)	35.5	1.2	42	61.1	23.5	2.8	36.1	19.6	70.1	13.4	305.3

RESULTS AND DISCUSSION

Results of a two – year evaluation of production parameters are shown in Table 3.

Number of spikes per m^2

Emmer wheat varieties were characterized by 445 pieces of productive tillers per m^2 in average (Table 3). Agnone variety was characterized by the highest number of productive tillers per m^2 (468 pcs). When concerned year of growing, significantly the highest number of productive tillers per m^2 was found in 2011 (496 pcs) compared with 2012 (394 pcs). Since the seeds were sown equal in each plot, the spikes per m^2 were affected by germination rate and tillering capability. **Pagnotta *et al.* (2009)** noted that the number of spikes per m^2 had a wide range and varying from 233 pcs to 498 pcs, with an overall average of 319 spikes per m^2. It was interesting to note the non – significant differences among replications indicated that, in the same macro environment (year and location), the germination rate and the tillering capability were about the same within each accession. According to **Troccoli *et al.* (2005)** the "Farro" best fitted to the environmental conditions of south Italy, in regard to yield, higher grains weight and a great number of spikes per square meter. Emmer wheat reached 442 numbers per m^2, einkorn had 419 spikes per m^2 and spelt wheat had 354 spikes per m^2. Results are in agreement with **Codianni *et al.* (1996)** and **Troccoli *et al.* (1997)**, which found that emmer had under the same environmental conditions, the best performance in comparison to einkorn and spelt. **Marino *et al.* (2011)** found out the number of spikes per m^2 increased as the N rate increased. Nitrogen fertilization increased the number of spikes per m^2 linearly: about 30% for N_{30}, 74% for N_{60} and 90% for N_{90}.

Table 3 Production parameters of emmer wheat varieties (2011 – 2012)

	Number of productive tillers per m^2 (pc)	Stem length (cm)	Weight of grains per spike (g)	TGW (g)	Share of glumes (%)	Theoretical yield ($t.ha^{-1}$)
Varieties						
Agnone	468.67 n.s.	87.65 n.s.	1.59 a	45.62 a	26.81 n.s.	7.40 n.s.
Farvento	452.00 n.s.	86.05 n.s.	1.53 a	45.78 a	29.55 n.s.	6.78 n.s.
Molise sel Colli	443.33 n.s.	86.65 n.s.	1.50 a	44.84 a	28.58 n.s.	6.54 n.s.
Guardiaregia	418.67 n.s.	84.78 n.s.	1.88 b	54.45 b	27.72 n.s.	7.66 n.s.
Year						
2011	496.67 b	88.70 b	1.69 n.s.	47.07 n.s.	26.56 a	8.16 b
2012	394.67 a	83.86 a	1.56 n.s.	48.27 n.s.	29.77 b	6.03 a
Mean	**445.67±71.33**	**86.28±4.07**	**1.63±0.21**	**47.67±4.62**	**28.16±3.12**	**7.09±1.48**

Different small letters in the same column mean significant difference at alpha 0.05. No significant difference (n.s.) at alpha 0.05.

The weight of grains per spike

As mentioned above emmer wheat varieties were characterized by 445 pieces of productive tillers per m^2 in average, where spikes contained more than 36 grains with the weight of 1.63 g in average. The weight of grains per spike is also characterized as the yield component and could predict the wheat production. This quantitative parameter was significantly depended on variety. Significantly the highest weight of grains per spike – 1.88 g was achieved by Guardiaregia variety. The remaining three varieties had lower weight of grains per spike – 1.59 g (Agnone), 1.53 g (Farvento) and the lowest weight of grains per spike had Molise sel Colli (1.50 g). **Konvalina *et al.* (2010)** noted that the weight of grains per spike of spring emmer wheat plant (0.8 g) reached a half weight of grains in the spikes of the check plant – intermediate bread wheat (1.6 g). The lower weight of grains in their spikes than the weight of grains in the spikes of the check varieties should be compensated for by a higher number of productive tillers.

