THE IMPACT OF RATIONALIZATION ELEMENTS OF THE CULTIVATION TECHNOLOGY FOR BASIC INDICATORS OF ACCUMULATION POTENTIAL AND GRAIN YIELD OF WINTER BARLEY IN CONDITIONS OF CORN PRODUCTION AREAS OF SLOVAKIA

Molnárová Juliana*, Andrej Kupecsek, Jozef Žembery, Ivan Černý, Ján Čimo

* Slovak University of Agricuklture in Nitra, Faculty of Agrobiology and Food Resources, Deoartment of Crop Production, Adress: Tr. A. Hlinku 2, 949 76 Nitra, Slovensko, e-mail: juliana.molnarva@uniag.sk

Abstract

Under the intention to obtain knowledge about the effect of organo-mineral fertilizers and different tillage methods on the yield and yield components within the rationalization of cultivation technologies of winter barley we established a field polyfactorial trial in war corn production area of Slovakia in years 2007-2010. The negative effect of less favourable year was at the selected yield components partially eliminated by fertilization, tillage and variety. The use of organo-mineral fertilizers positively effected the formation of number of plants and spikes, number of grains per spike and yield. The yield increased significantly in comparison with control variant (by 1.11 to 1.23 t.ha^{-1}). The yields on the fertilized variants were balanced. We achieved a significantly higher number of plants (by 12.16 grains.m^{-2}) and spikes (by 31.56 grains.m^{-2}) at minimized tillage in comparison with conventional method. There was no significant difference among tillage methods for grain yields. The three year average showed that Graciosa reached a higher grain yield by 0.68 t.ha^{-1} compared to Malwinta.

Key words: winter barley, organo-mineral fertilizer, tillage method, variety, accumulation potential.

INTRODUCTION

The global climatic changes causing rapid fluctuations of weather are forcing us to monitor their impact on the crop production also. The impact of weather conditions on the growth and plant development is obvious, but less on nutrition and nutrient uptake through intensity of photosynthesis. The study of plant productivity in based on a conception, that production is a result of dynamic structure formation and optimal course of physiological processes. A basic physiological process, on which the phytomass production depends, is photosynthesis, respiration and growth (Kostrej, 1992). Growth and development is influenced along the right agrotechnics (soil condition, nutrition, variety selection and seed quality) mostly by temperature and precipitation, and not only during germination, but also through the entire growing season (Prášilová, 2001) and significantly affects the formation of yield components. For the most three important yield components Biberdžič et al. (2010) indicate the number of plants, number of grains per spike and thousand grain weight.

According to Molnárová and Kufelj (2000) the new biological material of winter barley forms yield through offshoot ears. The number of spikes is affected by moisture and nutrition level at the beginning of stem elongation, which determinates the intensity offshoot reduction and the rate of further evolving stems. This moisture certainty is often higher in conditions of maritime climate (Fazekašová, 2003), therefore we must place a greater emphasis to ensure a sufficient number of spikes and grains per area unit in conditions of continental climate (Macák et al., 2009).

Molnárová (1995) states, that the main tool of self-regulation of canopy density is the shooting, by which the consequences of adverse weather conditions are eliminated, but also the mistakes in agrotechnics. In addition to its self-regulation ability many external factors affect, whose are able to reduce some of the yield components, what can be ultimately reflected in the amount of grain yield (Žembery. 1997). Molnárová and Kufelj (2000) on the model characteristic of structural component of production and accumulation potential of winter barley for 8 $t.ha^{-1}$ grain yield achieved states number of plats per m^2 250-254, number of productive offshoots per m^2 471-492, number of spikes per m^2 734-747, number of grains per spike 21.05-21-70, grain weight per spike 0.97-1.09 g. The adverse effects of weather conditions can be partially eliminated by some actions of agrotechnics, such as nutrition and fertilization, tillage, variety selection and others. Optimal nutrition is a base for good growth and development of plants, its good health and sufficiently high final product. Unbalanced and insufficient nutrition has a result of adverse plant metabolism, which negatively effects the formation of yield components, amount of grain yield and yield quality. Different strategies of fertilization are based on the differences in nutrient requirements, which concludes form the modified yield potential of the varieties (Pan and Hopkins, 1991).Nitrogen is the nutrient, what barley takes up the most, then potassium and phosphorus (Kováčik, 2010). All measures at the canopy establishment should be aimed primarily at water management. Besides the conventional tillage system (with ploughing) we can use minimized technologies as well (Míša, 2001; Kováč and Žák, 2000).

