

## Chapter 3. CROP PRODUCTION

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### **SIMPLIFICATION OF WINTER RYE (*SECALE CEREALE* L.) CULTIVATION TECHNOLOGY**

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#### **Abstract**

The paper presents the data on winter rye cultivation technology studies conducted during the period 1989-2001. The field trials carried out on a *Haplic Luvisol* were designed to estimate the effects of soil preparation, seed rate and nitrogen fertilization on winter rye grain yield and on the number and mass of weeds. With increasing the sowing rate of winter rye from 2.7 million seed ha<sup>-1</sup> to 5.7 million seed ha<sup>-1</sup> the weed dry mass decreased from 27.7 g m<sup>-2</sup> to 19.8 g m<sup>-2</sup> in the disk – cultivated ploughed soil and from 36.5 g m<sup>-2</sup> to 23.6 g m<sup>-2</sup> in the ploughed soil. Nitrogen fertilization had a greater effect on the yield than the seed rate. Having used nitrogen, winter rye yield was by 70.4 % higher in the ploughed soil and by 66.6 % higher in the disked soil compared with the yield of rye crops that did not receive any nitrogen.

Key words: winter rye, soil cultivation, nitrogen fertilization, seed quantity, yield.

#### **Introduction**

Of all cereal species grown on light soils winter rye is the most important and most-widely grown crop. Its roots are capable of penetrating into deeper soil layers and can utilise nutrients more efficiently compared with other winter or spring cereals. Furthermore, winter rye is very good at utilising the moisture accumulated during winter, is less affected by drought and is tolerant of acid soils /Lazauskas, 1999/. Of all cereal crops grown at the Lithuanian Institute of Agriculture's Vokė Branch during the 1997-2000 period winter rye was found to be best at suppressing weeds. The number of weeds in winter rye crop was on average 87 per m<sup>2</sup> and the air-dry mass amounted to 19-24.2 g /Nedzinskas, 2001/. Winter rye is currently grown and in the future will be grown mostly in Lithuania's south eastern sub-zone and Šilutė district, where the area sown with winter cereals accounts for about 45-50 % of the total area under cereals /Magyla et al., 2001/.

With the current increase in the prices of fuel, lubricants, fertilizers and other agricultural inputs, simpler and cheaper soil tillage practices have become increasingly popular and attempts are being made to abandon the most difficult and costly technological process-inversion of the whole ploughlayer. Conventional deep ploughing is

being replaced by a shallower ploughing or loosening without inversion of the ploughlayer, and by sowing the seed into completely untilled or only in surface-loosened soil, however, in combination with better fertilization these practices can result in a high yield /Budzynski et al., 2003/. Other authors indicate that deeper ploughing forms a deeper ploughlayer, which secures a higher grain yield compared with shallower ploughing /Kouwenhoven et al., 2002/. It was found that in shallowly ploughed sandy loam soil cereal yield was by 10-13 % lower and in the direct-drilled soil by as much as 16-17 % lower compared with that in conventionally deeply ploughed soil /Kadžienė et al., 2006/. Research conducted in various countries confirm the fact that when there is no weed competition, reduced soil tillage does not decrease the yield of agricultural crops and makes the soil physical properties even more favourable for crops /Kahnt, 1995; Miedaner et al., 2003/. Experimental evidence obtained at the Lithuanian University of Agriculture's Experimental Station on neutral reaction soil with a medium humus status suggests that with no inversion of the whole arable layer and with ploughing or loosening at the 12-14 cm depth, weed seeds tend to concentrate in the upper soil layer. In the second crop rotation small-seeded weed species became highly prevalent /Stancevičius et al., 2002/. The best weed control on couch-grass infested sandy loam soil was achieved by stubble cultivation after harvesting and deep or moderately deep ploughing before sowing: there were 3-4 times fewer couch-grass stems in the rye crop compared with that in the soil without stubble cultivation but with only deep, moderately deep or shallow ploughing. In the soil with a low couch-grass incidence rye grain yield was very similar both in the treatments where the stubble was broken and the soil was deeply ploughed and in the treatments with stubble breaking but no ploughing and in the treatments with only shallow ploughing /Pranaitis, 2002/.

