PRODUCTION PROCESS OF WINTER WHEAT (*TRITICUM AESTIVUM* L.) UNDER DIFFERENT SOIL CULTIVATION AND FERTILIZATION

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Abstract: *The influence of conventional and minimal soil cultivation in interaction with mineral fertilization and utilization of the by-product on the winter wheat yield, uptake of nutrients by yield and energetic effectiveness in experimental years 2004-2006 was investigated in the experiment. Within each soil cultivation method, three treatments of fertilization were applied: 0 - control without fertilizing, PH - rational fertilization with mineral fertilizers, PZ - rational fertilization with mineral fertilizers and incorporation of post harvest residues into soil. The rates of mineral fertilizers were determined on the basis of soil analysis for contents of available nutrients and planned grain yield of winter wheat (6 t ha^{-1}). The rate of nitrogen was determined on the basis of soil and plant analysis. Different soil cultivation did not influence grain yield significantly. Higher yield by 0.17 t ha^{-1} was achieved at minimal cultivation than at ploughing. In fertilized treatments grain yield was significantly higher than in unfertilized control. On the average of three experimental years and cultivation methods, the highest yield of grain (7.26 t ha $^{-1}$) was gained in treatment rationally fertilized by mineral fertilizers. As far as the preceding crop is concerned, common pea (Pisum sativum L.) seems to be better forecrop than red clover (Trifolium pratense) which is confirmed by high grain yield (6.25 t ha^{-1}) on unfertilized treatment in year 2004 and by low fertilizer nitrogen rate (20 and 30 kg ha^{-1}) determined in fertilized treatments, respectively. Common pea accumulated by symbiotic fixation such amounts of nitrogen which enabled to omit fertilization with nitrogen before sowing as well as in the term of regeneration dressing. Increment of grain yield was influenced by forecrop (21.7 %), soil cultivation (3.3 %), fertilization (32.9 %) and year (42.1 %). There was found out strong linear relationship between yield of phytomass and NPK nutrients uptake (r = 0.817^{xxx}). One ton of grain and relevant amount of straw of variety Bonita took up 21.7 kg of N, 4.9 kg of P, 15.6 kg of K, 4.6 kg of Ca and 2.2 kg of Mg from soil. Energetic effectiveness of fertilization with nitrogen fertilizers is very good. On the average of three experimental years higher energetic effectiveness was determined under conventional soil cultivation (E = 15.3). Within fertilized treatments the highest energetic effectiveness of nitrogen fertilization was calculated in treatment fertilized with mineral fertilizers (E = 13.5).*

Key words**:** *winter wheat, tillage of soil, mineral fertilizers, post harvest residue, yield of grain, nutrients uptake*

INTRODUCTION

Winter wheat receives relatively the major attention in relation to fertilizing and nutrition conditions study (BERTIC et al., 2007; PEPO, 2007). It is particularly nitrogen which has special position in winter wheat nutrition. Winter wheat is capable to utilize nitrogen from both soil and applied fertilizers for grain yield formation during the whole growing season. Up to the beginning of shooting it takes up 41 % N, further 18 % N up to earing, 12 % till flowering and remaining 29 % of N to the harvest of yield (MICHALÍK, 2001). Considerable movement of mineral forms of nitrogen in soil and high potential for its losses require to implement system of split nutrition of winter wheat with nitrogen which is considered to be a regulator of yield-forming process (BÍZIK, 1989).

From the viewpoint of nitrogen nutrition effect on winter wheat grain yield, the most important periods are realized as follows: the beginning of tillering DC 25 (regeneration

dressing), end of tillering and shooting DC 29-30 (production dressing) and earing DC 56 (quality dressing).

MATERIAL AND METHODS

Field experiment was established in three replications on the fields of experimental basis of SPU Nitra at Dolná Malanta locality in the year 2003/2004 – 2005/2006. The locality is situated in maize productional region belonging to very warm and dry subregion with altitude of 175-180m above sea level. Average year air temperature is 9.7°C and average annual sum of precipitation accordingly to long-term normal represents 561mm. Soil is loamy brownsoil originated on proluvial loessial sediments. Agrochemical soil characteristics are stated in table 1.

Table 1

Agrochemical soil analysis

Year	Content of available nutrients in soil (mg.kg^{-1})			pH_{KCl}	K : Mg
	P	K	Mg		
2003/2004	78	373	202	6.88	0.54
2004/2005	79	408	252	6.38	0.62
2005/2006	79	408	224	6.37	0.55

In the experiment two methods of soil cultivation were examined: B_1 - conventional mouldboard plough tillage to the depth of 0.2m followed by surface cultivation of topsoil, B_2 - minimal cultivation - offset disc ploughing to depth of 0.15m and combined cultivator.