The aim of the article is to evaluate the basic indicators of accumulation potential and grain yield of two winter barley varieties depending on year, two tillage methods and different fertilization treatments and relationship among grain yield and indicators of accumulation potential.

MATERIAL AND METHODS

The polyfactorial field trials were established on the experimental base of the Faculty of Agrobiology and Food Resources SAU in Nitra in years 2008, 2009 and 2010. Experimental base is classified and characterized according to Špánik, Repa and Šiška (2002) as a macroregion - warm, region - mostly warm and subregion - very dry. The average total annual rainfall is 561 mm, for vegetation period 333 mm. The average annual temperature is 9.7 °C. Trials were conducted on orthic luvisoils. The soils phosphorus content was 48 - 64 $mg.kg^{-1}$ and potassium content was 206-345 mg kg^{-1}, with active pH 5.9 - 6.5 (Tobiášová, Šimanský, 2009). The trials were established by split plot method in three repetitions. After white mustard as a preceding crop, we monitored two winter barley varieties: Graciosa, Malwinta; four variants of nutrition and fertilization: a = unfertilized control, b =Condit mineral at the doses of 1 $t.ha^{-1}$ (organo - mineral fertilizer), c = 60 kg N as saltpeter nitrate with limestone + leaf fertilizer (Hakofyt extra)+ P (22,7 kg), K (36 kg), d = 60 kg N as NH_4NO_3 + leaf fertilizer (Hakofyt extra) + P (22,7 kg) and K (36 kg); two soil cultivation methods: conventional tillage (ploughing to the depth of 0.20 meters) and minimized tillage (disk harrowing to the depth from 0.10 to 0.12 meters). Soil samples were taken to determine the Nan, P and K content before fertilization. Doses of P and K of fertilizers were calculated according to substitution system for yield level of 7.0 t ha^{-1}.

The trial was set in split plot method in three replications. The size of each plot was 14 m^2. After harvesting, grain yield was measured in each plot, and standardized at moisture content of 14 %. To determine number of plants per m^2, numbers of spikes per m^2, number of grain per spike, grain weight per spike samples were taken at full maturity before harvest of two lines of length 1 m. The obtained results were evaluated by analysis of variance in Statistica 8, and the differences were compared with Tukey – test.

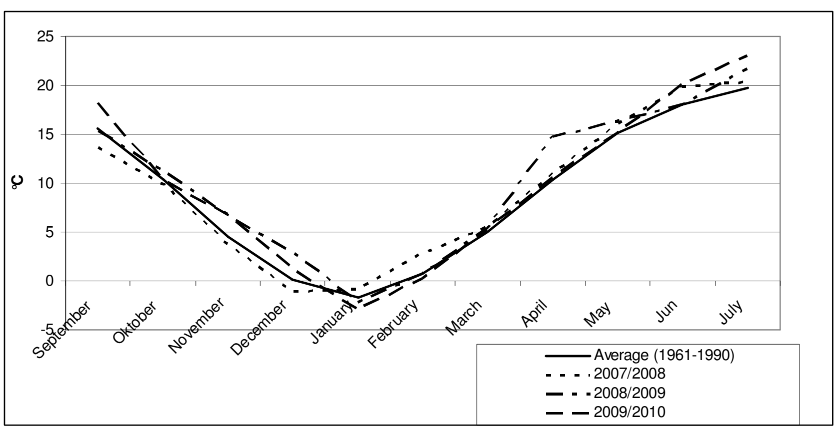

Fig. 1 Average monthly temperatures in seasons 2007/2008, 2008/2009 and 2009/2010 at Dolná Malanta

