THE ROOT SYSTEM CAPACITY DEVEVLOPMENT IN RELATION TO NUTRITION AND FERTILIZATION AND TILLAGE METHODS CONCERNING THE AMOUNT OF GRAIN PRODUCTION OF SPRING BARLEY

Kupecsek A., Molnárová J.

Department of Crop Production, Faculty of agrobiology and food resources, Slovak university of Agriculture in Nitra, A. Hlinku 2, 949 76 Nitra, Slovakia

E-mail: andrej.kupecsek@uniag.sk

ABSTRACT

The aim of the study was to monitor the development of the root system capacity (RSC) in relation to nutrition and fertilization and tillage impact on the amount of grain production of spring barley. The task was solved using polyfactorial field trials in agroecological conditions of warm corn production area in Slovakia in 2009. We monitored four spring barley varieties, two tillage methods, four variants of nutrition and fertilization. The RSC measurements were done using the LCR – meter in growth stages of BBCH 13 – 15; 23 – 25; 51; 85 – 89. Achievements were statistically evaluated in the program package Statistica 8. The results affirmed a positive correlation relationship between grain yield and fertilization (r = 0.44***). Due to the different types of the fertilization the highest values of the RSC were found at the variant with saltpetre nitrate with limestone. Conventional tillage had a favourable impact on RSC till the growth stage of tillering (BBCH 23-25) by all observed varieties, which also statistically affected the grain yield. The varieties were characterized by different RSC. The results showed that the highest RSC did not achieve the highest grain yield.

Key words: spring barley, nutrition and fertilization, tillage methods, root system electrical capacity, grain yield

Acknowledgments: Paper was elaborated due to financial support from VEGA 1/0551/08.

INTRODUCTION

Spring Barley crop is difficult crop for all of the factors affecting the yield formatting process, particularly on nutrition and fertilization. (Laco and Kováčová 2002). Nutrients uptake by plants is conditional particularly on the available nutrient content in soil, dose and form of fertilizer, depth and activity of root system as well as density of vegetation (Baier, 1999). Yield and quality of all cereals is heavily dependent on the availability of an adequate supply of soil mineral nutrients throughout the growing season. The higher the yield potential of the variety, the higher are the demands for nutrients (Morris and Bryce 2002). N uptake is influenced by available water degree of association between the roots and the soil, the supply of genotype, requirements and efficiency of N use, and other properties of the genotype and conditions of growing (Pruzulja and Momčilovič 2003). Nitrogen untaken from the fertilizers or from the soil is definitely applying to form the quality quantity of crops (Ložek 2000; Pruzulja and Momčilovič 2003). Based on the analysis of plant nutrition condition is good to response with leaf fertilizer. Plant leaf nutrition is based on the law of minimum, therefore together with nitrogen there is added an element, which the plant doesn't receives (Černý, 2007). Reduced and no tillage may give more yield than conventional tillage, especially in dry years. The no tillage system led to occasionally diminished yield through decreased N availability, which suggests that cereals under reduced tillage and no tillage may require additional N fertilizer to reach production levels similar to those of conventional tillage (Małecka and Blecherczik 2008). The primary beneficiaries of the minerals are the underground parts of plants, the roots. For this reason the plants fundamental need of NPK is supplied by classical fertilization through soil (Csekes 2002). Time and expanse are major constraints limiting the detection of genotypic differences in the length, structure and growth rate of root system. A conceptual model is presented that provides a rational basis for using plant root capacitance as an in-situ measurement for assessing plant root development. Capacitance maters may facilitate the non-destructive identification of genotypes with root characteristics that confer adaptation to various environments (van Beem, Smith and Zobel 1998; Dalton 1995). The electrical capacitance method is based on the polarization of biological membranes in the root system, and is dependent on the geometric and dielectric properties of the root system. The electrical capacitance or LCR meter measures the amount of electric charge stored by the root system for a given electric potential (in farads), which is dependent on the active root surface area and root length (McBride, Candido and Ferguson 2007). The aim of the study was to obtain knowledge about the influence of different variants of nutrition and fertilization, tillage methods on crop varieties and on the root system capacity (RSC).

