Effect of Different Soil Cultivation and Nitrogen Fertilization on Yield and Economic Parameters of Spring Triticale in Poland

Hanna Klikocka and Marian Wesolowski[1]

Introduction

High fertility of triticale is favourable to the increase of its growing. Triticale starts to be competitive not only for rye and barley growing, but even for wheat (Mackowak and al., 1993, and Mazurek, 1987, and Masarykova, 1997). First variety of spring triticale was introduced into cultivation in 1987. Borne on necessary soil tillage treatments and seed sowing, modern soil tillage technologies should- besides other purposes- influence the energy costs. Modern soil tillage or reduction of cultivation treatments can obtain this limitation (Korona and al.,1994). Simplifications of cultivation treatments cause decrease of grainyield, but this debasement isn't comparable with borne costs (Dzienia and al., 1994). Possibility of limitation of soil tillage should depend on type of the soil, its physical properties and abundance (Dziamba, 1982).Fertilization and plant preservation compose 50-65 % of costs in cost structure (Koziara and al., 1994). Many authors say that triticale should be fertilized in the doses of nitrogen and cultivated with the fertilization techniques similarly as wheat. Recommended doses are 60-120 kg N ha^{-1} (Tarkowski, 1989).The purpose of this paper is the introduction of the effects by using different technologies of spring triticale cultivation connected with using different doses of mineral fertilization.

Material and methods

In spring 1997, in Malice - a village near Zamosc (Poland), there was started a two-factorial field experiment by split-plot method in four replications. The experiment was carried out on leached brown soil, formed from light loamy silty soil (texture: sand 57 %, silt 28 %, clay 15 %), poor soil with 1.65 % of humus.pH in the topsoil was 6.3 and 5.9 in the subsoil.Total nitrogen content was on average 0.085 %. Content of plant aviable P in the topsoil (vanadium-molybden method according to Egner-Riehm; phosphorus with colorometric method and potassium with fotometric method) was 22.1mg P_2O_5 $100g^{-1}$ and for K 17.1g^{-1} K_2O $100g^{-1}$ .Content of magnesium was in average 3.7 mg 100 g^{-1} soil. Accumulation of manganese, cop-

Summary

The experiment was dedicated to study the effect of soil tillage systems (conventional and 2 simplified soil tillage methods) and three amounts of nitrogen fertilization (60, 90, 120 kgN ha^{-1}) on grain yield and economic parameters of spring triticale. The highest grain yield and the best economic parameters of spring triticale was obtained using conventional soil tillage and 60 kgN ha^{-1}.The use of simplifications in soil tillage systems (resigning autumn ploughing) and higher amounts of nitrogen fertilizers caused to decreasing grain yield and to worse effectiveness index.

Key Words: conventional soil tillage, simplified soil tillage, nitrogen fertilization, spring triticale, grainyield, economic parameters

Zusammenfassung

Auswirkungen unterschiedlicher Bodenbearbeitungssysteme und Höhe der Stickstoffdüngung auf den Ertrag sowie ökonomische Parameter von Sommertriticale in Polen

Der Versuch diente der Untersuchung des Einflusses von Bodenbearbeitung (konventionell und 2 vereinfachte Verfahren) und der Höhe der Stickstoffdüngung (60, 90, 120 kgN ha^{-1}) auf Ertrag sowie auf ökonomische Parameter von Sommertriticale. Der höchste Kornertrag und die besten ökonomischen Ergebnisse wurden mit konventioneller Bodenbearbeitung und einer Stickstoffgabe von 60 kgN ha^{-1} erzielt. Die Anwendung vereinfachter Bodenbearbeitugsverfahren (Verzicht auf die Herbstfurche) und höhere Stickstoffgaben führten zu geringeren Kornerträgen und zu schlechteren Effizienzindices.