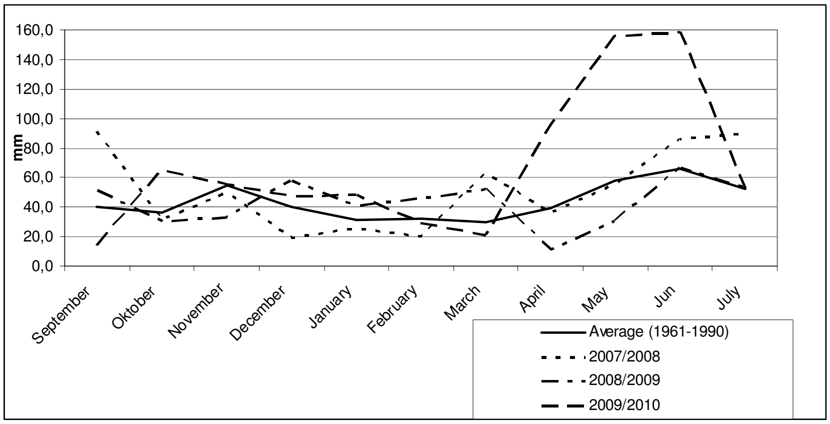

Fig. 2 Monthly amount precipitations in seasons 2007/2008, 2008/2009 and 2009/2010 at Dolná Malanta

RESULTS AND DISCUSSION

The results showed a significant effect of year, as a dominant source of variability, on number of plants before the harvest, number of spikes per area unit, grain weight per spike, thousand grain weight (TGW) and final grain yield. Similar results were found in our trials from previous years with spring barley (Líška, Žembery and Molnárová, 2003). Variety had a significant effect on the grain yield, number of spikes per unit area, number and weight of grain per spike. Tillage method had a significant effect on the number of plants and spikes per unit area. Fertilization had a significant effect on the grain yield, number of plants per unit area and number of grains per spike (Table 1).

From the results achieved (Table 2) significant yield differences between varieties are obvious in year 2007/2008. Graciosa variety achieved higher yield by 2.8 t.ha^{-1} compared to Malwinta. The highest grain yield during three monitored years was achieved in year 2009/2010 for both varieties 10.75 t.ha^{-1} for Graciosa, 1.05 t.ha^{-1} for Malwinta). In comparison with year 2008/2009 they are significantly higher values for both varieties by 3.34 and 3.19 t.ha^{-1}, respectively. In comparison with year 2007/2008 a significant difference was found only at Malwinta with yield difference of 3.26 t.ha^{-1}. The three year average shows, that significantly higher grain yield was achieved with Grasiosa by 0.68 t.ha^{-1} compared to Malwinta (Table 3). According to Žembery (1995), Sachs et al. (1999) the selection of variety for the given region is the most important step to successful cultivation.

Table 1

Analisys of variance for grain yield, number of plants per m^2, number of spikes per m^2, number of grains per spike, grain weight per spike and TGW

	D.f.	Grain yield	No. of plants	No. of spikes	No. of grains per spike	Grain weigh per spike	TGW g
Year (A)	2	**	**	**	NS	**	**
Variety (B)	1	**	*	NS	**	**	NS
Tillage method (C)	1	NS	*	*	NS	NS	NS
Fertilization (D)	3	**	*	NS	**	NS	NS
A x B	2	**	**	**	**	**	**
A x C	2	**	**	*	**	*	NS
B x C	1	NS	NS	NS	NS	NS	NS
A x D	6	**	**	*	**	*	NS
B x D	3	NS	NS	NS	NS	NS	NS
C x D	3	NS	NS	*	NS	NS	NS

d.f – degree of freedom, NS-not significant, *-significant at level of α=0.05-0.01, **- significant at level of α<0.01

Table 2

The interaction effect of year and variety on grain yield, number of plants per m^2, number of spikes per m^2, number of grains per spike, grain weight per spike and TGW