MATERIAL AND METHODS

The task was solved within polyfactorial field trials in agroecological conditions of warm corn production area at Malanta in 2009. The trials were established by split plot method in three repetitions. According to the 50 years climate normal, the average annual rainfall is 532.5 mm, the average annual air temperature is 9.8 ^{o}C (Špánik, Repa and Šiška 2002). We studied four spring barley varieties: Bojos, Kangoo, Marthe, Xanadu; two tillage methods: conventional tillage (ploughing to the depth of 0.18 meters) and minimize tillage (disk harrowing to the depth of 0.10 to 0.12 meters). Also we studied four variants of fertilization. The first was unfertilized. The second was fertilized with an organic fertilizer Condit mineral at a dose of 1 $t.ha^{-1}$ before sowing. On the third variant we applied 60 kg N as saltpetre nitrate with limestone + leaf fertilizer (Hakofyt extra), and on the fourth 60 kg N as NH_4NO_3 + leaf fertilizer (Hakofyt extra). Foliar fertilizer Hakofyt extra we applied on the base of leaf analysis. Soil samples were taken to determine the N_{an}, 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 root system capacity (RSC) measurements were done using LCR - meter type ELC – 133A at a frequency of 1 kHz. Measurements have taken place in four growth stages. At leaf development, in the stage of four leaves (BBCH 13 - 15), in full tillering (BBCH 23 - 25), in the stage heading (BBCH 51) and at the stage of ripening (BBCH 85 - 89). Measurements were made on all variants of nutrition and fertilization, and tillage methods. Achievements were statistically evaluated by multi-factorial analysis (ANOVA) in the program package Statistica 8 (Tukey test), and the relationship between grain yield, RSC, tillage methods and fertilization were expressed by correlation coefficient (r).

RESULTS AND DUSCUSION

The nutrition and fertilization had a statistically significant influence on the grain yield (p = 0.0000) and RSC (p = 0.004843). Due to the different types of fertilization the highest yield (4.74 $t.ha^{-1}$) was achieved at the third variant in combination of saltpetre nitrate with limestone and the leaf fertilizer Hakofyt extra (Table 1). This testifies the values of the RSC in all growth stages, where this variant dominated. RSC at the variants fertilized with Condit was compared with other variants of fertilization lower, but differences were not statistically significant beside the growth stage of heading. The grain yield of this variant was compared with variants fertilized with commercial fertilizers in combination with leaf fertilizer significantly lower (Table 1). A positive relationship between yield and fertilization was proved (r = 0.4400***) (Table 4).

Table 1 Effect of nutrition and fertilization on the RSC (ηF) and grail yield

	BBCH 13 -15	BBCH 23 - 25	BBCH 51	BBCH 85 - 89	Yield $t.ha^{-1}$
unfertilized control	0.50 a	0.86 b	0.35 a	0.16 b	3.52 b
Condit 1 $t.ha^{-1}$	0.55 ab	0.99 a	0.37 b	0.18 ab	4.20 c
LAV (60 $kg.ha^{-1}$)+ Hakofyt extra	0.61 b	1.05 a	0.40 a	0.19 a	4.74 a
NH_4NO_3 (60 $kg.ha^{-1}$)+ Hakofyt extra	0.60 ab	1.04 a	0.36 a	0.20 a	4.65 a

There was not a significant difference between the figures in the columns that are coded by the same letter (α < 0.05).

The tillage methods had a statistically significant influence on the grain yield (p = 0.01414) and the RSC (p = 0,00000). Conventional tillage had a favourable impact on RSC till the growth stage of tillering (BBCH 23-25) by all observed varieties. The conventional tillage had a significantly greater yield compared to the minimized tillage by 0.20 $t.ha^{-1}$ (Table 2). A negative relationship between tillage methods and RSC at the growth stage of tillering was proved (r = 0.6460***) (Table 4).

Table 2. Effect of tillage methods on the RSC (ηF) and grail yield

	BBCH 13 -15	BBCH 23 - 25	BBCH 51	BBCH 85 - 89	Yield $t.ha^{-1}$
Conventional tillage	0.57 a	1.17 a	0.35 a	0.18 a	4.44 b
Minimized tillage	0.56 a	0.80 b	0.38 b	0.18 a	4.14 a

There was not a significant difference between the figures in the columns that are coded by the same letter ($\alpha < 0.05$).

