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MODELLING OF SEEDBED STRUCTURE FOR SPRING BARLEY IN CLAY LOAM SOILS

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Abstract

An experiment to establish the theoretically optimum parameters of seedbed structure for spring barley was conducted at the Joniškėlis Experimental Station of the Lithuanian Institute of Agriculture over the period 2002-2004 on a clay loam *Gleyic Cambisol.* Four seedbed models were formed with different amount of various soil structural aggregates (< 2, 2-5 and > 5 mm) in three seedbed sublayers: 0-1.5, 1.5-3.0 and 3.0-4.5 cm. The predominating fractions of soil aggregates in the indicated seedbed sublayers amounted to 40 % in the 1st model, 60 % in the 2nd model, 80 % in the 3rd model, and 100 % in the 4th model. For seed germination dry conditions of post sowing period were created. Our experimental data suggest that increased sorting of coarse soil aggregates in seedbed upwards and fine aggregates downwards improved seed-soil contact and in the case of lower amount of moisture in clay loam topsoil and in dry post sowing period was the important factor for better field germination and rapid growing of spring barley at early stages. Such increased sorting and fractionation of soil aggregates in seedbed sublayers also helped to protect the soil surface from crusting and decreased the germination of annual small-seeded weeds.

Key words: clay loam, seedbed modelling, soil conditions, spring barley, weed.

Introduction

It is more difficult in the clayey soils having bad genetic physical properties or being degraded because of negative climatic factors, or anthropogenic activities, to form optimum conditions for the start of crops growth than in the sandy soil. In the clayey soils it is very important to secure a good germination of spring crops, which conditions their further growth, because having dry conditions in the topsoil available water content for plants is little, close to plant wilting moisture content /Hakansson et al., 2002; Velykis, Satkus, 2002; De Toro, Arvidsson; 2003; Pietola, Tanni, 2003/. Therefore, the quality of seedbed in various countries has become one of the most important characteristics of soil physical conditions influenced not only by soil tillage, but also by other agricultural practices: crop rotations, preceding crops, fertilizing and others /Guerif et al., 2001; Tapela, Colvin, 2002; Velykis, Satkus, 2005/.

The seedbed, as a research object, present in the junction of atmosphere and soil surfaces is receiving increasingly more attention of scientists. Physical processes concentrated in this junction affect the growth of plants, biological activity of the soil, water filtration, runoff and other factors. All the processes that occur here are very dynamic, therefore the technical means for the seedbed have to be chosen according to pedoclimatic, technological and socio-economic peculiarities /Guerif et al., 2001/.

Different principles and methods are used for the evaluation of seedbed quality in various countries, however, the main evaluation criteria are the soil structure which determines physical seed setting conditions. The soil structure is the basis for seedbed quality, because it is a complex quality, which combines genetic soil properties, and it is set by many technological conditions and functional environment processes. The quantity of soil structural aggregates, their compression and stratification in the seedbed determine humidity, air and warmth mode, seed contact with the soil, mechanical soil resistance for plant seedlings and roots /Guerif et al., 2001; Hakansson et al., 2002; Tapela, Colvin, 2002; De Toro, Arvidsson, 2003; Romaneckas, Šarauskis, 2003/.

Basic seedbed structure requirements are given in the academic studies of various countries. With reference to most of the research findings obtained in Norway, a good seedbed for cereals is such, when the structural soil aggregates of 0.5-6.0 mm in size account for about 50 % according to weight in the seedbed /Berntsen, Berre, 2002/. According to Finnish scientists, that warrants a good seed contact with the soil in the clayey soils, where the seedbed sublayer soil aggregates have to be 1-5 mm big /Pietola, Tanni, 2003/. Braunack and Dexter (1989) indicate that most “compromising” are 1-2 mm big soil aggregates.

It was determined in Sweden that the clay loam and clay soils’ structure is markedly improved by winter colds, and in spring usually in the 3-5 cm layer 1-5 mm structural aggregates dominate. However, this soil structure here can be soon destroyed by higher amount of precipitation. According to Swedish scientists, most valuable in the seedbed are 2-5 mm soil structural aggregates. Also, it is said that where there are frequent rainless springs the germination of spring crop seeds is poor. A finer, moisture-conserving seedbed is necessary here with more than 50% of soil structural aggregates, smaller than 5 mm. The amount of such aggregates depends on the soil texture, the influence of past cold, humidity, type of agricultural implements used and the number of soil tillage operations /Arvidsson et al., 2000; Hakansson, Lipiec, 2000; Hakansson et al., 2002; De Toro, Arvidsson, 2003/.