Within each cultivation method, three treatments of fertilization were applied: 0 - control without fertilizing, PH - rational fertilization with mineral fertilizers, PZ - rational fertilization with mineral fertilizers + incorporation of post harvest residues into soil.

The rates of mineral fertilizers were determined on the basis of soil analysis for contents of available nutrients and planned grain yield of winter wheat (6 t ha^{-1}). The rate of nitrogen for both pre-seeding and regeneration fertilizing was also determined by soil analysis and for productional and qualitative dressing on the basis of plant analysis, that is accordingly to the content of total nitrogen in aboveground phytomass and dry weight of 100 plants (MICHALÍK, LOŽEK, 1985).

Nitrogen was applied in the form of ammonium nitrate with dolomite, phosphorus in the form of 19 % superphosphate and potassium in the form of 60 % potassium salt (KCl). Applied rates of nutrients are illustrated in table 2.

As a preceding crop of winter wheat (variety Bonita) was common pea *(Pisum sativum* L.) + intercrop which was mustard (*Brassica hirta* Moench) in year 2003/2004. In the following experimental year the forecrop was red clover *(Trifolium pratense*). Sampling of plant material was carried out in full maturity of winter wheat. Uptake of nutrients was calculated on the basis of winter wheat yield and content of macronutrients in main and by-product. By means of multifactoral analysis (ŠPALDON et al., 1989) the portion of respective agrotechnical measures on the grain yield increment was calculated.

The aim of the contribution is evaluate productional process of winter wheat under conventional and minimal soil cultivation in interaction with mineral fertilization and utilization of organic matter of by-product in experimental years 2004-2006.

Table 2

Rates of nutrients for winter wheat fertilizing

Year	Treatment	Rate of nutrients (kg ha^{-1})					
		N				P	K
		Fertilizing					
		essential	regeneration	productional	qualitative		
2003/2004	B_1 - PH	-	-	20	-	30	-
	B_1 - PZ	-	-	20	10	30	-
	B_2 - PH	-	-	20	-	30	-
	B_2 - PZ	-	-	20	10	30	-
2004/2005	B_1 - PH	-	20	30	15	30	20
	B_1 - PZ	-	30	30	15	30	20
	B_2 - PH	-	30	45	20	30	20
	B_2 - PZ	-	30	45	15	30	20
2005/2006	B_1 - PH	-	40	20	-	30	20
	B_1 - PZ	-	30	0	15	30	20
	B_2 - PH	-	40	20	10	30	-
	B_2 - PZ	-	30	0	10	30	-

RESULTS AND DISCUSSIONS

Grain yield of winter wheat in experimental years 2003/2004 - 2005/2006 was affected by year that is by course of weather conditions in respective year, fertilization and forecrop (table 3).

In harvest year 2005 characterized with deficit of precipitation in critical periods for grain yield formation, statistically highly significantly lower yield of grain was obtained than in harvest years 2004 and 2006.

This yield was lower by 1.81 t ha^{-1} in comparison with year 2004 in spite of application higher doses of nitrogen fertilizers. In comparison to year 2006 the yield was lower by 1.49t ha^{-1}.

Different soil cultivation did not influence grain yield of winter wheat significantly. It was confirmed that winter wheat does not react substantially on the depth of soil cultivation and does not require loose soil for growth (KOVÁČ et al. 2005, MACÁK et al. 2009). Higher yield of grain (by 0.17 t ha^{-1}) was achieved with minimal technology than with ploughing. Different grain yields were influenced by fertilization in interaction with soil cultivation. The highest yield of grain (7.27 t ha^{-1}) was obtained under conventional soil cultivation in treatment with post harvest residues incorporation into the soil (B_1 - PZ). When minimal soil cultivation was carried out the highest grain yield (7.56 t ha^{-1}) was achieved in treatment with mineral fertilizers application (B_2 - PH). In the case that post harvest residues were shallowly incorporated into soil by disc cultivator the grain yield of winter wheat was lower by 0.59 t ha^{-1}. Post harvest residues situated on the soil surface are physically out of microorganisms activity and are exposed to drying and temperature extremes.

On the average of three years and methods of soil cultivation, fertilization showed highly significant effect on grain yield of winter wheat.

As far as the preceding crop is concerned, common pea (*Pisum sativum* L.) seems to be better forecrop than red clover (*Trifolium pratense*) which is confirmed by high grain yield (6.25 t ha^{-1}) on unfertilized treatment in year 2004 and determined low fertilizer nitrogen rate (20 and 30 kg ha^{-1}) in fertilized treatments, respectively. Common pea accumulated by symbiotic fixation such amounts of nitrogen which enabled to omit fertilization with nitrogen before sowing as well as in the term of regeneration dressing.

