Buletin USAMV-CN, 64/2007 (-)
ISSN 1454-2382

ECONOMIC ANALYSIS OF WINTER BARLEY PRODUCTION FOR DIFFERENT SOIL TILLAGE AND NITROGEN FERTILIZATION SYSTEMS

Stipesevic, B., D. Jug, M. Stosic, I. Zugec, I. Jug

Faculty of Agriculture Osijek, Trg Sv. Trojstva 3, 31000 Osijek, Croatia, bojans@pfos.hr

Key words: winter barley, soybean, mouldboard ploughing, diskharrowing, nitrogen, relative profit

Abstract. The winter barley crop production is not adequately researched regarding soil tillage systems, especially in crop rotation with the soybean, both crops gaining importance as food for the animals. The research at experimental site Boksic (Croatia), during the years 2005 and 2006, showed no difference in yields from conventional tillage, based on mouldboard ploughing, and reduced tillage, based on diskharrowing, in each of six nitrogen fertilization levels (0, 30, 60, 90, 120 and 150 kg N ha^{-1}). Regarding N fertilization, yield increase was not significantly higher after applied 90 kg N ha^{-1}. The diskharrowing with 90 kg N ha^{-1} showed to be the most profitable tillage system.

INTRODUCTION

The soil tillage systems for winter barley production had been reconsidered during the last decade, especially in the light of the Croatian needs for more affordable and high quality cattle fodder. This process is a result of worldwide trends and research results about tillage simplifications for higher sustainability of the agriculture, in which the environment protection and decreases of tillage costs is especially emphasised [1]. In the Slavonia, the most agricultural region of the Republic of Croatia, various systems of reduced tillage for different crops have been already tested [2, 3, 4, 5, 6], with main goals to decrease the costs of production, maintain agrosphere sustainability and to preserve high yield (characteristic for this region) despite the reduction of applied agritechniques. Along with the introduction of reduced tillage systems, the awareness has been raised of different approach toward fertilization, soil compaction, weed control and other problems connected with lesser soil agitation. The simplified soil tillage particularly raised the question of efficiency of fertilizers, especially nitrogen, in interaction with the tillage systems.

MATERIALS AND METHODS

This research was conducted near Boksic in Eastern Croatia, for the winter barley (*Hordeum vulgare L.*) in a crop rotation after soybeans (*Glycine max L.*) for crop seasons 2004/05-2005/2006. The site's soil type was determined as a eutric cambisol, with loamy clay texture, total porosity between 32.2-44.7%, bulk density from 1.30 to 1.70 kg dm^{-3}, neutral reaction (pH in KCl 6.8), with rather high content of humus (4.%), and with poor fertility (6.6 mg P_2O_5 and 6.8 mg K_2O per 100 g of soil, 2.8 % of $CaCO_3$) in 0-30 cm depth. The main experimental set-up was a split-plot design in three repetitions, where the main treatment was soil tillage with two steps: CT=conventional tillage (autumn ploughing up to 25 cm depth, spring diskharrowing, followed by seedbed preparation with rototiller and standard sowing) and DS=autumn diskharrowing up to 20 cm depth, seedbed preparation with rototiller in spring and standard sowing. The sub-treatment of the nitrogen fertilization consisted of six steps of nitrogen fertilization: N1=0, N2=30, N3=60, N4=90, N5=120 and N6=150 kg N ha^{-1} (see Table 1 for the nitrogen fertilization distribution), with the same amount of phosphorus (83 kg P_2O_5 ha^{-1}) and potassium (124 kg K_2O ha^{-1}) each season. The phosphorus and potassium amounts were determined by soil analyses and planned crop uptake recommendations. The basic experimental plot size was 5 m wide and 30 m long (total area of 150 m^2). The winter barley cultivar "Trenk" was sown, the creation of the Agricultural Institute Osijek, Croatia, in recommended plant density of 450 plants m^{-2}, within the optimal sowing dates (31. October 2004 and 20. October 2005). During the harvest time, plots were harvested one by one and complete grain mass from each plot was weighted on portable electronic scale, whereas moisture content was determined by "Dickey John GAC 2000" grain moisture meter, from ten subsamples taken during the harvest and preserved in the plastic bags. The split-split-plot ANOVA was performed by SAS statistic package (V 8.02, SAS Institute, Cary, NC, USA, 1999) with Year as the main level, Tillage as sub-level and added N as sub-sub-level for the winter barley yields. The Fisher protected LSD means comparisons were performed for P=0.05 significance levels. Regarding costs, everything is expressed as the difference in comparison with the lowest input treatment, which was the Diskharrowing + 0 kg N/ha. The mouldboarding ploughing tillage (CT) cost was for 600 HRK/ha greater than the diskharrowing tillage alone (DS), whereas 1 kg N cost was 5.18 HRK/kg, and winter barley price was 0,85 HRK/kg.