The soil that covers seeds from the top, according to theoretical seedbed model presented by Heinonen (1985), has to be stratified so that the smallest soil particles (soil structural aggregates) would be situated close to the seeds, in the bottom sublayer of the soil that covers the seeds. In the middle (in-between) of this cover sublayer medium-sized soil structural aggregates have to prevail. On the top (superficial layer) of the seedbed, the sublayer has to fetch up the biggest soil structural aggregates. This seedbed structure secures the best contact with the soil, maintains relevant water and air mode, protects the soil from crust formation and the surface from cracking.

It was ascertained in Estonia, that optimal seedbed in the soils of this country is when in the top layer there are 30-45 % soil structural aggregates of >5 mm in size. In the middle 40-50 % soil structural aggregates of 2-5 mm in size and on the bottom layer 20-40 % soil structural aggregates of < 2 mm in size /Nugis, 1997/.

The crust that forms after sowing on the top of clayey soil in spring is frequent and damaging phenomenon which aggravates germination of crops, especially of small – seeded ones. In the soil with a high content of silt particles and low content of organic matter, the danger of solid and heavy crust formation is even bigger. Therefore, formation of precision seedbed, when seeds sown at a sufficient depth on a moist base untouched by implements are covered by a layer of finer soil structural aggregates concentrating the larger ones on the soil surface, is an indispensable condition. It not only improves seed contact with the soil, and more effectively protects moisture from evaporation, but also helps to prevent damaging crust formation /Heinonen, 1985; Satkus, 2000; Guerif et al., 2001; Hakansson et al., 2002/.

Experiments were conducted at the LIA's Joniškėlis Experimental Station on a clay loam soil to study various primary, pre-sowing and post-sowing soil tillage methods and evaluate their effects on the quality of seedbed. Using conventional implements on heavy soils it is not easy to create a plant-friendly, fine-structured seedbed /Maikštė-nienė, 1997; Satkus, 2000; Velykis, Satkus, 2002; Velykis, Satkus, 2005/. Furthermore, it is very important in clayey soils to properly complete soil tillage implements, to apply primary and pre-sowing tillage methods, suitable to ensure physical quality of the soil and to secure formation of optimal seedbed by biological and other factors: crop rotations and preceding crops, various origin organic and mineral fertilizers and other means. In spring the seedbed structure for spring crops in heavy soils is usually finer compared with the autumn-prepared seedbed for winter crops /Lapins et al., 2001; Germanas, Lukošiūnas, 2004; Velykis, Satkus, 2005/.

However, by doing field experiments it is possible to find out the best soil tillage methods and to see how various implements can prepare the seedbed. It is not possible using a common field experiment method to determine theoretically the optimal structure of seedbed in a particular soil and to evaluate what implements, their combinations, working parts and their working principles let us make optimal or close to these parameters seedbed in available soil-climatic conditions. Also, there is no detailed research on optimal seedbed structure according to the proportions of different soil aggregates in seedbed sublayers. To solve these questions, micro-modelling research was done by simulating various seedbed models with different amounts of soil structural aggregates in the top, middle and bottom seedbed sublayers. Our objective was to find out optimum parameters of seedbed structure for spring barley in clay loam soils.

Materials and Methods

Site and soil description. This research was conducted at the Lithuanian Institute of Agriculture's Joniškėlis Experimental Station situated on the soils of the northern part of Central Lithuania's lowland ($56^o21'$ N, $24^o10'$ E) during the period 2002-2004. The experiments were carried out on a drained, clay loam on silty clay *Endocalcari-Endohypogleyic Cambisol*, whose parental rock is glacial lacustrine clay. Clay particles (< 0.002 mm) in A_a horizon (0-30 cm) made up 27.0 %, humus content 2.35 %, pH 7.1.