The objective of the present study was to identify and compare the effects of conventional and reduced soil tillage on winter rye as affected by different seed rates, moderate ( $N_{45}$ ) and increased ( $N_{90}$ ) nitrogen fertilizer rates.

### **Materials and methods**

The experiments were conducted at the Lithuanian Institute of Agriculture's Vokė Branch during the period 1989-2001. The soil where winter rye was grown is characterised as sandy loam *Haplic Luvisol* according to FAO classification, with a humus content of 1.85-2.06%, total nitrogen 0.127%, available phosphorus 177-193 mg kg<sup>-1</sup> and potassium 198-230 mg kg<sup>-1</sup> soil, and pH<sub>KCl</sub> 5.7-5.9. Oats were a pre-crop to rye. After oats harvesting (on August 8-13) the soil for rye was deeply ploughed (at the 22-24 cm depth) or only disked at the 8-10 cm depth.

The experiments were done observing the following design:

- (i) soil tillage (A factor): 1) soil for rye was ploughed, and 2) soil for rye was not ploughed but disked;
- (ii) nitrogen fertilization (B factor): 1) no nitrogen fertilization, 2)  $N_{45}$  fertilization and 3)  $N_{90}$  fertilization;
- (iii) winter rye seed rate (C factor): 1) 2.7 million viable seed (90 kg ha<sup>-1</sup>), 2) 4.2 million viable seed (140kg ha<sup>-1</sup>) and 3) 5.7 million viable seed (190 kg ha<sup>-1</sup>).

Prior to rye sowing (on September 2-4) the whole experimental field was applied with phosphorus and potassium fertilizers  $P_{60}K_{60}$  and was cultivated at the 5-7 cm depth. In the first ten-day period of September winter rye was sown by a sowing machine 'Saxonia'. In spring, after resumption of rye vegetative growth the respective treatments were fertilized with nitrogen. The number of rye seedlings was determined upon complete emergence and the number of plants was estimated upon resumption of vegetative growth after winter. The number of weeds, their species composition and air-dry mass were identified in the rye crop at the beginning of July. The above-mentioned parameters were estimated in each treatment by counting and/or taking samples from two 0.25 m<sup>2</sup> plots. Rye was harvested by a combine harvester 'Sampo'. While thrashing, 1 kg samples were taken for estimating grain moisture, purity and 1000 grain weight. Rye grain data were adjusted to 15 % moisture.

Initial plot area was 75 m<sup>2</sup>. Harvested plot area 47 m<sup>2</sup>. Experimental treatments were replicated 4 times. The data were processed by the analysis of variance method.

### Results and Discussion

Autumn soil tillage practically had no effect on rye emergence, the number of plants increased in proportion to the seed rate sown both in the ploughed and disked treatments. Rye demonstrated the best over winter survival when the soil had been ploughed, fertilized with phosphorus and potassium before sowing. Averaged data suggest that 80-83 % of the autumn-emerged plants survived the winter. When the soil had not been ploughed but had been disked and not fertilized, the over winter survival of rye plants was by 6.0-7.5 % lower.

Rye over winter survival was also affected by the seed rate. The best over winter survival (86-91 %) was demonstrated by the rye that had been sown at the lowest sowing rate of 2.7 million seed ha<sup>-1</sup>. Having increased the seed rate to 5.7 million ha<sup>-1</sup> in ploughed and  $P_{60}K_{60}$  – applied soil, 65-73 % of autumn-emerged plants survived the winter, but when the soil had not been ploughed but only had been disked and treated with potassium and phosphorus the plants that survived the winter amounted to 62-68 %.

#### *Weed incidence in the rye crop*

The total number of weeds was found to be very similar both in ploughed and disked soil, however, there were more perennial weeds in the unploughed soil. Part of the perennial weeds revived after disking, pre-sowing cultivation did not give a complete control of the weeds. In the ploughed soil on average 88 weeds emerged per 1 m<sup>2</sup> of which 28.3 were perennial, whereas in the disked soil on average 99.0 weeds emerged per 1 m<sup>2</sup>, of which 35.0 were perennial. It was noticed that a large part of weeds grew in separate patches, especially couch-grass and dandelion (Table 1).