Red clover is less favourable preceding crop in dry years in which the yield considerably declines; what was also manifested in year 2005.

In assessed period, forecrop contributed to the grain yield by 21.7 %, soil cultivation by 3.3 %, fertilization by 32.9 % and year by 42.1 % (Figure 1).

Table 3

Yield of winter wheat grain, variety Bonita

Year	Treatment	Tillage of soil				Average	
		B_1		B_2			
		Yield of grain					
		t ha^{-1}	relat. %	t ha^{-1}	Relat. %	t ha^{-1}	relat. %
2003/2004	Control	6.45 a	100.0	6.02 a	100.0	6.25 a	100.0
	Mineral fertilizers	7.96 b	123.4	7.39 b	122.8	7.68 b	122.9
	Post harvest residue	8.84 b	137.1	7.96 b	132.2	8.40 b	134.4
	Average	**7.75**		**7.12**		**7.43**	
2004/2005	Control	4.54 a	100.0	5.51 a	100.0	5.03 a	100.0
	Mineral fertilizers	5.97 b	131.5	6.10 a	110.7	6.04 a	120.1
	Post harvest residue	5.98 b	131.7	5.63 a	102.2	5.81 a	115.5
	Average	**5.50**		**5.75**		**5.62**	
2005/2006	Control	6.09 a	100.0	6.17 a	100.0	6.13 a	100.0
	Mineral fertilizers	6.93 a	113.8	9.20 b	149.1	8.07 b	131.7
	Post harvest residue	6.99 a	114.8	7.32 b	118.6	7.16 ab	116.8
	Average	**6.67**		**7.56**		**7.11**	
Average	Control	5.69 a	100.0	5.90 a	100.0	5.80 a	100.0
	Mineral fertilizers	6.95 b	122.1	7.56 b	128.1	7.26 b	125.2
	Post harvest residue	7.27 b	127.8	6.97 b	118.1	7.12 b	122.8
	Average	**6.64**		**6.81**		**6.72**	

Years Hd $_{0.05}$ = 0.8494 Hd $_{0.01}$ = 1.0759

Tillage of soil Hd $_{0.05}$ = 0.7922 Hd $_{0.01}$ = 1.0556

Fertilization Hd $_{0.05}$ = 1.0468 Hd $_{0.01}$ = 1.3239

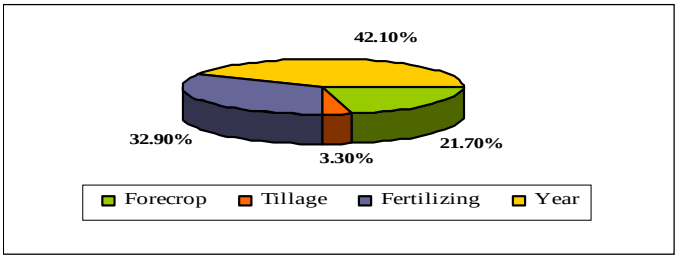

Figure 1: Contribution of respective articles of agrotechnics and year to the increment of winter wheat grain yield

On the average of three years, the yield of straw was not statistically significantly influenced by soil cultivation technology. There was visible tendency of grain/straw ratio decrease with increasing nitrogen rate in respective years.

High energy requirements in nitrogen fertilizers production create a strong emphasize on their rational utilization in agricultural practice. Energetical input of mineral fertilizers should be adequate to an increase of organic matter produced by agricultural crop. If it is not so, then in addition, further constant input energy (mechanical, human, chemical etc.) is not utilized effectively.

Higher energetic effectiveness of fertilization was achieved under conventional soil cultivation

(E = 15.3) on the average of three experimental years. Within the framework of fertilization treatments the higher energetic effectiveness was manifested in treatment fertilized with mineral fertilizers (E = 13.5). Energetic effectiveness of winter wheat fertilization found out on the basis of soil and plant analyses in this experiment can be accepted as very good (Figure 2).

Only the nutrients taken up by plant can be utilized for yield formation. Three year results show that different soil cultivation did not influence markedly uptake of nutrients by both grain and straw yields on the average of fertilization treatments and experimental years. However, uptake of nutrients by plants was influenced by fertilization. The lowest uptake of nutrients by wheat phytomass was determined in control treatment, the highest one on the treatment fertilized with mineral fertilizers together with incorporation of post harvest residues (PZ). Difference between fertilized treatments was small (Table 4).