Experimental design. In the modelling approach we investigated different seedbed structure for spring barley. The seedbed structure differed in soil aggregate fractionation in its sublayers. We evaluated seedbed models where on the top seedbed sublayer (from 0 to 1.5 cm) large-scale (> 5 mm) soil structural aggregates prevailed; middle sublayer (from 1.5 to 3.0 cm) where medium-sized (2-5 mm) soil structural aggregates prevailed, and bottom sublayer (from 3.0 to 4.5 cm) where the smallest (< 2 mm) structural aggregates made up to 40% in the 1st, 60% in the 2nd, 80% in the

3rd and 100 % in the 4th model (Table 1). The field experiment was set up in small plots of 0.5 x 0.5 = 0.25 m^2 size with 6 replications.

Table 1. Seedbed models
1 lentelė. *Sėklų guolio modeliai*

Seedbed sublayer cm / *Sėklų guolio sluoksniai cm*	Seedbed models / *Sėklų guolio modeliai* amount of soil structural aggregates % / *dirvožemio struktūrinių agregatų kiekis %*		
	< 2 mm	2-5 mm	> 5 mm
1st model / *1-as modelis*			
0-1.5	30	30	40
1.5-3.0	30	40	30
3.0-4.5	40	30	30
2nd model / *2-as modelis*			
0-1.5	20	20	60
1.5-3.0	20	60	20
3.0-4.5	60	20	20
3rd model / *3-as modelis*			
0-1.5	10	10	80
1.5-3.0	10	80	10
3.0-4.5	80	10	10
4th model / *4-as modelis*			
0-1.5	0	0	100
1.5-3.0	0	100	0
3.0-4.5	100	0	0

The soil was smoothed down after ploughing in autumn, and it was loosened by hand to 5 cm depth in spring, when setting up the experiment. After loosening the soil, a loose soil layer was removed in the band where small plots had been arranged. The collected soil was sifted out through sieves set and so separated into fractions according to the size of aggregates: 1) > 5 mm; 2) 2-5 mm; 3) <2 mm. According to such parameters of soil aggregate size fractions the method for characterization of the quality of seedbed was developed, which is frequently used in Sweden /Kritz, 1983; Hakansson et al., 2002; Romaneckas, Šarauskis, 2003/. According to the experimental design, a soil compound for every seedbed sublayer was made from various aggregate fractions of the structure for all treatments. The amount of soil compound in volume units was calculated according to the volume of layer and various soil aggregates proportions in every seedbed sublayer.

Spring barley cv. 'Ula' was grown in the experimental plots. Ninety seeds were sown per plot according to a seed rate of 4.5 million ha^{-1} of viable seeds. The preceding crop was winter wheat. The seeds were sown by hand on the firm base of the seedbed in rows of 10.0 cm interlines and even spaces in the row between seeds. Then following the experimental design, the soil prepared beforehand, was placed in separate layers, beginning from the bottom and finishing on the top. Spring barley was fertilized with $N_{60}P_{60}K_{60}$, mixing the fertilizers with the soil of seedbed bottom sublayer. Herbicides were not sprayed on spring barley.

For the evaluation of the influence of seedbed structure, dry post-sowing conditions were simulated. As a result, experimental plots were kept covered by polythene wrap during the period after sowing till the final spring barley emergence.

Measurements and assessments. Before setting up the experiments topsoil characteristics were determined: texture, humus content and pH. Each year, before setting up the experiment the soil moisture content was measured in samples taken from 0-5, 5-15 and 15-25 cm depths by a weighing method, drying them in a thermostat till constant weight at +105°C.

The following *physical soil properties* were determined: soil moisture content (weighing method) every three days from the beginning of spring barley germination till final germination, and at the end of crop growth also soil bulk density (Kachinsky method) and total and air-filled porosity at the beginning, middle and the end of barley growth in the 0-5 and 5-10 cm depth, crust on soil surface (weighing method); *crop productivity*: seed germination (number of seedlings) and height of seedlings every three days from the beginning of spring barley germination till final germination. Germination intensity coefficient (C_{ge}) for estimation of seed germination intensity was calculated in the following way: $C_{ge} = (D_{Sl}/l_1+D_{S2}/l_2 +...+D_{Sn}/l_n)/N$, where D_{Sl}, D_{S2}, ... D_{Sn} – number of seedlings per 0.25 m^2, l_1, l_2, ... l_n – period of days from the date of spring barley sowing till the final seedlings calculation, N – seedling calculating stages. Growing intensity coefficient (C_{gr}) for estimation of crop growth intensity was calculated in the following way: $C_{gr} = (D_{Cl}/l_1+D_{C2}/l_2 +...+D_{Cn}/l_n)/N$, where D_{Cl}, D_{C2}, ... D_{Cn} – seedling height mm, l_1, l_2, ... l_n – period of days from the date of spring barley sowing till the final seedling measurements, N – seedling height measurements, weed incidence (number of annual weeds and mass of weed dry matter, at spring barley milky stage).