In the rye stands there were identified 7-12 annual and 8-9 perennial weed species. Abundant specimens of *Poaceae* (*Gramineae*) family were couch-grass plants (*Elytrigia repens* L.), in the ploughed soil there were on average 10.5; in the disked soil 14.5 stems m<sup>-2</sup>. *Asteraceae* (*Compositae*) family was also abundant in weed species. The most abundant species were scentless chamomile (*Tripleurospermum inodorum* L.) 16.9-22.4 weeds m<sup>-2</sup>, thistle (*Cirsium avense* L.) 2.2-4.0 weeds m<sup>-2</sup>, field sowthistle (*Sonchus arvensis* L.) 5.3-6.6 weeds m<sup>-2</sup>. There was an especially high number of *Violaceae*

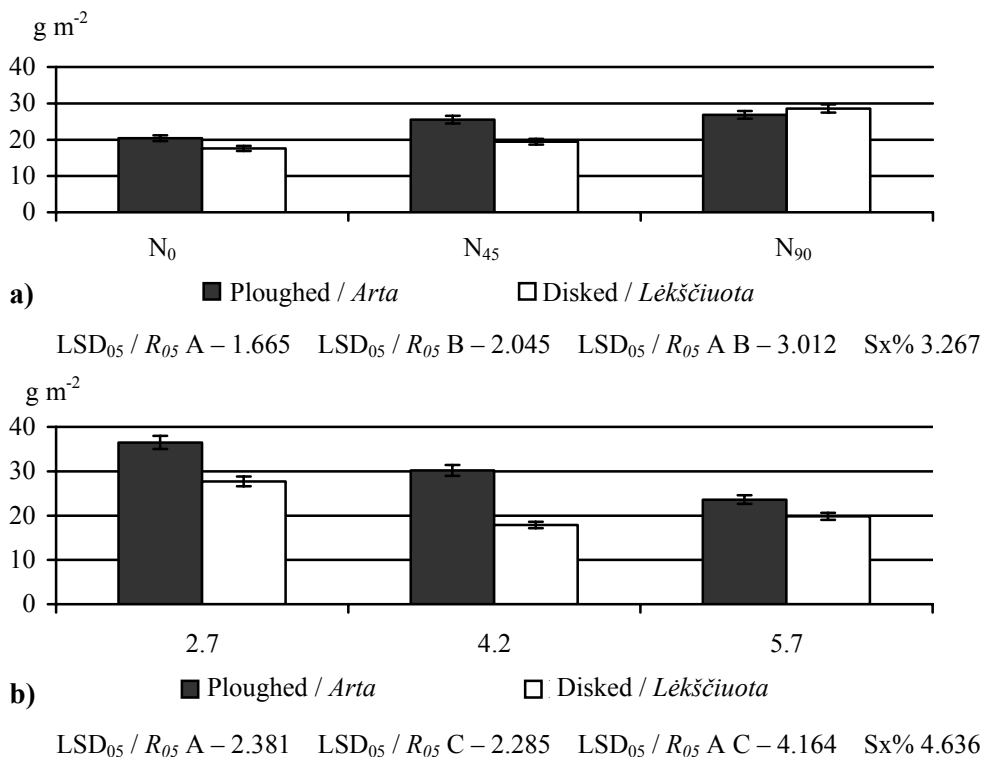
family specimens in the rye crop: *Viola arvensis* L. 6.2-9.5 weeds m<sup>-2</sup>, *Boragineae* – *Myosotis arvensis* Hill. – 6.3-7.5 weeds m<sup>-2</sup>.