The varieties were characterized by different RSC. Results showed that the highest RSC did not achieve the highest grain yield as Cerkal et al. (2008) states. The difference is probably contingent by a nature of other biological material and different conditions of a site. CRS by the highest yield by the variety Kangoo (4.50 $t.ha^{-1}$) was compared to the highest achieved CRS, achieved by the variety Bojos, 9.8 to 18.7% lower.The obtained results indicate a different adaptability of observed varieties on the uneven distribution of rainfall during the vegetation.

Table 3. Effect of variety on the RSC (ηF) and grail yield

	BBCH 13 -15	BBCH 23 - 25	BBCH 51	BBCH 85 - 89	Yield ($t.ha^{-1}$)
Xanadu	0.51 a	1.04 a	0.38 a	0.18 ab	4.13 a
Bojos	0.63 b	1.07 a	0.41 a	0.21 b	4.18 a
Marthe	0.58 ab	0.96 ab	0.31 b	0.16 a	4.35 a
Kangoo	0.52 a	0.87 b	0.37 a	0.18 ab	4.50 a

There was not a significant difference between the figures in the columns that are coded by the same letter ($\alpha < 0.05$).

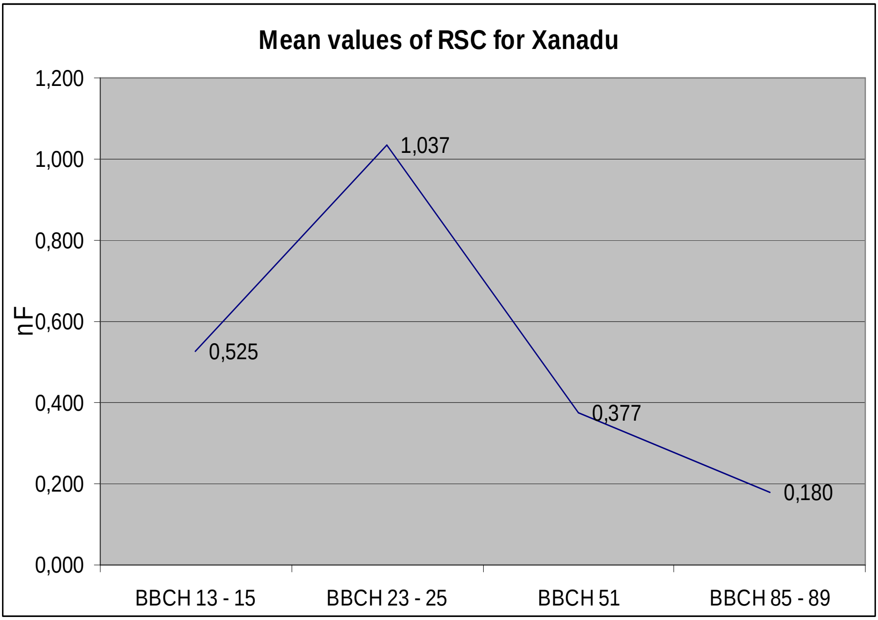
Table 4. Correlation coefficient among yield, RSC at the growth stages, variety, tillage and fertilization (n = 96)

	BBCH 13 - 15	BBCH 23 - 25	BBCH 51	BBCH 85 - 89	Variety	Tillage	Fertilization
Yield	0,1572	0,2344*	0,0818	0,1036	0,1157	-0,1575	0,4400***
BBCH 15-15		0,2122*	0,1715	-0,0876	-0,0341	-0,0423	0,1605
BBCH 23 - 25			0,0310	0,1438	-0,2441*	-0,6460 ***	0,2363*
BBCH 51				0,1212	-0,1305	0,1685	0,0604
BBCH 85 - 89					-0,1043	0,0731	0,2843**