To estimate the weather conditions during the growing season, meteorological records of the Lithuanian Institute of Agriculture's Joniškėlis Experimental Station were used. Hydrothermic coefficient (HTC) was calculated according to the formula of Seleninov – HTC = P/0.1T, where P – amount of precipitation mm through investigated period, T – sum of temperatures >10°C through adequate period of time. Evaluation scale: when HTC is from 0.3 to 0.5 – drought, 0.6-0.7 – dry, 0.8-1.0 – moisture is insufficient, 1.1-1.5 – optimal moisture, >1.5 – excess of moisture /Dirsė, 2001/.

Meteorological conditions. The spring in 2002 was early, warm and dry. Spring barley was sown in the experimental plots on the 22nd of April. There was insufficient moisture in April (HTC – 0.79), but May was very dry (HTC – 0.35). It rained more in June. Afterwards the weather became warm and dry during the July-August period (Table 2). The spring of 2003 was warm. But the soil for spring sowing dried slowly and barley was sown on April 25. There was enough moisture in April (HTC – 1.27). May and June were warm and had enough rainfall. In 2004 April was cold and very dry (HTC – 0.11). Barley was sown on April19. May was dry (HTC – 0.56) and cool. The amount of rainfall and temperatures in July were close to average.

Statistics. Significant differences of statistically analysed data are presented at 95 % and 99 % probability level. The data of weed count and mass measurements used for the evaluation of statistically significant differences were transformed according to the formula: $\sqrt{x+1}$.

Table 2. Hydrothermic coefficients of the growing seasons
2 lentelė. *Vegetacijos periodų hidroterminiai koeficientai*

Year *Metai*	Month / *Mėnuo*				
	April *Balandis*	May *Gegužė*	June *Birželis*	July *Liepa*	August *Rugpjūtis*
2002	0.79	0.35	1.61	0.71	0.17
2003	1.27	1.71	1.67	0.80	1.04
2004	0.11	0.56	1.12	1.36	1.04

Results and Discussion

Physical soil properties. Each year modelling seedbed experiments were set up after the upper topsoil layers had dried to the moisture content close to soil physical maturity. The clay loam soil in our experimental site reaches physical maturity at 17-18 % moisture content and the plant wilting moisture content of this soil amounts to 11.0 % /Maikštėnienė, 1997/. The soils dried very differently in separate experimental years. In 2002, when the seedbed layer (0-5 cm) dried to the moisture of 15.0 %, in the deeper layers (5-15 and 15-25 cm) the moisture content was 17.1 and 17.8 %, respectively. In 2003 while setting up the experiment the moisture content in the above-mentioned layers was higher – 15.9, 17.9 and 18.1 %, respectively. The soils dried very unequally in 2004. After having dried the seedbed layer to 13.7 %, the soil moisture was still quite high deeper – 19.8 and 21.1 %, respectively. Thus moisture reserves for the seed germination in the topsoil were different in separate years of the experiment.

In the soil sieved out into different size fractions the content of moisture was differed. Each experimental year the lowest moisture content was identified in the biggest (> 5 mm) soil structural aggregates, on average 6.34 % (Table 3). Middle – sized (2-5 mm) soil fraction had the highest moisture content 8.14 %, and the smallest (< 2 mm) fraction had moderate moisture content (7.26 %).