Year	Variety	Grain yield ($t.ha^{-1}$)	No. of plants (m^{-2})	No. o f spikes (m^{-2})	No. of grain ($spike^{-1}$)	Grain weight ($g.spike^{-1}$)	TGW (g)
2007/2008	Graciosa	10,59 b	163,17 bc	492,33 ab	25,01 c	1,15 a	46,13 a
	Malwinta	7,79 a	152,50 b	484,08 ab	21,95 a	1,28 b	59,10 cd
2008/2009	Graciosa	7,41 a	175,67 cd	472,00 b	20,75 a	1,28 b	61,92 d
	Malwinta	7,86 a	201,88 a	545,58 ac	26,34 d	1,46 c	55,35 bc
2009/2010	Graciosa	10,75 b	190,00 ad	543,17 ac	23,29 b	1,19 ab	51,42 b
	Malwinta	11,05 b	206,75 a	584,67 c	24,15 bc	1,12 a	46,29 a

Mean values followed by the same letter within columns do not differ significantly

Table 3

The effect of variety on on grain yield, number of plants per m^2, number of spikes per m^2, number of grains per spike, grain weight per spike and TGW

Variety	Grain yield ($t.ha^{-1}$)	No. of plants (m^{-2})	No. o f spikes (m^{-2})	No. of grain ($spike^{-1}$)	Grain weight ($g.spike^{-1}$)	TGW (g)
Malwinta	8,90 a	176,28 a	516,33 a	23,01 a	1,21 a	53,16 a
Graciosa	9,58 b	187.04 b	524,28 a	24,14 b	1,28 b	53,58 a

Mean values followed by the same letter within columns do not differ significantly

The higher grain yield for Graciosa in comparison with Malwinta was contributed by higher number of plants (by 10.67) and spikes (8.25) per unit area and by higher number of grains per spike (by 3.06) in year 2007/2008. Greater number of plants and spikes, as well as greater number of grains per spike was reached by Malwinta in following years, thus achieved higher grain yield. Significant differences among varieties in number of grains per spike was found in year 2007/2008, where Graciosa reached 25.01 grains per spike and Malwinta 21.95 grains per spike, as well as in year 2008/2009, where significantly higher values were found at variety Malwinta (26.34 grains per spike) in comparison with Graciosa (20.75 grains per spike). There was no significant difference found among varieties in year 2009/2010. There was a significant difference found also among varieties for grain weight per spike in years 2007/2008 and 2008/2009. Higher values of grain weight per spike was found at variety Malwinta in year 2007/2008 1.28 g.spike^{-1}, in year 2008/2009 1.46 g.spike^{-1}. Significant difference among varieties was not found in year 2009/2010 (Table 2).

Table 4

The effect of tillage method on grain yield, number of plants per m^2, number of spikes per m^2, number of grains per spike, grain weight per spike and TGW

Tillage method	Grain yield (t.ha^{-1})	No. of plants (m^{-2})	No. o f spikes (m^{-2})	No. of grain (spike^{-1})	Grain weight (g.spike^{-1})	TGW (g)
Conventional	9,31 a	176,62 a	504,53 a	23,36 a	1,24 a	53,59 a
Minimized	9,17 a	186,69 b	536,08 b	23,80 a	1,26 a	53,15 a

Mean values followed by the same letter within columns do not differ significantly

We found significant differences among tillage methods for number of plants per unit area (conventional tillage (CT) - 174.06 plants.m^{-2}, minimized tillage (MT) - 186.22 plants.m^{-2}) and for number of spikes per unit area (CT – 174.06 plants.m^{-2}, MT – 536.07 plants.m^{-2}) in favour of MT. There was no significant difference found among tillage methods for grain yield in three years average. Our findings suggests, that MT, which has lower energy and economic demands can be used within rational cultivation technologies of winter barley, which is proposed by Míša (2001), Kováč and Žák (2000) at winter wheat also (Table 4).