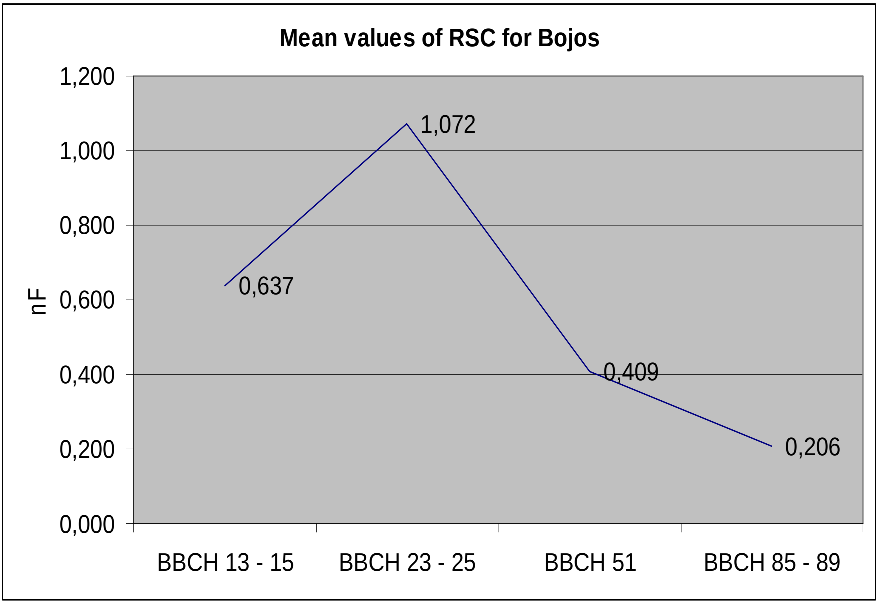
* Represents significance level of 0.05-0.01, ** 0.01-0.001, and *** <0.001.

Course development of RSC is demonstrated with Graphs 1 to 4. The curve has an almost identical course for each variant. The highest values were measured during the growth stage of tillering and at the other stages the RSC values decreased. According to Pietola (2005), after grain formation the root numbers decreased toward full ripeness.