Table 3. Moisture content in the fractions of soil aggregates after sieving
3 lentelė. *Drėgmės kiekis dirvožemio agregatų frakcijose po sijojimo*

Fractions of soil aggregates *Dirvožemio agregatų frakcijos*	Soil moisture content % *Dirvožemio drėgmės kiekis %*			
	year / *metai*			average *vidurkis*
	2002	2003	2004	
< 2 mm	7.20	6.83	7.75	7.26
2-5 mm	7.94	8.17	8.31	8.14
> 5 mm	5.94	5.89	7.18	6.34

The influence of seedbed structure on the soil moisture changing dynamics during the spring barley germination period and end of the growing season was estimated in the 0-5 cm and 5-10 cm topsoil layers. The obtained findings suggest that in the 0-5 cm topsoil layer, in most cases the seedbed soil moisture content, during barley germination period tended to remain higher because of more fractionated seedbed, i.e. when sorted bigger soil structural aggregates were taken to the surface, middle-sized aggregates prevailed in the middle layer and smaller ones concentrated in the deeper seedbed layers, closer to the seeds. The differences in separate cases, especially in 2002, were significant (Table 4). Similar changes in the 0-5 cm depth persisted at the end of barley growing season.

Table 4. The effect of seedbed structure on moisture content in the soil layer of 0-5 cm. 2002
4 lentelė. *Sėklų guolio sandaros įtaka drėgmės kiekiui 0-5 cm dirvožemio sluoksnyje. 2002 m.*

Seedbed models (prevailing soil aggregates %) *Sėklų guolio modeliai (vyraujantys dirvože-mio agregatai %)*	Soil moisture content % *Dirvožemio drėgmės kiekis %*						
	beginning of growing season *vegetacijos periodo pradžia*						end of growing season *vegetacijos periodo pabaiga*
	measurements (days from sowing) *matavimai (dienų skaičius nuo sėjos)*					average *vidurkis*	
	I(10)	II(13)	III(16)	IV(19)	V(21)		
1st / *1-as* (40 %)	8.86	7.93	7.83	7.74	7.90	8.05	10.81
2nd / *2-as* (60 %)	8.47	8.93	7.63	7.53	9.00	8.31	11.39
3rd / *3-as* (80 %)	8.99	9.35	8.71	8.28	9.11	8.89	11.73
4th / *4-as* (100 %)	8.59	10.32	10.26	8.54	9.21	9.38	12.30
LSD_{05} / R_{05}	1.141	1.681	1.681	2.002	1.575	1.640	1.104

The research results suggest that the influence of the seedbed structure on the soil bulk density, also on the total and air-filled porosity changes in the 0-5 and 5-10 cm topsoil layers was not very significant (data not shown). With the increased seedbed fractionating the total soil porosity in the 0-5 cm topsoil layers at the beginning of crop growing season in separate cases was higher (2002 and 2003), but in 2003 such changes persisted until the middle of spring barley growing season. Seedbed structure had no significant influence on porosity changes in the 5-10 cm topsoil layer.

The effect of the seedbed structure on crust formation on soil surface was assessed after final spring barley germination, when polythene wrap cover had been removed from the experimental plots. It was determined that with increasing seedbed fractionating a consistent reduction trend occurred in the soil crust that had formed after rain. But according to the results from the year 2002 of the 4th seedbed model, the weight of formed crust on the surface of the soil was 27.5 % lower compared with the seedbed of the 1st model (Table 5).

Series of our previous field trials showed that the finer the seedbed was prepared in spring on clay loam soil, the bigger crust formed on the soil surface after rain. It decreased seed germination, seedling emergence and yield of spring-sown cereals /Satkus, 2000; Velykis, Satkus, 2002; Velykis, Satkus, 2005/.

Table 5. Effect of seedbed structure on soil crust
5 lentelė. *Sėklų guolio sandaros įtaka dirvos plutai*

Seedbed models (prevailing soil aggregates %) *Sėklų guolio modeliai (vyraujantys dirvožemio agregatai %)*	Year / *Metai*			Average *Vidurkis*	Relative values *Santykiniai skaičiai*
	2002	2003	2004		
	soil crust kg per 0.25 m^2 *dirvos pluta iš 0,25 m^2*				%
1st / *1-as* (40 %)	6.94	12.70	6.66	8.77	100
2nd / *2-as* (60 %)	6.37	12.28	5.24	7.96	90.8
3rd / *3-as* (80 %)	5.53	11.76	5.13	7.47	85.2
4th / *4-as* (100 %)	5.03	11.22	5.76	7.34	83.7
LSD_{05} / R_{05}	1.888	2.773	2.010	2.258	-

Spring barley germination dynamics and intensity. During separate experimental years with different moisture of the topsoil at sowing, the structure of the seedbed unequally conditioned the germination of spring barley (Table 6).