The weight of thousand grains

The weight of thousand grains (TGW) is an important yield forming parameter. It is indicating seed dimension, which in hulled wheat is usually small. TGW averaging for emmer wheat about 47.67 g. Statistical evaluation of TGW indicated statistically significant influence of the variety. Significantly the highest TGW was observed in Guardiaregia (54.45 g) and the lowest in Molise sel Colli (44.84 g). Weather condition had no significant influence on TGW. Most literature reports for TWG of winter emmer values similar to the presented data. TGW of Italian grown winter landraces varied between 19.1 and 55.8 g **(Galterio *et al.*, 2003; Pagnotta, 2004)**. Also the results of Jantsch and Trautz (2001) for German grown emmer are in the same range (40 – 50 g) **(Mondini *et al.*, 2014)**. Significantly higher TGW are reported for north Spanish emmer wheat landraces by **Oliveira (2001)**, who measured a mean TGW of 65.4 g. **Konvalina *et al.* (2008)** noted that TGW of spring landraces is by 10 g lower (33 g) than TGW of the spring modern varieties (45 g). Generally, spring emmer accessions showed lower grains weights than winter types **(Mondini *et al.*, 2014)**. **Marconi** and **Cubadda (2005)** stated the same figures, they indicated TGW varying between

30 – 45g and they emphasised it was influenced by the genotype and environment. The TGW of emmer wheat cultivar was lower than that of the modern common and durum wheat cultivar. According to **De Vita *et al.* (2006)** landraces had the lowest TGW (37.5 g) higher TGW reached genotypes selected from landraces (39.0 g) and the highest TGW reached modern cultivars as Mosé or Padre Pio (44.2 g). Only one genotype (PLV 12) obtained by selection from landraces showed similar value (45.6 g). The results of **Mondini *et al.* (2014)** for thousand grains weight of winter emmer accessions analysis of variance showed highly significant environmental and genotypic effects. In contrast to yield, TGW was stable over environments and no serious cross – over interactions was observed.

Yield

Italian authors present yields for emmer landraces ranging between 0.65t.ha^{-1} and 6.10t.ha^{-1} **(Galterio *et al.*, 2003; Pagnotta *et al.*, 2009)**. Theoretical yield in our research was varying between 6.54t.ha^{-1} (Molise sel Colli) to 7.66t.ha^{-1} (Guardiaregia). Variety had no significant influence on yield. Statistical evaluation of yield indicated statistically significant influence of the weather condition. When concerned the year of growing, significantly the lowest yield was found in 2012 (6.03 t.ha^{-1}) when compared with 2011 (8.16 t.ha^{-1}). **Mondini *et al.* (2014)** noted the highest yield was reached in the environments, which received also the highest rates of N fertilizer, while the lowest yields were observed in the organic and low N input trials. Despite the increase of yield with increasing N fertilization, a significant levelling off was observed: locality with fertilization 107 kg N ha^{-1} out yielded locality with fertilization 88 kg N ha^{-1} by only 0.03t.ha^{-1}. It is supposed that emmer wheat is not suitable for too high N fertilization rates. Most probably high input of N will result in severe lodging, resulting in ear breakage and poor grain filling and therefore, yield loss. Under Italian conditions yields of emmer are comparable to those of spelt wheats, which ranged from 1.16 to 5.50t.ha^{-1} **(Galterio *et al.*, 2003)**. **Bulinska – Radomska *et al.* (2006)** conducted a survey where in seven certified organic farms of central and northern part of Poland, field performance and yielding potential of emmer were studied. Yield of winter emmer wheat cultivars were ranging from 0.75t.ha^{-1} to 4.09t.ha^{-1}. According to **Konvalina *et al.* (2007)** when compared theoretical yield of varieties of emmer wheat and modern varieties, found out the average theoretical yield (weight of grain in spike x optimal number of spikes per area unit) reached 3.78t.ha^{-1}, therefore, 72.4% of theoretical yield of modern varieties.

