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EVALUATION OF SOIL TILLAGE PROCESS TO IMPROVE SEEDBED PREPARATION AND CROP DENSITY

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Abstract: The humidity of the soil and the quality of seedbed preparation is an important factor influencing crop density and early establishment. It largely depends on weather conditions, but partly it can be controlled by soil management system. Field experiments of different soil tillage methods were carried out at Experimental Station of Aleksandras Stulginskis University in 2009. Treatments involved: 1) direct drilling, 2) shallow ploughing (10 cm depth), and 3) deep ploughing (20 cm depth). In the experiment spring barley (Hordeum vulgare L.) variety 'Simba' was cultivated. The soil of experimental site – Calc(ar)i-Endohypogleyic Luvisol (Drainic). The aim of the research was to estimate the influence of soil management system on seedbed parameters and crop density. It was estimated, that the highest roughness of the soil surface (31.8 mm) was, when the soil was ploughed at 20 cm depth, but contrarily the seedbed roughness was the lowest (15.2 mm). Estimated direct drilling depth was 15.6 mm and in ploughed soil it was 51.7–57.4 mm. In ploughed soil at 20 cm depth the seeds were sown too deep – 88.4 % of them were below sowing depth. When direct drilling was used – too shallow – 57.8 % of seeds were above sowing depth. The highest accuracy was estimated in shallow ploughed soil – 43.8 % of the seeds were at sowing depth. Nevertheless in the dry weather conditions spring barley germinated faster when direct drilling was used, later on, experimental results showed, that spring barley crop density was significantly thinner (180 plants per m^2) compared to deep or shallow ploughing, whereas depth of the ploughing did not influence thickness of crop stand: it was 431–445 plants per m^2.
Keywords:deep and shallow ploughing, direct drilling, seedbed, crop stand density

INTRODUCTION

Seedbed preparation is crucial for the growth of seedlings, plant establishment and the final yield of crops. A great consideration is needed to determine the most suitable conditions for crop growth. An important aspect of this is the physical characteristics of the seedbed such as soil strength, bulk density, water content, water retention, aggregate size and distribution, aggregate stability, temperature, oxygen and nutrient availability [2,8]. Experimental evidence suggests that different soil tillage and sowing methods has a significant effect on soil structure, soil bulk density, total and air-filled porosity, soil moisture and crop yield [5,14,12,9,6].

A seedbed is defined as a loose shallow surface layer, tilled during seedbed preparation with a basal layer underneath which is untilled and usually firm [3]. A seedbed is required to provide a medium for germination, root growth, emergence and establishment [1], as such this covers a wide range of determinate factors. Seedbed preparation and sowing, often referred to as secondary tillage, aim primarily to create suitable soil conditions for germination, plant emergence and subsequent crop growth: the seed should be placed at a desired depth; the soil at sowing depth should contain enough water and suitable temperature and aeration conditions for germination; the seedbed should act as an evaporative barrier; the soil should not be over-compacted; tillage operations should also control weeds [1]. Seedbed practices are therefore key as cultivation implements impose varying degrees of alterations to both the surface soil and sub-soil. As such it is crucial to determine the best practice for seedbed preparation to maximise crop establishment and yield. The aim of our experiment was to estimate the influence of soil management system on seedbed parameters and crop density.