Table 6. The effect of seedbed structure on barley germination dynamics and intensity
6 lentelė. *Sėklų guolio sandaros įtaka miežių dygimo dinamikai ir intensyvumui*

Seedbed models (prevailing soil aggregates %) *Sėklų guolio modeliai (vyraujantys dirvožemio agregatai %)*	Seedling count stages (days from sowing) *Daigų skaičiavimo etapai (dienų skaičius nuo sėjos)*					Germination intensity coefficient *Dygimo intensyvumo koeficientas*
	I (10)	II (13)	III (16)	IV (19)	V (21)	
	number of seedlings per 0.25 m^2 *daigų skaičius iš 0,25 m^2*					
2002						
1st / *1-as* (40 %)	27.0	50.0	64.5	68.5	70.2	1.39
2nd / *2-as* (60 %)	32.3	57.2	68.2	71.0	72.7	1.52
3rd / *3-as* (80 %)	40.7	62.3	72.8	74.5	75.5	1.68
4th / *4-as* (100 %)	46.7	67.8	74.8	77.0	77.7	1.79
LSD_{05} / R_{05}	12.50	8.75	6.28	6.18	6.57	0.196
2003						
1st / *1-as* (40 %)	38.0	49.0	59.5	65.5	79.2	1.36
2nd / *2-as* (60 %)	32.7	52.3	70.2	74.8	81.3	1.45
3rd / *3-as* (80 %)	46.3	66.2	77.0	79.8	82.5	1.71
4th / *4-as* (100 %)	37.3	55.8	71.8	75.0	80.0	1.52
LSD_{05} / R_{05}	16.80	16.93	15.17	13.77	5.79	0.379
2004						
1st / *1-as* (40 %)	31.2	73.3	79.7	78.7	80.3	1.72
2nd / *2-as* (60 %)	28.8	76.0	81.7	82.3	82.8	1.75
3rd / *3-as* (80 %)	24.3	74.3	79.2	80.8	81.5	1.67
4th / *4-as* (100 %)	25.3	75.2	80.7	81.0	81.5	1.70
LSD_{05} / R_{05}	11.50	8.03	5.62	5.39	5.18	0.161

In 2002 when the topsoil was the driest of all experimental years, increased seedbed fractionating (1st model→2nd model→3rd model→4th model) resulted in a consistent improvement in barley seed germination in all the five seedlings count stages. In 2002 the best germination of barley was recorded in the 4th model, where 86.3 % of the sown seed germinated in the fifth final stage (90 seeds per model). The intensity of spring barley germination here also varied similarly to the number of seedlings and was the highest in 4th model. When moisture content was higher in the topsoil during the sowing time in 2003, most of the spring barley seeds germinated and their germination intensity was the highest in the 3rd model, where 91.7 % of the total seed sown germinated. When the moisture content in the topsoil during the sowing time was the highest (2004), the seedbed fractionating did not condition a consequent improvement in spring barley germination. Under that year's conditions, most seed (92.0 %) germinated and the highest germination intensity was recorded in the 2nd model's seedbed.

Crop growth dynamics and intensity. The structure of the seedbed had a smaller influence on the height and growth intensity of the spring barley than on germination (Table 7). However, similar trends remained.

Table 7. Effect of seedbed structure on barley growth dynamics and intensity
7 lentelė. *Sėklų guolio sandaros įtaka miežių augimo dinamikai ir intensyvumui*