**Table 1.** The effect of soil tillage on the number of weed species in rye before harvesting *I lentelė*. Dirvos dirbimo įtaka piktžolių rūšių skaičiui žieminiuose rugiuose prieš derliaus nuėmimą

Weed species <i>Piktžolių rūšys</i>	Number of weeds per m <sup>2</sup> <i>Piktžolių skaičius m<sup>2</sup></i>	
	Soil ploughed for winter rye <i>Dirva arta žieminiams rugiams</i>	Soil disked for winter rye <i>Dirva lėkščiuota žieminiams rugiams</i>
<i>Galeopsis tetrakit</i> L.	4.8	5.5
<i>Chenopodium album</i> L.	6.5	8.3
<i>Viola arvensis</i> Murr.	9.5	6.2
<i>Myosotis arvensis</i> (L.), Hill	6.3	7.5
<i>Polygonum lapathifolium</i> L.	2.4	4.1
<i>Tripleurospermum inodorum</i> L.	16.9	22.4
<i>Stellaria media</i> (L.), Vill	6.4	7.0
Others / <i>Kitos</i>	6.9	3.0
Annual / <i>Vienametės</i>	59.7	64.0
<i>Plantago major</i> L.	1.4	2.0
<i>Mentha arvensis</i> L.	3.8	3.2
<i>Equisetum arvense</i> L.	1.8	2.3
<i>Sonchus arvensis</i> L.	5.3	6.6
<i>Cirsium arvense</i> L.	2.2	4.0
<i>Elytrigia repens</i> (L.), Nevski	10.5	14.5
Others / <i>Kitos</i>	3.3	2.4
Perennial / <i>Daugiametės</i>	28.3	35.0
Total number of weeds	88.0	99.0
<i>Bendras piktžolių skaičius</i>		
Air-dry mass of weeds g m <sup>-2</sup>	27.1	21.8
<i>Orasausė piktžolių masė g m<sup>-2</sup></i>		
	LSD <sub>05</sub> / R <sub>05</sub>	5.03

With increasing the seed rate from 2.7 million viable seed ha<sup>-1</sup> to 5.7 million ha<sup>-1</sup> the number of weeds inappreciably declined, however, their air-dry mass consistently declined with an increase in seed rate (Figure 1). Having sown 2.7 million seed ha<sup>-1</sup> in the ploughed soil the air-dry mass of weeds per 1 m<sup>2</sup> amounted to 36.5 g, and having sown 5.7 million seed ha<sup>-1</sup> the air-dry mass of weeds declined to 23.6 g and the weeds were small because of the dense rye crop which competed well with weeds.

When the soil for rye had not been ploughed but had been disked, the weed mass was markedly lower, but no consistent reduction with increasing seed rate was observed. As was mentioned, the weed incidence in the rye crop was very diverse, and especially in the unploughed soil, which determined their inconsistent reduction.



**Figure 1.** The effect of nitrogen fertilization (a) and seed rate (b) on the number of weeds in winter rye and on weed mass  $\text{g m}^{-2}$

**1 paveikslas.** Dirvos dirbimo, tręšimo azotu ir sėklos normos įtaka žieminių rugių pasėlio piktžolėtumui (piktžolių masė  $\text{g m}^{-2}$ )