Schlüsselworte: konventionelle Bodenbearbeitung, vereinfachte Bodenbearbeitung, Stickstoffdüngung, Sommertriticale, Kornertrag, ökonomische Parameter

[1] Agricultural University of Lublin, Institute of Agricultural Sciences in Zamosc, Poland

per and iron was the average content for mineral soils, and zinc content was rather high (Mn – 91, Cu - 3.62, Fe – 294 and Zn – 5,25 mg kg^{-1} soil).

On such characterised object there were marked 36 plots with an area of 30 m^2 each. The area of plots put into harvest was 19.5 m^2 (3m.* 6.5m.). The crop preceding triticale have been potatoes, cattle-manure in a dose of 30 t ha^{-1}. After harvesting potatoes there were carried out 3 different soil tillage methods and 3 doses of nitrogen fertilization (60, 90, 120 kg N ha^{-1}). Phosphorus-potassium fertilization depended on abundance of plant available forms and has been 90 kg P_2O_5 and 100 kg K_2O ha^{-1} Methods of soil tillage have been as follows:

A. Conventional soil tillage: medium ploughing in autumn, harrowing, cultivation, PK fertilization, harrowing, sowing, harrowing in spring.
B. The simplified soil tillage, with double cultivation: cultivation in autumn, cultivation, PK fertilization, harrowing, sowing, and harrowing in spring.
C. The simplified soil tillage, with simple cultivation: without tillage in autumn, cultivation, PK fertilization, harrowing, sowing, and harrowing in spring.

Nitrogen fertilization was used in doses of 1 - 60, 2 - 90, 3 - 120 kg N ha^{-1}. Fertilization was used three times: 1st dose - 1/3 before sowing; 2nd dose - 1/3 when vegetation started; 3rd dose - 1/3 in phase of stalk shooting up.

In the end of the spreading phase, there was used the herbicide Granstar in a dose of 20 g ha^{-1}.

Total rainfalls in the seasons 1997-1999 have been higher by 161, 102 and 74 mm than the long-term sum of 358 mm. Only June 1997, and May and July 1999 have been dry, but other months of three years had higher rainfalls. In 1998 one didn't observe heavy droughts and rains. Generally rainfalls in particular months of shown vegetation seasons were regular and didn't differentiate growth phases of triticale. The month averages of the air temperatures in the vegetation season in 1997-1999 were much higher than in a long term. June, July and August were particularly hot month.

Generally, we can say that the vegetation seasons 1997-1999 were very warm and wet (table 1).

In this experiment the grain yield of spring triticale has been in the center of interest. Labour consumption, energy input (MJ ha^{-1}) and economical effectiveness index is counted by Maniecki cited by Lorencowicz (1996) and by Muzalewski (1997-1999). In the experiment traktor C-360 3p. (35 kW) and machines were used and calculated with 70 % energy demand for light soils and fields 100 m long (table 2). Costs of materials for triticale production and costs of triticale grain are mean costs in Zamosc region. Costs of human work are 1 hours work of traktor-worker. Energy effectiveness index was counted by Beres (1993). The use of index: 100 kg of rye grain = 927,2 MJ. 1 oat feed unit = 7.6 MJ of netto energy. Besides one counted by Krasowicz and Podolska (1996) that, human labour is 40 MJ, nitrogen fertilizer (N) = 77 MJ kg^{-1}, phospohorus fertlizer (P_2O_5) = 14 MJ kg^{-1}, potassium fertilizers (K_2O) = 10 MJ kg^{-1} and pesticides (A.S.) = 300 MJ kg^{-1}.

Obtained findings were fixed with statistic method calculating lowest significant differences (α=0.05) with Tukey-test.