Table 1: Fertilization scheme for the Boksic experimental trial

Fertilization levels	Autumn fertilization			1st Sidedressing	2nd Sidedressing
	0PK 0:20:30	NPK 8:22:33	Urea 46% N	KAN 27% N	KAN 27% N
N1: 0 kg N ha^{-1}	413	-	-	-	-
N2: 30 kg N ha^{-1}	-	375	-	-	-
N3: 60 kg N ha^{-1}	-	375	-	111	-
N4: 90 kg N ha^{-1}	-	375	-	111	111
N5: 120 kg N ha^{-1}	-	375	-	167	167
N6: 150 kg N ha^{-1}	-	375	65	167	167

RESULTS AND DISCUSSION

The rather favourable weather condition in both years managed rather high yields for winter barley under both tillage systems with adequate available nitrogen, with no statistical differences between Tillage treatments for all Nitrogen treatment levels (Table 2), although DS tended to be slightly higher, especially at lower Nitrogen levels (N1 through N3). This effect was probably the result of higher concentration of incorporated soybean residues in shallower upper soil layers. At the fertilization levels higher than 60 kg N ha^{-1} (N4 through N6), this difference tended to decrease due to the sufficient nitrogen supply in both Tillage treatments. These results were in accordance with some authors whose trials included ploughing and continuous diskharrowing, who reported that, under favourable agroecological conditions, yields did not differ among conventional tillage and other reduced tillage systems [7]. However, some other authors with similar soil tillage treatments recorded that usually conventional tillage had better results than reduced soil tillage systems [8, 9], although some of them [9] pointed out that different placement and higher amount of nitrogen could alleviate negative effects of reduced tillage and thus unfavourable soil preparation for cereals growth at the yield level achieved with the conventional tillage based on ploughing. Along with the increase of N amount, the winter barley responded with significant yield growth between N2 to N3 (2.69 to 3.35 t ha^{-1}, respectively) and between N3 to N4 (from 3.35 to 3.85 t ha^{-1}), with better crop reaction between N2 to N3 (for 663 kg ha^{-1} or increase of 25% in comparison with the yield at N2 level), than between N3 to N4 (for 498 kg ha^{-1} or 15% if compared with N3). These yield leaps are corresponding with the Mitscherlich's theory of lowering yield's increase, and roughly determining Nitrogen levels N3 and N4 as Baule 2 and Baule 3 values of added nutrient, respectively. Subsequently, nitrogen rates higher than 90 kg N ha^{-1} did not produce significantly higher winter barley yields.

In comparison with the treatment which requires the lowest input, which was DS in combination with N1 (0 kg N ha^{-1}), as the treatment with the highest relative profit, calculated as the difference between variable costs of input and winter barley grain yield, the DS and 90 kg N ha^{-1} was pointed out (Graph 1), with the profit of +85 EUR ha^{-1} higher than the DS + N1. Although the grain yields for N5 and N6 were higher, higher investment in additional nitrogen fertilizers reduced relative profit at the +72 and +71 EUR ha^{-1} (respectively) in comparison with the DS+N1. It is also important to point out the DS+N3 treatment, with the profit of +62 EUR ha^{-1}, as the lowest nitrogen rate which produced significant profit.

Regarding CT treatments, which were for 80 EUR ha^{-1} more expensive than DS, the only treatment which achieved relative profit greater than 0 (or, in other words, costs were "covered" with the produced grain yield) was CT+N3 (90 kg N ha^{-1}), so, the same nitrogen fertilization rate as for the best profit at DS treatments. But, since that relative profit was lesser than 2 EUR ha^{-1}, it is very questionable whether this profit is sufficient for other costs of winter barley production.