MATERIALS AND METHODS

- **Experimental site and soil.** Field experiments were carried out at the Experimental Station of the Aleksandras Stulginskis University (former Lithuanian University of Agriculture) (54°53′ N, 23°50′ E) in 2009. The soil of the experimental site is Calc(ar)i-Endohypogleyic Luvisol (Drainic) according to the WRB 2014 [4]. The main soil properties were: soil pH_{KCl} 6.7–7.2, arable layer 25 cm, humus content in the arable layer 2.2–3.0%, total N 1.47 g kg^{-1}, available phosphorus (P_2O_5) 119–242 mg kg^{-1}, and available potassium (K_2O) 100–124 mg kg^{-1}.
- **Experimental design.** The experiment had a one-factor design. It was performed in four replications. Spring barley (Hordeum vulgare L.) variety 'Simba' was cultivated using different soil management practices: 1) direct drilling, 2) minimum tillage (10 cm depth), 3) deep tillage (20 cm depth).
- **Method to characterize the quality of a seedbed.** Immediately after sowing the mean depth is determined by transferring all loose soil within a 40x40 cm^2 steel frame to a measuring cylinder. Before this, the difference in elevation between the highest and the lowest points of the soil surface within the frame is measured to give a simple characterization of the roughness of the surface, and afterwards, the roughness of the base of the seedbed is determined in the same way. The seedbed in the open frame at the side is separated into two or three sub-layers using a scoop and simple hand tools. The soil from each sub-layer is transferred to a hand sieve set to determine the aggregate size distribution and the number of seeds.
- **Crop density.** Density of spring barley crop was evaluated by counting method (with 20 x 30 cm frame) in 16 places of each plot.
- **Meteorological conditions.** April 2009 was 2.8 times warmer compared to the annual average and extremely dry. Rainfall was 4.5 times less than usual and all it dropped out during the first ten days, the hydrothermal coefficient of the April was 3.8 (very wet). During the sowing time of spring crops, the hydrothermal coefficient of the second and third ten days was 0; there were no rainfall at all. At May, the average temperature was 2°C below the annual average. At the end of the first ten days started to rain, but moisture, however, was too low, because during the second ten days was too little rainfall. A little more rainfall was only at the end of May. This month's average hydrothermal coefficient was 1.3 (sufficient moisture). June was nearly 1°C cooler and precipitation was 1.7 times more than the usual, hydrothermal coefficient 2.6 (very wet). The air temperature and precipitation in July was a close to the annual average estimate hydrothermal coefficient 1 (sufficient moisture). August was wet (hydrothermal coefficient 1.7), although the average air temperature and precipitation was close to the annual average. However, the first ten days was favourable for harvesting, there were no rainfall.
- **Statistics.** Statistical significance of differences between treatments was evaluated by Fisher's protected least significant difference test at $P_{(level)} < 0.05$ was performed using package of statistical programmes SELEKCIJA [15].

RESULTS

The roughness of the soil surface shows the difference in elevation between the lowest and highest points of the surface. In our experiment the influence of soil management practices on soil surface roughness was significant (Figure 1). The highest unevenness of soil surface after barley sowing was when the soil was deep ploughed in autumn, compared with shallow ploughing (8.5 %) and direct drilling (18.6 %). The lowest soil surface roughness was in direct sowing plots. A. Kairyte (2005) found that all methods of minimised soil tillage and direct drilling significantly reduced the soil surface roughness in comparison with deep ploughing in autumn [7]. In our experiment the highest roughness of the base of the seedbed was in shallow ploughed soil – 39.9 % higher compared to direct drilling, and 49.0% if compared with deep ploughing in the autumn.

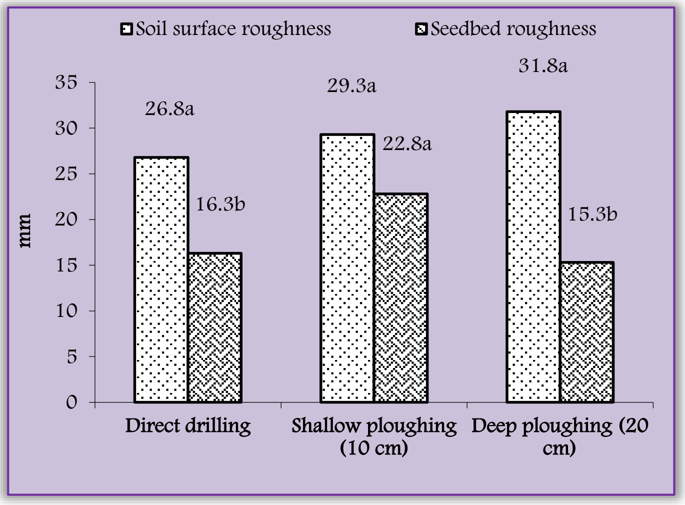

Figure 1 – The roughness of the soil surface (LSD_{05} = 6.40) and the roughness of the base of the seedbed (LSD_{05} =4.34) using different soil management practices

Seedbed quality/conditions determine plant uniformity and growth intensity in the beginning of the vegetation. Fast and uniformly emerged crops have capability to smoother weeds and are the basis

for a good harvest. The quality of seedbed depends on tillage and quantity of organic matter [16,11].
According to I. Hakansson et al. (2002), A. Velykis and A. Satkus (2005) the optimal depth for sowing in heavy soils is 3–5 cm [3,16]. In our experiment sowing depth closest to the optimal was in the shallow and deep ploughed soil (51.7–57.4 mm) (Figure 2). In direct drilling sowing depth was on average 3.4 times shallower than in autumn ploughed soil. This difference was significant.