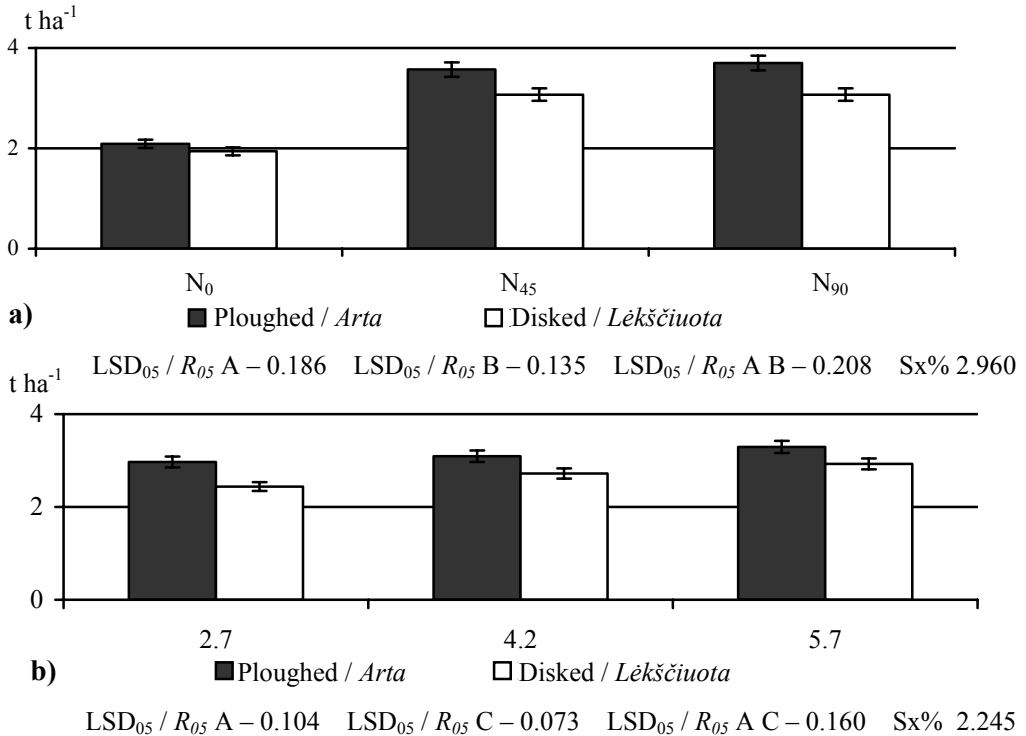
Trakų Vokė, averaged data from 1989-2001 / 1989-2001 m. vidutiniai duomenys

With nitrogen application to rye both in the ploughed and unploughed but disked soil weed mass consistently increased. When the soil for rye was ploughed and was not applied with nitrogen weed mass per  $1 \text{ m}^2$  amounted to  $20.4 \text{ g}$ , with the application of  $\text{N}_{45}$  weed mass increased to  $25.5 \text{ g m}^{-2}$ , and with increasing nitrogen rate to  $\text{N}_{90}$ , weed mass increased to  $26.8 \text{ g m}^{-2}$ . A similar increase in the weed mass in the rye crop in relation to nitrogen fertilizer rate occurred in the rye stand where the soil had not been ploughed but disked. In the plots where the soil had not been ploughed but had been disked and rye had not been fertilized with nitrogen, weed mass was very low  $17.6 \text{ g}$  per  $1 \text{ m}^2$ . Having applied  $\text{N}_{90}$  the weed mass increased to  $28.6 \text{ g}$ .

When increasing the seed rate of rye from  $2.7 \text{ million ha}^{-1}$  to  $5.7 \text{ million viable seed ha}^{-1}$  in the ploughed soil the number of annual and perennial weeds consistently declined. When the soil had not been ploughed but had been disked, increasing of rye seed rate practically did not have any effect on the incidence of perennial weeds, there was found a similar number of weeds both in the treatments sown with the lowest and the highest seed rates.

### Rye grain yield

Agricultural practices such as soil tillage and nitrogen fertilization as well as seed rate had also some effect on rye grain yield. Averaged data indicate that when the soil had been ploughed for rye the grain yield amounted to 3.11 t ha<sup>-1</sup> and when the soil had not been ploughed but had been disked the grain yield was by 13.2 % lower (Figure 2).



**Figure 2.** The effect of nitrogen fertilizer (a) and seed rate (b) on winter rye yield t ha<sup>-1</sup> *2 paveikslas. Dirvos dirbimo, tręšimo azotu ir sėklos normos įtaka žieminių rugių grūdų derliui t ha<sup>-1</sup>*

Trakų Vokė, averaged data from 1989-2001 / 1989-2001 m. vidutiniai duomenys

Nitrogen fertilization had the greatest effect on winter rye grain yield. In the ploughed soil not applied with nitrogen rye grain yield was low 2.09 t ha<sup>-1</sup>, in disked soil the grain yield amounted to 1.94 t ha<sup>-1</sup>. Having fertilized rye with N<sub>45</sub> rye yield in ploughed soil was by 70.4 % higher and in disked soil by 66.6 % higher compared with the grain yield of rye that had not received nitrogen fertilization. When fertilized with N<sub>90</sub> rye was slightly lodged in separate years and the yield increased only inappreciably compared with that from the treatment fertilized with N<sub>45</sub> rate.