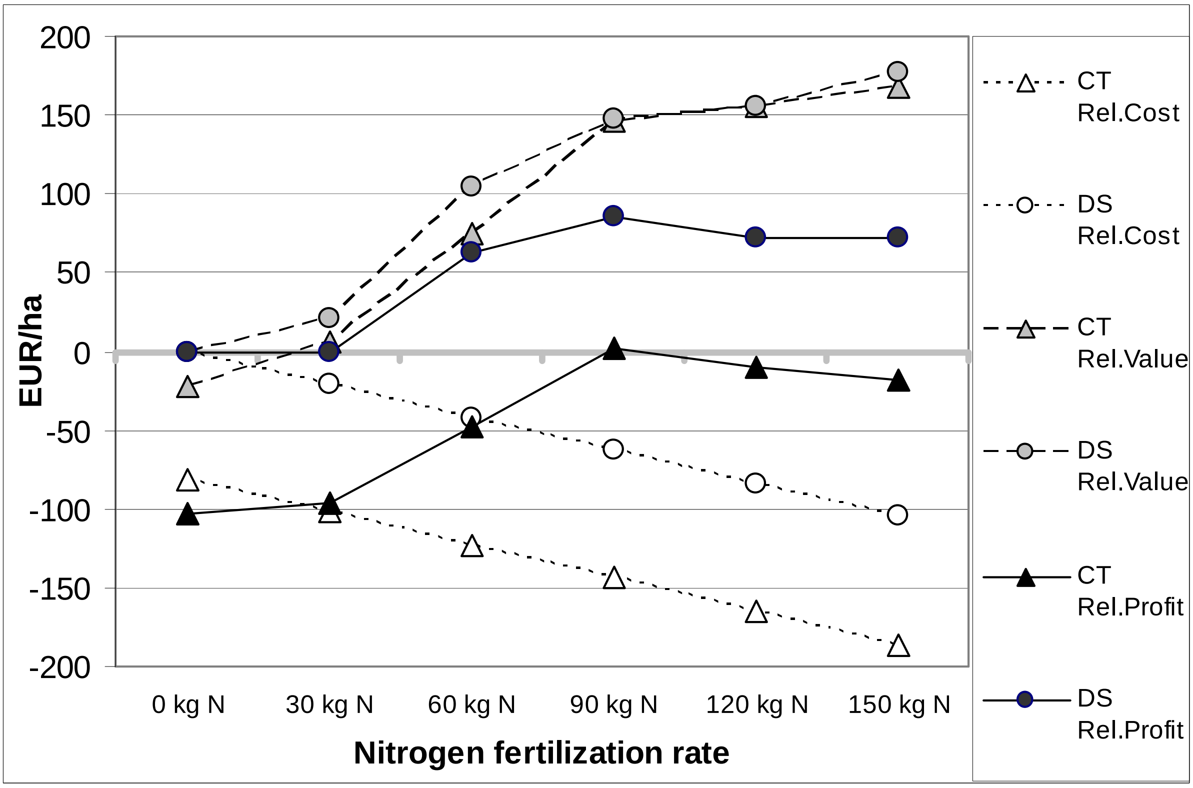
Table 2: Winter barley grain yield (kg ha^{-1}) at 13% grain moisture, Boksic site, Croatia, average for both years (2005 and 2006)

N level	CT (Ploughing)	DS (Diskharrowing)	Average (N)
N1 (0 kg N ha^{-1})	2380 a[†]	2571 a	2475 A[‡]
N2 (30 kg N ha^{-1})	2625 a	2752 a	2688 A
N3 (60 kg N ha^{-1})	3224 b	3479 b	3351 B
N4 (90 kg N ha^{-1})	3841 c	3858 bc	3849 C
N5 (120 kg N ha^{-1})	3923 c	3928 bc	3925 C
N6 (150 kg N ha^{-1})	4036 c	4107 c	4072 C
average (Tillage)	3338 n.s.	3449 n.s.	