The share of glumes

Emmer wheat is hulled wheat species in which grain is strongly closed in glumes. Typical emmer characteristic is high share of glumes. It is believed that higher share of glumes played an important role by protecting the grain against negative influences of the environment. Emmer wheat varieties cultivated without fertilization and any chemical treatment achieved results reflect the adaptability of this ancient hulled wheat to growing conditions as well as good resistance against weeds and diseases. Share of glumes varied during 2010 – 2012 growing seasons between 26.56% (2011) and 29.77% (2012). Statistical evaluation of share of glumes indicated statistically significant influence of weather conditions (Table 3). The variety did not affect this parameter. The highest share of glumes had Farvento variety (29.55%), the lowest share Agnone variety (26.81%). **Konvalina *et al.* (2011)** found out share of grains to glumes varied between 72.63% and 78.75% in the case of the emmer wheat landraces. It means share of glumes varied between 21.25% and 27.37%.

The length of stem

Important factor according to lodging resistance is the length of stem. In more dry conditions of southern Slovakia, as compared with Western Europe, the stem length of emmer wheat ranged from 84.78 cm (Guardiaregia) to 87.65 cm (Agnone). There is no information about length of stem of emmer wheat in scientific literature because many foreign studies indicate parameter "plant height". Plant height is measured in all plots, during the milk – waxy maturation when the maximum height level is achieved. According to **Pagnotta *et al.* (2009)** hulled wheats are generally tall plants and the analysed varieties were, on average, 1 m high. **De Vita *et al.* (2006)** noted that the mean value of plant height for all genotypes (landraces, genotypes selected from landraces and modern cultivars) was 112 cm. Landraces (109 cm) and genotypes selected from landraces (112 cm) were generally tall then modern cultivars (mean 94cm). **Troccoli *et al.* (2005)** compared plant height of three hulled wheats – spelt, emmer and einkorn during 1995 – 1996 growing seasons. The highest plant was emmer with an average height of 127 cm, lower was einkorn with an average height of 116 cm and the lowest was spelt (112 cm). They found out that seeding rate had significant influence on height of plant. The lowest seeding rate (100 seeds per m^2) resulted in significant increase of plant height (120 cm) compared with seeding rate 200 seeds per m^2 (117 cm). **Konvalina *et al.* (2010)** mentioned the plants (emmer, einkorn, spelt) were very long (112.7 cm on average), but 25% of them were longer than 125 cm. The shortest was einkorn – 101 cm on average, emmer had 107 cm and spelt 112 cm on average. The plants were long enough to be able to compete with weeds, but on the other hand, the long plants were more inclined to lodging.

CONCLUSIONS

In our study were analysed agronomical properties of four emmer wheat varieties cultivated in organic farming system in the south region of Slovak republic. Weather conditions during experimental years showed higher influence on selected production parameters than tasted varieties. Statistical analysis confirmed significant differences between varieties only in parameters: weight of grains per spike and TGW. Guardiaregia variety had the highest theoretical yield, weight of thousand grains and weight of grains per spike but the lowest number of productive tillers per m^2. The highest number of productive tillers per m^2 had Agnone variety with theoretical yield 7.40 t.ha^{-1}. The average yield of emmer wheat varieties was 7.09t.ha^{-1}, TGW averaging about 47.67 g and average weight of grains per spike was 1.63 g. Generally spoken, emmer wheat is suitable, advantageous and profitable crop when cultivated in marginal areas and under conditions of sustainable and organic agriculture, where modern wheats are unable to develop their full productive potentials because they have been genetically selected for favourable pedoclimatic and agronomic conditions. It is only under these conditions that emmer cultivation is justified and its agronomic performance – yield becomes profitable with respect to modern free – threshing wheats.

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