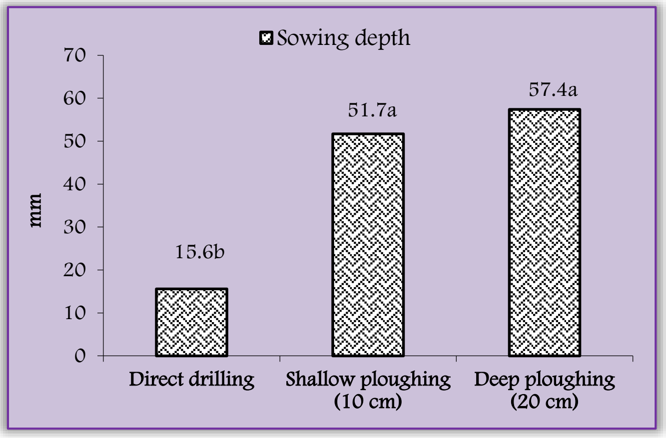

Figure 2 –Sowing depth using different soil management practices (LSD_{05} = 13.45)

Table 1. The effect of primary soil tillage on the seed distribution in seedbed layers

Soil management practices	Spring barley seed distribution %		
	Soil surface (L1)	Sowing depth (L2)	Under sowing depth (L3)
Direct drilling	57.8	37.0	5.2
Shallow ploughing (10 cm)	10.7	43.8	45.5
Deep ploughing (20 cm)	0	11.6	88.4
	LSD_{05} = 10.44	LSD_{05} = 13.39	LSD_{05} = 25.43

The highest quantity of seeds (57.8%) in the top seedbed layer (L1) were distributed when direct drilling was used, that was significantly higher (5.8 times more) compared to shallow ploughing plot (Table 1). In this layer no seeds were found when deep ploughing in the autumn was used. In the sowing depth (L2) the most quantity of seeds (43.8%) were when soil was shallow ploughed in the autumn: that was 1.2 times and 3.8 times more compared with direct drilling and deep ploughing, accordingly. When soil was shallowly ploughed in the autumn, almost half of seeds (45.5%) were distributed deeper than the optimum sowing depth (4–5 cm), and when the soil was ploughed deeply, most of the seeds (88.4%) were incorporated too deep. It could be stated that sowing depth of spring crops in direct drilling largely depends on soil compaction. Autumn and pre-sowing tillage allows more even seed distribution in soil and less seeds remains on soil surface. Experiments made by other authors showed that even seed introduction was also reduced when the intensity of soil tillage was minimized, because the soil surface became harder, the greater part of the plant residues remained in the soil surface or was introduced into the upper soil layers, preventing seed introduction [11].

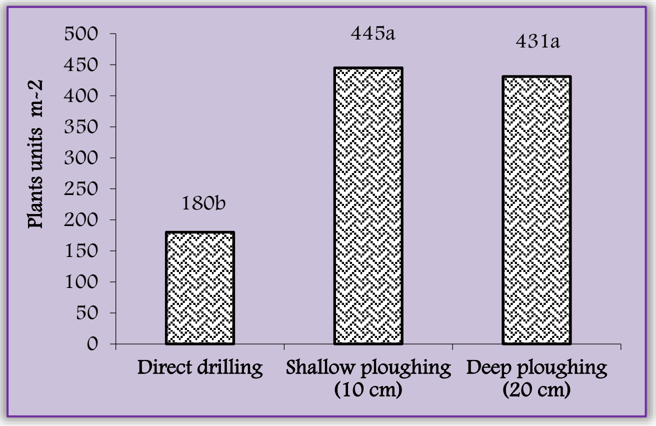

Figure 3 – Spring barley germination using different soil management practices (LSD_{05} = 87.14)

The quality of soil preparation for sowing, soil physical mechanical properties, and moisture content has a great influence on the field seeds germination. Proper seedbed preparation significantly increases seeds contact with the soil. Our experiment showed that a soil management practice has a significant effect on the germination of spring barley (Figure 3).
When the soil in the autumn was deeply or shallowly ploughed the germination of barely was on average 2.4 times higher than in direct drilling. Nevertheless the moisture content in the no tilled soil was sufficient, but during winter soil was compacted therefore the seed was sown too shallow and that had significant influence on poor germination of barley. Minimum soil tillage according to seedbed quality in heavy soils is more suitable for the winter crops than for spring crops [16,10]. Reduced primary soil tillage can be applied in cereal cultivation on Central Lithuania's cultivated sandy light loamy soils: instead of conventional soil tillage (stubble breaking at a depth of 10–12 cm and deep ploughing at a depth of 22–25 cm) it is feasible to apply direct drilling or minimal soil tillage at a depth of 10–12 cm. Replacement of conventional soil tillage by direct drilling into non-tilled and into minimally tilled soil suits best for oats and winter wheat grown after good preceding crops [14]. Application of shallow ploughing for the pea provided the worst germination [17].Spring barley and peas were more susceptible to the simplification of autumn soil tillage: when barley and peas were sown into minimally tilled soil or direct-drilled into non-tilled soil spray-applied with Roundup (4 l ha^{-1}), a significantly lower yield was obtained [14].