Table 5

The effect of tillage method on grain yield, number of plants per m^2, number of spikes per m^2, number of grains per spike, grain weight per spike and TGW

Fertilization variants	Yield (t.ha^{-1})	No. of plants (m^{-2})	No. o f spikes (m^{-2})	No. of grain (spike^{-1})	Grain weight (g.spike^{-1})	TGW (g)
Control (a)	8,36 a	170,00 b	509,14 a	23,35 a	1,23 a	53,17 a
Condit 1 t.ha^{-1} (b)	9,47 b	184,14 ab	508,75 a	24,63 b	1,28 a	52,62 a
SNL+Hakofyt extra (c)	9,59 b	186,56 a	531,14 a	23,46 a	1,23 a	52,80 a
NH_4NO_3 +Hakofyt extra (d)	9,55 b	185,94 a	532,19 a	22.88 a	1,24 a	54,89 a

Mean values followed by the same letter within columns do not differ significantly

In terms of fertilization significant differences were found for grain yield among fertilized treatments and unfertilized control. The yields on the fertilized variants were almost stable with no significant difference (from 9.74 to 9.59 t.ha^{-1}). The values of grain yield significantly higher (from 1.11 to 1.23 t.ha^{-1}) in comparison with control variant (8.36 t.ha^{-1}). The monitored varieties responded positively on the different forms of fertilizers. We found in our trials with spring barley, that Condit has a favourable effect on the grain yield in humid years and significantly reduces the yield in dry years (Kupecsek and Molnárová, 2010). The values of number of plants were lower on the control variant (170.00 plants.m^{-2}) by 14.14 – 16.56 plants.m^{-2} compared to fertilized variants. The differences among the fertilized variants were minimal. Gouis et al. (1999) states, that the number of spikes per m^2 was affected with fertilization the most, number of spikes are increasing with increasing N rate. Condit had a positive effect on the number of spikes, whereby the differences among the other variants of fertilization were significant (1.17-1.75 grain.spike^{-1}). There were no significant differences found among the fertilization variants for number of spikes per unit area, grain weight per spike and TGW.

The importance of yield components in terms of yield are confirmed by correlation relationships, according to which we found a significant relationship among grain yield, number of plants (0.21*), number of spike (0.26**) and number of grains per spike (0.22**). Among grain yield, grain weight per spike(-0,52***) and TGW (-0,61***) an indirect relationship was proved (Table 6). As the relationship among yield component and grain yield is closer, the greater attention should be given to its formation respectively to its reduction during vegetation.

Table 6

Correlation coefficients among grain yield, number of plants per m^2, number of spikes per m^2, number of grains per spike, grain weight per spike and TGW

	No. of plants (m^{-2})	No. o f spikes (m^{-2})	No. of grain (spike^{-1})	Grain weight (g.spike^{-1})	TGW (g)
Grain yield	0.21*	0.26**	0.22**	-0,52***	-0,61***
No. of plants (m^{-2})		0,75***	0,43***	0,15	-0,21*
No. of spikes (m^{-2})			0,37***	0,04	-0,26**
No. of grain (spike^{-1})				0,24**	-0,56***
Grain weight (g.spike^{-1})					0,66***

*Represents significant level of *0.05-0.01, **0,01-0,001, ***<0,001*

CONCLUSION

Significant relationship from the monitored indicators on accumulation potential of grain was found among grain yield and number of plant and spikes per m^2, as well as number of grains per spike. The year appeared as a dominant source of variability, which significantly affected the number of plants and spikes per unit area, grain weight per spike and grain yield also. Negative effect of less favourable year was at the development of selected indicators of accumulation potential partially eliminated by fertilization, tillage and variety. The elements of accumulation potential and grain yield were positively influenced by application of different forms of organo-mineral fertilizers (Condit and Hakofyt extra), which was reflected mainly at the increase on number of plants and number of grains per spike. The results confirmed the possibility of the use of economically favourable MT for winter barley also, at which significantly higher number of plants and spikes per unit area was found and thus in comparison with the arduous CT there was similar grain yield achieved.

The difference among the monitored varieties in three year average was 0.68 $t.ha^{-1}$ in favour of Malwinta.

Acknowledgement

This paper was written under the financial support of project Vega 1/0388/09/8 and 1/0237/11.