Results and discussion

The yield of springtriticale was on average 4.29 t ha^{-1}. Methods of soil tillage and doses of nitrogen fertilization modified it. The highest yield was obtained using the conventional soil tillage (5.04 t ha^{-1}), introducing simplifying technologies radically yield decrease was watched. Using

Table 1. Sums of rainfall [mm] and temperature [0C] in the growing seasons 1997-1999 and in long-term period at Zamosc
Tab.1: Niederschlagssummen (mm) und Temperatur (0C) in den Wachstumsperioden 1997-1999 im langjährigem Mittel in Zamosc

Years	Month						Sum
	April	May	June	July	Aug.	Sept.	
	Rainfall						
1997	57	69	28	198	93	74	519
1998	58	53	124	115	67	43	460
1999	114	32	108	69	58	51	432
1981-94	37	53	73	76	57	62	358
	Mean Temperature						
1997	7,8	12,8	16,0	19,0	18,1	13,4	2662
1998	10,1	13,7	17,9	18,2	16,5	12,8	2724
1998	9,6	12,0	18,8	20,0	16,9	14,9	2815
1981-94	7,0	12,9	14,8	17,5	16,6	12,1	2474

Table 2: Machines characteristics, used for spring triticale cultivation
Tab.2: Kenndaten der für die Sommertriticaleproduktion benutzten Maschinen

Machine units	Symbol	Nominal power		Mechanical labor consumption (h ha^{-1})	Energy input (MJ ha^{-1}) (4*5*70%)
		(kW)	(MJ)		
1	2	3	4	5	6
Tractor + harrow	C-360 + U-212/2	35	126	0,4	35,28
Tractor + plough	C-360 + U-023/1	35	126	2,5	220,50
Tractor + cultivator	-	35	126	1,0	88,20
Tractor + lime distributor	C-360 + N-012	35	126	0,5	44,10
Tractor + seed drill	C-360 + S-052/1	35	126	0,7	61,74
Tractor + sprayer	C-360 + P.-068/3	35	126	0,5	44,10
Grain combine	Bizon-Super Z056/8	70	252	1,0	176,40
Stationary press	C -360 + Z224/1	35	126	1,0	88,20
Tractor + tractor trailer	C-360 + T-040	35	126	5,0	441,00

the simplified soil tillage with double cultivation made the yield lower by 0.96 t ha^{-1} (19 %), and the soil tillage with simple cultivation by 1.31 t ha^{-1} (26 %) in comparison with the conventional soil tillage (table 3). Such a radical decrease of yield caused by realised simplifications, issued from radical debasement of stalks with spikes per m^2 because in objects with simplified soil tillage methods this characteristic was fundamentally lower (10 % in average) than results obtained from plots with conventional soil tillage Similar results were obtained in works of Starczewski and co-authors (1993,1995) and Oettller (1996), and Michalski (1993) and Royo (1997).

Nitrogen fertilization modified the yield of triticale grain. The highest one was obtained using 60 kg N ha^{-1} (4.67 t ha^{-1}). Using 90 kg N ha^{-1} gave smaller yield, i.e. 4.46 t ha^{-1}, and the highest dose decreased it fundamentally from the others on average by 18 % (table 3). These results are confirmed in works of Poznanski and Piech

Table 3: Grainyield of spring triticale (t ha^{-1}) (Ø 1997-99)
Tab. 3: Kornertrag von Sommertriticale (t ha^{-1}) (Ø 1997-99)

Method of Soil tillage	Nitrogen fertilizers			
	1 N	1,5 N	2 N	Mean
A	5.54	4.53	4.16	5.04
B	4.57	4.12	3.57	4.08
C	3.90	3.82	3.48	3.73
Mean	4.67	4.46	3.73	4.29

LSD(α=0,05) between soil tillage = 0.43;
between nitrogen fertilization = 0.43;
Interaction soil tillage*fertilizers = 0.74.