CONCLUSIONS

Experiments of different soil tillage methods showed, that the highest roughness of the soil surface (31.8 mm) was when the soil was ploughed in the autumn at 20 cm depth, but contrarily the seedbed roughness was the lowest (15.2 mm).

Sowing depth of spring crops in direct drilling largely depended on soil compaction. Deep or shallow soil ploughing allowed more even seed distribution in soil and less seeds remained on soil surface. The highest accuracy was estimated in shallow ploughed soil – 43.8 % of the seeds were at sowing depth.

When the soil in the autumn was deeply or shallowly ploughed the germination of barely was on average 2.4 times higher than in direct drilling. Nevertheless in the dry weather conditions spring barley germinated faster when direct drilling was used. Later on, spring barley crop density was significantly thinner (180 plants per m^2) compared to deep or shallow ploughing, whereas depth of the ploughing did not influence thickness of crop stand: it was 431–445 plants per m^2.

References

[1.] Arvidsson J., Rydberg T., Feiza V. (2000) - Seedbed preparation in Sweden. Soil and Tillage Research, 53: 145–155.
[2.] Atkinson B. S. (2008) - Identification of optimum seedbed preparation and establishment using soil structural visualisation: doctoral thesis, the University of Nottingham, UK.
[3.] Håkansson I., Myrbeck Å., Etana A. (2002) - A review of research on seedbed preparation for small grains in Sweden. Soil and Tillage Research, 64: 23–40.
[4.] IUSS Working Group WRB (2014) - World reference base for soil resources 2014. International soil classification system for naming soils and creating legends for soil maps. World soil resources reports No. 106. FAO, Rome
[5.] Jodaugienė D. (2002) - The influence of long term ploughing and loosening on soil and crops in the system of reduced soil tillage: Doctoral Dissertation, LŽŪU, Akademija.
[6.] Juchnevičienė A., Raudonius S., Avižienytė D., Romaneckas K., Bogužas V. (2012) - Effect of long-term reduced soil tillage and direct seeding on winter wheat crop. Agricultural Sciences, 3: 139–150.
[7.] Kairytė A. (2005). Tillage intensity and straw incorporation effect on barley agrocenosis: Doctoral Dissertation:, LŽŪU, Akademija.
[8.] Romaneckas K., Pilipavičius V., Šarauskis E. (2010) - Impact of seedbed density on sugar beet (Beta vulgaris L.) seed germination, yield and quality of roots. Journal of Food, Agriculture & Environment, 8: 599–601.
[9.] Romaneckas K., Šarauskis E., Pilipavičius V., Sakalauskas A. (2011) - Impact of short-term ploughless tillage on soil physical properties, winter oilseed rape seedbed formation and productivity parameters. Journal of Food, Agriculture & Environment, 9(2): 295–299.
[10.] Satkus A., Velykis A. (2008) - Modelling of seedbed creation for spring cereals in clayey soils. Agronomy Research, 6: 329–339.
[11.] Šarauskis E., Vaiciukevičius E., Sakalauskas A., Romaneckas K., Jasinskas A., Lillak R. (2008) - Impact of sowing speed on the introduction of winter wheat seeds in differently-tilled soils. Agronomy Research, 6: 315–327.
[12.] Šarauskis E., Romaneckas K., Buragienė S. (2009) - Impact of conventional and sustainable soil tillage and sowing technologies on physical-mechanical soil properties. Environmental Research, Engineering and Management, 3(49): 36–43.
[13.] Šimanskaitė D. (2002) - Effect of different soil tillage and sowing methods on soil and yield. Žemdirbystė-Agriculture. T. 79. P. 131–138.
[14.] Šimanskaitė D. (2007) - The effect of ploughing and ploughless soil tillage on soil physical properties and crop productivity. Agricultural Sciences, 14(1): 9–19.
[15.] Tarakanovas P., Raudonius S. (2003) – Statistical data analysis in agronomic research using computer programs ANOVA, STAT, SPLIT-PLOT from the packages SELEKCIJA and IRRISTAT. Akademija.
[16.] Velykis A., Satkus A. 2005. Factors of seedbed quality on heavy soils. Žemdirbystė=Agriculture, 1(89): 53–66.
[17.] Velykis A., Satkus A. 2012. Response of field pea (Pisum sativum L.) growth to reduced tillage of clayey soil. Žemdirbystė=Agriculture, 99(1): 61–70.

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