Seedbed models (prevailing soil aggregates %) *Sėklų guolio modeliai (vyraujantys dirvožemio agregatai %)*	Seedling height measurements (days from sowing) *Daigų aukščio matavimai (dienų skaičius nuo sėjos)*					Growing intensity coefficient *Augimo intensyvumo koeficientas*
	I (10)	II (13)	III (16)	IV (19)	V (21)	
	seedling height mm / *daigų aukštis mm*					
2002						
1st / *1-as* (40 %)	18.7	32.1	58.6	75.8	103.0	1.23
2nd / *2-as* (60 %)	18.5	35.8	70.4	86.5	115.0	1.39
3rd / *3-as* (80 %)	19.8	39.8	69.6	85.4	116.1	1.42
4th / *4-as* (100 %)	25.1	41.1	71.6	87.5	118.1	1.50
LSD_{05} / R_{05}	5.11	7.15	13.28	9.11	18.89	0.189
2003						
1st / *1-as* (40 %)	20.4	34.8	74.6	85.4	97.6	1.37
2nd / *2-as* (60 %)	22.0	43.4	70.8	87.0	101.0	1.43
3rd / *3-as* (80 %)	24.1	41.7	74.0	88.4	103.6	1.46
4th / *4-as* (100 %)	19.7	31.4	66.2	82.0	87.7	1.27
LSD_{05} / R_{05}	8.80	11.02	11.16	9.26	15.90	0.229
2004						
1st / *1-as* (40 %)	15.1	50.5	84.8	107.1	128.6	1.61
2nd / *2-as* (60 %)	12.5	47.3	80.4	97.8	125.7	1.49
3rd / *3-as* (80 %)	10.7	50.7	86.9	104.5	125.0	1.57
4th / *4-as* (100 %)	10.9	47.0	83.1	107.9	130.9	1.55
LSD_{05} / R_{05}	1.95	15.86	10.89	15.41	23.95	0.234

Having sown in the drier soil (2002) and having increased fractionating of the seedbed, spring barley seedlings were taller and grew more intensively. When the topsoil moisture was increased (2003) during the sowing time, the tallest spring barley seedlings grew and their growing intensity was the highest in the seedbed of the 3rd model. When the moisture of the topsoil was higher, the seedbed structure (2004) had no consistent influence on the growth of barley.

According to Swedish scientists, based on new experiments, sorting of coarse soil aggregates upwards and fine aggregates downwards in the seedbed should not be regarded as a goal in the case of using modern seeders, whose coulters can penetrate below the base of the seedbed /Hakansson et al., 2002/. They pointed out that it seems to be relatively harmless, however probably complicatedly realizable in practical seedbed preparation with traditional implements. However, they also noted that a more detailed study of the influences of various soil aggregate fractions in seedbed would be valuable. Unlike our research, the experiments in Sweden were carried out in shallow plastic boxes and there was no effect from natural structured topsoil and subsoil layers on seedbed and crop emergence, which occurred in the field conditions.

Weed infestation. The effect of the seedbed structure on the weed infestation was evaluated according to the number and mass of dry matter of annual weeds, at the milky stage of spring barley. It was determined that with increasing seedbed fractionating, the number of annual weeds and their mass decreased (Table 8). The reason of that is a worse germination of small weed seed, present in the upper layer (0-2 cm) of the seedbed, because of the worse contact with the coarse soil aggregates and smaller reserves of the moisture in it.

Table 8. The effect of the seedbed structure on annual weed infestation in spring barley
8 lentelė. *Sėklų guolio sandaros įtaka trumpaamžių piktžolių išplitimui vasariniuose miežiuose*

Joniškėlis, 2002-2004 averaged data
Joniškėlis, 2002-2004 m. vidutiniai duomenys

Seedbed models (prevailing soil aggregates %) *Sėklų guolio modeliai (vyraujantys dirvožemio agregatai %)*	Annual weeds /*Trumpaamžės piktžolės*				
	total number per m^2 *bendras skaičius iš m^2*	among them predominating *iš jų vyraujančios*			mass of dry matter g m^{-2} *sausųjų medžiagų masė g m^{-2}*
		Chenopodium album L.	*Stellaria media* (L.) Vill	*Veronica arvensis* L.	
1st / *1-as* (40%)	83.3	14.4	23.7	11.1	15.0
2nd / *2-as* (60%)	58.2*	8.7	12.2	9.1	10.3*
3rd / *3-as* (80%)	48.4**	4.2	11.6	4.9	9.4**
4th / *4-as* (100%)	46.2**	4.1*	9.8	6.4	8.3**

* Differences significant at 95 % probability level / *Esminiai skirtumai esant 95 % tikimybės lygiui*
** At 99 % / *Esant 99 %*

Some experiments conducted in the United Kingdom show an enhanced seedling emergence when weed seeds were covered by coarser soil aggregates in contrast to our investigations /Cussans et al., 1996/. However, in this experiment artificial watering was used and penetration of soil by light was the major controlling factor. In our study, where dry conditions were simulated after sowing and soil moisture content was the limiting factor, increasing the amount of coarse soil aggregates in the upper layers of seedbed worsened the emergence of small-seeded weeds.