REFERENCES

1. Biberdžič, M. - Stošovič, D. – Deletišč, N. – Barač, S. – Stojkovič, S. (2010) Yield components of winter barley and triticale as affected by nitrogen fertilization. In research journal of agricultural science, 42 (1). p. 9-13.
2. Fazekašová, D.: 2003. Trvalo udržateľné využívanie pôdy – vymedzenie a hodnotenie indikátorov a parametrov vývoja pôdy. Prešov : FHPV PU,. 76 p.
3. Gouis, J.Le. – Delebarre, O. – Beghin, D. – Heumez, E. Pluchard, P. (1999) Nitrogen uptake and utilization efficiency of two – row and six row winter barley cultivars grown at two n levels. In European journal of agronomy. 10 (2), p. 73–79.
4. Kostrej, A. (1992) Kvantitatívne charakteristiky a modelovanie produkčného procesu. In Acta Fytotechnica. Nitra : VŠP, pp. 197.
5. Kováč, K. – Žák, Š. (2000) Využitie minimalizačných technológií pri zakladaní porastu jačmeňa jarného. Jačmeň-výroba a zhodnotenie ,Nitra, SPU, 2000, p. 70.
6. Kováčik, P. (2010) Výživa jačmeňa jarného dusíkom, fosforom a draslíkom. In Naše pole, 13 (3). p.
7. Kupecsek, A. - Molnárová, J. (2010) Effect of tillage methods, fertilization and variety on the grain yield and accumulation potential of spring barley. In proceedings of V. Vedecká konferencia doktorandov pri príležitosti Európskeho týždňa vedy, p. 245-248.
8. Líška, Žembery, J. - Molnárová, J. (2003) The influence of tillage system and fertilization on yield of spging barley. In proceedings of Udržateľné poľnohospodárstvo a rozvoj vidieka.p. 90-92.
9. Macák, M. – Žák, Š. – Birkás, M. – Slamka, P. (2008) The Influence of an ecological and low input system on yield and yield components of spring barley. In Cereal research communications, 36, Suppl. p. 1343 – 11346.
10. Miša, P. (2001) Zakladani porostu a hnojeni ozimeho ječmene. In Úroda, 30 (4), p. 6-7.
11. Molnárová, J. (1995) Úrodotvorný proces ozimného jačmeňa vo vzťahu k niektorým základným článkom agrotechniky a agroekologickým podmienkam ročníka. In Poľnohospodárstvo, 41 (11), p. 828-838.
12. Molnárová, J. – Kufelj, D. (2000) Vzťah medzi redukciou rastlín jačmeňa dvojradového ozimného vyzimovaním a stavom porastu pred prezimovaním. In Poľnohospodárstvo.46 (8), p. 605-618.
13. Pan, W. L. -Hopkins, A. H. (1991) Plant development, and N and P use of winter barley. In plant and soil, 135, p. 21-29.
14. Prášilová, P.: Růsta a vývoj ozimů v zimě 2000/01. In: Úroda, roč. 49, 2001, č. 5, s. 22 – 23.
15. Tobiášová, E. – Šimanský, V. (2009) Kvantifikácia pôdnych vlastností a ich vzájomných vzťahov ovplyvnených antropickou činnosťou. Nitra: SPU, p. 114.
16. Sachs, E. – Bivour, W. – Krumbiegel, D. (1999) Auswinterungsschaden an wintergerste (*Hordeum vulgare* L.), winterweizen (*Triticum aestivum* L.) Und wintertriticale (*Triticosecale* Wittm.) in Guterfelde/Brandenburg 1996/97. In Nachrichtenblatt des deutschen pflanzenschutzdienstes, 51(1), p. 9–13.
17. Špánik, F.- Repa, Š.- Šiška, B. (2002) Agroklimatické a fenologické pomery nitry (1991-2000). Nitra : SPU, 20 p.
18. Žembery, J. (1995) Vplyv niektorých antropogénnych zásahov na tvorbu úrody ozimného jačmeňa: kandidátska dizertačná práca. Nitra: SPU, p. 139 – 142.
19. Žembery, J. (1997) Vplyv ročníka a sledovaných antropogénnych zásahov na úrodotvorný proces viacradového ozimného jačmeňa. In Jačmeň - výroba a zhodnotenie : Odborný seminár s medzinárodnou účasťou. Nitra : SPU, p. 172-177.