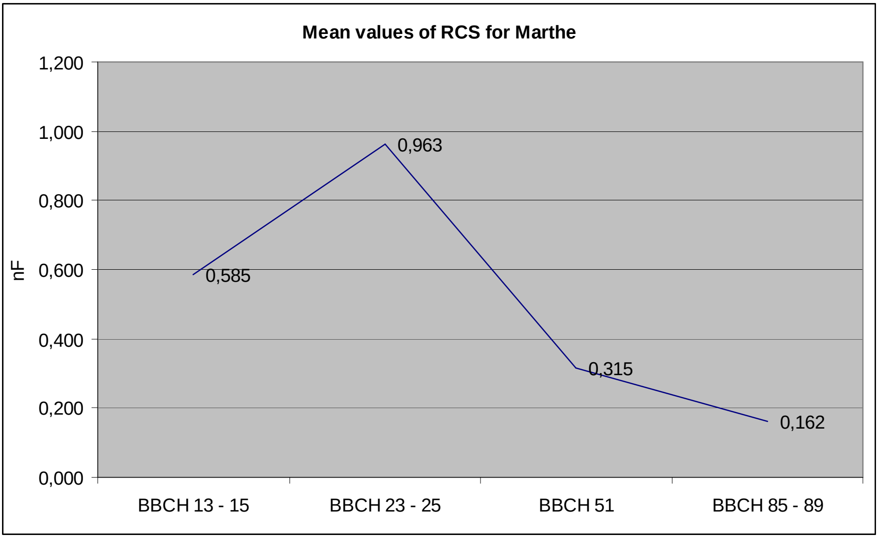
Graph 1



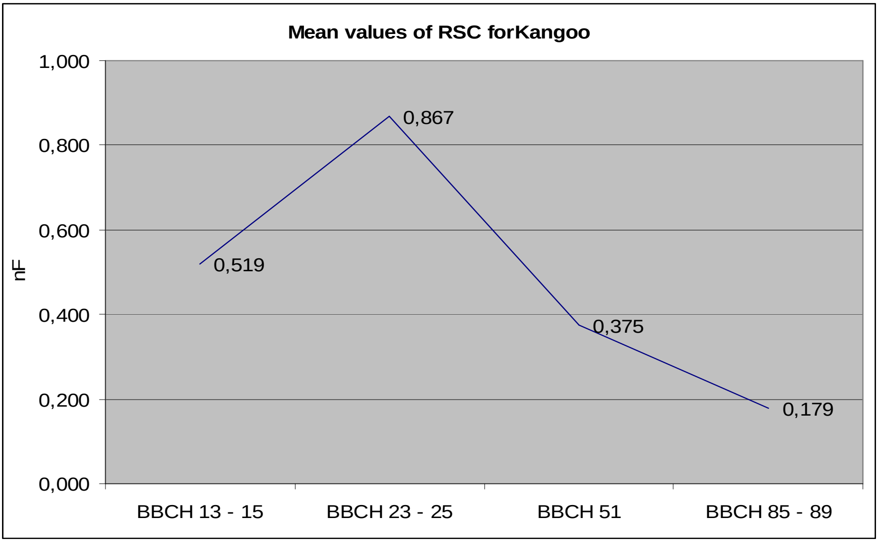
Graph 2



Graph 3



Graph 4



CONCLUSION

1. In terms of reached yield and RSC the application of chemical fertilizers in combination with leaf fertilizer Hakofyt extra compared with the Condit application was advantageous,

2. The conventional tillage had a favourable effect on the grain yield compared to the minimized tillage till the growth stage of tillering and ensured a statistically higher yield (by 0.20 $t.ha^{-1}$)

3. The greater RSC doesn’t leads to higher yields.

REFERENCES

Been van J., Smith M.E., Zobel R.W. (1998): Estimating root mass in maize using portable capacitance mater. Agronomy Journal 94 (4): 566 – 570. ISSN: 0002 – 1962.

Baier J. (1999): Soudobý přínos mimokořenová výživy obilnin. Výskumný ústav rostlinné výroby Praha.

Cerkal R., Vejražka K., Ryant P.,Hřivna L.,Prokeš J. (2008): Root capacity and its influence on nutrient uptake by malting barley grain. Cereal research communications (36): 111 - 114. ISSN: 0133 – 3720.

Černý L., Vašák J., Křováček J., Hájek M. (2007): Jerní sladovnícký ječmen. ČZU Praha, 39 s, ISBN 978-80-87111-04-8.

Dalton, F.N. (1995): In-situ root extent measurement by electrical capacitance methods. Plant and soil (173): 157 – 165. ISSN: 0032 – 079X.

Csekes Z. (2000): Všeobecná rastlinná výroba. SPU Nitra, 2000. 160 s. ISBN 80-7137-695-7.

Laco O., Kováčová E. (2002): Vzťah medzi úrodou, kvalitou a hnojením jarného jačmeňa. Agrochémia (42): s. 18.

Ložek O., (2000): Racionálna výživa a hnojenie jarného jačmeňa so zreteľom na sladovnícku kvalitu zrna. Jačmeň - výroba a zhodnotenie. SPU Nitra, 2000. str. 81. ISBN 80-7137-681-7.

Małecka I., Blecharczy K. A. (2008): Effect of tillage systems, mulches and nitrogen fertilization on spring barley (*Hordeum vulgare*). Agronomy Research 6 (2): 517–529.

McBride R , Candido M., Ferguson J., (2008): Estimating root mass in maize genotypes using the electrical capacitance method. Agronomy and Soil Science (54): 215 – 226. ISSN 1476-3567.

Morris P.C., Bryce J.H. (2002): Cereal Biotechnology. Woodhead Publishing . 252 p. ISBN 978-1-59124-026-6.

Pietola L.M. (2005): Root growth dynamics of spring cereals with discontinuation of mouldboard ploughing. Soil & Tillage Research (80): 103 – 114. ISSN**:** 0167-1987.

Pruzulja N., Momčilovič V. (2003): Dry matter and nitrogen accumulation and use in spring barley. Plant, Soil and Enviroment (49): 36-47. ISSN 1214-1178.

Špánik F., Repa Š., Šiška B. (2002): Agroklimatické a fenologické pomery Nitry (1991-2000). SPU Nitra, 20s. ISBN 80-7137-987-5.