Table 4

Uptake of nutrients by winter wheat (average of years 2004-2006)

Treatment			Uptake of nutrients (kg ha^{-1})				
			N	P	K	Ca	Mg
B_1	0	Grain	97.6	22.43	19.81	7.04	6.78
	PH		125.93	27.44	24.46	8.45	8.15
	PZ		135.11	28.22	25.60	8.47	8.47
Average B_1			**119.40**	**26.03**	**23.29**	**7.99**	**7.80**
B_2	0		96.23	22.17	19.74	7.14	6.75
	PH		134.02	28.71	25.51	9.40	8.43
	PZ		134.16	26.23	22.36	7.78	7.68
Average B_2			**121.47**	**25.70**	**22.54**	**8.11**	**7.62**
Average B_1, B_2			*120.44*	*25.87*	*22.91*	*8.05*	*7.71*
B_1	0	Phytomass	121.19	28.11	91.16	26.25	12.27
	PH		155.22	34.22	115.08	31.44	14.46
	PZ		164.03	34.71	116.43	31.76	16.11
Average B_1			**146.81**	**32.35**	**107.56**	**29.82**	**14.28**
B_2	0		119.05	27.85	89.48	25.53	12.51
	PH		166.27	35.43	111.78	34.29	15.93
	PZ		160.78	31.83	102.55	30.65	14.26
Average B_2			**148.70**	**31.70**	**101.27**	**30.16**	**14.23**
Average B_1, B_2			*147.76*	*32.03*	*104.41*	*29.99*	*14.26*

On the average of years, cultivation and fertilization, wheat phytomass took up 147.8 kg ha^{-1} N, 32.0 kg ha^{-1} P, 104.4 kg ha^{-1} K, 30.0 kg ha^{-1} Ca and 14.3 kg ha^{-1} Mg. Very high linear relationship between yield of winter wheat phytomass and NPK nutrients uptake (r = 0.817^{xxx}) was found out (Fig. 3).

Uptake of nutrients by 1 ton of grain and relevant amount of straw of Bonita variety fluctuated within the range 20.1 - 22.6 kg (N), 4.7 - 5.2 kg (P), 14.7 - 16.7 kg (K), 4.3 - 4.7 kg (Ca) and 2.1 - 2.3 kg (Mg). Results achieved in this parameter are comparable with data of FECENKO and LOŽEK, (2000) and VANĚK et al. (2007).

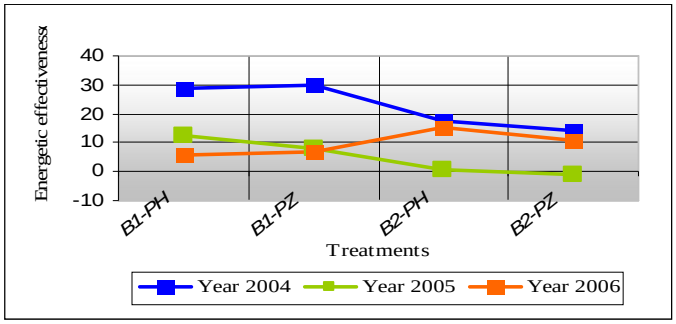

Figure 2: Dependence of energetic effectiveness of winter wheat fertilization by nitrogen on soil cultivation technology

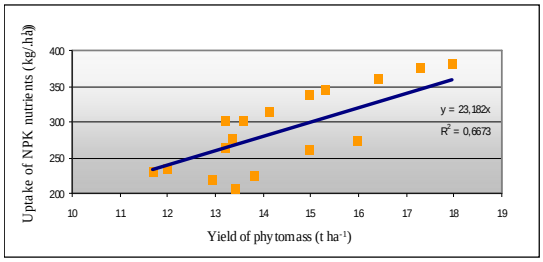

Figure 3: Correlation between the phytomass yield and uptake of NPK nutrients

CONCLUSION

Different soil cultivation did not influence grain yield significantly. Higher yield by 0.17 t ha^{-1} was achieved at minimal cultivation than at ploughing. In fertilized treatments grain yield was significantly higher than in unfertilized control. On the average of three experimental years and cultivation methods, the highest yield of grain (7.26 t ha^{-1}) was gained in treatment rationally fertilized by mineral fertilizers. Red clover is less favourable forecrop in dry years in which the yield considerably declines, what was also manifested in year 2005. There was found out strong linear relationship between yield of phytomass and NPK nutrients uptake (r = 0.817^{xxx}). One ton of grain and relevant amount of straw of variety Bonita took up 21.7 kg of N, 4.9 kg of P, 15.6 kg of K, 4.6 kg of Ca and 2.2 kg of Mg from soil.

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