Table 4: Working hours (hours ha^{-1}) and energy input (MJ ha^{-1}) in spring triticale cultivation
Tab.4: Arbeitsstunden (h ha^{-1}) und Energieinput (MJ ha^{-1}) für den Sommertriticaleanbau

Factors	Labour consumption		Energy input	
	Human	Mechanical	Human labour	Mechanical Treatments
Tillage				
A	14.3	10.3	572	5654
B	12.4	8.4	496	5487
C	11.0	7.0	440	5363
N-fertilizers				
1 N	1.5	1.5	60	4752
1,5 N	1.5	1.5	60	7062
2 N	1.5	1.5	60	9372

Table 5: Total costs of spring triticale production (DM ha^{-1}) , (Ø 1997-1999)
Tab.5: Gesamtkosten der Sommertriticaleproduktion (DM ha^{-1}), (Ø 1997-1999)

Specification of costs	A			B			C		
	1 N	1,5 N	2 N	1 N	1,5 N	2 N	1 N	1,5 N	2 N
Tillage and cultivation	61.4	61.4	61.4	47.5	47.5	47.5	38.7	38.7	38.7
N-fertilization	45.4	62.3	79.2	45.4	62.3	79.2	45.4	62.3	79.2
PK-fertilization	95.4	95.4	95.4	95.4	95.4	95.4	95.4	95.4	95.4
Seed and sowing	109.0	109.0	109.0	109.0	109.0	109.0	109.0	109.0	109.0
Grain harvesting	102.4	102.4	102.4	102.4	102.4	102.4	102.4	102.4	102.4
Straw harvesting	39.4	39.4	39.4	39.4	39.4	39.4	39.4	39.4	39.4
Human labour	31.6	31.6	31.6	27.8	27.8	27.8	25.0	25.0	25.0
Total production costs	484.6	501.5	518.4	466.9	483.8	500.7	455.3	472.2	489.1
Value of yield	967.3	953.9	741.1	792.1	722.4	627.4	677.0	668.1	601.9
Profit	482.7	452.4	222.7	325.2	238.6	126.7	221.7	195.9	112.8
Economical effektiveness index	2.01	1.92	1.45	1.71	1.51	1.26	1.50	1.42	1.23
Energy effectiveness index	4.63	3.76	2.45	3.90	2.90	2.13	3.42	2.73	2.11

1 DM = 2.08 PLN

(1993) and Wrobel and Budzynski (1994)Nitrogen fertilization didn't modify the stalks with spikes.

It was stated, that using simplifications of soil tillage decreases labour consumption and energy costs of machines' work and human labour (MJ) (table 4). Using conventional soil tillage ensures the most profitable index of energy effectiveness, connected with the lowest dose of nitrogen fertilization, i.e. 60 kg N ha^{-1} (4.63), (table 5). The most profitable financial effect is ensured by conventional soil tillage with 60 kg N ha^{-1} (profit 482.7 DM ha^{-1}, economical effectiveness - 2.01). The use of simplifications in soil tillage methods and higher doses (90 and 120 kg N ha^{-1}) of nitrogen is economically groundless, because they cause biological decrease of grainyield and increase costs of production.

The costs of soil tillage is known in average 10 % of production costs. Cost of nitrogen fertilization is 13 % of production costs. A large share in costs is PK fertilization (20 %), that is why one should consider it in similar categories. Highest costs in cultivation of spring triticale were determined seed and sowing (22 %) and grain harvesting (with combine harvester 21 %). Human work in Poland is not expensive and costs mean 2 DM per hour (in 1997-2000) (7 % of total costs in cultivation of spring triticale). Simplifications in soil tillage methods can be recommended only for organising reasons, because they have influence only on decrease of labour consumption and increase - in effect- size of costs in soil cultivation (lower costs of production aren't made up by level of costs issuing from value of the yield, because yield is also smaller) (table 4,5).

Danksagung

Hern Dr. Bramm danke für die wertvollen fachlichen Diskussionen während meines Aufenthaltes vom 15.06. bis 15.09.2000 in der FAL und die Durchsicht des Beitrages. Herrn Dipl.-Ing. Krentler habe ich für die Unterstützung bei der Übersetzung zu danken, Frau Führmann für die Korrektur des Textes.

Dank auch an den KAAD für die finanzielle Unterstützung des Deutschlandaufenthaltes.

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