Our tests suggest that the optimal seed rate on sandy loam soil was 5.7 million viable seed ha<sup>-1</sup> or 190 kg ha<sup>-1</sup>. Averaged data from long-term trials show that having sown 2.7 million seed ha<sup>-1</sup> the grain yield of rye amounted to 2.70 t ha<sup>-1</sup>, the seed rate of

4.2 million ha<sup>-1</sup> generated a grain yield of 2.91 t ha<sup>-1</sup>, and having increased the seed rate to 5.7 million ha<sup>-1</sup>, the grain yield increased to 3.11 t ha<sup>-1</sup>.

### Conclusions

Having ploughed the soil for winter rye at the 22-24 cm depth or having disked at the 8-10 cm depth, weed species composition practically did not differ – 7 annual and 6 perennial weed species prevailed. Of annual weeds the most numerous was *Tripleurospermum inodorum* L. 16.9-22.4 weeds m<sup>-2</sup> and of perennial weeds – *Elytrigia repens* (L.) 10.5-14.5 weeds m<sup>-2</sup>. The total number of weeds in ploughed or only in disked soil was similar, however, the weed mass was much higher when the soil for rye had been ploughed.

The weed incidence in rye crop was most markedly affected by nitrogen fertilization and sowing rate. Having fertilised rye with nitrogen N<sub>90</sub> rate, the weed mass was by 31.4 % higher in ploughed soil and by 62.5 % higher in disked soil compared with the weed mass in the plots that did not receive nitrogen.

With increasing the sowing rate of rye from 2.7 million seed ha<sup>-1</sup> to 5.7 million seed ha<sup>-1</sup> weed mass consistently increased.

Rye yielded better in ploughed soil where grain yield was by 13.2 % higher than in unploughed but disked soil. Nitrogen fertilizer had the greatest effect on rye grain yield. Having fertilized rye with N<sub>45</sub> in the ploughed soil the grain yield was by 70.4 % higher and in the disked soil by 66.6 % higher compared with the grain yield from the treatment that did not receive nitrogen. When increasing the sowing rate from 2.7 million seed ha<sup>-1</sup> to 5.7 million seed ha<sup>-1</sup> rye grain yield increased by on average 15.5 %.

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## SUPAPRASTINTA ŽIEMINIŲ RUGIŲ AUGINIMO TECHNOLOGIJA

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### Santrauka

Lietuvos žemdirbystės instituto Vokės filialo bandymų lauke, kuriame vyravo priesmėlis ant karbonatinio fliuvioglacialinio žvyro paprastojo išplautžemio (Idp) *Haplic Luvisols* (LVh), 1989-2001 metais atlikti lauko bandymai, kur tirta įprastinio ir supaprastinto žemės dirbimo įtaka žieminiams rugiams. Dirva buvo suarta arba tik sulėkščiuota, žiemiai rugiai netręšti ir tręšti  $N_{45}$  ir  $N_{90}$   $kg\ ha^{-1}$  norma, sėta 2,7, 4,2 ir 5,7 mln. daigių žieminių rugių ‘Duoniai’ sėklų į hektarą.

Nustatyta, kad tik lėkščiuotoje dirvoje padidinus žieminių rugių sėklos normą nuo 2,7 iki 5,7 mln.  $ha^{-1}$ , piktžolių masė sumažėjo nuo 27,7  $g\ m^{-2}$  iki 19,8  $g\ m^{-2}$ . Kai dirva žieminiams rugiams buvo suarta, išsėjus tokią pačią žieminių rugių sėklos normą, piktžolių masė sumažėjo atitinkamai nuo 36,5  $g\ m^{-2}$  iki 23,6  $g\ m^{-2}$ . Tręšiant azotu, nuosekliai padidėjo žieminių rugių grūdų derlius. Rugius patręšus azotu, artoje dirvoje derlius buvo 70,4 %, o lėkščiuotoje dirvoje – 66,6 % didesnis, palyginus su netręšto pasėlio derliumi.

Reikšminiai žodžiai: žieminiai rugiai, dirvos dirbimas, tręšimas azotu, sėklos norma, derlius.