[†] The winter barley yields within the same Tillage level and labeled with the same lowercase letter are not different at the P=0.01 significance level

[‡] The winter barley yields labeled with the same uppercase letter are not different at the P=0.01 significance level

n.s. The tillage averages are not statistically different at the P=0.01 significance level



Graph 1: Tillage (CT=mouldboard ploughing, DS=Diskharrowing only) and Nitrogen fertilization (0, 30, 60, 90, 120 and 150 kg N ha^{-1}) treatments relative costs, relative winter barley grain yield values and relative profits (EUR ha^{-1}), all expressed in comparison with the lowest input treatment, DS + 0 kg N ha^{-1}, Boksic site, years 2005 and 2006.

CONCLUSION

For given agroecological conditions and observed cultivar of winter barley in crop rotation after the soybean, the grain yields did not differ between tested tillage systems, conventional tillage, based on the mouldboard ploughing, and reduced tillage, based on diskharrowing. The highest yields were obtained at the nitrogen rate of 150 kg N ha^{-1}, but not statistically significant than lower N rates of 90 and 120 kg N ha^{-1}. Regarding the economical analysis, the highest profit was achieved with diskharrowing tillage system and 90 kg N ha^{-1}, whereas mouldboard ploughing showed no decent profit at all six N fertilization levels.

ACKNOWLEDGEMENTS

This research has been sponsored by Croatian Ministry for Agriculture, Forestry and Water Management (VIP Project V-29-7/04) and family farm "Oto Kovacevic" from Boksic, Croatia, on whose land this experimental site had been established. Authors would like to express their deep gratitude to Oto and Pavao Kovacevic for their contribution during this project. Gratitude should also been given to the "Arvi" ltd., Croatian branch, for their contribution in fertilizers used for this experiment.

BIBLIOGRAPHY

[1]Karlen, D.L., Wollenhaupt, D.C., Erbach, E.C., Berry, J.B., Swan, N.S., Eash, J.L., Jordahl., I., 1994, Long-term tillage effects on soil quality. Soil Tillage Res 32: 313-327 p.

[2]Stipesevic, B., Zugec, I., Juric, I., Petrac, B., 1997, Possibility of reduced soil tillage for winter wheat in East-Croatia conditions. Fragmenta Agronomica, 2B/97, 613-616 p.

[3]Stipesevic, B., Zugec, I., Josipovic, M., 2000, Investigation of Rational Soil Tillage for Maize (*Zea mays L.)* in Eastern Croatia. ISTRO 15th Proc. Fort Worth, Texas, USA (CD-ROM)

[4]Zugec, I., Stipesevic, B., Kelava, I., 2000, Rational Soil Tillage for Cereals (Winter Wheat - *Triticum aestivum L*. And Spring Barley - *Hordeum vulgare L*.) in Eastern Croatia. Proceedings of the 15th Conference of the International Soil Tillage Research Organization (ISTRO), CD-ROM, 2-7 VII 2000., Fort Worth, Texas, SAD

[5] Filipovic, D, Husnjak, S, Kosutic, S., Gospodaric, Z., 2006, Effects of tillage systems on compaction and crop yield of Albic Luvisol in Croatia. J. of Terramechanics, 43 (2): 177-189 p.

[6]Jug, D., Stipesevic, B., Zugec, I., Horvat, D., Josipovic, M., 2006, Reduced soil tillage systems for crop rotations improving nutritional value of grain crops. Cereal Res. Comm., 34 (1): 521-524 p.

[7]Halvorson, A.D., Black, A.L., Krupinsky, J.M., Merrill, S.D., Tanaka, D.L., 1999, Dryland winter wheat response to tillage and N within an annual cropping system. Agron. J. 91 (4), 637-642 p.

[8]Varvel, G.E., Havlin, J.L., Peterson, T.A., 1989, Nitrogen placement evaluation for winter wheat in three fallow tillage systems, SSSA J. 53 (1), 288-292 p.

[9] Birkas, M., Szalai, T., Gyuricza, C., Gecse, M., Bordas, K., 2002, Effect of disk tillage on soil. condition, crop yield and weed infestation. Rostlinna Vyroba, 48(1), 20-26 p.