Conclusions

1. The seedbed models constructed on a clay loam soil showed that spring barley germination dynamics and intensity were dependent on the structure of the seedbed and on the moisture content in the deeper soil layers. When the topsoil moisture under the seedbed was decreasing, the spring barley seeds were germinating more intensively, and more seed germinated, when the seedbed was more fractionated, i.e. when bigger soil structural aggregates were taken to the surface, and smaller ones were concentrated in the deeper seedbed layers, closer to the seeds.
2. The effect of the seedbed structure on the dynamics and intensity of spring barley seedling growth depended on the topsoil moisture content. When there was less moisture in the topsoil, spring barley grew more intensively and taller in the more fractionated seedbed.
3. With increasing the sorting of coarse soil aggregates upwards and fine aggregates downwards there was more moisture and higher porosity, or the same trends prevailed in the whole seedbed (0-5 cm) throughout the spring barley germination period.
4. When seedbed fractionating had been increased according to the soil structural aggregates, less crust formed on the soil surface after rain at a more advanced barley growth stage.
5. Annual weeds germinated worse in the spring barley crop when there was increased fractionating of the seedbed.
6. The data of modelling research suggest that if topsoil in clay loam is relatively dry and when seeds are placed directly on a firm seedbed base, optimal seedbed structure for spring barley is when on the top (0-1.5 cm) seedbed layer soil structural aggregates > 5 mm, in the middle (1.5-3.0 cm) layer – middle-sized aggregates 2-5 mm and in the bottom (3.0-4.5 cm) layer aggregates < 2 mm account for 80-100 %. Such seedbed structure ensures intensive and good germination and growth of spring barley during a dry post-sowing period, and in the case of lower moisture reserves in the topsoil, decreases the weed infestation and helps prevent soil physical degradation.

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SĖKLŲ GUOLIO SANDAROS MODELIAVIMAS VASARINIAMS MIEŽIAMS SUNKIAME PRIEMOLYJE

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Santrauka

Teoriškai optimalių sėklos guolio sandaros parametrų nustatymo tyrimai atlikti Lietuvos žemdirbystės instituto Joniškėlio bandymų stotyje sunkaus priemolio glėjiškame rudžemyje. Buvo sudaryti keturi sėklų guolio modeliai su skirtingu įvairaus dydžio dirvožemio struktūrinių agregatų (< 2, 2-5 ir > 5 mm) kiekiu trijuose sėklų guolio sluoksniuose: 0-1,5, 1,5-3,0 ir 3,0-4,5 cm. Vyraujančios dirvožemio struktūrinių agregatų frakcijos minėtuose sėklų guolio sluoksniuose 1-ame modelyje sudarė 40 %, 2-ame – 60 %, 3-iame – 80 % ir 4-ame – 100 %. Sėkloms dygti posėjiniame periode buvo sudarytos sauso oro ir dirvožemio sąlygos.

Remiantis tyrimų duomenimis nustatyta, kad dirvožemio struktūrinių agregatų surūšiavimas sėklų guolyje, stambesniųjų daugiau iškeliant link dirvos paviršiaus, o smulkesniųjų daugiau sutelkiant apačioje, gerino sėklų sąlytį su dirvožemiu ir, esant mažesniam drėgmės kiekiui sunkaus priemolio armenyje, sausu posėjiniu periodu buvo svarbus veiksnys geresniam vasarinių miežių sėklų sudygimui ir greitesniam jų augimui ankstyvais tarpsniais. Toks dirvožemio agregatų surūšiavimas ir suskirstymas frakcijomis sėklų guolio sluoksniuose padėjo apsaugoti dirvos paviršių ir nuo plutos susidarymo bei sumažino smulkiasėklių trumpaamžių piktžolių sudygimą.

Reikšminiai žodžiai: sunkus priemolis, sėklų guolio modeliavimas, dirvožemio būklė, vasariniai miežiai, piktžolės.